SPITSBERGEN WATERS

OCEANOGRAPHIC OBSERVATIONS DURING THE CRUISE OF THE "VESLEMÖY" TO SPITSBERGEN IN 1912

BY

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A. W. BRØGGERS BOKTRYKKERI A-S

To his Old Friend

PROFESSOR H. MOHN

the Pioneer of Mechanical Oceanography,

on his Eightieth Birthday

from

the Author.

CONTENTS.

Introduction.

During the Fram-Expedition 1893—1896 the deep North Polar Basin was discovered. This basin was found to be filled with water of Atlantic origin below a depth of 200 or 300 metres. According to our observations the salinity of this deep-water and bottom-water should be considerably higher than that of the deep-water of the Norwegian Sea, and its temperature was also higher. Our determinations of the salinity, or rather the specific gravity, of the sea-water were, however, made chiefly with the floating hydrometer, and this method is not sufficiently accurate. As the knowledge of the accurate salinity of the deep-waters of the North Polar Basin is of great importance in several interesting questions connected with the configuration of the bottom and the circulation of the Northern Seas, I had attempted to obtain new samples of the deep-water of the sea north of Spitsbergen, in order to control our observations made during the Fram-expedition. Three different expeditions had promised to do their best to collect such samples, but had failed. I therefore decided to make an attempt to go with my yacht »Veslemöy« to the sea north of Spitsbergen in order to fetch some samples of the deep-water.

It was my plan at the same time to try the practicability of making exact measurements of the currents and movements of the water at the different depths of the sea from a ship moored to the drifting ice. This was a method of investigating the currents of the deep sea, which I had recommended years ago, but had never yet had an opportunity of trying, nor had anybody else done so. I also wished to investigate the waters of some of the Spitsbergen fjords, and to examine other problems connected with the Spitsbergen waters, which Professor Helland-Hansen and I had discussed in our paper, »On the Sea West of Spitsbergen« [1912].

The crew of the »Veslemöy« consisted of four men; *viz.* two sailors on deck, an engineer for the paraffine motor, and a steward. And then there were Cand. Mag. Illit Gröndahl and my son Kåre (nearly 15 years old), as passengers, besides myself who was master of the ship. We were thus seven men all told.

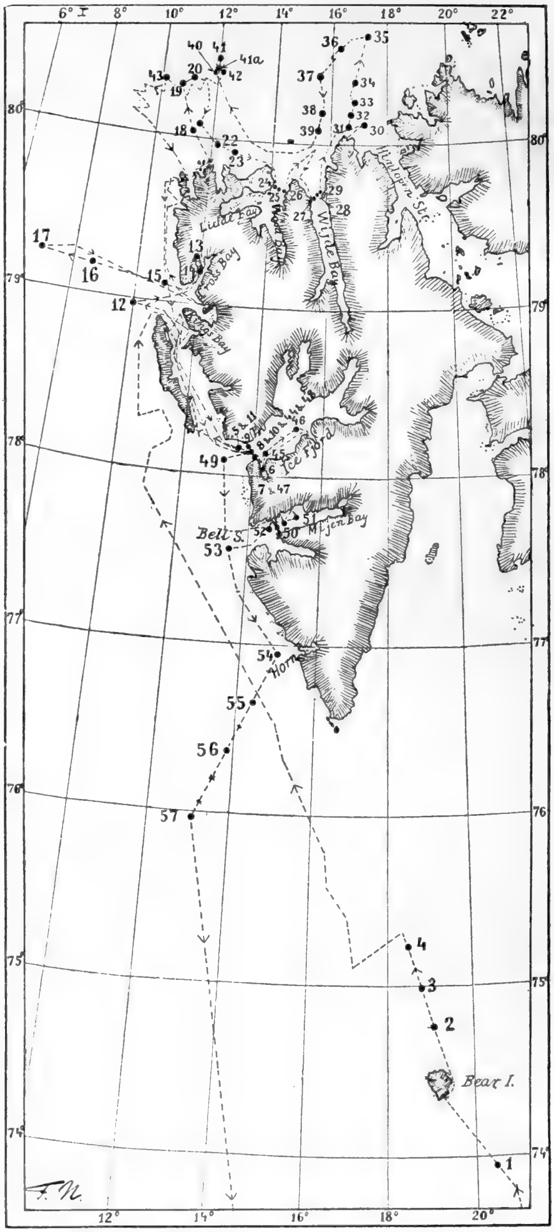


Fig. 1. The route of the Veslemöy, July 10 to September 2, with Stations (1—57). Scale 1 : 5,000,00.

We sailed from Hammerfest on July 8th 1912, reached Bear Island on July 10th, and took some few oceanographic stations on the Bear Island Platform south and north of the island. Some few days later we reached Spitsbergen, and came to Green Harbour on July 16th. During the following days, from July 18th to 21st, two oceanographic stations were taken at the mouth of Ice Fjord. We then sailed northwards along the west coast of Spitsbergen, in very stormy weather. We went into Cross Bay, where two oceanographic stations were taken, on July 29th. We tried to take a section with stations seawards from the mouth of Kings Bay, but after having taken only a few stations we were hindered by storm. Our forestay was broken, and as there was danger of losing our rigging we had to return to Kings Bay for repair. We then sailed north-wards along the coast, and a few days later, on August 3rd, we sailed north-north-westwards from Norway Islands, near the north-western corner of Spitsbergen, to the edge of the ice-pack, taking two oceanographic stations (Stats. 18 and 19). We went as far into the ice as we could get, moored the ship to the biggest ice-floe we could find, and remained there for some time, making observations. This was at Stat. 19; but in the evening of August 4th the ice tightened, the wind increased, and there was so much swell coming from the open sea outside, that there was no little danger in remaining there between the heavy floes, and we therefore moved a few miles towards north-

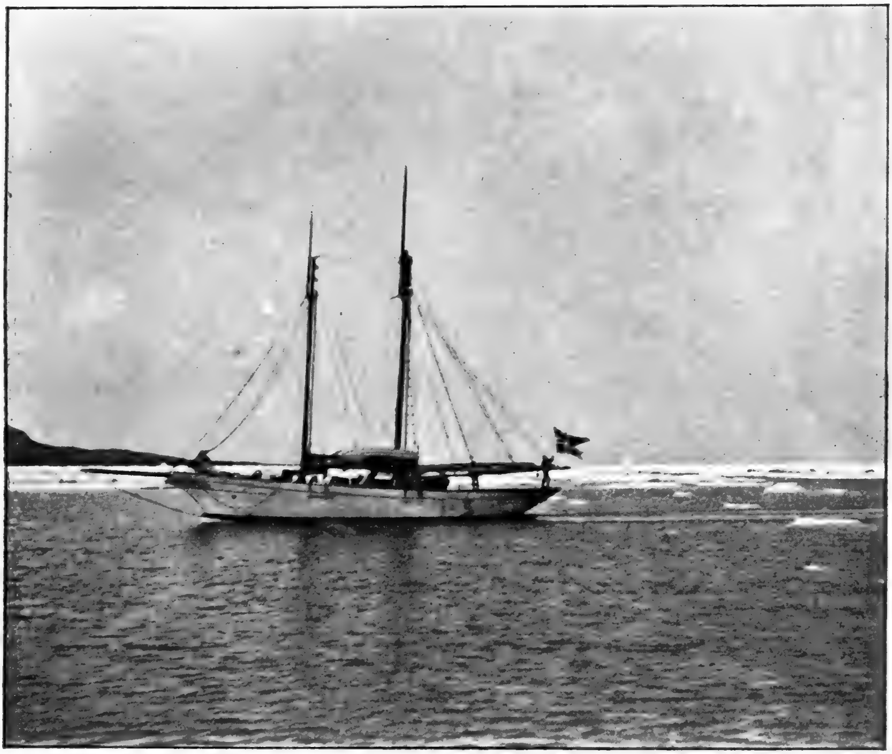


Fig. 2. The Veslemøy at the mouth of Ice Fjord, Aug. 24th, 1912.

north-east, where the ice was more open, and here the ship was moored to another floe. There we remained during the following day, continuing our current-measurements and other observations. After midnight, in the early morning of August 6th, the wind and swell had increased much, and it was necessary to go out of the ice again. Three oceanographic stations (Stats. 21—23) were taken on our way towards the north coast of Spitsbergen.

On August 9th a section was taken across the mouth of Wood Bay (and Liefde Bay), with 3 stations. On the following day a similar section, with 3 stations, was taken across Wijde Bay.

During the following days researches were made at the mouth of Hinlopen Strait and in the sea to the north of it.

On August 13th we sailed northwards, hoping to reach the deep water to the north of Spitsbergen, but unfortunately we were stopped by the ice in about 80° 39′ N. and 17° 14′ E. (Stat. 35). East of this place, however, at Stat. 36, we found a depth of 620 metres, being obviously in a submarine channel passing from Hinlopen Strait across the submarine platform into the North Polar Basin; and the water near the bottom of this channel was evidently of the same kind as the deep-water of the North Polar Basin.

We now had to return, there being no prospect of getting farther north, as the ice was drifting rapidly southwards. We went again westwards, and made a new attempt to penetrate northwards, north of the north-western corner of Spitsbergen; but in 80° 29′ N. and about 12° E. we were stopped by tight ice at Stat. 41. The ship was moored to an ice-floe on August 17th in the evening, and during the following two days, current-measurements and other observations were continuously taken. In the afternoon of August 19th, at 6.20 p. m., the tightening of the ice-floes round the ship, and the heavy swell coming from the sea outside, made it necessary to leave the ice; and heavy gales during the following days prevented us from going into the ice again.

On August 24th we returned to Green Harbour. During the next few days we took several stations at the mouth of Ice Fjord, and as far in as off Advent Bay.

On August 29th we sailed southwards from Ice Fjord along the west coast of Spitsbergen. On the following day we paid a visit into Bell Sound, and took a few oceanographic stations there during August 30th and 31st. We then sailed southwards, taking a few oceanographic stations, till we were off the mouth of Horn Sound. From that place we took a section with 4 oceanographic stations (Stat. 54—57) towards SSW. We then got a gale and shaped our course for Norway. After a stormy passage we reached Harstad in northern Norway on September 5th.

57 oceanographic stations with vertical series of temperatures and water-samples were taken during the cruise, chiefly on the west coast and to the north of Spitsbergen. Investigations were also made in the following fjords: Ice Fjord, Cross Bay and Kings Bay, Wood Bay and Liefde Bay, Wijde Bay, Hinlopen Strait, and Bell Sound. It was mentioned above that the ice prevented us from coming sufficiently far north to reach the deep sea, but at the deepest stations water-samples were taken, which seem to be of the same kind as the deep water of the North Polar Basin.

On two occasions we went into the ice, and remained there for some time making current-measurements while the ship was moored to the ice-floes, and the practicability of this method was proved.

The quantity and oxygen of the sea water was examined by the WINKLER method at various depths at a number of stations. The ionic concentration of hydrogen of the sea-water was examined by the Palitzsch method. Samples were also taken for the determination of the nitrogen compounds of the sea-water, the samples being sterilized by sublimate; but as no sufficiently accurate method has yet been found for these investigations, the results obtained are of no value.

During the cruise, all observations and readings were taken by myself, with the exception of the surface-observations which in most cases were taken by Mr. GRÖNDAHL.

Water-Bottles. The water-samples were taken with the following water-bottles:

An Automatic Insulating Water-bottle (marked A in the Tables) used at the first 5 stations. This water-bottle, which was also used on the cruise of the »Frithjof« in 1910 [1913, p. 7], works very well, and gives reliable samples. The instrument has not yet been described.

The PETTERSSON-NANSEN Insulating Water-bottle (marked PN in the Tables) was used on several occasions.

An EKMAN Reversing Water-bottle (marked E in the Tables) was also used. In order to avoid the possibility of this bottle not closing properly when reversed, the end of the reversing cylinder had been given an extra weight of lead, which made the bottle close more safely; but on a few occasions the samples taken with this bottle seem none the less somewhat doubtful.

Two stop-cock water-bottles of my construction (marked I and II in the Tables) with an arrangement for reversing thermometers were used at most stations, and were attached to the side of the same line at different depths. They were the same bottles that were used during the cruise of the "Frithjof" in 1910 [1913, p. 7]. They always worked well. I had now had the reversing tube fitted with an extra tube, so that two reversing thermometers could be used simultaneously in each instrument.

The Reversing Stop-cock Water-bottle of my construction (marked RB in the Tables), mentioned in my paper on the cruise of the Frithjof [1913, p. 7] was also used at a number of stations. It was attached to the side of the line.

Except at the first few stations, several water-bottles were always used on one line attached at different depths. By using the PETTERSSON-NANSEN water-bottle at the end of the line, and the EKMAN reversing water-bottle, the two stop-cock water-bottles, and the reversing stop-cock water-bottle attached to the side of the line, we were able to take the temperatures and water samples from as many as 5 different depths in the same haul.

The Temperatures. The temperature of the sea-surface was taken with a water bucket (marked B in the Tables) and an ordinary thermometer, and water-samples were taken simultaneously.

The temperature of the sea-water at the different depths was as a rule determined by the RICHTER reversing thermometer, and two thermometers were often used simultaneously at the same depth. Sometimes the temperature was also taken by the PETTERSSON-NANSEN insulating water-bottle, and the NANSEN deep-sea thermometer; but the readings of the latter were as a rule checked by the RICHTER reversing thermometer. At the first five stations where the depth did not exceed 150 metres, the temperatures were taken with the new automatic, insulating water-bottle and an ordinary thermometer.

All thermometers were old instruments, which had been carefully tested. Most of them were the same thermometers that had been used during the cruise with the "Frithjof" in 1910. All readings of the thermometers, except those of the sea-surface, were taken by myself, with a reading lense. The readings of the reversing thermometers have been corrected for the instrumental error, the error of freezing-point, and the error caused by the temperature at which the thermometer was read off. The thermometer-readings of the insulating water-bottles have been corrected for the instrumental error of the thermometer, as well as the error caused by the adiabatic cooling.

The accuracy of the values of temperature obtained by the reversing thermometers may be expected to lie within ± 0.01° C.

On some occasions the second thermometer (No. P.T.R. 375 47) of the Ekman Reversing Water-bottle (*E*) suddenly registered irregularly. During the first part of the cruise its readings agreed very well with those of the other thermometer (No. P.T.R. 375 46) of the same water-bottle, except once, on August 4th (Stat. 19 d, at 80 metres), when it gave — 0.64° C. instead of — 0.82° C. But suddenly on August 10th (Stat. 27) it gave — 0.61° C. and — 0.86° C. instead of 1.71° C. and 0.78° C. During August 10th, 11th, and 13th, the thermometer continued to give too low readings (between — 0.52° C. and — 1.72° C.) except at 100 metres, at Stat. 29, where its value of temperature (— 0.12° C.) agreed perfectly with that of the first thermometer. On the afternoons of August 13th the second thermometer again registered correctly, and after that time it showed no such appreciable irregularities except on August 26th (Stat. 46, 100 metres) and 31st (Stat. 52, 20 metres) when it gave — 1.09° C. and 0.20° C. instead of — 0.40° C. and 0.36° C. If only the one thermometer had been used on these occasions there would hardly have been any reason to doubt the trustworthyness of the readings, and the result would have been quite erroneous values of temperature. It proves the great desirability of always using two thermometers at each depth.

Another peculiarity with this thermometer, No. P.T.R. 375 47, is that it now and then seems to alter its correction about 0.03° C. In most cases there was either no difference or a difference of about 0.01° C. between the temperature-values of this instrument and those of the first thermometer of the same water-bottle, while frequently the former were about 0.03° C. higher than the latter. The cause of this variation is probably slight variations in the manner in which the mercury thread is broken off.

The observations taken with the two stop-cock water-bottles I and II show an almost permanent difference of 0.01° C. between the temperature-values obtained by the first and the second thermometer of each bottle. This must be due to slight changes in the errors of freezing-point of at least two of these thermometers which, however, were all of them very trustworthy instrument as is also proved by the agreement between their readings.

The Salinities. All water-samples were preserved in glass-bottles with porcelain stoppers, fitted with rubber washers and lever fastenings. The bottles would hold about 200 c.cm. The salinities of the water-samples have been determined with the interferometer, constructed by Dr. Löwe (Carl Zeiss, Jena). The double chambers of the interferometer used for these investigations had been especially constructed for me by Zeiss, and were made of glass. They had lengths of 1 and 2 cm., and gave very satisfactory results. The readings of the interferometer were checked by the ordinary standard water supplied by the Bureau of the International Council at Copenhagen, and also by some other sets of water-samples with various salinities, which had been carefully determined by several series of titrations (Mohr's method), carried out by Professor Helland-Hansen and his assistant, Mr. Torbjörn Gaarder. I wish to express here my sincere gratitude for their valuable assistance. The determinations with the interferometer were made with great care and accuracy by my assistant, Cand. Real. Jacob Helland, in the winter of 1912—1913. Now and then some determinations were also made by myself as a control, but we nearly always arrived at the same results. Two or three determinations were made of most samples with different glass-chambers, and they nearly always agreed very well. In all cases where there could be the least doubt as to the values of salinity obtained, new determinations were made.

A great number of water-samples have been re-examined with the interferometer by my assistant, Mr. A. Öyan, this autumn and winter (1914—1915), two years after they were taken. The values of salinity found differed, however, only very slightly from those found by the original examination.

As a rule, or at least in the case of all important samples, the accuracy of the salinity given in Table I may be expected to lie within $\pm$ 0.01 $^0/_{00}$. This method would easily allow of a much higher degree of accuracy; the difficulty is, however, to acquire the sets of standard water for the control, sufficiently accurately determined for the purpose. Exact determinations of the specific gravity of the standard waters would naturally be preferable to the determination of their chlorine.

At **Stat. 17**, 1100 metres, **Stat. 30**, 400 and 440 metres, **Stat. 36**, 400, 500, and 580 metres, and at **Stat. 57**, 900 metres, two separate water-samples were collected from the water-bottle for each of the mentioned depths. Examined with the interferometer these double sets of samples gave values of salinity which agreed within a few thousandths of one per mille for each depth. At Stat. 19 two water-samples were taken in the same manner from 610 metres, but their salinities were found to be 34.916 $^0/_{00}$ and 34.90 $^0/_{00}$. The samples were first examined by Mr. J. Helland, and a year later by Mr. A. Öyan, but with very nearly the same results. It seemed at first dificult to understand the reason of this difference. The explanation must be, however, that the samples were taken with the Reversing Stop-cock Water-bottle, where the reversing thermometer was placed inside the bottle, which therefore had to be opened at the upper end (when reversed) and the thermometer had to be lifted before the temperature could be read off. During this operation a drop or two of water may have fallen into the water-bottle from outside its upper part when removed, or from the sounding-line; and as this water would have been from the sea-surface, a drop or two of it might reduce the salinity of the upper layers of the water inside the water-bottle appreciably when added to it. Thus the last water-sample collected from the water-bottle, and containing these uppermost layers, would get a lower salinity than the first sample. This incident shows how very careful one ought to be, when collecting the water-samples, in order to avoid that any drop of foreign water be added to the sample. On the other hand it also bears testimony to the accuracy of our determinations with the interferometer.

Bank-Water.

During our northward course we took several vertical series of observations (Stations 1—4) on the Bear Island Bank. They demonstrate the tendency of the bank-water towards vertical uniformity over the shallow parts of the banks of the Ocean. I have previously [see especially 1913, p. 24, *et seq.*] pointed out that this must be so, owing to the vertical circulation caused by the cooling of the sea-surface during winter and spring. In these northern regions it is also of importance for the vertical circulation during the winter that the salinity of the surface-layer is much increased by the formation of ice during the winter [see 1906, p. 31]. In the course of the winter the shallow banks of the ocean are thus gradually covered with comparatively cold layers of water, which have nearly uniform

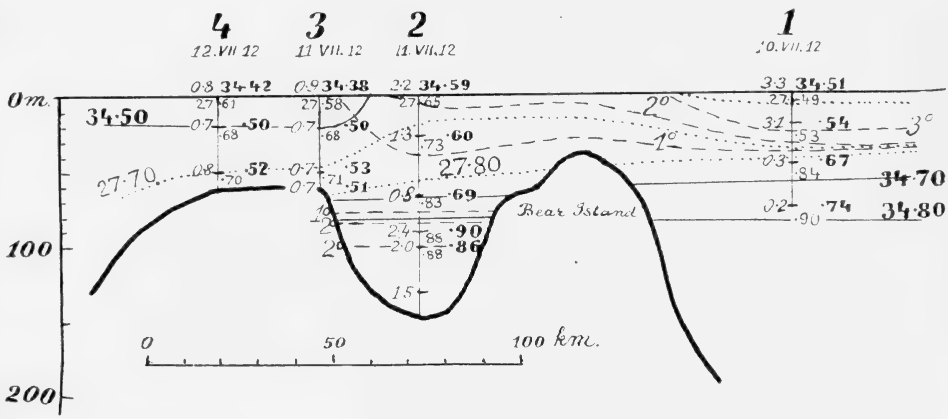


Fig. 3. Section across the Bear Island Bank, July 10—12, 1912 (see Fig. 1).
Horizontal Scale 1 : 2,000,000. Vertical Scale 1 : 5,000.

temperature and salinity between the surface and the bottom. These nearly homogeneous masses of water remain as a rule over the banks for a remarkable long time into the summer. The greater and shallower the bank, the longer does this period become, and this fact seems to show that the horizontal circulation of the water over the bank must be unusually slow, so that it takes a long time for the water to be removed and replaced by other water-masses. The slow horizontal circulation of the banks must be due to the uneven bottom, which offers much resistance to the horizontal movement of the water. The tidal currents may nevertheless be very strong over the banks, because the tidal waves are much increased in hight over the shallow sea; but these periodical currents, or orbital movements, do not finally transport the water away from the banks.

Our first two series, at Stations 1 and 2, were taken at somewhat deeper places than the next series, at Stations 3 and 4, and there was a much greater variation in the temperature and salinity vertically at the former localities than at the latter, showing a more active horizontal circulation. At Stat. 2, over a submarine channel in the bank north of Bear Island, we found a layer of comparatively warm Atlantic water below a depth of 100 metres. At Stat. 3, where the depth was 60 metres, and at Stat. 4 with a similar depth, the water was practically homogeneous in all layers except near the surface, with a temperature of about 0.7° C., and a salinity of 34.51 ‰. This water seems to have been fairly stationary, and is what we may call the winter-water of the bank. The vertical distribution of temperature and salinity differs from that of the upper layers of the Polar Current, where there is not, as a rule, such uniformity; the temperature has generally a minimum at about 60 or 70 metres, and the salinity increases downwards from the uppermost layer.

It was evidently also due to the slow circulation of this bank-water, that a little north of Stat. 4 we met with much ice extending south-westwards to a short distance beyond the edge of the shallow bank. It is evidently a general feature of the Arctic seas that the drifting ice has a tendency to remain for a long time over the shallow banks, while it is swept away by the currents outside the edge of the banks, where they run with comparatively great velocity [cf. HELLAND-HANSEN and KOEFOED, 1909].

The Spitsbergen Atlantic Current.

Our Stations 56 and 57 (Fig. 11), Stat. 17 (Fig. 12), Stat. 19 (Fig. 13), and 20 (Fig. 14) are all of them (see Fig. 1) situated in the Spitsbergen Atlantic Current running northwards along the shelf west and north-west of Spitsbergen. In our paper on the Spitsbergen Sea, HELLAND-HANSEN and I pointed out [1912, pp. 14 *et seq.* and 20 *et seq.*] that the maximum salinity of this current south-west and west of Spitsbergen cannot rise much above 35.00 ‰. The correctness of this view is also proved by the observations of 1912, the maximum salinity observed being 35.04 ‰ found at 100 metres at Stat. 57, south-west of Spitsbergen. The other high salinities were between 35.00 and 35.02 ‰ at Stations 56 and 57. At Stations 19 and 20, north-west of Spitsbergen, the salinity of the Atlantic water had decreased to between 34.91 and 34.93 ‰.

Our observations of 1912 show great similarity to those taken in this region during the ISACHSEN Expedition of 1910. Our Stations 56 and 57 are nearly in the same localities as the Stations 10 and 11 of the ISACHSEN expediton (76° 16′ N., 12° 30′ E., and 76° 20′ N., 13° 45′ E.) taken on June 27th, 1910. At these stations the following observations were taken:

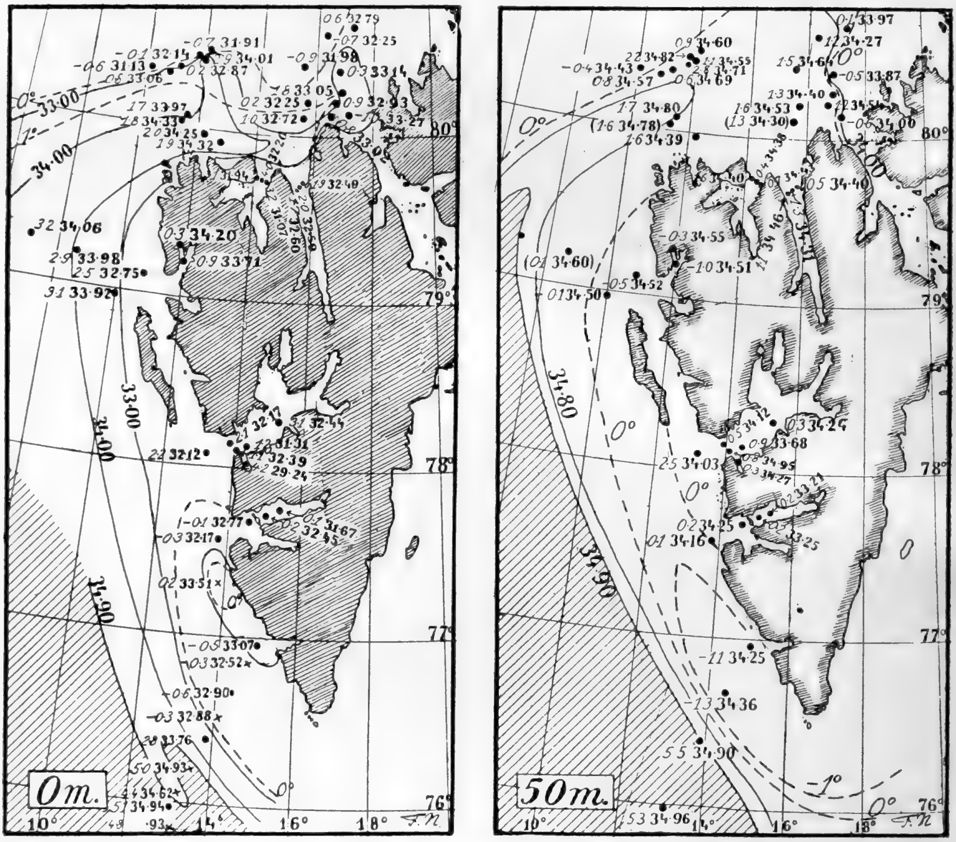
Depth in Metres	Stat. 10. 27, VI, 1910 76° 16′ N., 12° 30′ E.		Stat. 57. 1, IX, 1912 75° 58′ N., 13° 6′ E.		Stat. 11. 27, VI, 1910 76° 20′ N., 13° 45′ E.		Stat. 56. 1, IX, 1912 76° 25′ N., 13° 42′ E.	
0	4.32° C.	34.79 ‰	5.1 ° C.	34.94 ‰	4.63° C	34.70 ‰	2.8 ° C.	33.76 ‰
20	4.29	.86			5.35	.96	4.30	34.43
50	4.40	.99	5.26	.96	3.90	.88	5.46	.90
100	3.86	[.96]?	3.92	35.04	4.55	35.04	4.47	35.02
200	3.23	35.06	3.06	.02	3.86	.05	3.38	.01
300	2.60	34.99	2.28	.00	3.37	.05	2.73	34.97
400	2.09	.96	1.69		2.62	.04		
500			1.22	34.92			1.62	.91
600	0.45	.99			1.84	34.97		
700			0.08	.91				

There is a great similarity both in temperature and in salinity at these stations of different years (cf. Figs. 15 & 16). It looks as if the salinities of 1910 have a tendency to be a little too high, on the whole, at the two stations 10 and 11, considering that at 600 metres there were found salinities of 34.97 and 34.99 ‰ with temperatures of 1.84° and 0.45° C. At a temperature of 0.45° C. the salinies hardly can have been much above 34.91, or 34.92 ‰ at most.

Our Stat. 17 (79° 13′ N., 7° 0′ E.), with a depth of 1 210 metres, was 20 miles north of Stat. 17 of the Isachsen Expedition (78° 53′ N., 7° 20′ E.) with the same depth of 1 210 metres, and 20 miles south of the Isachsen, Stat. 37 (79° 33′ N., 8° 10′ E.). Owing to bad weather we had to stop before the observations between the surface and 300 metres had been taken. Below 300 metres the following observations were taken at the three stations:

Depth in Metres	Stat. 17. 17, VII, 1910 78° 53′ N., 7° 20′ E.		Stat. 17. 30, VII, 1912 79° 13′ N., 7° 00′ E.		Stat. 37. 19, VIII, 1910 79° 33′ N., 8° 10′ E.	
0	6.03° C.	34.17 ‰	3.2 ° C.	34.06 ‰	3.04° C.	33.56 ‰
300	2.59	.95	1.69	.95	2.56	35.00
500	2.11	.97	1.00	.906		34.96
600	1.79	.97				.97
700			−0.16	.895		
800	0.51	.96				.89
1100			−1.07	.895		
1200	−1.14	.91				

At 300 metres the temperature was lower in 1912 than in 1910; at 500 and 700 metres both temperatures and salinities were considerably

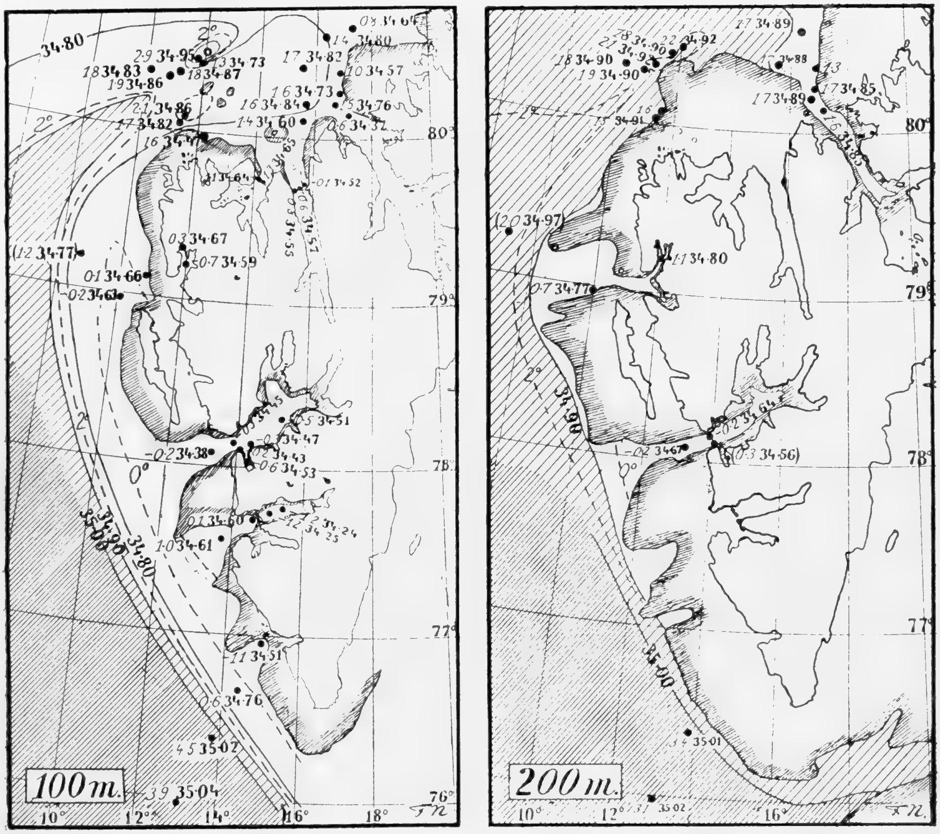


Figs. 4 & 5. Temperatures and Salinities at the Sea-Surface and at the Depths of 50 Metres, July 27—September 1, 1912. Scale 1 : 5,000,000.

lower in 1912 than in 1910, and it is obvious that the upper boundary of the cold deep-water with temperature below 0° C. was lying considerably higher on July 30th 1912 than on July 17th 1910 (see Fig. 17 & 18). It seems, however, as if the salinities found in 1910 for the depths between 400 and 800 metres (see Fig. 17) are sometimes too high; for it is hardly probable that at 800 metres, with a temperature of 0.51° C., the salinity could be as high as 34.96 ‰; it has probably been not much above 34.92 or 34.91 ‰.

The temperatures at 300 and 500 metres are lower at our Stat. 17 than at the same depths at our Stat. 56, to the south, which has an exactly similar position just outside the edge of the continental shelf west of South Cape, at a depth of 1 020 metres. The salinity of the water is also decreased on its way northward, as might be expected (see Figs. 8, 9, 11, 12).

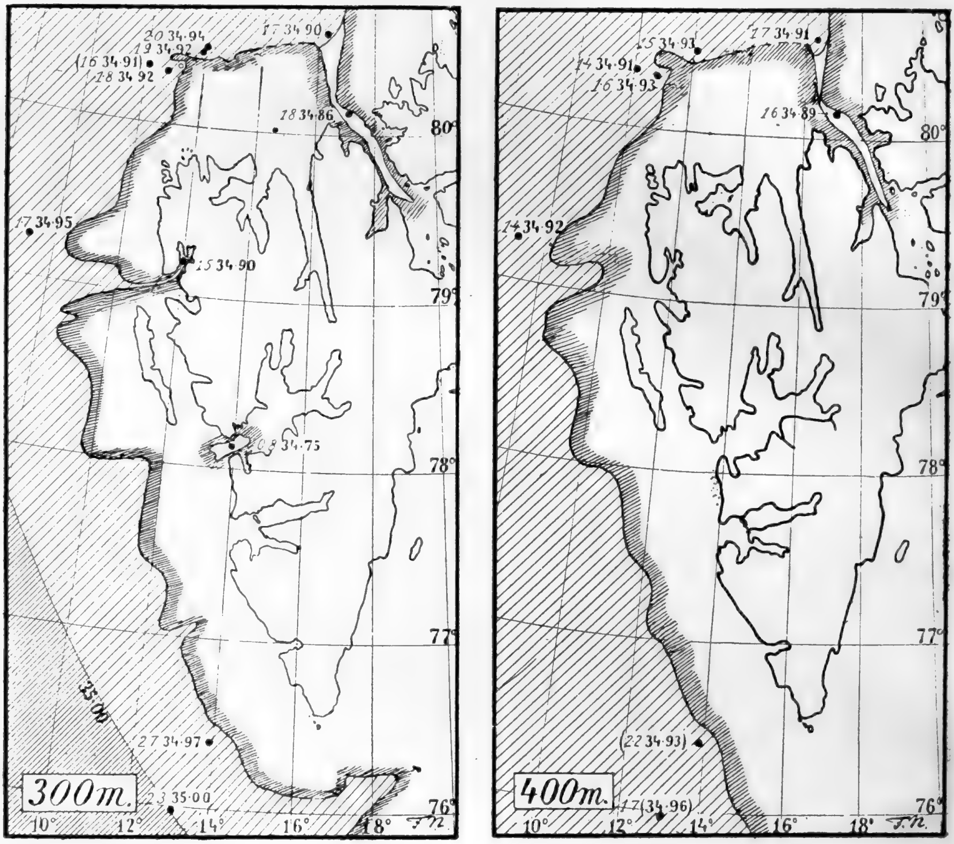
The mean temperature of the water between 50 and 450 metres, computed from the temperatures at 100, 200, 300 and 400 metres, was



Figs. 6 & 7. Temperatures and Salinities at the Depths of 100 and 200 Metres, July 27—September 1, 1912. Scale 1 : 5,000,000.

about 3.32° C. at Stat. 56 (see the curve Fig. 16) and probably about 1.98° C. at Stat. 17 (see the curve Fig. 18), giving a difference of 1.34° C. The distance between the stations was about 335 miles, which gives a decrease of temperature of 0.04° C. for every 10 miles. The observations at Stat. 56 were, however, taken 32 days later than those at Stat. 17, and, if Helland-Hansen and I are right [1912, p. 25], the mean temperature of the strata between 50 and 450 metres at Stat. 56 has therefore to be reduced by about 0.30° C. to be comparable with the corresponding temperature at Stat. 17. We then find that the decrease in the temperature of the current is 0.034° C. in 10 miles. Helland-Hansen and I have found before [1912, p. 26] that the mean temperature of the Spitsbergen Atlantic Current, between 50 and 450 metres, is on the average lowered about 0.038° C. for every 10 miles the water travels northward, which is a fair agreement.

Our Stat. 19 (80° 18′ N., 10° 45′ E., depth 623 metres) and Stat. 20 (80° 21′ N., 11° 10′ E., depth 587 metres), and also Stats. 43 and 41, were



Figs. 8 & 9. Temperatures and Salinities at the Depths of 300 and 400 Metres.
Scale 1 : 5,000,000.

situated north-east and east of the Belgica Stat. 11 A (79° 52′ N., 9° 42′ E., depth 310 metres), Stat. 12 (80° 05′ N., 9° 40′ E., depth about 550 metres?) and Stat. 13 (80° 14′ N., 7° 42′ E.‘ depth 560 metres). The Belgica stations were taken on July 7th and 8th, 1905. The temperatures of our stations are on the whole similar to those of the Belgica Stations 12 and 13. Our salinities are on the whole somewhat lower, except at depths of 500, 540 and 630 metres at the Belgica Stats. 13 and 11 B, where the salinities of 34.92 and 34.91 ⁰/₀₀ are nearly the same as the salinity found at similar depths at our stations.

On the whole, our observations seem to indicate as a general law that when the temperatures of the deep layers of the sea in this region west or north-west of Spitsbergen decreases towards 1° C. or lower, the salinity has a tendency to approach 34.92 ⁰/₀₀, or even 34.90 ⁰/₀₀.

At the Belgica Stat. 11 A the temperatures and salinities are considerably higher than at our above-mentioned stations, and the water-layers at depths between 100 and 500 metres have a considerably more Atlantic character, with salinities as high as 35.01 ⁰/₀₀.

Depth in Metres	Belgica Stat. 13. 8, VII, 1905 80° 14′ N., 7°42′ E.		Belgica Stat. 12. 7, VII, 1905 80° 5′ N., 9° 40′ E.		Stat. 43. 20, VIII, 1912 80° 20′ N., 10° 4′ E.		Stat. 19. 3, VIII, 1912 80°18′ N., 10°45′ E.		Stat. 41. 19, VIII. 1912 80°26′ N., 12°00′ E.		Belgica Stat. 11 A. 7, VII, 1590. 79°52′ N, 10°42′	
0	0.37° C.	33.20‰			−0.6°C.	31.13‰	0.8° C.	33.06‰	0.3° C.	32.22‰	2.88° C.	34.59‰
20	0.19	.39	−0.46°C.	33.68‰			1.17	.56	1.54	33.99	2.90	.60
50	1.79	34.75	1.62	34.72	−0.39	34.43	0.75	34.57	0.83	34.65	3.81	.98
100	2.01	.92	2.16	.94	1.79	.83	1.91	.86	2.87	.95	3.66	35.01
150	1.90	.95	1.64	.94							3.15	.01
200	1.80	.96	1.82	35.01	1.83	.90	1.90	.895	2.19	.93	2.73	.01
300	1.29	.95	1.49	.01					1.89	.94	2.42	.01
310							1.80	.92				
400	0.80	.96	1.21	34.98	1.36	.91			1.48	.92		
410							1.55	.93				
500	0.27	.92	0.86	.96								
510							1.29					
540	0.23	.92							1.08[2]	.91[2]		
610							0.90	.91				
630			0.24[1]	.91[1]								

1 These observations were taken at the Belgica Station 11 B, in 80° 4′ N., 10° 5′ E., depth to the bottom 6 metres, on July 7, 1905.
2 These observations were taken at 530 metres, on August 18, 1912.

Stat. 11 A was, however, about 26 and 28 geographical miles to the south of our Stats. 19 and 43; but it was only 12 miles and 15 miles to the south-west of our Stats, 18 and 21, nevertheless there is a remarkable difference between the salinities of these stations as the following table shows:

Depth in Metres	Belgica Stat. 11 A. 7, VII, 1905 79° 52′ N., 10° 42′ E.		Stat. 18. 3, VIII, 1912 80° 2′ N., 11° 20′ E.		Stat. 21. 6, VIII, 1912 80° 4′ N., 11° 30′ E.	
0	2.88° C.	34.59‰	1.8° C.	34.33‰	1.7° C.	33.97‰
10	2.86	.60			1.8	34.08
20	2.90	.60				
30					1.7	.72
50	3.81	.98			1.70	.80
60			1.56	.79		
100	3.66	35.01			2.1	.86
110			1.69	.82		
140					1.86	.86
150	3.15	.01				
200	2.73	.01			1.64	
210			1.82	.91		
240			1.83	.91		
300	2.42	.01				

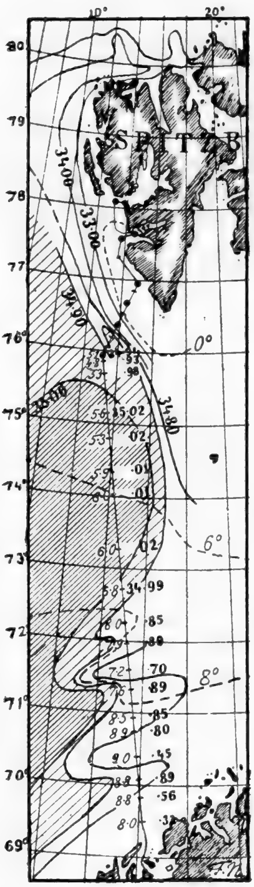


Fig. 10. The Distribution of Temperature and Salinity at the Sea-Surface, Sept. 1—5, 1912. Scale 1 : 12,000,000.

At Stat. 18 the depth of the sea was 247 metres, at Stat. 21 242 metres, while at the Belgica Stat. 11 A it was 310 metres. The former stations were thus in a somewhat shallower sea, and may have had a little more coastal water than the latter, though they were not nearer to the coast. Their more north-easterly situation may also tend to give them lower salinities and lower temperatures; but this is hardly sufficient to explain the striking difference between them and the Belgica station in these respects. It seems as if in this region the water of the Spitsbergen Atlantic Current, had a much more Atlantic character in the summer of 1905, than in the summer of 1912.

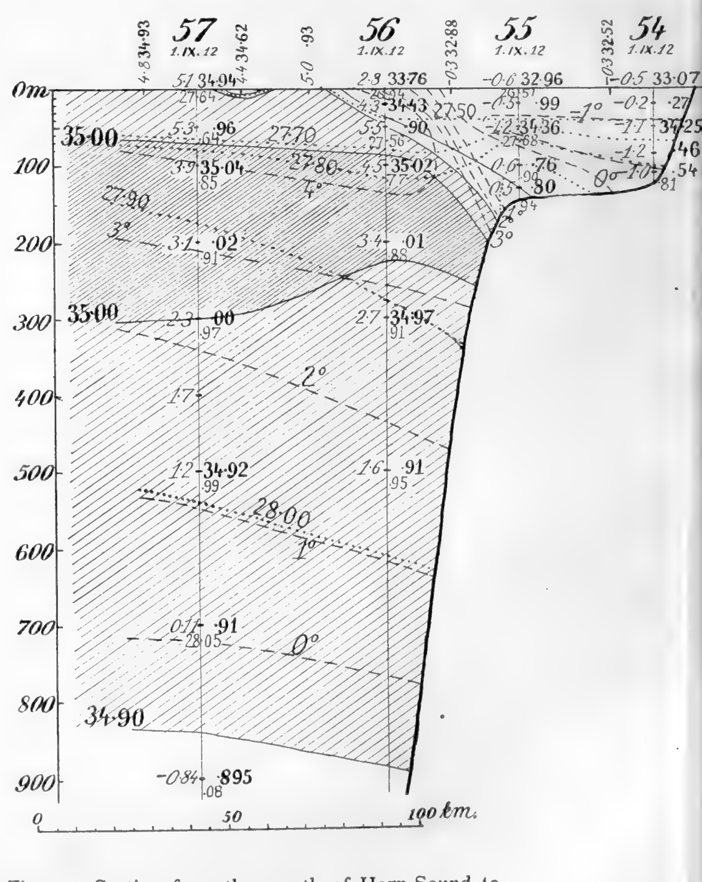


Fig. 11. Section from the mouth of Horn Sound to Stat. 57, Sept. 1, 1912 (see Fig. 1). Horizontal Scale 1 : 200,000. Vertical Scale 1 : 10,000.

A comparison between the observations at our stations and the corresponding stations of the Isachsen Expedition of 1910 (see above) shows that the waters of the Spitsbergen Atlantic Current had a much less Atlantic character (*i. e.* much lower salinities)

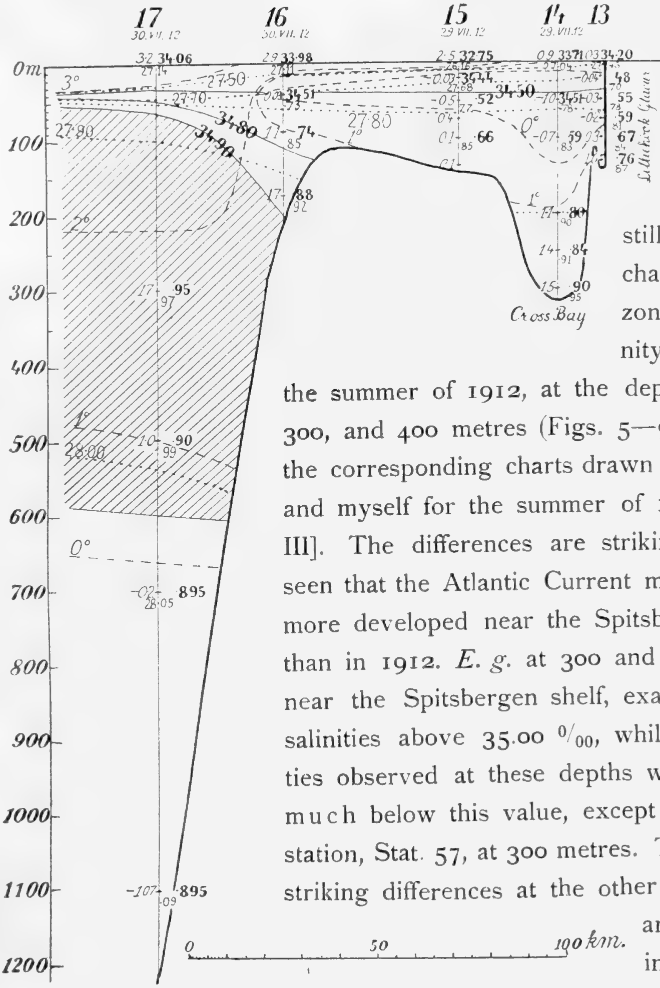


Fig. 12. Section from Station 13, at the Lilliehöök Glacier, along Cross Bay (Stat. 14) to Stat. 17 west of the Spitsbergen coast (see Fig. 1). Scales same as in Fig. 11.

in the summer of 1912 than in the summer of 1910. This is perhaps still better seen if our charts giving the horizontal distribution of salinity and temperature in the summer of 1912, at the depths of 50, 100, 200, 300, and 400 metres (Figs. 5—9) be compared with the corresponding charts drawn by Helland-Hansen and myself for the summer of 1910 [1912, Pls. II & III]. The differences are striking, and it is easily seen that the Atlantic Current must have been much more developed near the Spitsbergen coast in 1910 than in 1912. *E. g.* at 300 and 400 metres all water near the Spitsbergen shelf, examined in 1910, had salinities above 35.00 ‰, while in 1912 all salinities observed at these depths were below and even much below this value, except at the southernmost station, Stat. 57, at 300 metres. There are also similar striking differences at the other depths, of 200, 100, and 50 metres, indicating that the Spitsbergen Atlantic Current must have been comparatively little developed in 1912.

If the chart Fig. 10, showing the distribution of Temperature and Salinity at the Sea-Surface during our homeward voyage, September 1st to 5th, 1912, is compared with the corresponding chart for September 6th to 9th, 1910, in Helland-Hansen's and my paper on the Spitsbergen Sea [1912, Pl. I], it is seen that the Atlantic surface-water with salinities above 35.00 ‰, and also above 34.90 ‰ had probably a wider distribution towards the north-east in September 1912 than in September 1910, at least between 76° and 74° N. where our route was near that of the Isachsen Expedition. But the surface-temperature was considerable lower during

September 1—5, 1912, than during September 6—9, 1910, and still lower than during September 6—9, 1909. The isotherms of 6° C. was in the latter year about two degrees farther north (in 76° N., 14° E) than in September 1912 (in 74° N., 14° E.), and about one degree farther north than in September 1910 (in 75° N., 14° E.). The isotherm of 8° C. showed similar differences.

The Temperature of the Atlantic Current. Our observations in the Atlantic Current are not sufficiently numerous to enable us to say much about its average temperature in 1912 west of Spitsbergen; but the comparisons given above seem to show that the current west and south-west of Spitsbergen was on the whole colder in 1912 than in 1910, as we also have seen that its salinities were lower.

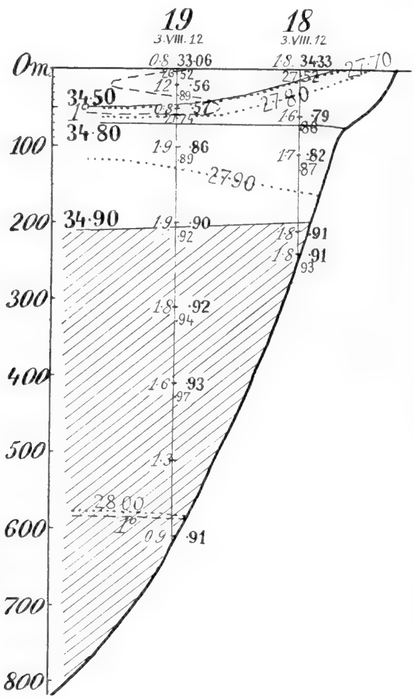


Fig. 13. Section from Norway Islands to Station 19. Aug. 3, 1912 (see Fig. 1). Scales same as in Fig. 11.

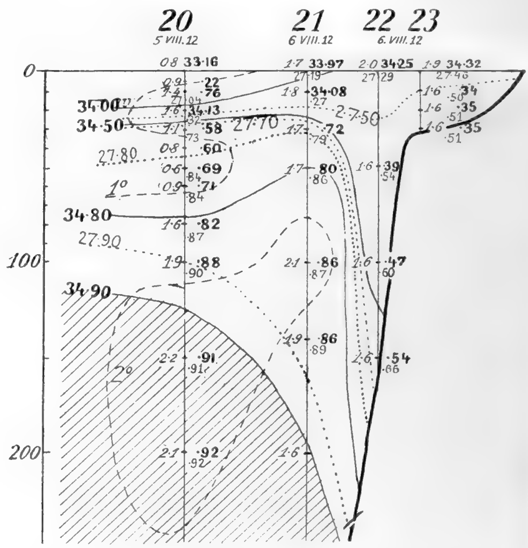


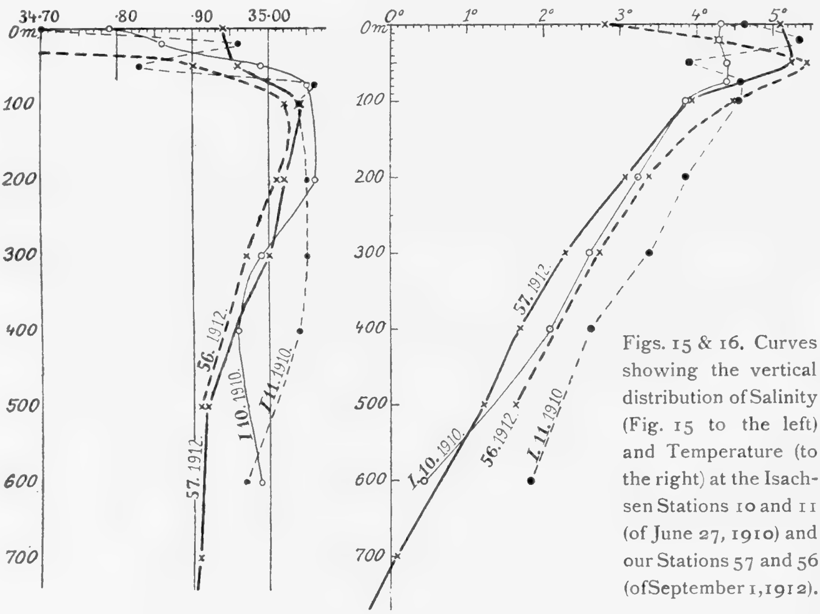
Fig. 14. Section from the north coast of Spitsbergen to Stat. 20 (Aug. 5 & 6, 1912). Horizontal Scale 1 : 200,000. Vertical Scale 1 : 4,000.

At our Stat. 17 the mean value of the temperatures at 100, 200, 300, and 400 metres would be about 2.06° C. (see the curve Fig. 18), at the Isachsen Stat. 17 3.13° C., and at the Isachsen Stat. 37 2.79° C. Our Stat. 17 was situated very nearly midway between the two Isachsen stations, and was taken 13 days later in the season than the one, and 20 days earlier than the other. If, therefore, we consider its mean temperature to be comparable to the mean value (2.96° C.) of the temperatures of the two Isachsen stations combined, we find that the water of the Atlantic Current, between

50 and 450 metres, in this region was **0.90° C.** colder in the summer of 1912 than in the summer of 1910.

The mean value of the temperatures at 100, 200, 300, and 400 metres, was 2.74° C. at our Stat. 57, and 2.95° C. at the Isachsen Stat. 10, giving a difference of 0.21° C. As Stat. 57 was situated 20 miles south-south-west of Stat. 10, and was taken 66 days later in the season, this difference would have to be increased by about 0,08° C. and 0.66° C.[1], and we find that the current was about **0.95° C.** colder in 1912 than in 1910.

If the mean temperatures at our Stat. 56 (3.19° C,) and the Isachsen Stat. 11 (3.60° C.) be compared in the same manner, we find that the

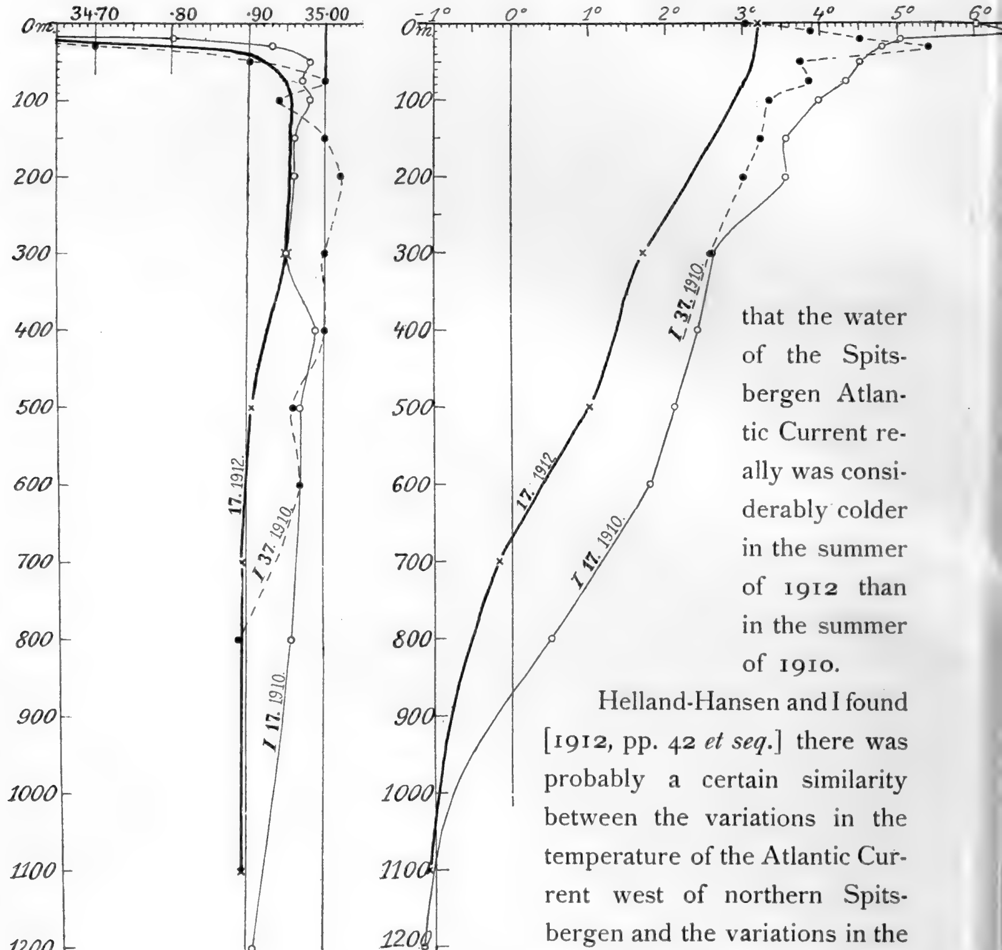


Figs. 15 & 16. Curves showing the vertical distribution of Salinity (Fig. 15 to the left) and Temperature (to the right) at the Isachsen Stations 10 and 11 (of June 27, 1910) and our Stations 57 and 56 (of September 1, 1912).

Atlantic Current was in that locality about **1.07° C.** colder in 1912 than in 1910.

It is not possible to draw any certain conclusions as to changes in the temperatures of the current from the comparison of the observations at such a small number of stations, especially considering how wery much the conditions may alter at each station in very short time, both by vertical and by horizontal movements of the water. Nevertheles there is a fair agreement between the differences 0.90° C., 0.95° C., and 1.07° C., found independently in three different localities, and it seems to indicate

[1] Helland-Hansen and I found [1912, pp. 24—25] that the mean temperature of the water, between 50 and 450 metres, of the Spitsbergen Atlantic Current was on the average raised 0.10° C. in 10 days during the summer, from June and July to September.



Figs. 17 & 18. Curves showing the vertical distribution of Salinity (Fig. 17 to the left) and Temperature (to the right) at the Isachsen Stations 17 and 37 (of July 17 and Aug. 19, 1910) and our Stat. 17 (of July 30, 1912).

that the water of the Spitsbergen Atlantic Current really was considerably colder in the summer of 1912 than in the summer of 1910.

Helland-Hansen and I found [1912, pp. 42 *et seq.*] there was probably a certain similarity between the variations in the temperature of the Atlantic Current west of northern Spitsbergen and the variations in the mean winter-temperature (*i. e.* for the six months December 1 to May 31) of the five northern meteorological stations of Norway, Andenes, Tromsö, Alten, Vardö, and Syd-Varanger, during the winter a year and a half earlier. The mean temperature anomaly for December 1st 1900 to May 31st 1911 was, however, 1.06° C. at these five stations, while it was only 0.68° C. in the winter 1908 to 1909. This is consequently contrary to what it ought to have been according to our former results.

But we thought that the variations in the temperature of the Atlantic Current in the region south-west of southern Spitsbergen might have more similarity to the variations in the mean temperature at the five northern Norwegian stations during the preceding winter, or rather the variations in the means of the two preceding winters.

The mean temperature-anomaly for December 1st 1911 to May 31st 1912 was — 0.43° C. at the five Norwegian stations, while for December 1st 1909 to May 31st 1910 it was 1.61° C. The mean anomaly for the two winters 1910 to 1911 and 1911 to 1912 was 0.32° C., and for the two winters 1908 to 1909 and 1909 to 1910 was 1.15° C. [see 1912, pp. 42 and 43]. The differences between these mean temperatures are consequently in better harmony with the difference of temperature (about 1.0° C.) which the Spitsbergen Atlantic Current was colder in 1912 than in 1910, according to our observations.

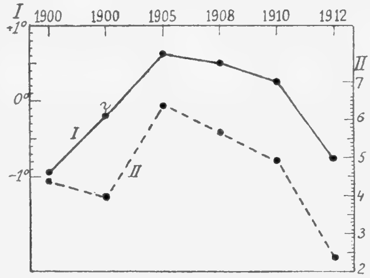


Fig. 19. Curve I, Temperature-Anomaly of the Spitsbergen Atlantic Current (scale to the left). Curve II, The Area, in hundred-thausands of square kilometres of Open Water in the Barents Sea in May (scale to the right).

Helland-Hansen and I also pointed out [1912, pp. 44 *et seq.*] that the anual variations in the distribution of ice in the Barents Sea in May seem to agree with the anual variations in the temperature of the Spitsbergen Atlantic Current in the same years.

The area of open water in the Barents Sea east of 20° E. Long. was about 237 000 square kilometres in May 1912 (according to the charts published by the Danish Meteorological Institute) and 492 000 square kilometres in May 1910. There was in fact an exceptionally small area of open water in the Barents Sea in May 1912, and this is in good agreement with the low temperature of the Spitsbergen Atlantic Current that summer.

The curves in Fig. 19 demonstrate the variations in the temperature-anomaly of the Spitsbergen Atlantic Current and in the open water in the Barents Sea in May for the years when there are observations. It ought, however, to be remembered that the assumed anomalies of the Spitsbergen Current are based on an imperfect observation-material, and the obtained results cannot therefore be considered as very trustworthy.

The Water of the Spitsbergen Fjords, and the Coast Water.

In our paper "On the Sea West of Spitsbergen" Helland-Hansen and I [1912, pp. 54 *et seq.*] have discussed the nature and origin of the water of the Spitsbergen fjords, especially Ice Fjord. The observations of 1912 confirm on the whole the correctness of the views which we then held in this respect, though they may have to be slightly modified as regards the

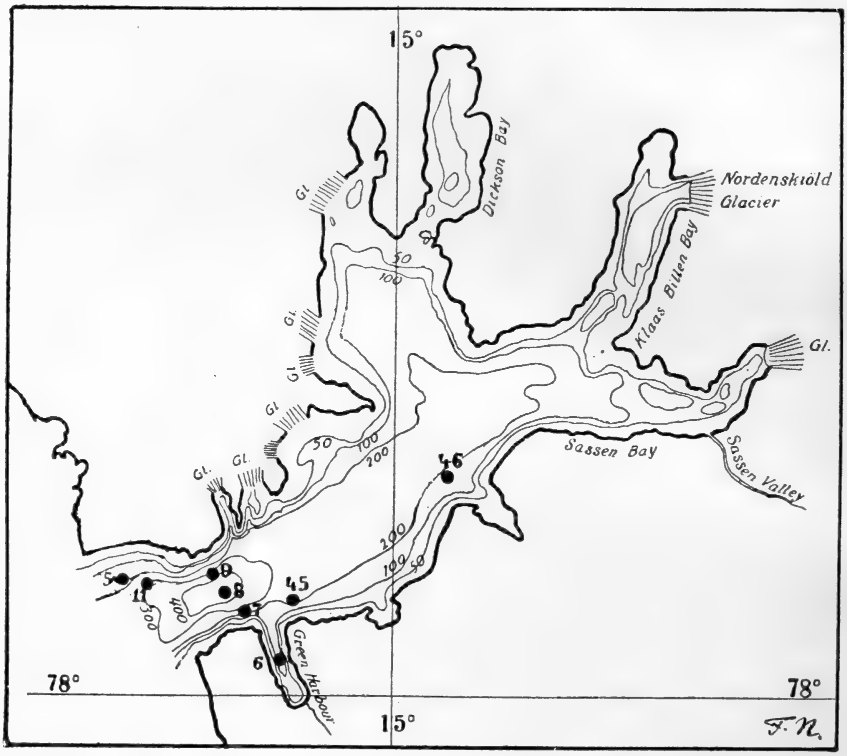


Fig. 20. The Stations in Ice Fjord, in July and August 1912. Stat. 7 of July 18, 1912, is in about the same place as Stat. 47 of Aug. 29, 1912. Stat. 8 of July 18, 1912, is in about the same place as Stat. 10 of July 21, 1912, Stat. 44 of Aug. 24, 1912, and Stat. 48 of Aug. 28, 1912. Scale 1 : 1,000,000.

nature of the intermediate layers with a minimum temperature, observed in the summer, especially in Ice Fjord. Our view was that they were due to the vertical circulation of the upper water-strata of the fjord during the winter. The observations of 1912 in Ice Fjord, as well as in other Spitsbergen fjords, seem, however, to prove that these cold intermediate layers cannot be quite so local as we were then inclined to believe; to some extent they seem to have some connection with the water over the shelf outside the mouth of the fjord.

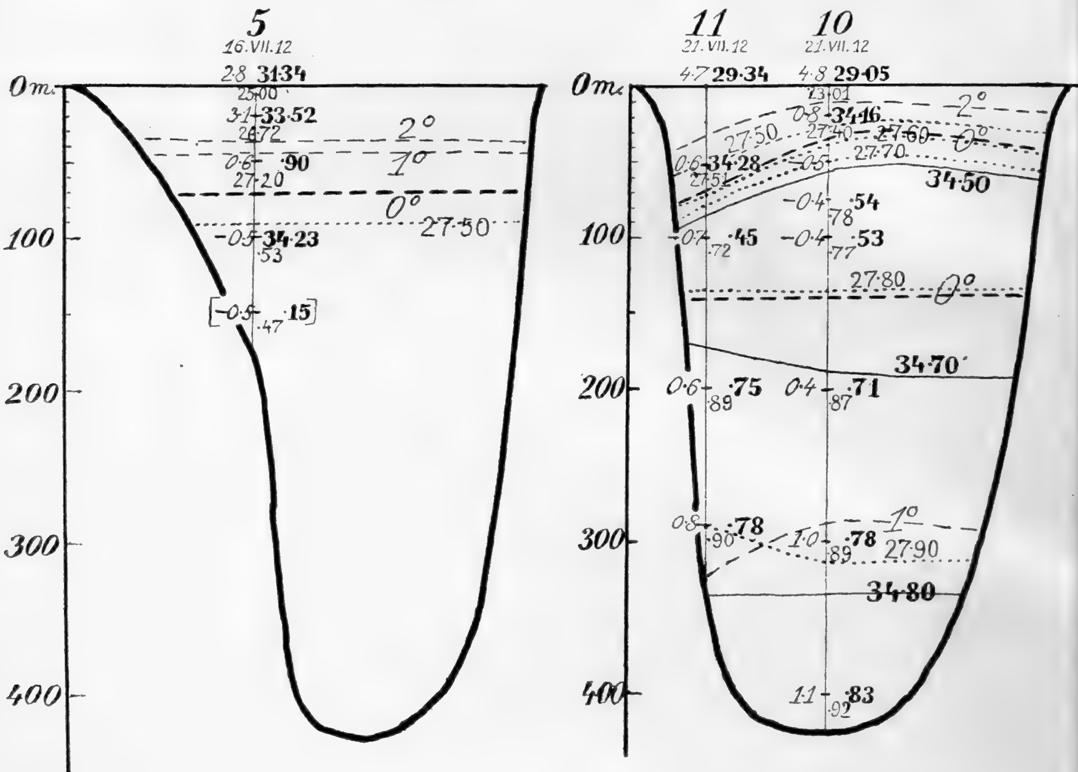
In very nearly the same localities, at the mouth of Ice Fjord, I took several vertical series of observations on different dates: July 16, 18 21, August 24 and 29. They prove that there are considerable variations in the water-strata of the fjords, even within short intervals of time. We see that also the water near the bottom of the fjord may change to some extent from time to time, and may differ even at short distances at the same time, (cf. the water at 380 and 400 metres at Stations 8 and 9, on July 18th, 4.50 and 6.40 p. m., Fig. 23).

The intermediate layer, with temperatures below 0° C., may differ much in thickness and situation, as well as in temperature, from time to time. On July 16th I found the upper boundary at about 70 metres (cf. the isotherm of 0° in Fig. 21). On July 18th this boundary was probably at a depth of about 65 metres, and the layer had a thickness of about 190 metres (Fig. 23). On July 21st the upper boundary of this layer was at about 35 metres, and had a thickness of about 120 metres (Fig. 22). On August 24th the upper boundary of the cold layer was at a depth of about 85 metres. Its lower boundary was at about 225 metres, giving a thickness of about 140 metres (Fig. 24). On August 29th the upper boundary was at a depth of about 70 metres, and its lower boundary at about 215 metres (Fig. 25). It is chiefly the conditions at the stations midway in the mouth of the fjord that have here been considered.

On the whole the temperature of this cold intermediate layer had risen appreciably from July to the 24th and 29th August, showing that this cold water is gradually heated during the course of the summer by contact and intermixture with the overlying and underlying water-strata. It is evident, however, that the temperature of the layer may change a great deal from one day to another at the same place (cf. our observations at Stations 44 and 48, and also at our Stations 7, 8 and 9 compared with the observations at Station 10, and also Station 5).

These rapid changes are obviously due to the horizontal circulation caused by the tidal currents, which flow in and out of the fjords, often with considerable velocity. In this manner the water in the outer part of the fjord may sometimes be carried out of it, and on to the shelf outside the coast, at other times it is carried into the fjord again (cf. Fig. 26). Owing to the variations in the velocity of the current in the fjord, the thickness of the intermediate cold layer may also vary, as it is sometimes extended and made thinner by an increased velocity, or *vice versa*.

It will thus be understood that this intermediate cold water of the fjord cannot be quite so local as described in our paper of 1912. It may to some extent be influenced by the nature of the water over the shelf outside the coast of Spitsbergen, in any case where the fjords have no well-developed sill, and are fairly open. This seems to be verified by my observations in the different fjords. In Cross Bay I also found an intermediate layer with temperatures below 0° C. (Fig. 12), it was thinner in Cross Bay than in Ice Fjord. In Wood Bay, and Wijde Bay there was no such intermediate layer with temperatures below 0° C. (Fig. a7 and 28). Only at one station in Wijde Bay, Stat. 29, did I observe temperatures below 0° C. at 100 and 150 metres; but the two other stations in that fjord gave



Figs. 21 & 22. Sections across the mouth of Ice Fjord. Horizontal Scale 1 : 200,000. Vertical Scale 1 : 5,000.

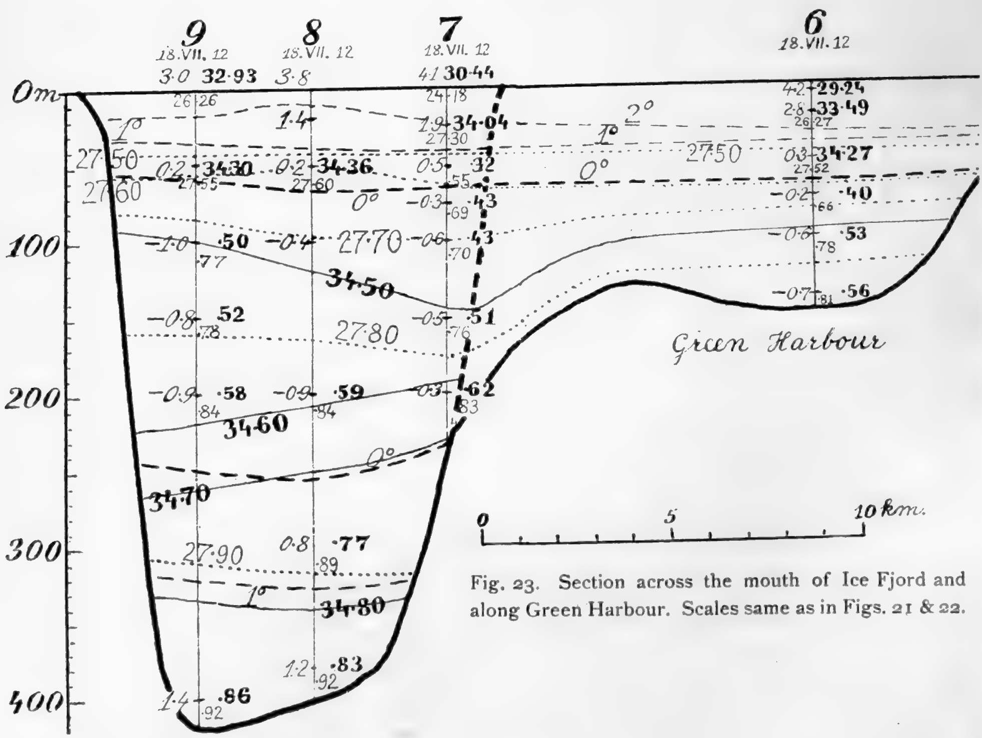
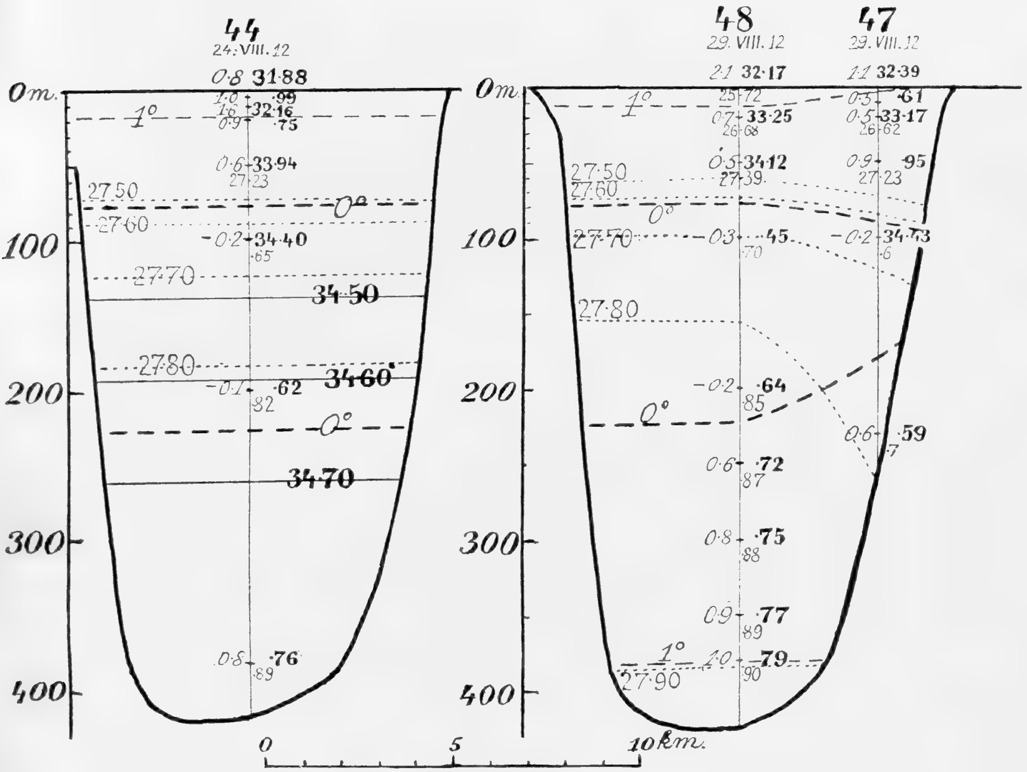


Fig. 23. Section across the mouth of Ice Fjord and along Green Harbour. Scales same as in Figs. 21 & 22.



Figs. 24 & 25. Sections across the mouth of Ice Fjord. Scales same as in Figs. 21 & 22. The observations at Stat. 47, 230 metres, seem doubtful, see Table I.

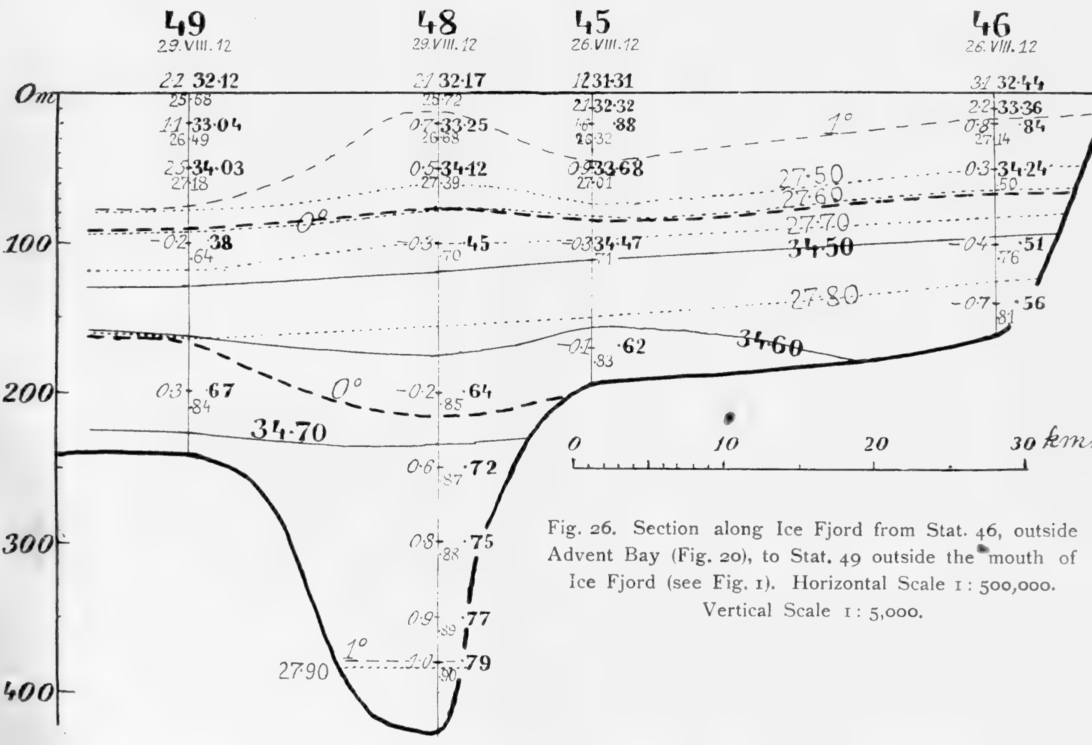


Fig. 26. Section along Ice Fjord from Stat. 46, outside Advent Bay (Fig. 20), to Stat. 49 outside the mouth of Ice Fjord (see Fig. 1). Horizontal Scale 1 : 500,000. Vertical Scale 1 : 5,000.

considerably higher temperatures. I cannot but think that the cooling of the surface of these fjords during the winter, goes on quite as actively as in Cross Bay and Ice Fjord, and there is probably more ice formed in the northern than in the southern fjords. It is possible that the more rapid formation of ice in the autumn and winter protects the underlying water from being cooled to the same degree as in the more southern fjords; but the chief cause of the difference in temperature must be the nature of the water on the shelf outside the fjords.

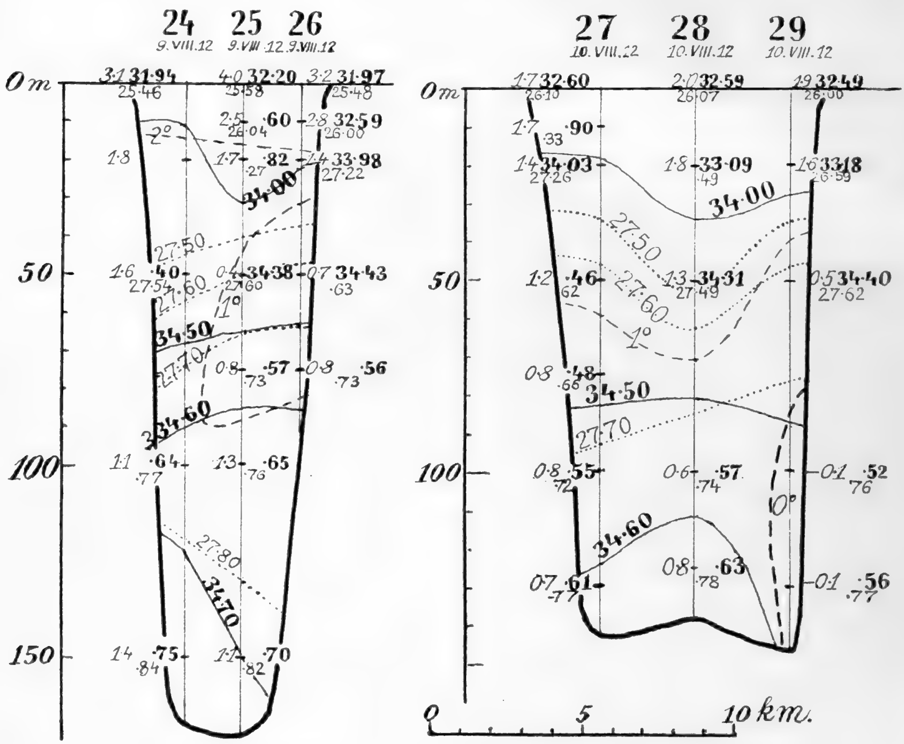


Fig. 27 & 28. Sections across the mouths of Wood Bay and Wijde Bay (see Fig. 1). Horizontal Scale 1 : 250,000. Vertical Scale 1 : 2,000.

The Spitsbergen Polar Current, coming from the east round South Cape, and running northwards along the west coast, covers the shelf along this coast with comparatively cold water, as far north as Cross Bay. This water of the shelf is naturally much cooled by the radiation of heat from the sea-surface during the winter. On the other hand the water over the shelf off the north-west and north coast of Spitsbergen is intermixed with the water of the warm Atlantic Current, and there is a more active horizontal circulation preventing the formation of an intermediate layer with such low temperatures as on the shelf off the west coast farther south. Owing to the tidal currents, the water covering the shelf, is carried in and out of the fjords inside, and will thus have an influence upon the nature of the water filling the fjords, or in any case their outer part. The intermediate layers in the fjords and on the shelf will thus acquire a somewhat higher salinity in the north, than at the corresponding levels in the fjords and on the shelf farther south. The sea over the shelf in the north will be covered by a thin layer of Arctic water with low salinities, and by ice, and the vertical circulation caused by the cooling during the winter will thus not be so effective there as in the south. There will consequently not be the same conditions for the formation of an intermediate layer with low temperatures at 60 and 100 metres.

In the following table are given the vertical series of observations taken at several stations on the shelf along the west coast of Spitsbergen. Stat. 54 (Sept. 1) is taken outside the mouth of Horn Sound, Stat. 53 (Aug. 31) outside Bell Sound, Stat. 49 (Aug. 29) outside the mouth of Ice Fjord, Stat. 12 (July 27) on the shelf far outside Kings Bay, and Stat. 15 (July 29) outside Cross Bay (see Fig. 1).

Depth in Metres	**Stat. 54.** Outside Horn Sound Depth 125 m.		**Stat. 53.** Outside Bell Sound Depth 146 m.		**Stat. 49.** Outside Ice Fjord Depth 242 m.		**Stat. 12.** Northwest of Prince Charles Foreland Depth 250 m		**Stat 15.** Outside Cross Bay Depth 135 m.	
0	−0.5	33.07	−0.3	32.17	2.2	32.12	3.1	33.92	2.5	32.75
20	−0.24	.27	1.65		1.11	33.04			−0.03	34.44
50	−1.07	34.25	0.09	34.16	2.47	34.03	−0.10	34.50	−0.52	.52
75									0.37	
85	−1.19	.46								
100			1.04	.61	−0.22	.38	−0.20	.63	0.07	.66
110	−0.98	.54								
130			0.67	.68					0.05	
135										
200					0.30	.67	0.72	.77		
240							1.23	.84		

On the whole, the intermediate layer with minimum temperatures is much colder in the south than farther north, in spite of the later season. At the southernmost station, 54, the temperatures are below zero at all depths between the surface and the bottom, and the minimum temperature at 85 metres is −1.19° C. Farther north, at Station 53, off Bell Sound, the water is very much warmer. It was only at the surface that I happened to observe a temperature below zero in the one vertical series taken at this station. The intermediate water-layer seems, however, to change very rapidly on the shelf; for only half an hour later a new vertical series of observations taken at the same station, 53, gave appreciably lower temperatures at 20 and 50 metres, the temperature at the latter depth being even below zero (see Table I). The layer may have been lifted about 10 metres. There are also great differences between the temperatures of the intermediate layer at Stations 12 and 15, and we may also mention Station 16, situated on the same shelf outside Kings Bay and Cross Bay, with no great distance between them. The changes in the intermediate layer are probably due, to a great extent, to the tidal currents carrying the waters to and fro.

But the changes at the same stations in short intervals of time are evidently due to vertical oscillations of the strata, and they occur on the shelf, *e. g.* at Stat. 53, as well as in the fjords. At Stat. 50, on August 30th, 1912, 2.00 p. m., — 1.06^0 C. was observed at 90 metres; half an hour later — 0.54^0 C. was observed at the same depth indicating a vertical displacement of the water strata. But as there was just at this level evidently a sharply defined boundary between the cold bottom-layer and the warmer and much lighter overlying strata, no great vertical movement would be required to cause a difference in temperature of 0.5^0 C. At Stat. 44, on August 24th, 1912, 9.50 a. m. 1.45^0 C. and 32.77 $^0/_{00}$ were observed at 20 metres, half an hour later, at 10.20 a. m., 0.89^0 C. and 32.75 $^0/_{00}$ were observed at the same depth. As the densities would not differ much (σ_t = 26.25 and 26.28) it is, however, possible that there has been a horizontal movement of the water in this case.

On the whole it may, however, be said that there is a certain relation between the temperatures and the salinities of the intermediate layer; temperatures below zero, for instance, being as a rule combined with salinities of between 34.35 and 34.65 $^0/_{00}$, while the underlying layer with temperatures above zero has salinities above 34.65 $^0/_{00}$ and increasing with rising temperature. This fact seems to prove that it is the same intermediate cold layer we find at the different stations, but sometimes situated nearer the surface, at other times deeper; and on the other hand, the cold layer may sometimes be thinner, sometimes thicker, a condition which probably depends on the currents. The reason why at the southernmost station (Stat. 54), the water-layers are so much colder than at the stations farther north, is obviously that we here meet the water of the Spitsbergen Polar Current less intermixed with summer waters, and the conditions are more like those of the winter, and very much like those we find in the Polar Current east of Spitsbergen.

A comparison between the vertical series of observations at the stations on the shelf and those at the stations at the mouth of the fjords within, shows that the intermediate layer with minimum temperatures is considerably thicker, and also colder, at the mouth of the fjords than on the shelf outside. As an example compare Stations 53 and 52 at the mouth of Bell Sound (Fig. 29), Stations 49 and 48 at the mouth of Ice Fjord (Fig. 26), and Stations 16, 15, and 14 outside and in Cross Bay (Fig. 12). This seems to prove that, although the cold water of the intermediate layer is carried out and in by the tidal currents, at any rate in the outer part of the fjords, it remains for a long time during the summer, in the fjords, and is carried away only very slowly, and is gradually heated, chiefly by intermixture with the water of the overlying and underlying layers.

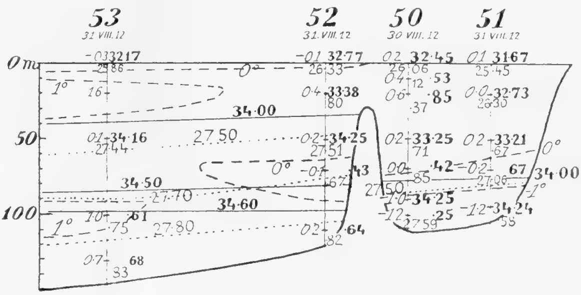


Fig. 29. Section along Van Mijen Bay and Bell Sound (see Fig. 1). Horizontal Scale 1 : 1,000,000. Vertical Scale 1 : 5,000. The intermediate isotherm of 0° C. at Stat. 52, ought to have passed westwards beyond Stat. 53 in about 60 metres, indicating a thin layer with temperatures below zero at that station.

The Swedish oceanographers (cf. Svenska Hydrografisk-biologiska Kommissionen 1911, pp. 13 *et seq.*) maintain that the melting of the surface ice and the glacier ice during the spring and summer has a considerable cooling effect upon the water-strata of the Spitsbergen fjords; and they believe that the cold intermediate strata, as well as the strata of somewhat warmer water near the bottom, are formed by a vertical circulation caused by this cooling.

In the summer of 1912 I got, however, a convincing illustration of how very little cooling effect the melting of the ice on the sea-surface has on the underlying strata. After having taken several vertical series of observations in the mouth of Ice Fjord between July 16th and 21st we went north and did not return to Ice Fjord until August 24th. The fjord was then full of ice, which some time before had been carried into it by the current along the coast from the south (see Fig. 2). There was so much ice that it was difficult to navigate between the floes, and several ships had not been able to reach Green Harbour.

The ice remained in the fjord, and outside for a long time, and was melting there. The water at 50 metres and the intermediate cold layer, with a minimum temperature, were much warmer in August than we had found them to be in July, when there was no ice in the fjord, and had not been for a long time. This was clearly proved by the vertical series of observations taken at the mouth of the fjord between August 24th and 29th, very nearly at the same places as the vertical series taken in July (see Figs. 21—25). The intermediate layer had obviously been heated during

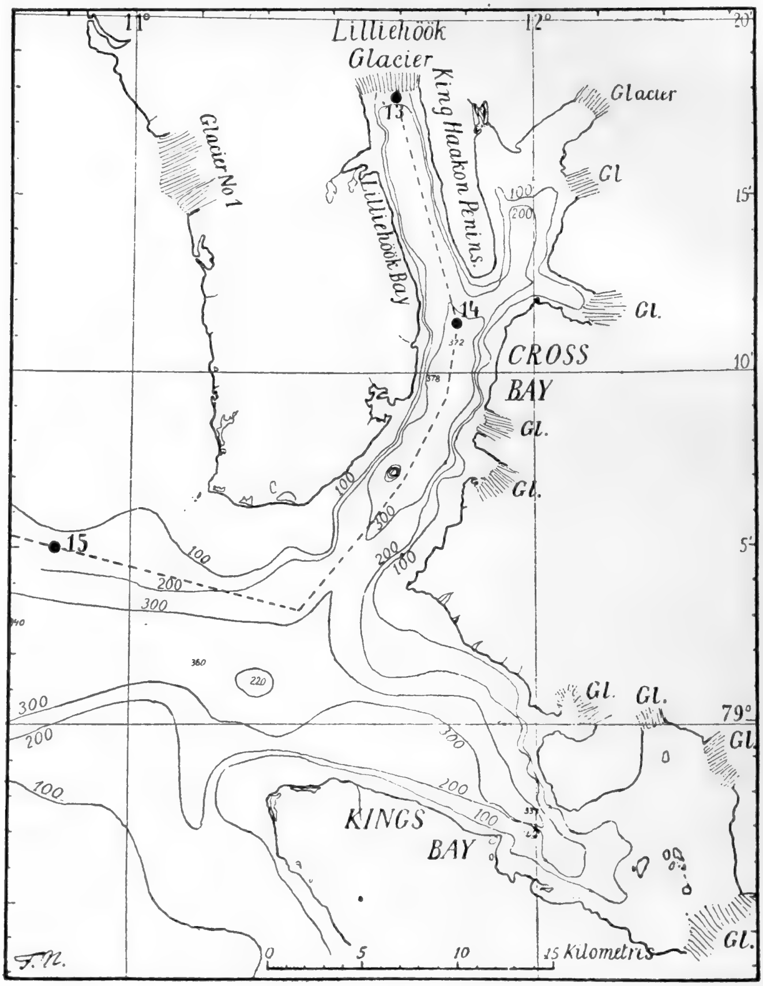


Fig. 30. The Stations 13 and 14 in Cross Bay and Stat. 15 on the shelf outside. Bathymetrical curves are drawn for 100, 200, and 300 metres, based on Capt. G. Isachsen's chart. Scale 1 : 400,000.

the month which had passed, and the melting of the ice on the surface during the week previous to August 24th, had evidently had no effect upon the temperature of the cold intermediate strata, and of course still less on the deeper strata.

At Station 13 at the inner end of Cross Bay, we took a vertical series of observations (Fig. 12), which is very interesting in this connection, showing how very little effect the melting of ice even when it reaches deeper, has on the temperature of the water-strata. The series of observations was taken first at a distance of about 200 metres, and then at 100 metres from the perpendicular ice-wall of the Lilliehöök Glacier descending to the bottom of the sea (Figs. 30 and 81). The depth of the fjord, 200 metres from the ice-wall, was about 114 metres, and 100 metres from the glacier about 140 metres. The strange fact is that the cold intermediate layer at this station, near the glacier, was considerably thinner and

Fig. 31. The ice-wall of the Lilliehöök Glacier, seen from the Veslemöy at Stat. 13, July 19th, 1912.

warmer than at Stat. 14 farther out in the fjord, and even the minimum temperature was higher than at the latter station (see Fig. 12). At Stat. 13 the minimum temperature was $-0.25°$ C. at 50 metres, while at Stat. 14 it was $-1.01°$ C. at the same depth; and strange to say, the salinity was somewhat higher at Stat. 13 than at Stat. 14. Though the sea-water should be cooled to its freezing-point by contact with fresh-water ice (glacier ice) still these observations might almost seem to indicate that in this case the mass of glacier ice may, in some way or other, have helped to raise the temperature of the cold intermediate layer of the fjord. It is also remarkable that at 100 metres near the wall of the glacier I observed a temperature of 0.32° C., and at 130 metres near the foot of the glacier the temperature of the sea-water was 1.05° C. These observations demonstrate clearly, how very little cooling effect the glacier ice has upon the sea-water. If this effect had been appreciable, it was to be expected that the heavy water created by the cooling would have accumulated at the bottom of the glacier; but on the contrary we find here a comparatively high temperature, even higher than at the same level farther out in the fjord. The salinity, 34.76 ‰, seems to be the same as would be found in the corresponding water-layer with a similar temperature farther out in the fjord; but at Station 14 this water-layer was situated somewhat deeper. A temperature of 1.12° C. and a salinity of 34.80 ‰ were there observed at 200 metres, and only a short distance above this level both temperature and salinity must have been approximately the same as at 130 metres at Stat. 13. At Stat. 16 on the edge of the shelf, far outside the fjord, 1.07° C. and 34.74 ‰ were observed at 90 metres. This is evidently the corresponding layer. At Stat. 12, on the shelf farther south, two days before, this layer must have been situated much deeper, somewhere between 200 and 240 metres.

These observations show that there is much difference in the levels of this and other layers in this region. On the other hand the observations indicate a fairly active horizontal circulation between the water-layers of Cross Bay and those on the shelf outside; and in the inner end of the fjord the deep water-layers are somewhat lifted along the rising bottom towards the Lilliehöök Glacier.

The surface observations at our Station 13 are also noteworthy. Although a great quantity of pieces of ice, fallen down from the glacier, were floating about in all directions on the sea-surface, the surface-temperature was 0.3° C., and what is still more remarkable, the salinity was unusually high, 34.20 ‰. At Station 14 farther out in the fjord, the surface-salinity was 33.71 ‰, and at Station 15 it was 32.75 ‰ with a temperature of 2.5° C. The salinity of the surface-water thus rapidly increased towards the inner end of the fjord and towards the glacier, which is contrary to what it ought to be, if much ice were melting there. It proves that the glacier-ice cannot melt very rapidly at the inner end of the fjord; while there are better conditions for melting farther out where the temperature of the surface-layers is higher, and where the low surface-salinity may also be due to the waters with lower salinities carried in by the horizontal circulation from the surface-layers outside (cf. Stat. 15, Fig. 12).

The waters with comparatively high salinities at the inner end of the fjord, must be remnants from the spring and winter when much ice was formed on the sea-surface, by which process the salinity of the fjord-water had been much increased.

The nature of the water near the bottom of the fjords varies with the configuration of the fjord. In Van Mijen Bay, inside Bell Sound, where there is a high sill, and the entrance is much blocked by Axel Island, the coldest water, with temperatures about —1.2° C., is found near the bottom at 95 and 100 metres (Fig. 29). The salinity at this depth is 34.25 ‰. No such water was found in Bell Sound outside the sill, but at Station 54, outside Horn Sound, a similar water-layer with a temperature of —1.075° C. and salinity 34.25 ‰ was found at 50 metres below the surface. The very cold bottom water in Van Mijen Bay might be a remnant of the cold water formed in the Bay during the cooling of the surface and the formation of ice during the winter, but more probably it has come in over the sill from the water outside, which has certainly been much colder during the winter and the spring, than that found in Bell Sound on August 31st, 1912.

In Ice Fjord (and Cross Bay) there is, however, considerable differences in the temperature and the salinity of the water even near the bottom, which proves that these fjords cannot be closed by any sill of importance, but that there must be comparatively free communication with the water-layers of the sea outside, from which the deep waters of the fjords have obviously been carried in, as they cannot possibly have been formed in the fjords themselves. In the deep hollow at the mouth of Ice Fjord, the temperature and salinity of the water near the bottom varied from one day to another, and there were even variations at stations not for apart and taken with intervals of a few hours only; but the densities did not vary much. Thus even these deep layers show less uniformity than might be expected, which indicates that there must be a fairly active horizontal circulation, even near the bottom.

On the shelf to the north of Spitsbergen, vertical series of observations were taken at Stations 18, 22, 23, 31—35, 38, and 39. As a rule there is no indication of a cold intermediate layer at these stations. On the whole the temperatures are fairly uniform between the surface and the bottom on the shelf north of Spitsbergen, especially in its western part near Stations 22 and 23, while the salinities are gradually increasing towards the bottom (Fig. 14). These conditions are very similar to those observed at the Isachsen Stations 38, 39, and 40 north of Spitsbergen in August 1910 (see Helland-Hansen and Nansen, 1912, Section IX, Pl. VI.) The uniformity in the vertical distribution of the temperature is very conspicuous at Stations 22 and 23, which were not far from the Isachsen stations just mentioned; but while the temperature on August 26th, 1910, was between 2.87 and 3.13° C., on August 6th, 1912, it was about 1.58° C. at all depths below the surface. The difference may to some extent be due to the fact that the observations in 1912 were taken nearly 3 weeks earlier in the season, but nevertheless the sea to the north of Spitsbergen was obviously somewhat colder in the summer of 1912 than in the summer of 1910 (see above p. 19). The vertical uniformity of the water-layers over the shelf in this region may possibly to some extent be due to the orbital motion of the water, caused by the tidal currents over the shallow bank.

At the more eastern stations on the shelf north of Spitsbergen there is somewhat less uniformity in the vertical distribution of temperature which may on the whole have a tendency to increase slightly towards the bottom (cf. Stations 31—33, and 38, 39, Figs. 32—34). At Station 34 there was found a cold intermediate layer, with a minimum temperature of —0.45° C. at 50 metres. The same layer was also observed at Stat. 35, but not so cold (minimum = 0.07° C. at 50 metres). This was evidently the typical cold intermediate layer of the ice-covered North Polar seas. At Stat. 30, outside Hinlopen Strait, the top layers were cold, and they were evidently the same kind of cold water, but there the minimum temperature (— 1.0 °C.) was at the surface (Fig. 33). At Stat. 20 (Fig. 14) there was also a cold intermediate layer, with a minimum of 0.59° C. at 50 metres, but this station was on the edge of the shelf and nearer the region of the North Polar Current; it was in the drifting ice. At other times much lower temperatures were observed at this station and Station 19 only a short distance off (see Table I).

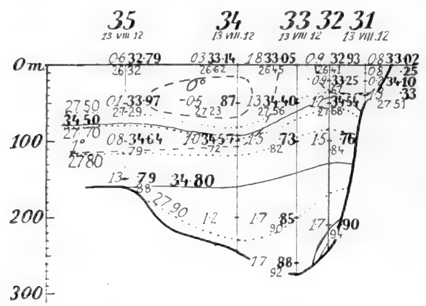


Fig. 32. Section across the shelf and the submerged channel north-north-east of Hinlopen Strait, from Verlegen Hook to Stat. 35, Aug. 13, 1912 (see Fig. 1). Scales same as in Figs. 11—13.

The vertical distribution of temperature and salinity in the northern fjords, Wood Bay and Wijde Bay (Figs. 27 & 28), is, on the whole, very different from what was observed on the shelf to the north, outside these fjords. The upper layers, at the surface and at 20 metres, sometimes even at 50 metres, are much warmer in the fjords than over the shelf outside, while the deeper layers, below 50 metres, are very much colder in the fjords than outside (see Figs. 4—6). On the whole, the temperature of the fjords decreases rapidly from the surface downwards towards the bottom, and at a few stations only, especially at Stat. 25 in the middle of Wood Bay, there are indications of an intermediate layer with a minimum temperature at about 50 metres. At some stations there is a slight minimum at 100 metres.

It seems probable that the cold deep-water of these fjords, especially of Wijde Bay, must be a local formation of the inner fjord, as a corresponding cold water was not observed on the shelf outside the fjord. It may be cold water that has been formed by vertical circulation during the cooling of the sea-surface in the inner fjord in the winter and spring; and

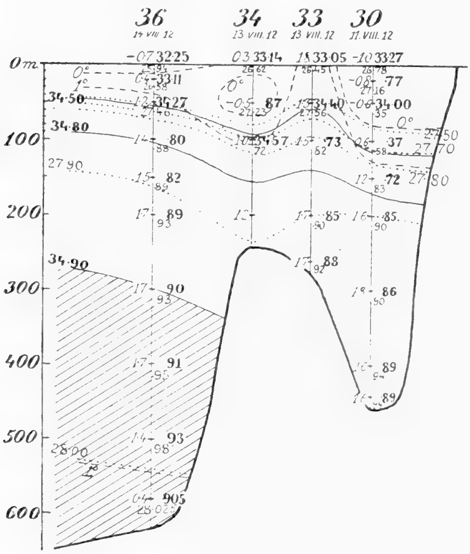


Fig. 33. Section from Stat. 30 at the mouth of Hinlopen Strait to Stat. 36, Aug. 11—14, 1912 (see Fig. 1). Scales same as in Figs. 11—13.

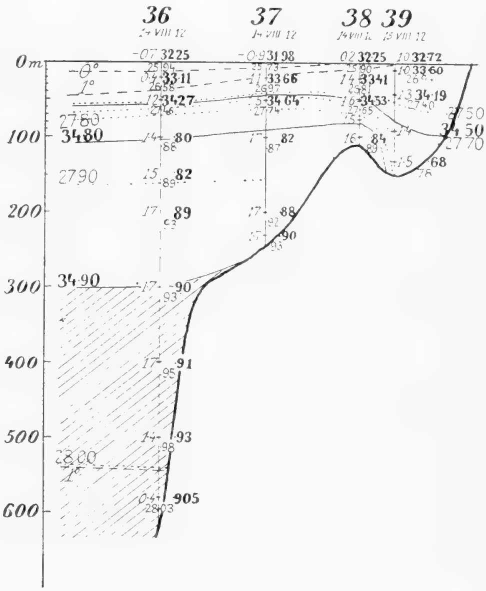


Fig. 34. Section from Stat. 36 across the shelf to Stat. 39 and the Spitsbergen coast, Aug. 14—15, 1912 (see Fig. 1). Scales same in Figs. 11—13.

these layers of cold water, filling the deep parts of the fjords, had not, even in August, been washed out by the horizontal circulation.

It is a striking feature that in both our sections across Wood Bay and Wijde Bay the lowest temperature, especially of the deeper layers, was found at the easternmost stations, near the eastern coast of the fjords. This was especially conspicuous in Wijde Bay, where, at Station 29, at depths of 100 and 130 metres, the temperature sank even below zero. It is difficult to say what the reason of this strange distribution of the waters may be.

If the cold water observed at 100 and 130 metres, at Stat. 29 in Wijde Bay, originated from the inner part of the fjord, and was flowing outwards, it should be driven towards the eastern side of the fjord by the Earth's rotation, as we found it. If we assume that the velocities of this outward motion were greatest near the bottom, it would also explain the inclination of the isopycnals, at the higher levels between Stat. 29 and Stat. 28 (Fig. 28), but the distribution of density near the bottom does not indicate any such rapid motion in the deep layers. If we assume that there was lateral equilibrium in our section (Fig. 28), and we compute the velocities by the simple method described by me [1913, p. 49], we find the following differences of velocity (along the components perpendicular to the section): between 130 metres and

the Surface	18.9	cm.	per	second
20 metres	23.0	»	»	»
50 »	8.3	»	»	»
100 »	0.4	»	»	»

The components of these relative movements were directed south-eastwards. As the component at 100 metres, though small, also was directed south-eastwards, according to these computations, it does not indicate that there could have been any rapid northward movement at that depth.

If there really was lateral equilibrium in the section, the vertical distribution of density would rather indicate that between Stats. 29 and 28 the water was running southwards with a velocity at the surface of about 19 cm. per second, and at 20 metres with a velocity of about 23 cm. per second, while along the western side of the fjord, between Stats. 27 and 28 it was chiefly running in the opposite direction with the following velocities, provided that the motion at 130 metres was negligible:

At	the Surface		46.4	cm.	per	second
»	20 metres		25.0	»	»	»
»	50	»	4.4	»	»	»
»	80	»	—2.5	»	»	»
»	100	»	—1.4	»	»	»

These values do not seem probable, especially not the high velocity of the outward flowing current at the surface, although at that hour (Aug. 10, 3.50 p. m.) the tidal current was probably running out of the fjord. If we assume that the difference between high-water at this place and the transit of the moon across the Greenwich meridian, is about 1 hour and 30 minutes, there should have been high-water about 12.14 a. m. (central European time) on August 10th, and the water would be running out at 3 50 p. m. But this would not explain that the water was running in at Stat. 29, at 6.10 p. m., as low-water would not occur before about 6.30 p. m.

The peculiar vertical distribution of density in the section across Wood Bay (Fig. 27) would also be difficult to explain by tidal currents. The inclinations of the isopycnals might seem to indicate an inward running current between noon and 1.50 p. m., on August 9th, but high-water probably occurred at about 11 a. m.

It seems also doubtful whether the steep inclinations of the isopycnals in our sections Figs. 22 and 25, across Ice Fjord, are due to horizontal motion of the water. The inclinations of the isopycnals of 27.70 and 27.80 between Stats. 48 and 47 are probably much to steep in Fig. 25, as the low density at 230 metres, at Stat. 47, is hardly correct (se note Table I); but at Stat. 11, Fig. 22, there seems really to have been a considerable depression of the strata at about 50 and 100 metres.

It is, however, hardly probable tat there has been lateral equilibrium in these sections. As vas pointed out above (p. 28), several observations indicate appreciable vertical changes in the situation of the water-strata in short time, in the fjords as well as in the sea outside. The series of observation from Wijde Bay and Wood Bay may also indicate such vertical oscillations. *E. g.* at 75 metres at Stats. 27 and 25 observations were taken 25 and 20 minutes later than the observations at the levels above and below. The densities found at 75 metres lie, however, outside the regular "vertical" curves formed by the densities at the other levels, indicating that the water-layer at 75 metres may have been depressed about 10 metres at Stat. 27 and lifted about 10 metres at Stat. 25 in the 25 and 20 minutes.

In seems, therefore, probable that the peculiar vertical distribution of density in some of our sections across the Spitsbergen fjords, is not so much due to the horizontal motion of the water, as to vertical oscillations of the strata.

The Deep-Water of the North Polar Basin.

I had hoped to be able to penetrate so far north of Spitsbergen that we could reach depths greater than 1 000 metres, and thus obtain samples of the cold deep-water of the North Polar Basin; but unfortunately inpenetrable ice prevented us everywhere from getting so far, the ice being distributed comparatively far south in the summer and autunm of 1912. North of Hinlopen Strait I found, however, a submarine channel extending towards north-north-west. At Stat. 36 (Figs. 32 and 33) it had a depth of 620 metres, and the channel evidently communicates with the North Polar Basin. At a depth of 580 metres the temperature was 0.43° C., and the salinity was 43.905 $^0/_{00}$. Two water-samples were taken from this depth, and they both gave the same salinity, differing only 0.002 $^0/_{00}$. At 500 metres the temperature was 1.41° C. and the salinity 34.93 $^0/_{00}$. At 400 metres the salinity was 34.91 $^0/_{00}$, and the temperature was 1.68° C. Two water-samples were taken from each of these depths. The water observed at 400 and 500 metres must be chiefly Atlantic water that is carried northwards with the Atlantic Current west of Spitsbergen, and which we also observed at the Stations 19 and 41 to the north of western Spitsbergen.

The cold water at 580 metres is evidently of the same kind as the deep-water filling the North Polar Basin. We thus come to the conclusion that the salinity of the latter cannot be much above 34.90 $^0/_{00}$, or exactly the same as the salinity of the cold deep-water of the Norwegian Sea. I found a somewhat higher salinity 34.916 $^0/_{00}$[1], with a somewhat higher temperature, 0.90° C., at 610 metres at Station 19, north of Spitsbergen farther west. At Stat. 41, north-east of Stat. 19, 34.91 $^0/_{00}$ was found, with a still higher temperature of 1.08° C., at 530 metres.

These salinities obtained by very accurate determinations are much lower than the values given by the many determinations of the deep-water of the North Polar Basin during the Fram expedition in 1893—96. By a revision of our determinations, made with the hydrometer during that expedition, I came to the conclusion [1906, p. 100] that the salinity of the deep water of the North Polar Basin should have been about 35.10 $^0/_{00}$, a value which, however, seemed to me to be higher than was probable; and at the same time I pointed out that the determinations of the water-samples brought home by Doctor BLESSING, and taken at 800 and 850 metres in the North Polar Basin, gave salinities of 34.99 $^0/_{00}$ and 35.01 $^0/_{00}$, which seem to be nearer the value that might be probable. I also pointed out that if these water-samples had been exposed to any evaporation, especially while placed for sterilization in boiling water for half an hour, before being finally closed and soldered with paraffin wax, the salinity of the samples may originally have been somewhat lower, and we then approach the value of the deep-water of the Norwegian Sea. This has evidently been the case.

The salinity of the deep-water of the North Polar Basin should consequently be about 34.905 $^0/_{00}$. Perhaps it is sligthly lower, because this salinity was found with a temperature of 0.43° C. at 580 metres, at Station 36, while at greater depths in the North Polar Basin the temperature is lower, below zero, and in the Norwegian Sea we find that as a rule the

[1] See my remarks on the values of salinity of the two water-samples from this depth, above p. 8.

deeper strata of the deep-water, with temperatures below zero, have a slightly lower salinity than the strata at higher levels, with temperatures above zero.

We thus see that the salinity of the deep-water of the North Polar Basin is exactly the same as that of the deep-water of the Norwegian Sea. It seems then probable that it is the same kind of water that is originally formed during the winter at the surface of the Norwegian Sea in the limited area between Jan Mayen and Spitsbergen, as I have described on a previous occasion [1906, p. 75 *et seq.*; see also HELLAND-HANSEN and NANSEN 1912]. The fact that the deep water of the North Polar Basin has a higher temperatur — with a minimum of about —0.8° C. or —0.9° C. — than the deep-water of the Norwegian Sea, where the temperature is about —1.2° C. or —1.1° C., might be due to its becoming heated (by intermixture) in its circulation from the Norwegian Sea northwards into the North Polar Basin. If this explanation were accepted, it would not be necessary to assume that there is a continuous submarine ridge between Spitsbergen and the northern part of Greenland, the existense of which I previously thought was proved by the assumed difference of salinity between the deep-water of the North Polar Basin and that of the Norwegian Sea.

It is, however, possible that the difference of temperature in the two basins might be explained by a low continous ridge between Spitsbergen and Greenland, which prevents the coldest deep-water near the bottom of the Norwegian Sea from running into the North Polar Basin. It would then be only the deep-water at some higher level, where the temperature is higher, that could flow over this ridge and form the deep-water of the North Polar Basin. A submarine ridge rising to levels of between 1 500 and 1 200 metres below the sea-surface, and extending continuously from Spitsbergen to Greenland, might be sufficient to prevent the coldest deep-water of the Norwegian Sea, with temperatures below —0.9° C., from running into the North Polar Basin (cf. the Belgica Stations 15—18, north-west of Spitsbergen [see DUC D'ORLEANS, 1907, Pl. LXVI]).

The Deep-Water of the Norwegian Sea.

At Stations 17 and 57 we collected some samples of the cold deep-water of the Norwegian Sea. At Station 57, cold water was observed at 900 metres with a temperature of —0.84° C. and a salinity of 34.896 ‰. At 700 metres, at the same station, the salinity was 34.91 ‰, and the temperature was slightly above zero.

At Station 17 still colder deep-water was observed. At 700 metres the temperature was —0.16° C., and the salinity 34.895 ‰, At 1 100 metres the temperature was —1.07° C., and the salinity 34.895 ‰. The values obtained by these very accurate determinations thus agree fairly well with the values obtained by previous expeditions, especially the Belgica expedition 1905 [Helland-Hansen and Koefoed 1909]; the Amundsen expedition 1901 [Nansen 1906]; the Isachsen expedition 1910 [Helland-Hansen and Nansen 1912]. See also Helland-Hansen's and my work on the Norwegian Sea [Helland-Hansen and Nansen 1909].

On the whole the value of 34.895 ‰ seems slightly lower than the majority of the salinities of the cold deep-water, obtained by the most accurate determinations of earlier years, *e. g.* those of the Belgica Expedition 1905 (between 34.90 and 34.93 ‰), and those of the Michal Sars expeditions 1900 and 1904 [Helland-Hansen and Nansen, 1909, pp. 332—333, 336—337] which were between 34.905 and 34.945 when obtained by determinations of specific gravity, but on the average 0,008 ‰ lower when opbtained by titrations. As our determinations with the Interferometer are based upon standard waters, determined by titration only, this may possibly be the explanation of our comparetively low values.

Current Measurements.

In 1905 [1906, pp. 27 *et seq.*] I recommended a method of measuring the currents of the open sea from a steadily drifting ship — held by drift-anchors or by the drifting ice — by using simultaneously two current-meters, one lowered to the quiet water near the bottom of the sea, in order to determine the movement of the ship or the drifting ice, and the other instrument lowered to the depth where observations were desired. This method was, however, not tried, by myself or others, until 1910, when Professor Björn Helland-Hansen made several measurements of this kind from the "Michael Sars" in the Atlantic, while the ship was drifting slowly, held by the biggest tow-nets. In 1911 I made some experiments with the "Veslemöy", drifting with a big drift-anchor made of canvas. These experiments fully proved the possibility of making useful current-measurements in this manner.

In 1912 I had, however, a better opportunity of trying the method during the days from August 4th to 6th and August 18th and 19th. The ship was then moored to the biggest and heaviest floe that could be found among the ice-floes. A thick, heavy piece of ice such as this, of great extent, has naturally a very steady movement. During August 4th to 6th, at

Station 19, the depth of the sea varied between 626 and 572 metres; during August 18th and 19th, at Station 41, the depth varied between 540 and 340 metres.

The drift of the ice and the ship was determined by a current-meter lowered to the deep water-strata as near the bottom as we dared go without running the risk of dragging the current-meter along the bottom, which actually happened once when there had been an unexpected great change in the depth. During August 18th and 19th observations were taken as

Fig. 35. The Veslemöy moored to an ice-floe for current-measurements. Stat. 41, Aug. 18th, 1912.

often as possible simultaneously with two current-meters, one in the strata near the bottom, and one at some higher level.

By means of these simultaneous observations the actual movement of the water at the latter level may be computed by a simple construction, provided that the water near the bottom has no appreciable movement. In this case the observations in the water-strata near the bottom give directly the velocity of the ship, and the direction in which she is drifting. A line is drawn with a length corresponding to the velocity observed, and in the observed direction, and from the end of this line another is drawn with a length and direction corresponding to the velocity and direction of the relative movement observed at another depth. The length and direction of a line connecting the ends of these two lines will then give the actual movement of the water at the last-mentioned depth [for this method see NANSEN, 1906, pp. 29 & 30]. Let us take an example. At station 41, on August 18, between 3.04 and 3.14 a. m. a velocity was observed, at 450 metres, of 23.5 cm. per second coming from S 70° E (magnetic); and at 100 metres a velocity of 13 cm. per second from S 49° E. The depth of the sea was about 490 metres. If we assume that the water had no movement at 450 metres, the ship has consequently, during those 10 minutes, been drifting towards S 70° E with a velocity of 23.5 cm. per second, while at the same time the water at 100 metres has been moving towards N 49° W with a velocity of 13 cm. per second in relation to the ship. If therefore we draw on paper a line 23.5 cm. long, at an angle of S 70° E with the magnetic meridian, and from the end of this line draw another line 13 cm. long towards N 49° W, the actual current at 100 metres will be represented by a line drawn from the starting-point of the first-line to the termination of the latter line. The current is thus found to be 12.2 cm. per second towards N 88° E magnetic or N 76° E (true).

The values obtained in this manner cannot be expected to be very accurate, because on the one hand the directions of the movements are not measured with a sufficiently high accuracy, it being only within ± 10°, as the compass-box is divided into chambers of 10° each. On the other hand it is assumed that the water at 450 metres, near the bottom, has practically no movement. If this assumption is not correct, the velocities and directions found for the currents at the higher levels and at the surface will obviously be inaccurate; and the greater the movement of the water near the bottom, the more will this be the case. As will be pointed out later, it is, however, hardly probable that the movements of the water of the deep strata were, as a rule, considerable, and at any rate not at Station 41.

Another method of measuring the drift of the ship was also attempted. The sounding-lead was sent down into the bottom-mud with as much speed as possible, in order to make it go deep in and stick well. While the sounding-line was then continuously kept as tight as possible without running too great risk of dragging the lead along the bottom, as much line was gradually paid out as was made necessary by the movement of the ship. This was at first done by hand, later by putting a moderate break on to the sounding-winch, so that line was run out when its strain became sufficiently great.

By noting how many metres had to be paid out for every 10 minutes, it should thus be possible to compute the velocity with which the ship was drifting, and the direction of the drift was indicated by the direction of the vertical plane of the sloping sounding-line. Theoretically this method should give fairly accurate results., but practically this is hardly the case. Owing to its weight, the sounding-line will form a curve, and the greater its angle with the vertical, the greater does the curve become. It will consequently be necessary to pay out more line than would have been the case if the line could have been kept straight; and it is hardly possible to calculate how much. Owing to this circumstance the method will therefore give too great values for the drift of the ship. On the other hand there is naturally a risk that the lead may be dragged along the bottom, and if so this will naturally tend to make the mearurements of the drift too small. Another drawback with this method is the difficulty of measuring the direction of drift with sufficient accuracy, and it is especially difficult to measure the changes in the direction of the drift during the time of the observations, because the direction (*i. e.* the azimuth) indicated by the line will change much more slowely than the direction of the drift, especially if the line forms a great angle with the vertical, and there is a great distance between the ship and the lead on the bottom. If the line is kept tight it will point the whole time towards the lead, and even though the direction of the drift may change a great deal, it can cause only a very slow alteration in the direction of the line. The currents at intermediate depths may also have appreciable effect upon the direction of the sloping line. This kind of observation is not therefore of much value for computing the actual current at higher levels from observations made simultaneously with a current-meter from the drifting ship.

The method might, however, have been useful for controlling the observations of the drift of the ship made by a current-meter lowered to the water-strata near the bottom. But unfortunately this was not done regularly, as we had too few winches with sounding-line, and too few men for the observations. After having made several attempts with the above method at Stations 19 and 20, on August 4th and 5th, and after having found by computation that it did not give satisfactory results, I gave up this method, and decided instead to work with two current-meters, one lowered to a water-stratum near the bottom, and the other used simultaneously at higher levels. Some few observations were, however, made simultaneously with the two methods.

On August 5th, from 4.11 to 4.21 p. m. an observation vas made with a current-meter at 540 metres. The depth of the sea was then 575 metres. The observation gave no movement, and at that time and during the previous hour the observations also gave no movements at higher levels. It was just one of those periods which, according to our observations, occurred at certain intervals, when there was no relative movement of the water, at all levels between the surface and the water strata near the bottom. During the same time observations of the drift of the ship were made with a sounding-line and the lead lying on the bottom, between 3.10 and 4.20 p. m., giving an average drift of the ship of 25.6 cm. per second towards S 34° W (magn.). Between 4.10 and 4.20 p. m. the drift of the ship should have had a velocity of 23.4 cm. per second in the same direction, according to these observations with the sounding-line. At this last hour the sounding-line formed, however, a very great angle with the vertical, and it is impossible to calculate the curve of the line; it is possible that the strain of the line would cause more to be paid out, even if the ship were not moving. The observations must therefore be considered as very unreliable. They might, however, indicate that the ship was actually drifting, approximately towards S 34° W, between 3.10 and 4.20 p. m., while the observations with the current-meter gave no relative movement of the water between the surface and 540 metres. If this be correct the whole volume of water, from the surface down to this depth, should consequently have been moving with a perfectly uniform velocity south-westwards, and in that case the observations with the deepest current-meter did not give the drift of the ship correctly.

That the values of the drift, obtained by these observations with the lead and the sounding-line, are not trustworthy, however, also appears probable from the fact that when a heavier sounding-lead was used, so that the line could be kept tigther, then much smaller velocities of the drift were obtained. At first an ordinary lead, weighing less than 10 kilograms, was used, but then on August 5th, between 6.40 and 7.50 p. m. a lead of 20 kilograms was used, and the line was kept much tighter. The result was an average velocity of 12.1 cm. per second only, though at that time the drift was comparatively rapid, as was shown by the observations at the depths of 50 and 100 metres; while earlier on the same day, between 3.10 and 4.20 p. m., the observations with the lighter lead gave an average velocity of 25.6 cm. per second when the current-meter showed no motion between the surface and 540 metres. It is, however, probable that after the tightening of the line at 7.05 p. m., the heavy lead has got loosened, and has been dragged along the bottom. The observation between 6.40 and 7.05 p. m. gave 20.1 cm. per second, which agrees fairly well with the observation with the current-meter at 520 metres between 6.19 and 6.29¼ p. m., giving a velocity of 15.3 cm. per second, considering that the value of the velocity obtained by the sounding-line has to be reduced owing to the curve of the latter, caused by its weight. The directions of the movements obtained by the two observations also agree fairly well. According to our curves Figs. 58 & 59, the velocity and direction of the drift at 6.50 p. m. should have been about 17.5 cm. per second and towards S 33° W, while the sounding-line gave S 39° W as an average between 6.40 and 8.45 p. m.

On August 18th, at 4.30 p. m., a sounding was made and gave 510 metres. The sounding-line was then hanging vertically, and remained so till it was hauled up. Some minutes later an observation was made with a current-meter at 450 metres, and gave no movement of the water, thus indicating that there was no drift of the ship, if it may be assumed that the water at 450 metres had no movement. In this case the observations with the sounding-line and the lead on the bottom, and with the current-meter at 450 metres, thus agree perfectly. An observation taken simultaneously at 20 metres gave a considerable movement at that depth.

On August 19th, at 1.15 a. m., a sounding gave 502 metres, and the sounding-line remained vertical till it was hauled up. A few minutes later an observation with the current-meter at 450 metres gave a relative movement of the water of only 1.5 cm. per second, which consequently meant a very slow surface drift, if the water at 450 metres can be assumed to have had no movement. This drift of 1.5 cm. per second is so slow that it could not be expected to be observed by the sounding-line; and in this case the observations with both methods consequently also agree.

At other times the sounding-line showed a great deflection which indicated a rapid surface-drift, and this was then found to agree with the apparent surface-drift given by the observations with the current-meter in the deep water-strata. On August 18th, at 8.30 p. m., a sounding gave 520 metres, and it is noted in the journal that the sounding-line was much deflected towards NE, indicating a rapid surface-drift towards SW. Simultaneously an observation with the current-meter at 450 metres gave a surface-drift with a velocity of 13.7 cm. per second towards S 70° W (magn.), provided that the water at 450 metres had no movement. The disagreement between the directions of the two observations might to some extent be explained by the fact that the deflection of the sounding-line was not measured accurately, but was only given according to the general impression; it is not therefore altogether improbable that it may have been a point or two wrong.

On August 19th, at 1.00 p. m., a sounding gave 436 metres, and the sounding-line was deflected towards E by N. Ten minutes later, an observation with the current-meter at 400 metres, gave a surface-drift of 17 cm.

per second towards S 70^{0} W (magn.), assuming that the water at 400 metres had no movement. Thus the observations with the two methods agree fairly well in this case.

On the whole, it would naturally have been desirable to have had a greater number of observations at smaller intervals at all depths, but this was difficult to attain as I had to read all the instruments myself, and some rest proved necessary during the many consecutive hours, day and night, that the observations lasted.

In addition to the current-measurements I also repeatedly took the temperature and water-saples at different depths during the same time, in order to follow the vertical oscillations of the strata, and compare them with the changes in the current. There was altogether so much work for one man that it would have been difficult to do more.

The current-observations were made with 3 Ekman current-meters, No. 49, 52, and 53. No. 52 got out of working-order on August 4th, in the evening, and No. 53 was used instead after that time. The formulae for computing the velocity, directly observed with the different instruments, were the following:

For current-meter No. 49, if the velocity be between 3.5 and 101 cm./sec.:

$$v = 0.9 + 26.0 \times n$$

The current-meter No. 52, if the velocity be between 3.3 and 100.5 cm./sec.:

$$v = 0.7 + 26.7 \times n$$

For current-meter No. 53, if the velocity be between 3.3 and 30.7 cm./sec. (or less than 1.3 revolutions of the propeller per second):

$$v = 1.3 + 26.6 \times n$$

If the velocity be between 30.7 and 101 cm./sec. the formula is:

$$v = 0.1 + 27.5 \times n$$

n is the number of revolutions of the propeller of the instrument per second.

The original observations and the velocities thus computed are given in the six first columns of Table II. The latter values with the true direction of these observed movements are collected in special tables for each depth, pp. 47 and 48.

These observations give directly the differences between the movements of the ship and at the depth where the observations were taken.

Date & Hour	Movement relative to the Ship		Actual Current	
	Velocity cm./sec.	True Direction (towards)	Velocity cm./sec.	True Direction (towards)
10 Metres.				
Aug. 4. Station **19.**				
3.18 p. m.	23	N		
4.36 »	15	N 5° W		
7.13 »	17.7	S 83° W		
Aug. 5. Station **20.**				
1.01 p. m.	11.2	N 90° W		
3.07 »	0	0		
7.50 »	15	S 49° E		
Aug. 6.				
0.44 a. m.	30.6	N 81° W		
Aug. 18. Station **41.**				
4.03 a. m.	18	N 9° W		
7.26 »	15.5?	S 36° E		
9.11 »	43	N 88° E		
2.56 p. m.	12.5	S 9° E		
5.02 »	20	N 33° E		
8.33 »	5.7	N 78° E	8.5	S 45° W
9.54 »	28	N 68° E		
Aug. 19.				
2.05 a. m.	16.5	N 38° E		
2.55 »	16.5	N 58° E		
6.55 »	32	?		
7.04 »	33	N 47° E		
9.24 »	23	N 77° E		
2.00 p. m.	5.6	N 62° W?		
20 Metres.				
Aug. 4. Station **19.**				
1.47 a. m.	13.8	S 16° W		
3.46 »	14.7	N 43° E		
7.14 »	12	N 39° W		
Aug. 5. Station **20.**				
1.19 »	14.3	S 60° W		
3.21 »	0	0		
6.00 »	23.8	N 20° E		
7.30 »	14.7	N 87° E		
8.19 »	14.6	S 9° E		
8.52 »	7.2	S 22° W		
10.36 »	24.2	S 36° W		
Aug. 18. Station **41.**				
1.50 a. m.	31	S 36° W	5.3	S 52° W
3.42 »	27.5	N 41° W	12.5	N 4° W
7.05 »	48.5	N 2° E		
9.25 »	42	N 58° E	15.6	N 12° E
0.23 p. m.	30	S 55° E	11.3	S 32° E
3.07 »	14	S 2° E	14	S 58 W
4.44 »	28	N	28	N
5.32 »	34.5	N 2° W		
10.23 »	35	N 87° E		
Aug 19.				
2.02 a. m.	12.5	S 68° W		
2.45 »	19.5	N 59° W		
6.29 »	35	N 23° E		
9.13 »	37	N 66° E		
1.28 »	0	0		

Date & Hour	Movement relative to the Ship		Actual Current	
	Velocity cm./sec.	True Direction (towards)	Velocity cm./sec.	True Direction (towards)
50 Metres.				
Aug. 4. Station **19.**				
2.40 a. m.	1	0	14	N 7° W
11.30 »	0	0		
0.29 p. m.	0	0		
2.15 »	12.9	N 26° E	5.1	N 39° W
3.18 »	13.9	N 13° E		
3.46 »	9.2	N 15° E		
4.36 »	6.3	N 36° E		
6.30 »	2.5	N 13° W	1.6	N 32° W
9.25 »	4	S 87° W	7.8	S 19° W
Aug. 5 Station **20.**				
0.33 p. m.	10.4	S 76° E	(15.4	S 6° E)
1.52 »	5.6	S 51° E		
3.34 »	0	0		
7.30 »	23.2	N 65° E		
9.39 »	17.7	S 59° E	16.7	S 20° E
Aug. 6.				
0.44 a. m.	24.8	N 60° W		
Aug. 18 Station **41.**				
2.36 a. m.	10	S 80° W	11	N 76° E
4.19 »	12	N 88° W	15.5	S 48° W
7.53 »	27	N 38° E	13.8	S 84° W
1.35 p. m.	35.5	S 61° E	10.5	S 64° E
3.19 »	14.5	S 42° E	6.1	S 15° E
5.15 »	14	N 13° E	14	N 13° E
5.45 »	16	N 1° E	7	N 19° W
9.38 »	43	N 60° E	26	N 72° E
Aug. 19.				
1.25 a. m.	5.5	N 78° E	4	N 72° E
6.14 »	27	N 5° W	10.4	N 56° W
8.59 »	37	N 69° E	12.9	N 88° E
1.13 p. m.	23	N 61° E	6.1	N 70° E
6.18 »	19.5	N 10° W	6.7	N 22° W
100 Metres.				
Aug. 4. Station **19.**				
0.50 p. m.	4	N 47° E (?)		
5.32 »	8.7	N 46° W		
Aug. 5. Station **20.**				
3.50 p. m.	0	0		
7.50 »	18.6	N 57° E		
Aug. 18. Station **41.**				
3.09 a. m.	13	N 61° W	12.2	N 76° E
8.55 »	36	N 51° E	10.6	N 17° W
2.38 p. m.	20	S 47° E	7.0	S 27° E
6.02 »	18.5	N 36° E		
10.08 »	31	N 67° E	13	N 61° E
Aug. 19				
2.15 a. m.	0	0	3.5	S 10° W?
6.39 »	26.5	N 11° E	5	N 48° W
9.34 »	35	N 69° E	2.2	N 79° E
1.42 p. m.	13	N 68° E	9.4	N 60° E

Date & Hour	Movement relative to the Ship		Actual Current	
	Velocity cm./sec.	True Direction (towards)	Velocity cm./sec.	True Direction (towards)
200 Metres.				
Aug. 5. Station **20.**				
5.14 p. m.	17.5	N 4° E		
8.51 »	6.4	N 30° E		
11.18 »	10.2	N 59° W	7.2	S 67° W
Aug. 18. Station **41.**				
6.15 p. m.	14	N 10° E	2.5	S 67° W
10.37 »	22.7	N 81° E	8.4	N 31° E
Aug. 19.				
2.30 a. m.	0	0		

Where simultaneous observations were taken in the deep strata near the bottom, the computed actual current at the different depths have been added in the 4th and 5th column.

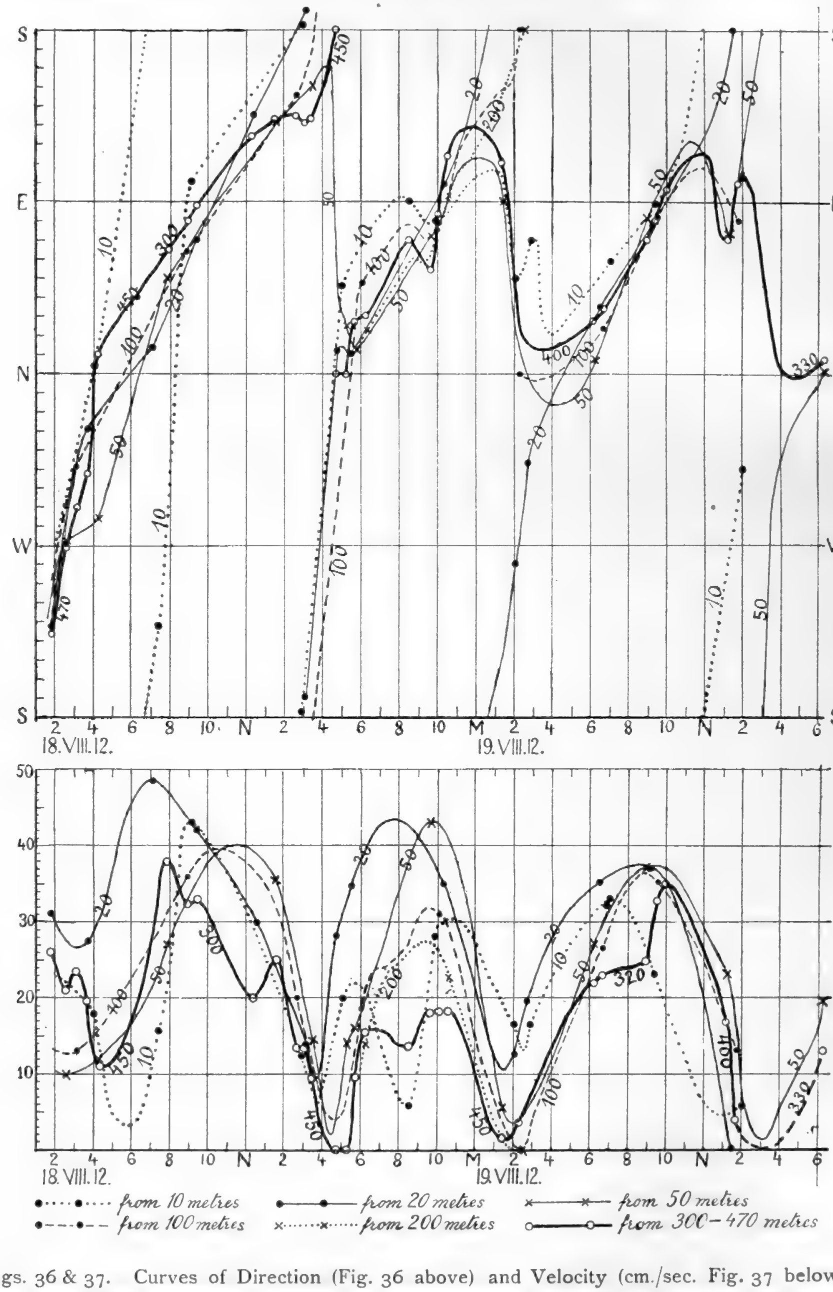
During August 4th to 6th, at Stations 19 and 20, few simultaneous observations were taken with two current-meters, and only a few observations were taken in the deep strata near the bottom. Instead of this, attempts were made to measure the drift of the ship by means of the sounding-line and the lead lying on the bottom; and the current measurements made during these days give therefore less complete results.

It is therefore preferable to discuss first the series of observations at Stat. 41, during August 18th and 19th.

Current Measurements at Stat. 41, on August 18th and 19th, 1912.

By means of the direct observations at Stat. 41, curves of relative velocity and direction have been constructed in Figures 36 and 37, for depths of 10, 20, 50, and 100 metres and for the strata near the bottom (depths between 470 and 300 metres). In these figures the hours are marked along the axis of abscissas, the direction (magnetic) and velocity (in cm. per second) along the axis of ordinates. The curves for the depth of 10 metres show great irregularity, which must obviously be due to the fact that the movements of the water at this level are much influenced by the movements of the ice which descended much deeper at its thickest parts. Thus the free movement of the water was probably much hindered at this level, and sudden irregularities might be caused by vortices, etc. Only three observations were taken at 200 metres, and these are not sufficient for the construction of curves for this depth; but an attempt has been made to draw probable curves for a short distance (between Aug. 18th 6 p. m. and Aug. 19th 2.30 a. m.).

The curves show, on the whole, a well-defined period of about tvelve hours, during which the velocities vary greatly from values of more than



Figs. 36 & 37. Curves of Direction (Fig. 36 above) and Velocity (cm./sec. Fig. 37 below) of the Relative Movements at different Depths at Stat. 41, Aug. 18—19, 1912. The directions are magnetic and are those towards which the water moved in relation to the ship. M means Midnight and N Noon.

40 cm. per second, to less than could be registered by the current-meters, and during the same period the directions shift as a rule continuously towards the right, on the whole about 360°. This continuous turning towards the right of the direction of the observed movements at all depths, is obviously due to the effect of the tidal wave, and the chief period observed seems also to coincide, approximately with the tidal period, though possibly somewhat shorter.

Our curves show, however, many irregularities. Some of them may naturally be due to irregular movements of the ship moored to the ice-floe, *e. g.* caused by turning of the floe, or by pressure against other floes, though on the whole the ice seemed to be very quiet. On account of such sudden irregular changes in the movements it may be difficult to draw the curves correctly where the intervals between the observations are not sufficiently short; and in many parts they cannot be considered as more than rough approximations.

But even if the movements observed had not been influenced by irregular, accidental movements of the ice-floe, and if the curves were correctly drawn, we must expect them to show many apparent irregularities; for the currents observed are obviously influenced by several factors. The permanent or average currents would naturally have a certain permanent direction at each depth, if not influencd by other agents; but the direction and velocity are, on the one hand, continuously being altered by the effect of the tidal wave coming from the Atlantic, which evidently causes the chief periodicity of the curves, of about twelve hours. On the other hand there must be a local tidal wave of the circumpolar North Polar Basin which also has a periodical effect upon the current, naturally much smaller, but still complicating the phenomena. Besides these more or less regular influences there may be apparantly quite irregular effects caused by incidental vortex-movements in the different strata. It is also possible that stationary submarine waves of different kinds, and pulsations of the prevailing currents may occur. The result must be very complicated movements giving apparantly very irregular curves of velocity and direction.

Amongst our curves those for the deepest strata, giving the drift of the ship moored to the ice-floe (see later), are the most accurate, as they are based on the greatest number of observations (32 in 40 hours). They also show most irregularities, probably because the details are better known; and if still more observations had been taken the number of irregularities would probably have been increased. As it is, the curve of velocity in particular shows a slight tendency towards a division of the great period of about twelve hours. In the first great wave of this curve there is a maximum at 8 a. m. (Aug. 18th) and a secondary maximum between 1 and 2 p. m. In the second great wave there is a secondary maximum at 6 p. m. and a greater maximum at about 10 p. m. In the third big wave there is also a tendency towards a simular development of a secondary maximum at about 6 or 7 a m. (Aug. 19th), besides the chief maximum at 10 a. m.

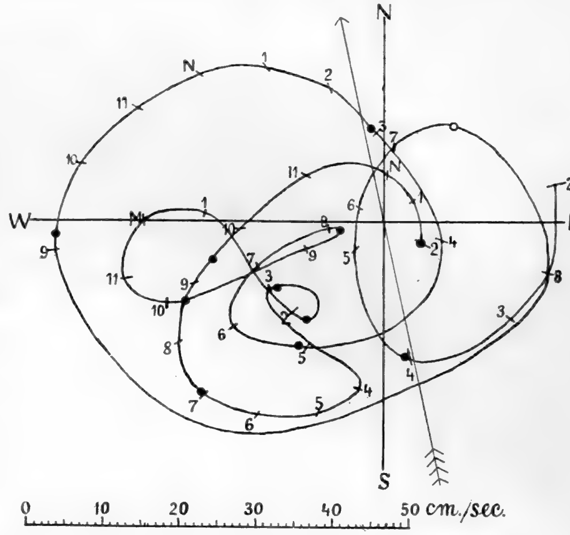


Fig. 38. Central Vector Diagram of the Relative Movement at **10 Metres**, at Stat. 41, from Aug. 18th 2 a. m. to Aug. 19th 2 p. m. N means Noon, M Midnight.

This might be due to the effect of the local tidal wave of the North Polar Basin in addition to the great tidal wave of the Atlantic; but without more complete material in the form of observations, nothing can be said with certainty in this respect. One remarkable and conspicuous effect of the great tidal period is that at intervals of about twelve hours, the movement at all depths, between the surface and the deepest layers, have a marked tendency to approach zero.

By taking the directions and velocities for each hour from our curves Figs. 36 & 37, the vector-diagrams, Figs. 38—43, have been constructed. The marks, with the numbers of the hours, along the curves indicate the direction and velo-

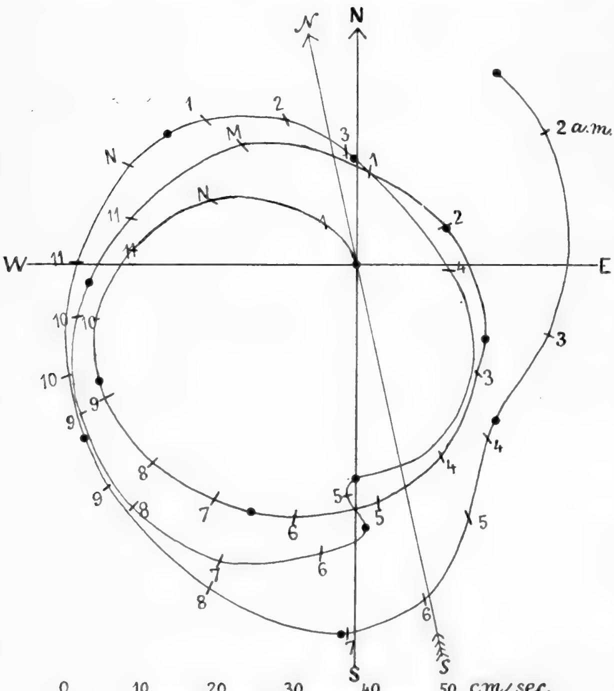
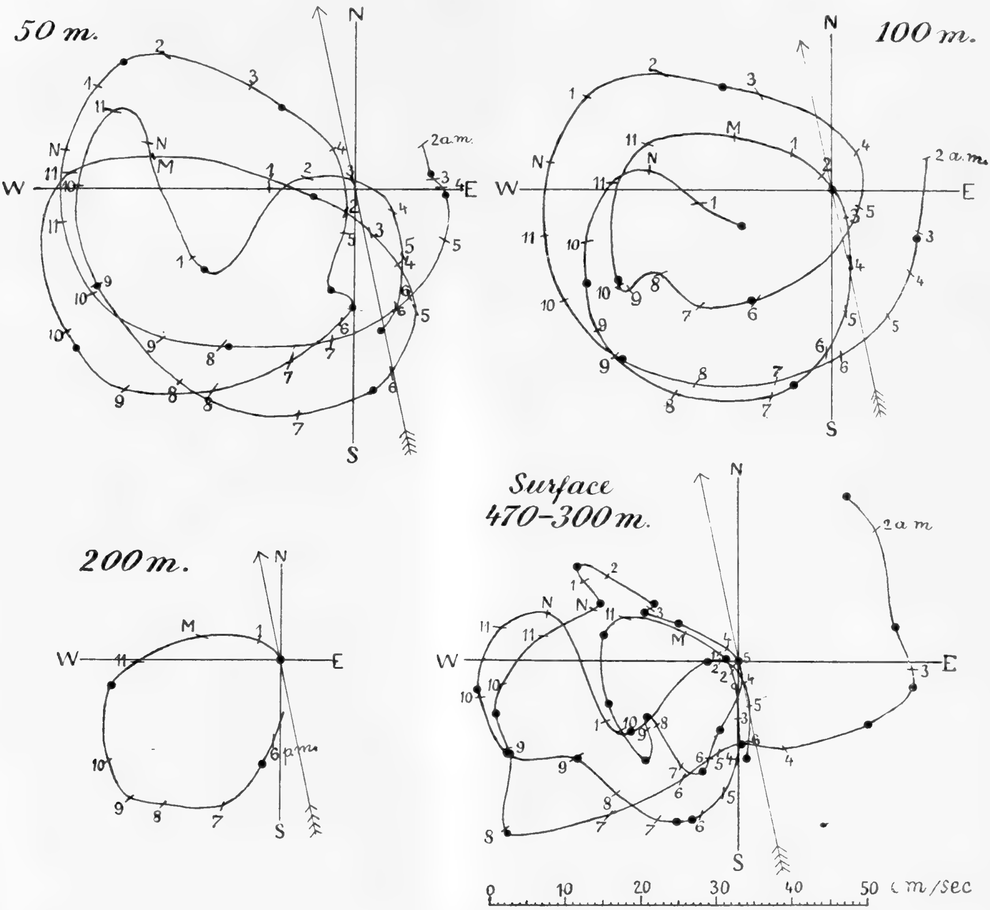


Fig. 39. Central Vector Diagram of the Relative Movement at **20 Metres**, at Stat. 41, from Aug. 18th 1.50 a. m. to Aug. 19th 1.28 p. m.

city (distance of mark from the centre of co-ordinates) of the relative movements. N means noon, and M midnigth; the direction given mean those f r o m which the water at the depth in question moved in relation to the ship (or ice-floe), or rather the direction t o w a r d s which the ice-floe moved in relation to the water at the depth in question. The black discs along



Figs. 40—43. Central Vector Diagrams of the Relative Movements at **50, 100**, and **200 Metres**, and at the depths of between **300** and **470 Metres**, at State 41. The last mentioned diagram, Fig. 43 probably gives approximately the velocities of the vessel and the surface layers, and the direction towards which they drifted.

the curves indicate the actual observations, a ring instead of a black disc indicates that the observation was doubtful.

These central vector-diagrams cannot be considered as more than very rough estimates, as they are based upon far too few observations. At 20 metres there are only 14 observations in 36 hours, at 50 metres 13 observations in about 40 hours, and at 100 metres 9 observations in $34^1/_2$ hours. The curves of the diagrams for these depths seem, however, fairly probable on

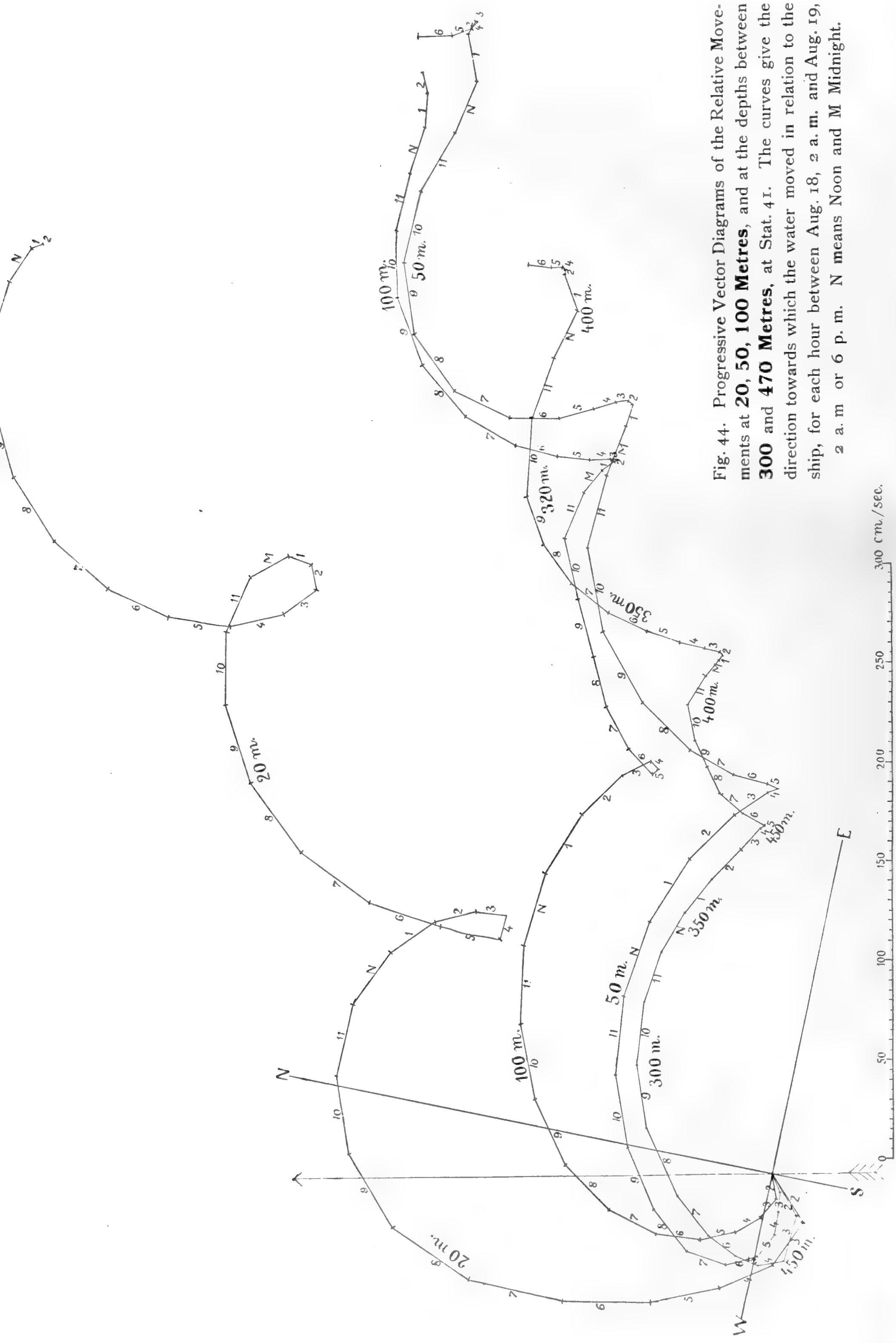


Fig. 44. Progressive Vector Diagrams of the Relative Movements at **20, 50, 100 Metres**, and at the depths between **300** and **470 Metres**, at Stat. 41. The curves give the direction towards which the water moved in relation to the ship, for each hour between Aug. 18, 2 a. m. and Aug. 19, 2 a. m or 6 p. m. N means Noon and M Midnight.

the whole. At the greatest depths, between 300 and 470 metres, 31 observations were taken in 40 hours; and the curve for these depths should consequently be the most trustworthy. At 10 metres there are 12 observations in 34 hours, but they show great irregularities, and the curve of the vector-diagram has a very improbable shape. The vector-diagram for 200 metres, based on only 3 observations, is naturally very uncertain, but may give an idea.

On the whole, the curves of these vector-diagrams show a tendency towards forming more or less irregular ellipses, which, *e. g.* at 20 metres, approach circles. The directions of the long axes of the ellipses may shift, but seem to have a tendency towards NW and SE or WNW and ESE.

By means of the directions and velocities of the relative movements for each hour, given by our curves in Figs. 36 & 37, the progressive vector-diagrams, Fig. 44, have been constructed. They show the directions towards which the water at each depth of observation was moving in relation to the ship or the ice-floe.

If we were to assume that the actual movements of the water at the greatest depths of observation were so insignificant, that they might be left out of consideration, the indications of the current-meter at these depths give the direction and velocity of the drift of the ice-floe and the ship. The progressive vector-diagram representing the movement of the deepest water in relation to the ship, consequently gives the drift of the ship or the ice-floe, if we turn it round so that North becomes South and East West.

During the period of observation the ship should thus have drifted from the end of the progressive vector-diagram to the right to its starting point to the left, *i. e.* towards S 66° W (S 78° W magnetic) with an average velocity of about 12.7 cm. per second (taking the observations between Aug. 18th 2 a. m. and Aug. 19th noon).

But during the same time the water at the other depths would have moved along their progressive vector-diagrams in relation to the ship. If, therefore, we draw lines from any point of the first vector-diagram to the corresponding points (*i. e.* corresponding to the same hours) of the others, these lines give the distance and direction of the active movement at the different depths during the period that has elapsed from the beginning of the observations till the moment chosen.

We thus find that from August 18th 2 a. m. till August 19th at noon, the water at **20 metres** should have moved towards N 6° W (N 6° E magnetic) with an average velocity of about 7.8 cm. per second.

At **50 metres** the water should have moved during the same period towards N 55° E (N 67° E magnetic) with an average velocity of 3.6 cm. per second.

At **100 metres** during the same period the water should have moved towards N 38° E (N 50° E magnetic) with an average velocity of 3.4 cm. per second.

As the observations of the relative movements at 10 metres give such very irregular values a progressive vector-diagram for this depth is not constructed for the whole time of observation (see later).

It seems astonishing that while the ice was moving with such a velocity towards S 66° W, the water at 20 metres was moving northwards at an angle of 108° with the movement of the ice, and at 50 metres the water was moving almost in the opposite direction of that of the ice (at an angle of 169°), while at 100 metres the water was moving in a direction between that at 20 metres and that at 50 metres.

If we are wrong in our supposition that the movements of the deepest water (near the bottom) are so insignificant that they can be left out of consideration, the above results would not be trustworthy. If, for instance, the water of the deepest layers had been moving with a considerable velocity in the same direction as the icc-floe, the actual movement of the latter would consequently be so much more rapid, and our progressive vector diagram in Fig. 44 would have to be lengthened towards the right; the direction and velocity of the movements at 20. 50, and 100 metres would also have to be altered. But even then the movements at these depths would be very much smaller than the movement of the ice-floe, and would be directed, at great angles, towards the right.

There seems, however, to be no reason why the movement of the water at great depths — greater than 300 metres — should be considerable in any south-westerly direction, considering that the water at 100 and at 50 metres, according to our observations, had such slow movements, and those in north-easterly directions. The water at depths greater than 300 metres is comparatively warm water which must come from the south, and evidently with very slow movement. We might thus expect that our results would give an approximate idea of the real movements of the water at the different depths.

A remarkable result of our observations is the great difference between the movement of the ice and the movement of the water at a depth of 20 metres, considering that the ice had a great thickness, and consequently its movement does not represent only the surface drift, but rather the movement of the whole top layer of the sea, down to a certain depth equal to that ot the ice. If we assume that the ice-floe, to which the ship was moored (see Fig. 35), had an average thickness of about 4 or 5 metres, it seems probable that its movement should represent the average movement of the upper layer — about 5 metres thick — of the sea; and there was no wind during the period of observation, which could influ.nce the drift of the ice appreciably.

As some parts of the ice may descend deeper, it may also be influenced by the movement of the water at this greater depth; but this must be of much less importance than the effect of the current of the top layer of the water upon the main body of the ice. On the other hand it must, however, be remembered that a heavy ice-floe, such as that to which the ship was moored, represents a great mass which has a considerable *vis inertiæ*, and cannot therefore be expectd to follow at once all changes in the movements of the water of the top layer of the sea. It seems therefore possible that the effect of the tidal wave may often turn the direction of the water somewhat more rapidly than that of the ice. Thus the direction of the movement of the ice and the top layer of the sea may not coincide at all moments, especially when there are rapid changes in the direction.

We may nevertheless expect, however, that the movement of the ice-floe represents on the whole the average movement of the top layer of the sea, although irregularities may, now and then, arise, especially, perhaps, from the pushing of the ice-floes against each other during the drift, as was mentioned before.

It would have been of much importance to the study of the above question, if our observations at 10 metres could have given fairly trustworthy information about the movement of the water at that depth; but unfornately the observations indicate that the movements often change so suddenly and so irregularly that we should want a much larger number of observations, taken at short intervals, in order to be able to trace the movements at this depth in their details.

Our curves of velocity and direction, Figs. 36 & 37, and our central vector diagram, Fig. 38, representing the movement at 10 metres. give an idea of the great irregularities. But even these curves had to be constructed hypothetically for long intervals; and if there had been more observations the curves would certainly have been much more irregular. An example of the irregularity of the movement at this depth is given, for instance, by the observations between 7.21 and 7.31 a. m. on August 18h, when, during the ten minutes the observation lasted, the direction of the movement at 10 metres changed 160^{0}, from N 40^{0} W to S 60^{0} E, and this changing direction shows a striking disagreement with the directions observed both before and after that hour. It is obvious that under such circumstances it is impossible to construct the probable curve of movement without having numerous and frequent observations. Our curve in Fig. 33 must thus be considered as quite unrealiable, and it this therefore difficult to discuss the motion at this depth.

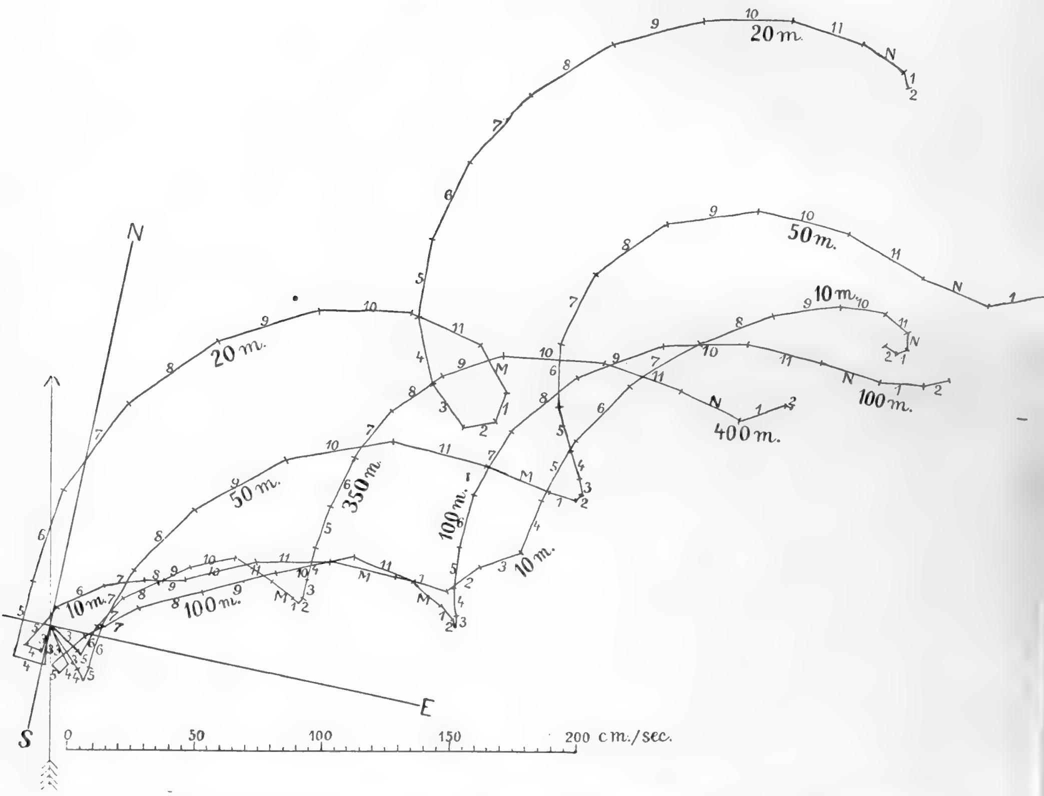


Fig. 45. Progressive Vector Diagrams of the Relative Movements at **10 Metres** and the other depths of Fig. 44, between Aug. 18th 3 p. m. and 19th 2 p. m. Stat. 41.

By using those parts of the curves of velocity and direction which should be most reliable, owing to a greater number of observations, I have attempted to construct a progressive vector diagram for the relative movements at 10 metres, between August 18th 3.00 p. m., and August 19th 2.00 p. m., and have compared it with the progressive vector diagram for the deepest water-layers (*i. e.* presumably representing the drift of the ship) during the same period (see Fig. 45).

The progressive vector diagrams of the relative movements give us (in the same manner as described above p. 55) the following values of the real currents between August 18th 3 p. m. and August 19th 2 p. m.:

At the Surface	12.6	cm/sec.	towards	S 62° W
„ 10 metres	1.9	„	„	N 44° E
„ 20 „	5.6	„	„	N 8° E
„ 50 „	4.8	„	„	N 57° E
„ 100 „	2.6	„	„	N 67° E

It is noticed that the values for 20, 50, and 100 metres differ somewhat from the values found above (pp. 55 and 56) at the same depths for the whole time of observation.

A remarkable result of this construction would be that while the ship drifted, with the ice and the surface-layer, towards S 62° W with an average velocity of about 12.6 cm. per second, the water at 10 metres would have moved in almost the opposite direction, towards N 44° E, with a mean velocity of 1.9 cm. per second.

This result may seem absurd, especially considering that the movements at 20, 50, and 100 metres were so very different.

It was pointet out above that the observations at 10 metres are not numerous enough for the construction of trustworthy curves, and there might have been many irregularities which our curves do not show. On the other hand, if we look at the central vector diagram for 10 metres (Fig. 38), we are struck by the fact that the majority of observations lie in the quadrant between south and west, which should indicate that the relative movement at this depth has, to a very great extent, had a north-easterly direction, and it seems somewhat difficult to believe that this should only have been quite accidental. It would consequently indicate that the actual movement of the water at 10 metres was very different from that of the drifting ice and the top layer of the sea.

Even at 5 metres the movement of the water seemed to be very different from that of the surface-water and the ice, as could often be seen if one watched the movements of the fan of the current-meter when it was lowered through the clear water; but only one regular observation was taken at this depth, namely, on August 5th, 8.15½—22 p. m.

The explanation of the great difference between the movement of the water at 10 metres and that of the ice and of the top layer of the sea may be that at 10 metres there was a reaction-current running in a direction more or less opposite to that of the surface-current. At Station 41, at 10 metres, there was water of very nearly the same kind as that of the surface, with a salinity of a little more than 32 ‰ and a temperature of about 0.1° C. The density (σ_t) was about 25.90. This water-layer, sometimes more than 10 metres thick, and sometimes less (cf. Aug. 19th, 3.20 p. m.), seems to be approximately homogeneous, being composed of water that was very different from the water at 20 metres, where a temperature of 1.11 ^{0} C. and a salinity of 34.11 $^0/_{00}$ were observed, giving a density of 27.34.

It seems probable that in the upper homogeneous layer, about 10 metres thick, the ice and the uppermost water-strata, with a thickness of some few metres, were moving in one direction, while the water in the lower part of the layer, about 10 metres below the surface, moved approximately in the opposite direction, in order to compensate the surface-movement.

While the central vector-diagrams for 20, 50, and 100 metres (Figs. 39—41) represent only the relative movements of the water at these depths, the diagram for the greatest depths, between 300 and 470 metres (Fig. 43) represents the actual movement of the ice-floe, provided that the movements of the water at these depths were negligible. If this be correct, it is simple, by a combination of this diagram with the other diagrams, to construct the vector-diagrams for the actual movements at the other depths. The simplest method is to take the diagram, *e. g.* for 20 metres, and place it on the diagram giving the drift of the ice. If the mark for any certain hour of the one diagram be placed exactly over the corresponding mark for the same hour of the other diagram, and both diagrams are placed in their correct position with their north-south co-ordinates parallel to each other, then the line between the centre of the diagram for 20 metres, and the centre of the other diagram, give the velocity and direction of the actual movement at 20 metres at that moment. By doing this for all hours during the period of observation, we obtain a vector-diagram showing the velocity and direction of the actual movement at 20 metres during that time. The directions are those from which the water was moving. If, however, it is desired to have the direction towards which the water was moving, all that is necessary is to turn the vector-diagram upside down, so that North takes the place of South. In this manner our vector-diagrams, Figs. 46—50, showing the actual movement at 20, 50, and 100 metres, have been constructed. The black discs in these figures indicate the results obtained by the observations at those depths.

By taking the values of velocity and direction from these vector-diagrams, the curves of velocity and direction, Figs. 51 & 52, have been constructed, and also the progressive vector-diagrams, Fig. 53, showing the actual movements at the depths of 20, 50, and 100 metres.

As might be expected the total movements at these depths, given by the latter diagrams, agree fairly well with the mean velocity and direction of the actual movements at the different depths, obtained by the combination of the progressive vector-diagrams of the relative movements (see pp. 55 and 56). According to the progressive vector-diagrams, Fig. 53, we find that from August 18th 2 a. m. to August 19th at noon, the water should have moved,

at a depth of **20 metres,** towards N 1° W (N 11° E magnetic) with a mean velocity of 7.6 cm. per second;

at **50 metres,** N 58° E (N 70° E magnetic) with a mean velocity of 3.6 cm. per second;

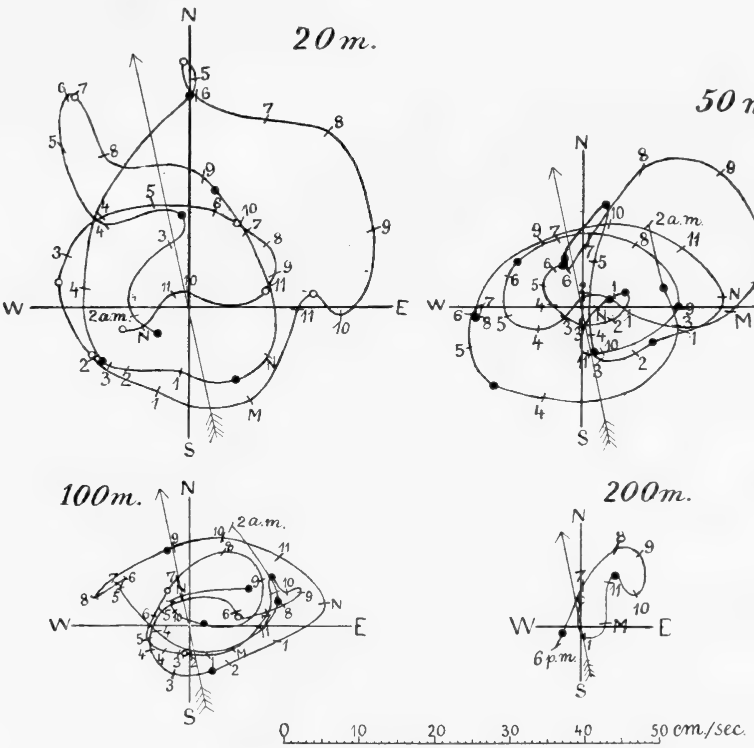


Fig. 46—50. Central Vector Diagrams of the Real Movements at **20, 50, 100,** and **200 Metres** as they probably were according to the measurements at Stat. 41.

at **100 metres,** towards N 42° E (N 54° E magnetic) with a mean velocity of 3.3 cm. per second.

The shifting of the direction of the water-movement towards the right with increasing depth, simultaneously with a decrease of the velocity, might appear to agree with what it theoretically ought to be (cf. NANSEN, 1902, p. 369 *et seq.*). While the average drift of the ice at the surface was about 13 cm. per second towards S 66° W, the current at 20 metres moved with an average velocity of about 8 cm. per second at an angle of about 110° towards the right of the direction of the surface movement, and at 50 metres the current moved with an average velocity of 3.6 cm. per second at an angle of about 170° towards the right from the direction of the surface-drift. The decrease of the velocity is, however, not so

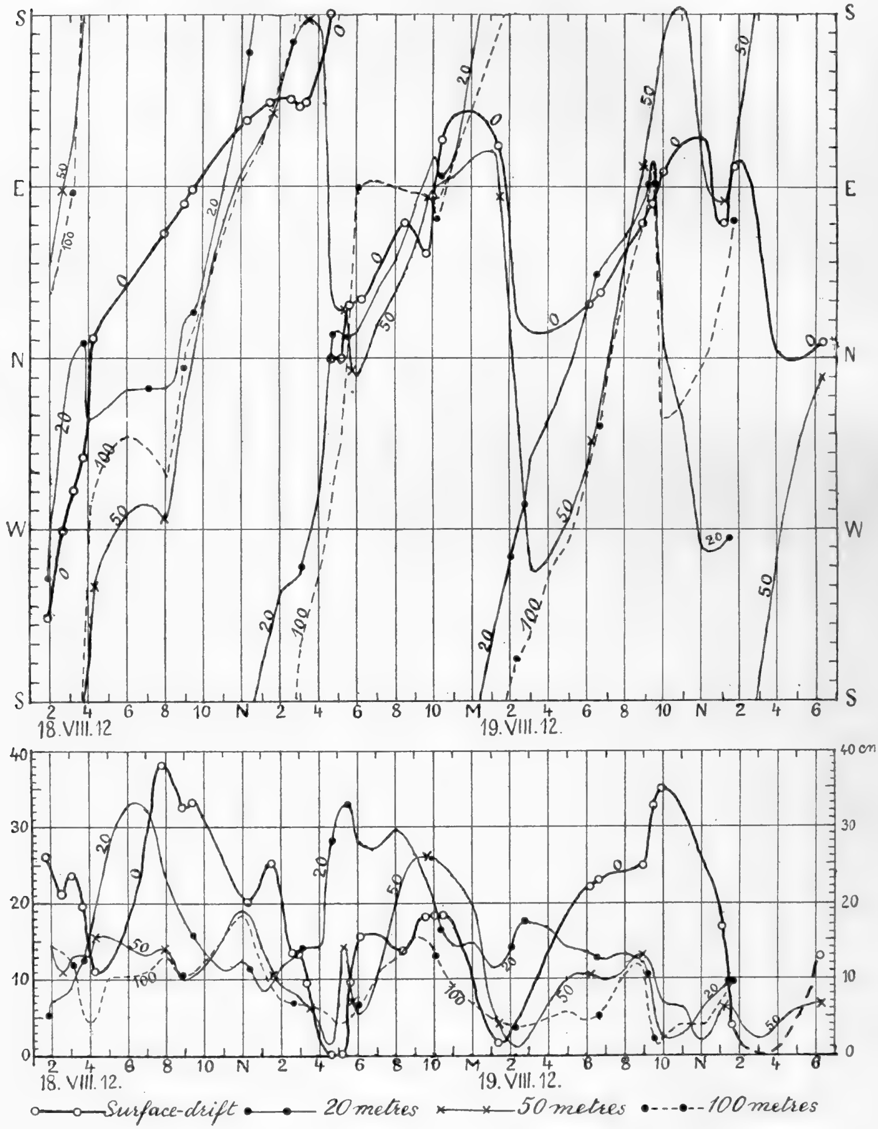


Fig. 51 & 52. Curves of Direction (magnetic) and Velocity (cm./sec.) of the Real Movements at different Depths, according to the measurements at Stat. 41. The Directions are those towards which the water moved, excepting that the curve for 0 metres (*i. e.* the drift of the ship) by a mistake gives the directions from which the water moved.

great as it ought to be with the observed deviation of the direction of the movement according to Professor V. Walfrid Ekman's theoretical calculations [1902, 1906, Nansen 1902, p. 371].

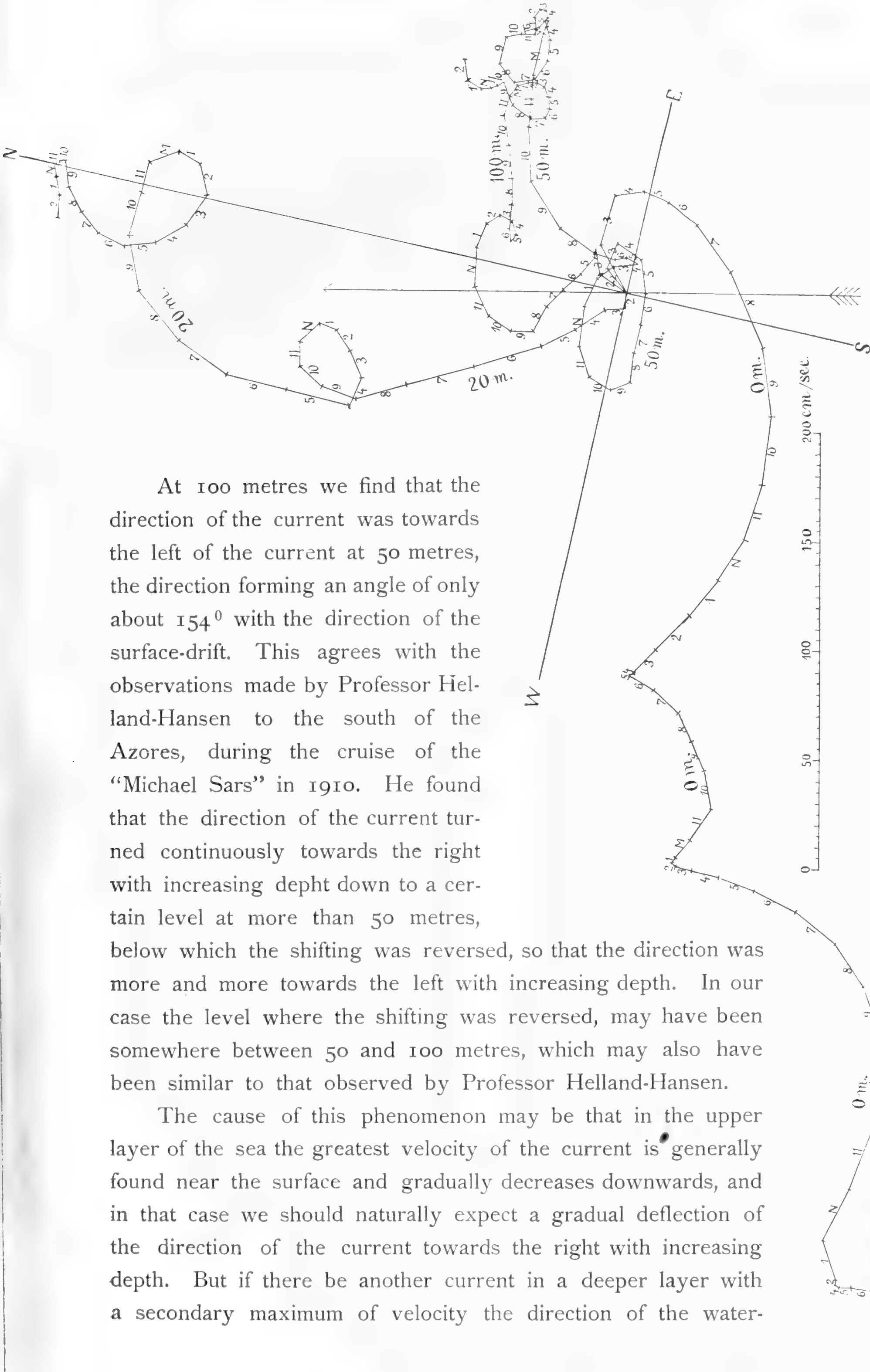


Fig. 53. Progressive Vector Diagrams of the Real Movements of the **Surface Layer** and at **20, 50,** and **100 Metres,** at Stat. 41. The curves give the directions, towards which the water moved, for each hour, between Aug. 18 2 a. m. and Aug. 19 2 or 6 p. m. N means Noon and M Midnight.

At 100 metres we find that the direction of the current was towards the left of the current at 50 metres, the direction forming an angle of only about 154^0 with the direction of the surface-drift. This agrees with the observations made by Professor Helland-Hansen to the south of the Azores, during the cruise of the "Michael Sars" in 1910. He found that the direction of the current turned continuously towards the right with increasing depht down to a certain level at more than 50 metres, below which the shifting was reversed, so that the direction was more and more towards the left with increasing depth. In our case the level where the shifting was reversed, may have been somewhere between 50 and 100 metres, which may also have been similar to that observed by Professor Helland-Hansen.

The cause of this phenomenon may be that in the upper layer of the sea the greatest velocity of the current is generally found near the surface and gradually decreases downwards, and in that case we should naturally expect a gradual deflection of the direction of the current towards the right with increasing depth. But if there be another current in a deeper layer with a secondary maximum of velocity the direction of the water-movement would have a tendency to be deflected towards the right both upwards and downwards from that layer, if no other forces have any influence upon the direction.

According to the measurements between August 18th 3 p.m. and August 19th 2 p.m. (see p. 59, and Fig. 45), the direction of the current at 100 metres was towards N 67° E, or 10° to the right of the current at 50 metres, and the velocity at 100 metres (2.6 cm. per second) was lower than that at 50 metres (4.8 cm. per second). The measurements between 2 a.m. and 2 p.m., August 18th, give the following values of the currents according to the progressive vector diagram Fig. 44:

At the Surface	12.6	cm./sec.	towards	S 74° W
» 20 metres	10.5	»	»	N 25° W
» 50 »	1.3	»	»	N 68° E
» 100 »	5.4	»	»	N 20° E

Hence we find that in those periods when the current at 100 metres had a higher velocity than that at 50 metres, its direction deviated towards the left of the latter, while it deviated towards the right when the velocity was lower. This would be in agreement with our theory. If, however, we take the mean values given by the measurements between August 18th 2 a.m. and August 19th 2 a.m. we get somewhat different results (see Fig. 44).

The observations that, at 10 metres the water probably formed a reaction-current, moving in a direction about opposite to that of the surface drift, makes, the whole current-system still more complicated in our case; and it is not probable that the direction of the current at 20 metres is directly influenced by the direction of the surface-drift. It seems more probable that the direct effects of the surface-drift was limited to the nearly homogeneous top layer with low salinity and density, a little more than 10 metres thick. This layer should thus have a current-system of its own, with an average surface-drift towards about S 66° W, in its upper part, and a current of compensation in an opposite direction in its lower part, about 10 metres; and there may even be many complications as to direction and velocity inside the small current-system of this top layer.

Below the light surface-layer there was warmer and more saline water which must evidently have come from the south. This is also borne out by our current-measurements, according to which the water at 20 metres was on the average flowing very nearly towards true north, with a mean velocity of about 8 cm. per second. The velocity of this current probably decreased with increasing depth, while its direction changed more and more towards the right down to some depth below 50 metres. Still deeper, the direction may, at least during some periods, have changed more and more towards the left with increasing depth, while the velocity may perhaps have increased somewhat down to a certain level. Our observations at 50 metres, at Stats. 41 a—42 (Table I), indicate great variations in temperature and salinity at this level. On August 18th, at 1.15 a. m., there was observed at 50 metres 0.85° C. and 34.60 ‰ (density = 27.76); at 10.00 a. m. on the following day, at the same depth, there was found 2.21° C. and 34.815 ‰ (density = 27.83), at 3.20 p. m. 0.83° C. and 34.65 ‰ (density = 27.80), and at 5.30 p. m. the temperature was —0.09° C. At 7.40 p. m. at Stat. 42, a few hundred yards outside the ice-edge, we found at 50 metres 2.82° C. and 34.71 ‰ (density = 27.69). Water of different types was consequently at intervals observed at this depth: a cold water (0.85° C.) with lower salinity (about 34.60 ‰) at 1.15 a. m. on August 18th, and at 3.20 p. m. on the following day (at 5.30 p. m. it was still colder) and a much warmer water (2.21° C.) with a higher salinity (34.815 ‰) at 10.00 a. m. on August 19th.

The cold and less saline water may come, more or less, from the ice-regions of the sea to the north or north-west, while the warmer and more saline water must come from the south. It is, however, noteworthy that when the cold water was observed at 50 metres, the water was moving in north-easterly directions, at that level relatively to the ship, while the water was moving westwards, relatively to the ship, when the warmer and more saline water was observed. The changes in the water cannot, therefore, be adequately explained simply by horizontal movements of the water at this depth; they are more probably due to vertical oscillations of the water-strata, chiefly caused by the changing tidal currents, as will be discussed later.

We must then assume that between the layer at twenty metres with 1.11° C. and 34.11 ‰, and the layer observed at 50 metres with 2.21° C. and 34.815 ‰, there was a colder layer with 0.85° C. and 34.60 ‰, which was sometimes lowered to 50 metres, while at other times the underlying warmer stratum was lifted to that level.

At 100 metres the water had a more uniform temperature of about 2.9° C. and a salinity of about 34.96 ‰; being the typical waters of the Atlantic Current running towards the north-east in this region.

Our observations show that the currents at all depths are greatly influenced by the tidal waves, as was already proved by Helland-Hansen's important observations some years ago [1906]. Thus the phenomena become very complicated, and in order to follow the variations of the direction and velocity of the currents in their details, it would be necessary to have observations at a great many depths, with much shorter intervals vertically, than is the case in our series of observations.

Though our observations are not sufficient to give in detail the changes in the currents at the different depths, they prove at any rate that the movements of the water in the currents of the sea are much more complicated than was generally assumed.

Computation of the Velocities of the Currents in the Region between Stats. 41 and 40, by means of Dynamic Sections.

It would be of much interest to examine to what extent the velocities of the currents at different depths found by our measurements, may agree with the corresponding values of velocity computed by means of dynamic sections. It has, however, to be considered, on the one hand, that the computations by sections should give the average velocity of the water at each depth in the whole region between every two stations, while the current-measurements give the velocities at one particular station, and there may be many local variations in the velocities, owing to vortex movements, etc.

On the other hand, our current-measurements prove that the velocities and directions of the currents change very quickly from hour to hour, while the sections will not, as a rule be representative for any special moment, because of the intervals of at least some hours, that generally will exist between the observations taken at two different stations af a section.

Moreover the computation of the velocities by means of dynamic sections is based upon the supposition that there is perfect lateral equilibrium in the sections; but with such rapidly changing currents it is not probable that such an equilibrium can ever be attained.

In addition to this, there may also be other agents producing temporary oscillations of the layers at the stations. Hence it follows that we cannot, even under favourable circumstances, expect to find a very close agreemeent between the values of velocity found by measurements and those found by dynamic computation.

In our case we have the two Stations 40 and 41 a, the latter situated perhaps a little more than 3.5 miles, or about 7 kilometres, towards the north from the former. The observations at the two stations were taken at an interval of 3 hours and 30 minutes. At Stat. 40 no observations were taken deeper than at 150 metres, and at Stat. 41 a no observations deeper than at 100 metres. The series of the latter station may, however be combined with the deeper series taken at Stat. 41 1 hour and 45 minutes earlier, and only a short distance off [1].

Fig. 54 represents the section through these stations. The inclination of the isopycnals indicate that the currents should have had westward directed components (perpendicular to the section) between the surface and 10 metres (see the isopycnal of 27.00), and eastward directed components between 20 and 200 metres (see the isopycnals of 27.50 to 27.90).

Let us assume that at depths of 300 metres there was no appreciable difference between the densities at the Stations (40, 41 and 41 a), and that the movements of the water at that depth were negligible. If we draw the curves of the vertical distribution of density at Stat. 40 and 41 a (and 41), Fig. 55, we can compute the velocities of the currents by means of the simple method that I have described [1913, p. 49]. We then find the following values of velocity for the components of the currents, directed eastwards at an angle of 90° with our section:

At the Surface		—11.6 cm.	per	second
At 10 metres		0.6	"	"
" 20	"	7.2	"	"
" 50	"	3.6	"	"
" 100	"	2.3	"	"
" 300	"	0.0	"	"

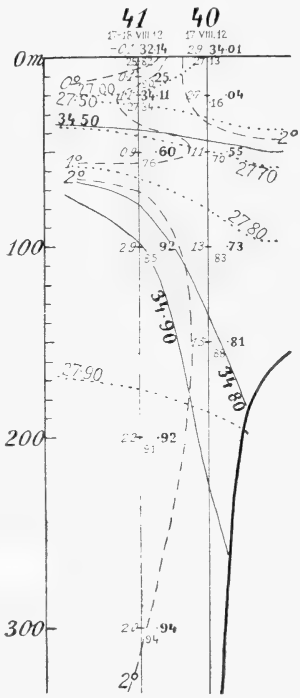


Fig. 54. Sections through Stats. 40 and 41 (and 41 a) Aug. 17—18, 1912. — Horizontal Scale 1 : 1,000,000. Vertical Scale 1:4,000. Stat. 41 a (*i. e.* the observations between 0 and 100 at 41) were taken about 2 kilometres nearer to Stat. 40 than given in this figure.

According to our current-measurements the average velocities and directions of the currents should have been about the following (see pp. 55, 59).

At the Surface	12.7	cm.	pr.	second	towards	S 66° W
" 10 metres	1.9	"	"	"		N 44° E
" 20 "	7.8	"	"	"		N 6° W
" 50 "	3.6	"	"	"		N 55° E
" 100 "	3.4	"	"	"		N 38° E

If our section was directed along the meridian, and these angles are introduced our computations will give the following values for the currents:

[1] Two later series of observations, taken at the same station (41 b and 41 c), gave higher densities than the series at 41 a. But they were taken more than a day later, and so long time after the observations at Stat. 40, that they cannot be used for computations such as these, even if we take into consideration the distance that the ship may have drifted in the mean time.

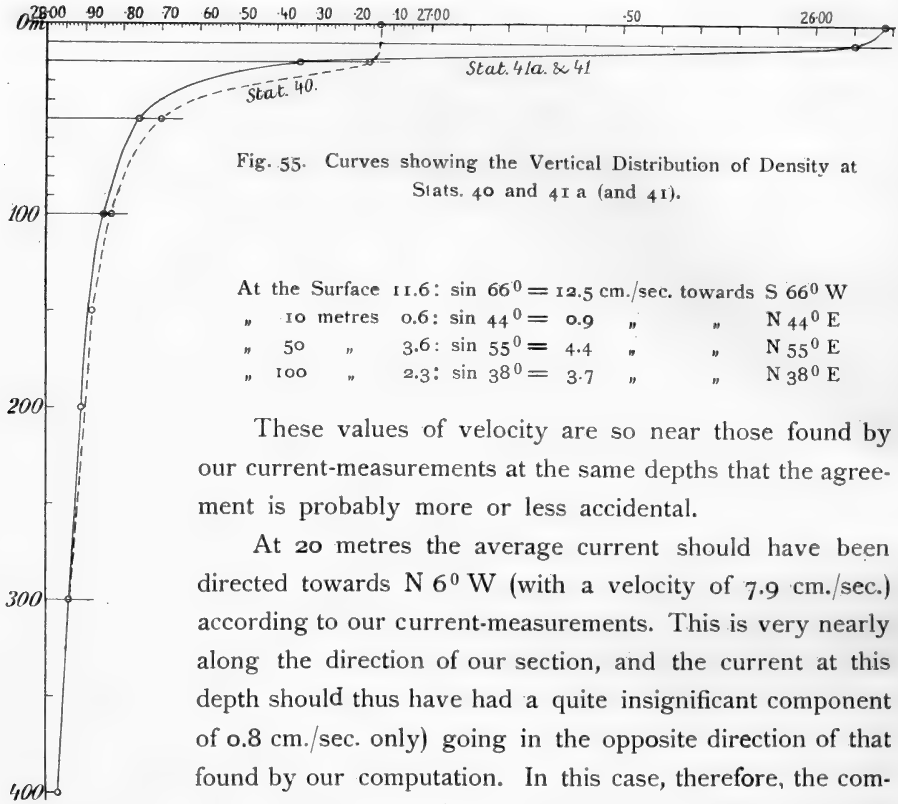


Fig. 55. Curves showing the Vertical Distribution of Density at Stats. 40 and 41 a (and 41).

At the Surface	11.6: sin 66° =	12.5 cm./sec.	towards	S 66° W
„ 10 metres	0.6: sin 44° =	0.9 „	„	N 44° E
„ 50 „	3.6: sin 55° =	4.4 „	„	N 55° E
„ 100 „	2.3: sin 38° =	3.7 „	„	N 38° E

These values of velocity are so near those found by our current-measurements at the same depths that the agreement is probably more or less accidental.

At 20 metres the average current should have been directed towards N 6° W (with a velocity of 7.9 cm./sec.) according to our current-measurements. This is very nearly along the direction of our section, and the current at this depth should thus have had a quite insignificant component of 0.8 cm./sec. only) going in the opposite direction of that found by our computation. In this case, therefore, the computed value (7.2 cm./sec.) does not agree with that found by the measurements (7.9 cm./sec.), on account of the observed average direction of the current. The latter was only observed at Stat. 41, and we do not know what the direction may have been in the region about Stat. 40, but our current-chart, Fig. 66, based on the distribution of density, indicates that it should have been approximately the same. It has, however, also to be kept in view that, at this depth, very slight vertical oscillations of the strata at Stats. 40 or 41 a, might have been sufficient to alter the densities essentially.

On the other hand, it is a general feature in sections going in the same direction as a current, that the densities are heavier at the stations towards which the current moves, than at those from which it moves. Such sections will therefore, if directly used for computations of the velocities in the above manner, give erroneous results. This longitudinal distribution of the densities, in the currents, will naturally influence the inclinations of the isopycnals in all sections that are not directed perpendicularly to the direction of the current. This circumstance should, therefore, also be taken into consideration by the computations of the velocities from such oblique dynamic sections, in order to improve the accuracy of the results.

As was pointed out above, the currents at all depths vary so much from hour to hour as to velocity and direction, that it is doubtful whether the inclinations of the strata may correspond chiefly to the average velocity and direction of the current, or whether these inclinations may change so rapidly that they are more in accordance with the actual current at every moment. The latter possibility seems, however, less probable, especially if the current is broad, because it would necessitate so considerable a transport of water that there would hardly be time for it.

By taking only the current-measurements made between August 18th 3 p. m. and August 19th 2 p. m. we found above (p. 59) the following average values for the currents:

At the Surface	12.6	cm./sec.	towards	S 62° W
„ 10 metres	1.9	„	„	N 44° E
„ 20 „	5.6	„	„	N 8° E
„ 50 „	4.8	„	„	N 57° E
„ 100 „	2.6	„	„	N 67° E

If these angles are introduced, our computations will giwe the following values:

At the Surface	13.1	cm./sec.	towards	S 62° W
„ 10 metres	0.9	„	„	N 44° E
„ 20 „	[51.9]	„	„	N 8° E
„ 50 „	4.3	„	„	N 57° E
„ 100 „	2.5	„	„	N 67° E

This agreement is also remarkably good, except of course at 20 metres.

Current Measurements on August 4th and 5th.

As was mentioned above, the current measurements made at Stations 19 and 20, on August 4th and 5th, were very incomplete, chiefly on account of the very small number of observations made in the deep layers near the bottom, by which the drift of the ship, moored to the ice, could be determined. During this time there were also many difficulties with the ice, which made it necessary to look after the ship; and the number of observations were thus reduced. As was also mentioned above, several attempts were made to determine the drift of the ship by means of the sounding-line and the lead lying on the bottom; but this method proved unsatisfactory.

Figs. 56 to 59 represent the curves of velocity and direction of the relative movements at the different depths, as far as it was possible to construct them with the incomplete observation material. Some of them are rather hypothetical, as there were too few observations. This is especially the case with the curve for the deepest layer (520—600 metres) near the bottom, giving the drift of the ship.

The curves of velocity show that the relative movements were much smaller at Stats. 19 and 20 than at Stat. 41. They also seem to indicate an interval of little more than 6 hours only between each time that the relative movement was reduced to 0 or to a minimum. The cause of the slow movement at Stats. 19 and 20 may to some extent have been the contrary wind, which probably reduced the south-westerly surface-drift. On the morning of August 5th the wind was about W by S (magnetic); in the course of the day the wind changed to about SSW and in the afternoon its velocity increased to between 5 and 6 metres per second. A wind of such a velocity has naturally an appreciable effect upon the drift of the ice. At Stat. 41, on the other hand, there was very little wind, and it was as a rule approximately in the same direction as the average drift of the ice. During the night and morning of August 18th the wind was NE by N and was not strong. In the afternoon and the evening it was northerly or north-north-easterly; after mignight and in the morning of August 19th there was no wind.

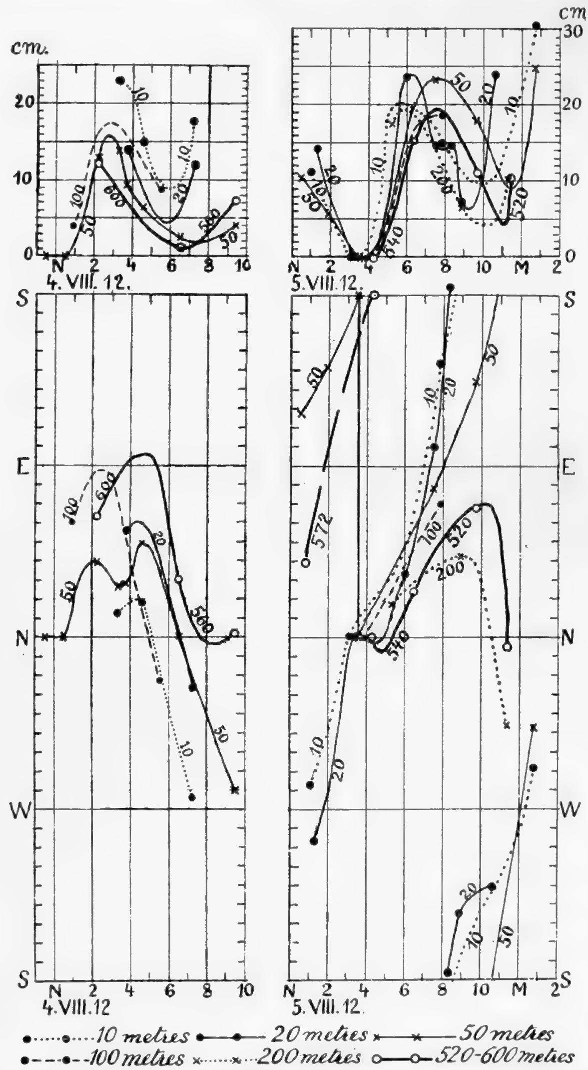


Fig. 56—59. Curves of Velocity (Figs. 56 & 58 above) and Direction (Figs. 57 & 59 below) of the Relative Movements at different depths at Stats. 19 and 29, Aug. 4 & 5, 1912. The directions are magnetic and are those towards which the water moved at the different depths relatively to the ship.

Figs. 60 to 63 give the central vector-diagrams of the relative movements at the various depths, as far as they could be constructed. They differ greatly from the vector-diagrams of the relative movements at Stat. 41 (Figs. 38 to 43).

I have also made an attempt, Fig. 64, to construct progressive vector-diagrams for the relative movements at the various depths, between 1.00

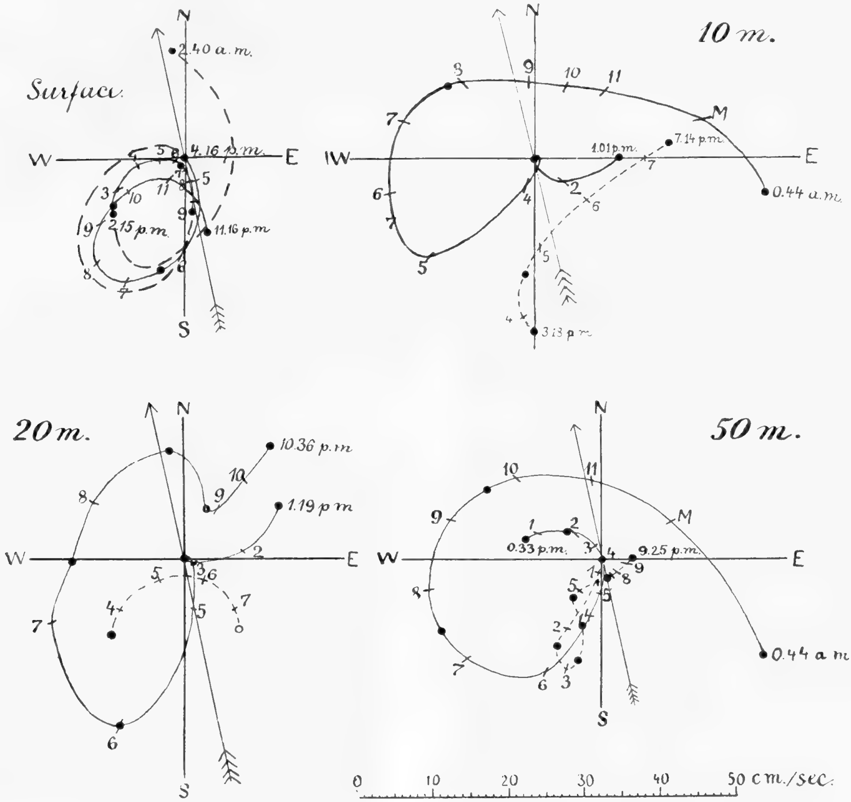


Fig. 60—63. Central Vector Diagrams of the Relative Movements at depths of **520** and **540** metres (indicating the Surface Drift), at **10**, **20**, and **50 Metres**. The directions are those from which the water moved at the different depths relatively to the ship, or towards which the ship moved relatively to the water at the different depths. Hence Fig. 60 gives the directions (with velocities) towards which the ship or the snrface layers moved, provided that the movements at 520 and 540 metres were negligible.

p. m. and midnight on August 5th; but the observations are not sufficiently numerous to give trustworthy curves, and our figure may therefore only be considered as an approximate experiment. It shows, however, that there must have ben a striking difference between the movements at this place (Stat. 20) and those at Stat. 41. This difference may to some extent be explained by the different situation, Stat. 20 being to the south-west of

Stat. 41. This may be the reason why the surface-drift at Stat. 20 had a more southerly direction than at Stat. 41.

The most striking difference is, however, that according to our diagrams, Fig. 64, the average real movements at 10 metres and 20 metres do not seem to have differed very much from the drift of the ship, and there cannot have been any reaction-current at 10 metres similar to that found at Stat. 41. The explanation is obviously that at Stations 19 and 20 there was no such well-marked surface-layer with low salinity and low density as was observed at Stat. 41. The salinity at the surface was in most cases above 33 $^0/_{00}$, and at 10 metres it was even, as a rule, about 33.50 $^0/_{00}$ or more. The salinity and density gradually increased downwards without any sharp boundary between a light top layer and the heavier underlying water. Thus a special system of currents could not be developed in the top layer.

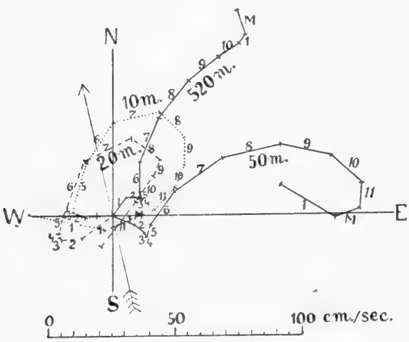


Fig. 64. Progressive Vector Diagrams of the relative movements at **10, 20, 50,** and **520** (and **540**) **Metres**, at Stat. 20. The curves give, for each hour, the direction (with velocity) towards which the water moved relatively to the ship, between Aug. 5 1 p. m. and Aug. 6 1 a. m.

By means of our progressive diagrams of the relative movements, Fig. 64, we find the following average velocities and directions of the real movements between noon and midnight on August 5th:

At the Surface	7.8	cm. per second	towards	S 31° W	(S 44° W magn.)
" 10 metres	8.4	" "	"	S 31° W	(S 44° W ")
" 20 "	9.2	" "	"	S 35° W	(S 48° W ")
" 50 "	7.5	" "	"	S 25° E	(S 12° E ")

The average direction of the current at 50 metres would consequently have been deflected about 56° towards the left of the average surface drift and the current at 10 metres, and 60° towards the left of the average direction of the current at 20 metres. This is quite different from our experiences at Stat. 41. It is an interesting fact that at the latter station the great deflection of the current towards the right from 20 metres to 50 metres, coincides with a great decrease in its velocity; while at Stat. 20 there seems to have been no great difference between the velocities of the currents at the surface, at 10, 20, and 50 metres. There is also no deflection towards the right (except the doubtful 4° from 10 to 20 metres), the deflection being in the opposite direction, towards the left, from 20 to 50 metres.

This might seem to be in fair harmony with our theory. If the velocity of the current decreases downwards, its direction should be more and more deflected towards the right with increasing depth; but if, for some reason or other (*e. g.* by contrary winds), the velocities in the upper layers of the current are reduced its deflection with increasing depth is diminished accordingly; and if the surface-velocities be reduced to values below the velocities of the deeper layers, the deflection with increasing depth may be reversed. Our observations, especially in the upper layers between the surface and 20 metres, seem thus to verify the correctness of our theory, as well as could be expected with the imperfect methods.

The water at 50 metres was on the whole colder at Stats. 20 and 19 than at Stat. 41; at Stat. 19 its temperature even sank to -1.51^0 C. and its salinity was then as low as 34.38 $^0/_{00}$. This water must naturally have come from the north or north-west.

Computation of the Velocities of the Currents at Stats. 18 to 22.

The sections through Stations 18 and 19 (Fig. 13) and through Stations 20 and 21 (Fig. 14) may be used for computation of the velocities of the currents in this region. The direction of the former section is about S 18^0 E, and of the latter section about S 15^0 E. The average direction of the surface-current at Stat. 20 was towards S 31^0 W according to the current-measurements (Fig. 64).

In the section through Stats. 18 and 19, all isopycnals at depths between the surface and about 90 metres, slope from Stat. 18 towards Stat. 19 (see the isopycnals of 27.70 and 27.80, Fig. 13) indicating that the currents at these depths had a component directed transversally to the section, *i. e.* towards S 70^0 W. This agrees well with the results of our current-measurements. At depths greater than 90 metres the isopycnals were sloping gently from Stat. 19 towards Stat. 18 (see the isopycnal of 27.90, Fig. 13) indicating that the current at the these depths had a very small component directed transversally to the section in the opposite direction of that of the current at higher levels.

At Stat. 19 several vertical series of observations vere taken, giving somewhat different densities; but all of them were taken a long time after the observations at Stat. 18. The two most complete series are those called **19** (taken on Aug. 3rd, 6.30 to 7.50 p. m.) and **19 c** (taken on Aug. 4th, 11 a. m. to 0.40 p. m.). The former series was taken about 8 hours after the observations at Stat. 18, and the latter series about 24 hours after these observations.

By using these two different series at Stat. 19 and the observations at Stat. 18 for our computation of the velocities of the current-conponents directed perpendicularly to the section, we find the following values:

	Vertical Series of Stat. 19.	Vertical Series of Stat. 19 c.
At the Surface	7.5 cm./sec.	8.6 cm./sec.
„ 10 metres	5.4 „	6.5 „
„ 20 „	3.7 „	4.8 „
„ 50 „	0.2 „	1.3 „
„ 90 „	—0.2 „	
„ 135 „		0.0 „
„ 180 „	0.0 „	

According to the progressive vector diagram of the relative movement, Fig. 64, the average velocities and directions of the current at Stat. 20 should have been the following:

At the Surface	7.8 cm./sec.	towards	S 31° W
„ 10 metres	8.4 „	„	S 31° W
„ 20 „	9.2 „	„	S 35° W
„ 50 „	7.5 „	„	S 25° E

If the angles which these currents would form with our section be introduced in our computation, we find the following values of velocity:

	Vertical Series of Stat. 19.	Vertical Series of Stat. 19 c.
At the Surface	9.8 cm./sec.	11.2 cm./sec.
„ 10 metres	7.1 „	8.5 „
„ 20 „	4.8 „	6.2 „

At 50 metres the current should have had a small eastward component in our section, according to the current-measurements, while our computations give small westward components. The dynamic current chart, Fig. 67, might seem to indicate a direction of the current at 50 metres, at Stat. 20, very different from the average direction found by the current-measurements.

On the whole, there is not a very good agreement between the velocities obtained by our computations and the results of the current-measurements. But it could hardly by expected to be better, considering the deficiency of the current-measurements, and that they were taken at another station a long time after the observations of the section. It has also to be considered that there was a great difference of time between the observations at the two stations of the section.

In the section through Stats. 20 and 21 the isopycnals between the surface and 80 metres are sloping from Stat. 21 towards Stat. 20 (see the isopycnals of 27.50, 27.70 and 27.80, Fig. 14) indicating a current with some westerly direction, while the isopycnals at depths greater than 80 metres are sloping in the opposite direction (see the isopycnal of 27.90) indicating a slow movement in some easterly direction.

Two vertical series of observations were taken at Stat. 20, one on August 5th 10.40 a. m. (called Stat. 20, see Table I) and another on the same day between 3.30 and 6.20 p. m. (called Stat. 20 a). These two series give somewhat different densities. By computation in the same manner as before, we find the following values of velocity for the current-components perpendicular to our section, *i. e.* directed towards S 75° W:

	Observations at Stat. 20. Aug. 5, 10.40 a. m.	Observatios at Stat. 20 a. Aug. 5. 6.20—3.30 p. m.
At the Surface	3.3 cm./sec.	2.6 cm./sec.
„ 10 metres	1.9 „	1.4 „
„ 20 —	0.9 „	1.2 „
„ 50 —	—0.32 „	—0.3 „
„ 80 —	—0.54 „	—0.54 „
„ 200 —	0.0 „	0.0 „

If we introduce into the computation the angles which the currents formed with our section at the different depths, we find that the above values of the components, would correspond to the following velocities of of the currents:

At the Surface	4.6 cm./sec.	or	3.6 cm./sec.
„ 10 metres	2.6 „	„	1.9 „
„ 20 „	1.8 „	„	1.1 „
„ 50 „	1.8 „	„	1.7 „

These values agree still less, than those of the section through Stats. 18 and 19, with the results of the current-measurements at Stat. 20. It may indicate great local differences in the currents in the region between Stats. 20 and 21. On the other hand it has also to be considered that the observations at Stat. 21 were taken many hours after those at Stat. 20 (and 20 a).

The vertical distribution of density at Stats. 21 and 22 (Fig. 14) Indicates a comparatively rapid current running in some north-easterly direction between these stations. The distance between the stations was 18 kilometres. Computed in the same manner as above. and provided that the motion of the water at 200 metres was negligible, we find the following values of velocity for the current-components perpendicular to the section:

At the surface	15.5 cm. per second
„ 15 metres	16 „ „
„ 150 „	1.8 „ „
„ 200 „	0.0 „ „

Dynamic Current Charts.

The following table gives the mean densities (σ_t) of the water between the depth of 200 metres and different levels, at all stations north of Spitsbergen (and Stat. 16 west of northern Spitsbergen) that are deeper than 150 metres, or in a few cases than 100 metres (see Figs. 1 and 6). These mean values were computed graphically, by means of the planimeter, from the curves of density drawn for each station similarly to those of Fig. 55.

Where the greatest depths of observation were less than 200 metres, the curve of density had to be drawn hypothetically down to 200 metres, and thus the values of density were estimated for the deepest layers.

Where there were several vertical series of observations at the same stations, the mean values of the most complete series were taken.

Stations	Between 0 and 200 Metres	Between 20 and 200 Metres	Between 50 and 200 Metres	Between 100 and 200 Metres
16	27.798	27.844	27.875	27.906
18	*.851*	*.877*	*.888*	.898
19	.678	.794	.867	.903
20	.754	.850	.887	*.908*
21	.811	.868	.885	.895
22	.585	.607	*.630*	*.659*
25	.520	.700	.784	.823
30	.550	.624	.691	.808
32	.633	.761	.851	.890
33	.613	.726	.823	.868
34	*.517*	*.605*	.723	.841
35	.539	.658	.782	.868
36	.566	.719	.850	.901
37	638	.792	.872	.898
38	.621	.754	.875	.902
39	.586	.679	.748	.818
40	.724	.791	.846	.878
41 a	.686	.838	.880	.902
43	.625	.814	.870	.904
Max △	0.334	0.272	0.258	0.249

The horizontal distribution of density at 200 metres and greater depths, indicates that there is very little current at these levels. Assuming the motion of the vater at the depth of 200 metres to be practically negligible, Prof. Helland-Hansen and I have constructed the dynamic current charts

Figs. 65 to 69 for the surface, and depths of 20, 50, and 100 metres, by introducing the above values at each station, and drawing the probable isopycnals for every 0.05 of σ_t. These charts give the probable circulation of the water at the mentioned depths according to the densities computed from the observations of temperature and salinity. The direction of the isopycnals should at each place give approximately the direction of the current, and its velocity is inversely proportional to the distances between the isopycnals.

In the chart of the Surface a distance between the isopycnals of 1 mm. corresponds to a velocity of 26 cm. der second (hence a distance between them of, for istance, 3 mm. would correspond to a velocity of 26 : 3 = 8.7 cm. per second, and a distance of 4 mm. to 26 : 4 = 6.5 cm. per second, etc.). In the same manner a distance of 1 mm. between the isopycnals corresponds to the following velocities in

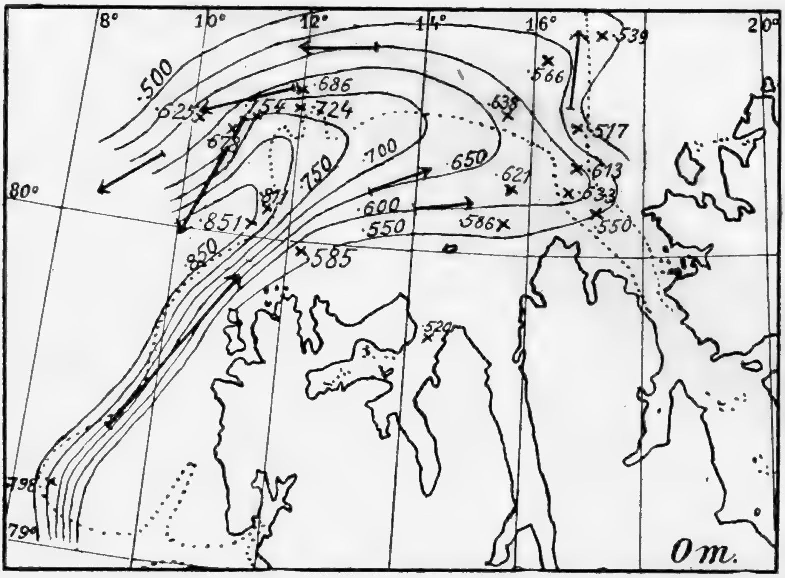
the chart for 20 metres	:	23.2 cm. per second
» — » 50 —	:	20.2 » » —
» — » 100 —	:	13 » » —

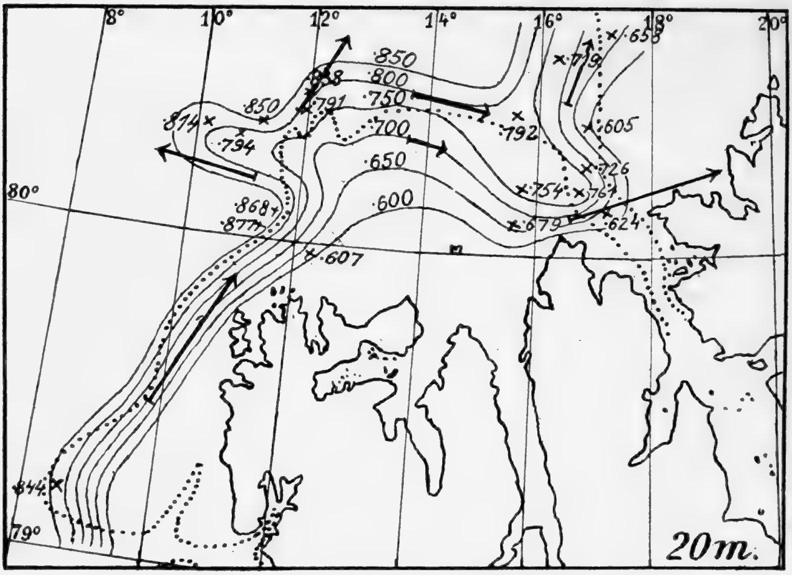
The arrows drawn in the charts give the direction and velocity of the currents at different places. The length of the arrows give the velocity 1 mm. = 1 cm. per second.

On the whole the currents given by these charts at the different depths agree fairly well with the results of our current-measurements at Stats. 20 and 41, especially at the latter station. It is noticed that while the surface current runs towards the north-east near the Spitsbergen coast, it runs approximately in the opposite direction farther seawards, near the ice-edge, and more westerly at our Stats. 40 and 41, than at our Stats. 20 and 19, which is in full accordance with our current-measurements.

It is also interesting to notice how the currents at 20, 50, and 100 metres seem to follow approximately the slope of the bottom, as indicated by the bathymetrical curve for 200 metres (the dotted line). This curve is, however, only a rough estimation, as there are much too few and too uncertain soundings in this region.

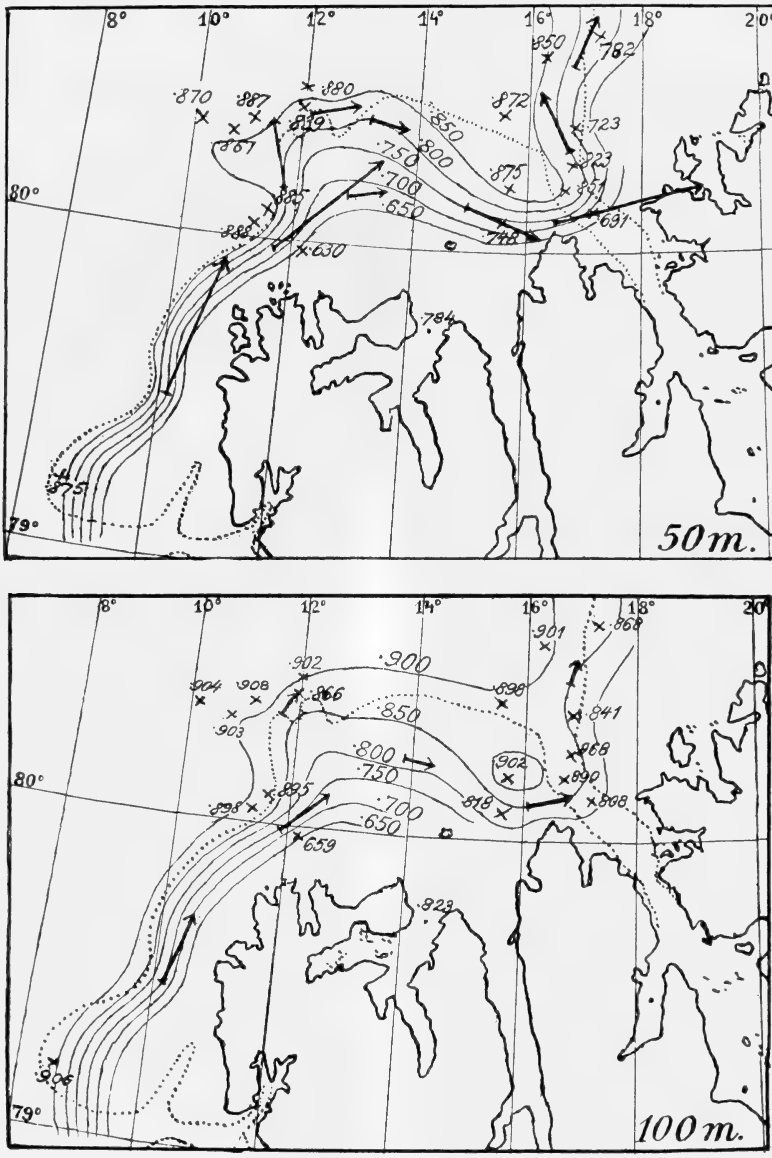
The remarkable bend of the current north-west of Hinlopen Strait is noteworthy. It seems as if the current follows the slope of the shelf, north of Spitsbergen, towards the mouth of Hinlopen Strait, but here it is forced towards the north by the bank north-west of North East Land, with depths of between 15 and 30 metres only, and the current must follow the edge of this bank. This is obviously the reason why, especially in this region, there was much open water extending north-wards, and why we there came farthest north.





Figs. 65 & 66. Charts of the Sea north of Spitsbergen, giving the Mean Density of the water between the Surface and 200 Metres, Fig. 65, and between 20 and 200 Metres, Fig. 66. August 1912. Scale 1 : 2,500,000. The dotted line is the bathymetrical curve for 200 Metres. The figures give the decimals of the densities (*i. e.* $\sigma_t - 27$). The arrows give the direction and velocity of the currents (1 mm. = 1 cm. per second).

In the region of Stats. 40 and 41 (12° E Long, see Fig. 1) the ice-edge also formed a bight extending comparatively far north, and the explanation may likewise be the northward current in the sea to the south (Fig. 65).



Figs. 67 & 68. Charts of the Sea north of Spitsbergen, giving the Mean Density of the water between 50 and 200 Metres, Fig. 67, and between 100 and 200 Metres, Fig. 68. August 1912. Scale 1 : 2,500,000.

The chart for 20 metres shows less agreement with the current-measurements. At Stat. 41 (12^0 E Long.) it indicates a current towards NNE with a velocity of about 11 cm. per second, while according to the measurements the average current should have gone towards N 6^0 W with about 7.8 cm. per second. At Stat. 20 the current of the chart is running in an easterly direction with about 12 cm. per second, while according to the measurements the average current was directed toward S 35° W with 9.2 cm. per second; but the latter measurements were especially very imperfect.

At Stat. 20, at 50 metres the measurements gave also an average current that differed much from that of the chart (Fig. 67). At Stat. 41 there is better agreement between the chart and measurements, and at 100 metres there is also good agreement.

The shapes of the curves in the region of Stat. 16, west of Cross Bay, are naturally quite hypothetical, as we do not know what the vertical distribution of density may have been over the edge of the shelf just east of Stat. 16. It is possible that in our section, Fig. 12, through Stats. 15 and 16, the layers may have been much depressed over the slope from the edge of the shelf to Stat. 16, indicating a rapid current along this slope (as indicated in our charts Figs. 65 to 68); but in that case the isotherms, isohalines, and isopycnals ought to have been drawn accordingly in Fig. 12.

Vertical Oscillations of the Water Strata.

At Stations 19, 20, and 41 a number of vertical series of observations were taken at different times, showing that, especially at the depths between the surface and 100 or 150 metres, there were considerable changes in the water strata at the same station, both as to temperature and salinity, often in comparatively short intervals of time. *E. g.* at 50 metres, at Stat. 19, comparatively high temperatures, of 0.75° C., were sometimes observed, and at other times temperatures as low as —1.48° C. and —1.51° C. In these cases, however, the salinities also differed so much that the dencity was very nearly the same, about 27.71, and thus the observed changes could not be due to vertical oscillations of strata with different densities, but were rather due to horizontal movements by which heterogeneous waters, of approximately the same density, came into our vertical series of observations.

In other cases appreciable differences in the densities of the water occurred at the same depths, and the changes were evidently more or less due to vertical oscillations of the water strata, lifting the same stratum sometimes to higher levels than at other times.

On previous occasions it was pointed out that great vertical oscillations of the strata may probably occur at intermediate depths in the sea [cf. Nansen, 1902, pp. 346 *et seq.*, Helland-Hansen and Nansen 1909, pp. 89 *et seq.*].

The great periodical changes in the velocities and directions of the currents, shown by our current-measurements, must inevitably cause vertical oscillations of the water strata. If there is lateral equilibrium in a current (*i. e.* if the inclinations of the strata exactly compensate the deflecting effect of the Earth's rotation, produced at the given velocities of the current), and then, for instance, the velocities in its upper layers, are much increased relatively to those of its lower layers, the lateral equilibrium is disturbed, and the strata will be depressed on the right hand side of the current, and lifted on its left hand side, in order to re-establish the lateral equilibrium. And *vice versa,* if the velocities in the upper layers are decreased relatively to those of its lower layers. Changes in the directions of the current in the different layers will naturally also alter the inclinations of the strata in a section, either the one way or the other. It is not probable that the lateral equilibrium is ever attained, because the changes both of velocity and direction are continuous.

Periodical vertical oscillations of the water-strata must consequently arrise in this manner; their magnitude will depend on the rate and magnitude of the changes in the differences of velocity, vertically, also on the changes in direction.

The effect of the periodical changes, as to these vertical oscillations, at any certain locality, will depend on the situation of this locality, whether it is near the left hand side or the right hand side of the current, or near the middle of it. On the left hand side the strata will be lifted when they are depressed on the right hand side, and *vice versa.*

At our Stations 19, 20, and 41 there are not sufficiently numerous measurements of the movement at different depths to ascertain the exact relation between the vertical oscillations of the strata and the changes in the currents at different depths.

Let us look at the observations at Stat. 41, where there are the greatest number of current-measurements, though even there the observations are far from numerous enough for the determination of the real movements at the different depths, at the moments desired.

As was mentioned above (p. 67), several vertical series of observations were taken at Stat. 41 which give different densities, especially at 20, 50, and 100 metres. On Aug. 19, at 10 a. m., a density of 27.83 was found at 50 metres. This is so much higher than the densities of the other series at the same depth, that the water stratum observed at 50 metres on Aug. 19, at 10 a. m., may have been about 10 metres lower at 3.20 p. m. on the same day, and nearly 30 metres lower at 1.15 a. m. on Aug. 18th.

According to our vector diagrams Figs. 46—49, the movements of the water may have been approximately the following:

	at 20 Metres	at 50 Metres	At 100 Metres
Aug. 18, 1.15 a.m.	5 cm./sec. (?) towards S 20° W (?)	15 cm./sec. (?) towards N 10° E	15 cm./sec. (?) towards N (?)
Aug. 19. 10.00 a.m.	2 cm./sec. towards N 4° W	7 cm./sec. towards S 24° E	3 cm./sec. towards N 44° W
Aug. 19, 3.20 p.m.	10 cm./sec. towards N 80° W (?)	3 cm.sec./ towards S 30° W	10 cm./sec. (?) towards S 60° E (?)

Let us assume that the prevailing current of the layers between 20 and 50 metres, at Stat. 41, was running on the average in a north-easterly direction more or less parallel to the average direction of the edge of the continental shelf, as indicated by our current charts, Figs. 66 and 67, and that Stat. 41 was situated nearest the right hand side of that current. It is then clear that the movements found at 10 a. m. on Aug. 19th, would have a tendency to lift the water-layers at 50 metres etc. because the water at this depth was then moving towards the right hand side (towards S 24° E) of the prevailing current while the water at 20 metres was moving nearly in the opposite direction.

At 1.15 a. m., on Aug. 18th, the water-layers at 50 metres ought to have been depressed if the water at 20 metres was flowing to wards S 20° W, or to some extent towards the right hand side of the prevailing current, while the water at 50 and 100 metres was flowing in the opposite direction with comparatively great velocities.

If at 3.20 p. m., on Aug. 19th, the water at 20 and 50 metres had westerly movements with greater velocities at 20 than at 50 metres and the water at 100 metres had an easterly movement, these movements would naturally tend to lift the layers, but not as much as the movements at 10 a. m. on the same day.

Hence it appears that the vertical movements of the water-strata, indicated by our observations at Stat. 41, agree with the vertical oscillations that presumably would be caused by the simultaneous horizontal movements, at 20, 50, and 100 metres, computed from our current-measurements. Of course, it has to be considered that the ship was drifting with the ice and the curface-current, on the average towards WSW, and changes in the water strata may also arise in this manner.

At Stations 19 and 20 a number of vertical series of temperatures and salinities were taken, but the current-measurements are so imperfect that an analysis of the relation between the vertical oscillations and the changes in the horizontal movements is hardly possible. At Stat. 19 the densities differed, *e. g.* at 100 metres between 27.84 and 27.89, and there may have been vertical oscillations of the layers of 30 or 40 metres.

It is obvious that the changes in the velocities and directions at the different depths of a current, must cause such vertical oscillations of the strata, and they must also cause much transport of the water-masses from one side of the current towards the other. Much force is therefore always spent on this great work towards establishing lateral equilibrium, and a considerable and continuous resistance must be offered to the currents in this manner.

Vertical oscillations of the water-strata may also be caused in other ways, *e. g.* by intermediate waves of various kinds, which may aquire great hights in the intermediate layers.

It was pointed out above (pp. 28, 37) that vertical movements of the strata probably occurred at several stations, even in the fjords, *e. g.* Stats. 25, 27, 44, 50, and 53, as there were considerable differences between observations taken at short intervals of time.

The Tidal Wave in the North Polar Basin.

Our curves of velocity and direction for the surface-drift (Figs. 36 & 37, see also the central vector-diagram, Fig. 43) show that the greatest maxima of velocity coincide with a south-westerly or westerly drift, while at the minima of velocity there is no current, *i. e.* the tidal current must have been sufficiently strong in the opposite direction as to entirely check the surface-drift, and also the current in the deeper layers. As the tidal wave must evidently be moving in some north-easterly direction in this region, we may conclude that low-water coincided with the maxima of velocity, while high-water coincided with the minima. We should consequently have had low-water at 8 a. m. and about 10 p. m. (*i. e.* 7 a. m. and 9 p. m. Greenwich time) on August 18th, and at about 10 a. m. (9 a. m. Greenwich time) on August 19th, while high-water would have occurred at about 4.30 a. m. and about 5 p. m. on August 18th, and at 2 a. m. and about 3 p. m. on August 19th.

Taking Greenwich time, the hours of the transits of the moon across the Greenwich meridian, the hours of high-water at our Stat. 41, the medium hours between every two transits of the moon, and the hours of low-water at Stat. 41, are given in the following tables:

Transits of the Moon Greenwich Meridian	High-water at Stat. 41	Difference
Aug. 17, 4.06 p. m. (visible)	Aug. 18, 3.30 a. m.	11 h. 24 m.
Aug. 18, 4.30 a. m. (invisible)	— - 4 p. m.	11 - 30 -
— - 4.54 p. m. (visible)	Aug. 19, 1 a. m.	8 - 6 -
Aug. 19, 5.18 a. m. (invisible)	— - 2 p. m.	8 - 42 -
Medium Hours between Transits of Moon Greenwich Meridian	**Low-water at Stat. 41**	**Difference**
Aug. 17, 10.18 p. m.	Aug. 18, 7 a. m.	8 h. 42 m.
Aug. 18, 10.42 a. m.	— - 9 p. m.	10 - 18 -
— - 11.06 p. m.	— - 9 a. m.	9 - 54 -
		Mean Difference 9 h. 48 m.

The mean difference between the hours of the transits (and the medium hours between them) of the moon across the Greenwich meridian and the hours of high-water (and low-water) at Stat. 41, according to our current-measurements, is thus 9 hours and 48 minutes.

The current-measurements at Stats. 19 and 20, on August 4th and 5th, are on the whole not so complete as to allow of a determination of the hours of high- and low-water. The only observations that may seem to give informations of some value in this respect were taken about 4 p. m. (3 p. m. Greenwich time) on August 5th, when there was a distinct minimum of movement, all layers being apparently at rest, and this should indicate high-water. The transit of the moon across the Greenwich meridian occurred at 4.59 a. m. (Greenwich time) and the difference will be 10 hours and 1 minute, which agrees fairly well with our above-mentioned result.

According to Mr. Rollin Harris's studies on "Arctic Tides" [1911] the mean semidiurnal tidal hour for Port Virgo, on the north-western coast of Spitsbergen (79° 43′ N. Lat., 10° 44′ E. Long) is XII.56 lunar hours, or just 13 solar hours.[1]

This is abuot 3 hours and 12 minutes longer than our observations gave for our stations in the sea only some 40 naut. miles, or 80 kilometres, to the north of Port Virgo. It has to be considered that Harris's tidal hour is referred to the occurrence of mean high water, and "is generally about twenty minutes less, than the tidal hour at full and change" of the moon. On the other hand our observations on August 17th to 19th were taken

[1] For Mosel Bay, farther east on the north coast of Spitsbergen (79° 53′ N. Lat., 16° E. Long.) it was about I.4, or about 13 solar hours and 52 minutes.

just before the first quarter of the moon, which occurred on August 19th. This may also make some difference but hardly of great importance.

As the distance to Port Virgo from the edge of the continental shelf outside (to the west) is short, only about 12 miles (22 kilometres), it is hardly probable that the tidal wave should reach this place much later than the station of our obervations to the north. If we assume the average depth to be 50 metres between the edge of the shelf and Port Virgo, and 450 metres between the sea west of Port Virgo and the station of our observations, about 80 kilometres to the north, the tidal wave should reach this station and Port Virgo nearly simultaneously.

The difference of a little more than three hours, found between high-water at Port Virgo and high-water at our station to the north, is consequently noteworthy. It is striking that this difference seems to be very nearly equal to a quarter (3 hours and 6 minutes) of a semidiurnal tidal period.

The series of current-measurements which Helland-Hansen took on Storeggen (outside Aalesund in Norway), on July 12th and 13th, 1906, shows, however, similar peculiarities when compared with the time of high-water at Christiansund. As Mr. WERNER WERENSKIOLD points out in a paper on the subject he is now writing, high-water occurred at Helland-Hansen's station on Storeggen, about 4 hours 48 minutes earlier than at Christiansund, the distance between the two places is 176 kilometres, and the tidal wave may travel this distance in about $1^h\ 42^m$ if the average depth be about 85 metres. This leaves a period of about $3^h\ 6^m$, which high-water came comparatively earlier on Storeggen than at Christiansund. Mr. Werenskiold's explanation of this apparent discrepancy is that high-water at the two places occurs at two different phases of the tidal wave. Over the deep sea, high-water occurs when the crest of the tidal wave passes the place, with maximum surface velocity in the direction of the propagation of the wave, while on a coast, with shallow water outside, high-water occurs at a later phase of the wave, midway between crest and trough, at the change of the tidal current, when it is slack. Hence it follows that the difference in time between the two high-waters should be a quarter of the semidiurnal tidal period, or about 3 hours and 6 minutes.

Though our current-measurements are not sufficiently complete to give exact results in the above respect, they prove, however, that by methodic researches of this kind, carried out from a steadily drifting ship, moored to the drifting ice (or kept by drift anchors), the tidal currents may be conveniently studied over the deep ocean.

Ice-Pressures and the Tidal Wave.

According to our observations the ice was comparatively tight at the minima of movement, when the water was at rest, *i. e.* at high-water, while the ice was comparatively slack, with much open water between the floes, when there was a maximum of movement in the water, *i. e.* at low-water.

This is in accordance with what might be expected to be the case owing to the horizontal movements of the surface-layers, caused by the tidal wave during its progress across the sea. Let us try to examine what the horizontal distribution of the tidal movements over a sea-surface may be at a certain moment, if we do not take the movements due to other causes (prevailing sea-current, wind, etc.) into consideration. This distribution of the movements might then be something similar to what is indicated in Fig. 69.

Maximum of movement, going in the same direction as the tidal wave, will be found where there is high-water at any given moment, *i. e.* along the crest of the tidal wave (Fig. 69, b); while maximum of movement going in the opposite direction will be found where there is low-water at the same moment, *i. e.* along the trough of the tidal wave (Fig. 69, aa).

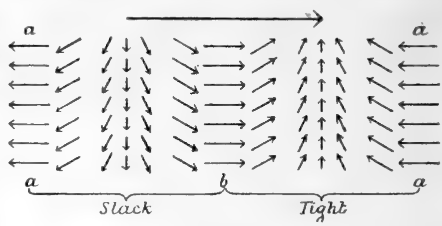


Fig. 69.

In the regions between the crest and the trough of the wave, the velocities will be decreasing towards a minimum midway between them, or midway between high-water and low-water. Owing to the effect of the Earth's rotation (or under certain circumstances also owing to other causes) the directions of the movements might change as indicated in Fig. 69. As our figure clearly demonstrates, the movements will be converging in the region between the trough and the crest on the front side of the advancing wave, but they will be dispersing between the crest and the trough on the back side of the wave. The converging movements will naturally tighten the ice, and may produce ice-pressures, that will reach their maximum near high-water (or near the crest of the wave). The dispersing movements will produce a slackening of the ice, that begins as soon as the crest of the wave has passed, and will reach its maximum near the trough of the wave (near low-water). As, however, the ice-masses are big and heavy, there may be a lag in their movements; for instance, ice-pressures caused by the tidal currents might also occur some short time after high-water.

During the drift of the Fram across the North Polar Basin, from 1893 to 1896, we had much opportunity of studying the ice-pressures. We found that in the sea north of the New Siberian Islands, where we were near the edge of the deep North Polar Basin, and in the sea north of Spitsbergen, ice-pressures occurred more or less regularly twice in 24 hours at spring-tide, about new moon or full moon, and a few days after. During the same days the ice also regularly opened up much twice in 24 hours, in the time between the pressures.

Provided that the heaviest ice-pressures occur at high-water, and the ice is most open at low-water, it would thus be possible to determine the progress of the tidal wave across the North Polar Basin by studying the movements of the ice.

I have tried to use our observations during the Fram-expedition for this purpose. It was, however, very difficult to decide at what moment the tidal pressures reached their maximum, or when they ceased, as they often proceeded somewhat irregularly.

In the sea north of Spitsbergen some few accurate observations of the time of the ice-pressures were taken by Captain S. Scott-Hansen in June 1896; but they give very different results, as will be seen from the following table:

Transit of Moon Greenwich Meridian, Greenwich Time, 1896	Ice-pressures in about 83° 1′ N, 12° 12′ E Greenwich time	Difference
June 8, 9 29 a. m.	June 9, 0.10 a m. The ship lifted highest by the pressures which began in the evening.	14 h. 41 m.
„ 9, 10.18 a. m.	„ 10, 0.20 a. m. Pressures ceased after having began in the evening.	14 „ 2 „
„ 10, 11.10 a. m.	„ 11, 1.00 a m. Pressures ceased after a few hours movement.	13 „ 50 „
	„ 11, 4.10 a. m. Sudden heavy pressures.	[17 „ 0 „]
„ 11, 0.06 p. m.	„ 11, 10.55 p. m. Pressures began, lifted the ship, and lasted for 5 minutes.	[10 „ 49 „]

On June 8th and 9th, 1896, the ship was in 83° 1′ N and 12° 12′ E. On June 11th, at 9.32 a. m. there was a new moon. According to the first three observations above, the difference between the transit of the moon across the Greenwich meridian and high-water at this place should have been about 14 hours and 11 minutes. This value is uncertain, but if correct, high-water should consequently occur here 4 hours and 23 minutes later than at our station of August 18th and 19th, 1912, 154 naut. miles (285 kilometres) to the south, although in this region, where the sea has probably an average depth of more than 1500 metres, at least, the tidal wave may be expected to travel with a velocity of more than 240 miles an hour. As was mentioned above, it is possible that the ice-pressures reach their maximum, or cease, some time after high-water, in which case our value of the difference between the transit of the moon and high-water will be too high. Whether the correction thus needed, would be sufficient to make up for the above discrepancy seems, however, doubtful. The above value (14^h 11^m) of the tidal hour would agree better with the time of high-water of Port Virgo (tidal hour = 13^h) and Mosel Bay (tidal hour = 13^h 50^m) on the north coast of Spitsbergen.

The sea where these observations were made in June 1896, was 3200 metres deep. It is interesting to note that regular heavy ice-pressures are caused by the tidal currents over such a deep sea. And there were many more such regular pressures, occurring twice (or sometimes only once) in 24 hours, than are mentioned above. This fact seems to indicate that the tidal wave was greater in this region than it is generally assumed that it should be over the deep Ocean.

During October, November, and December, 1893, when we were over the continental shelf north of Siberia, or near its edge, ice-pressures occurred in the days about every spring-tide, as a rule very regularly twice in 24 hours. I find the following observations in my diary. For the sake of convenience I give the notes in their original form with local time, but have then transformed the hours of the transit of the moon across the Greenwich meridian to this local time as well.

Latitude and Longitude	Transit of the Moon (Greenwich Meridian) Local Time 1893	Ice-Pressures (and Much Open Water) Local Time	Difference
			h. m.
78° 23′ N. Lat. 136° 5′ E. Long.	Oct. 8, 7.53 p. m.	Oct. 9, 2 to 3 p. m. and later in the afternoon. Heavy pressures. Perfectly open water in the evening.	[19]
	9, 8.14 a. m.	10, 4 to 5 a. m. Heavy pressures. Quite open water in the evening.	20 16
		11. Much pressure in the afternoon, the ice opened in the evening.	
	10, 9.19 p. m.	(11, 11 to 12 p. m. Much open sea).	20
		12. Before noon great open sea.	
78° 14′ N. Lat. 135° 57′ E. Long.	11, 10.02 p. m.	12, 6.30 p. m. Heavy pressure. Open water in the evening.	20 28
	12, 10.24 a. m.	13, 6 a. m. Violent pressures.	19 36
		(13, Noon. Much open water).	19 24
		(13, 1.30 p. m. The ice began to tighten).	
	10.47 p. m.	13, 8 p. m. Pressures.	21 13

Latitude and Longitude	Transit of the Moon (Greenwich Meridian) Local Time 1893	Ice-Pressures (and Much Open Water) Local Time	Difference
			h. m.
		Oct. 14, Much open water in the day.	
	Oct. 13, 11.33 p. m.	14, 8 p. m. Pressures, that ceased at 8.30 p. m.	20 26
	14, 12.24 p. m.	14, 10 to 11 p. m. The ice opens.	
	16, 1.41 p. m.	15, 7 p. m. A little pressure.	[18 36]
		17, 10.30 to 11.30 a. m. Heavy pressures.	[21 19]
78° 17′ N. Lat. 135° 27′ E. Long.	23, 6.52 a. m.	23. Indications of pressure in the afternoon.	
		24, 4 to 5 a. m. Heavy pressures. Much open water in the morning. 9.30 a. m. The ice tightened.	21 38
	7.16 p. m.	11 a. m. Heavy pressures. 4 to 4.30 p. m. Violent pressures.	21
78° 32′ N. Lat. 136° 12′ E. Long.	24, 7.39 a. m.	25, 1 to 2 a. m. Some pressure.	
		25, 3.45 to 5 a. m. Violent pressures.	20 43
		Mean:	20 36
77° 57′ N. Lat. 137° 49′ E. Long.	Nov. 7, 7.44 a. m.	Nov. 8, 5 a. m. Pressures.	21 16
		9. A little pressure in the morning.	
	8, 8.50 p. m.	9, 8 p. m. Pressures.	[23 10]
	9, 9.13 a. m.	10, 8 a. m. and later. Pressures. Open ice in the afternoon.	22 47
	9.36 p. m.	7.30 to 8 p. m. Heavy pressures.	22 9
	11, 10.50 a. m.	12, 3 to 3.30 a. m. Heavy pressures.	[16 40]
	15, 1.52 a. m.	15, 7 p m. A spell of pressures.	[17 8]
		Mean:	22 4
78° 38′ N. Lat. 139° 0′ E. Long.		23. In the afternoon pressures heard far away.	
	24, 9.47 p. m.	25, 4 p. m. Pressures heard far away.	18 13
	25, 10.20 a. m.	26, 4 to 5 a. m. Heavy pressures heard.	18 10
	26, 11.28 a. m.	27, 7 to 9 a. m. Pressures.	20 32
	12.0 p. m.	7.30 to 8.30 p. m. Pressures.	20
		Mean:	19 14
		Dec. 6, 8 p. m. A crack was formed in the ice. 12 p. m. The crack very open.	
78° 58′ N. Lat. 137° 32′ E. Long.	Dec. 6, 7.09 a. m.	7, 5 to 6 a. m. Pressures. 11 a. m. The ice opened a little. In the afternoon a little pressure.	22 21
	7, 7.55 a. m.	8, 7 to 8 a. m. Heavy pressures. 2.30 p. m. A loud crack, and movement in the ice.	[23 35]
	8.19 p. m.	6 to 6.30 p. m. Heavy pressures.	21 56
		Mean:	22 9
		Mean of all observations:	20 38

There was spring-tide on the following dates (local-time):

				Depth of the Sea
October	10,	5.31 a. m.	new moon	140 metres
	25,	4.33 p. m.	full moon	100 „
November	8,	10.08 p. m.	new moon	53 „
	24,	3.24 a. m.	full moon	100 „
December	8,	4.50 p. m.	new moon	no bottom

The mean difference between the transit of the moon across the Greenwich meridian and the heaviest ice-pressures was:

in October, 1893	20 hours	36	minutes
on November 8th to 10th	22 „	4	„
— 25th to 27th	19 „	14	„
December 7th to 8th	22 „	9	„

In October the ship was near the edge of the continental shelf, north of Siberia, while on November 6th to 9th she was farther south on the continental shelf, and the depth was between 53 and 58 metres. It is therefore natural that high-water should be somewhat later there than farther north, where we were in October 1893. On November 25th to 27th we had again drifted northwards towards the edge of the continental shelf, but about two degrees farther east than in October. The ice-pressures were now only heard at some distance, and their periods were less marked; the observations are therefore less trustworthy. In the beginning of December, 1893, we were farther north and over the deep sea, and it is therefore surprising that there should have been a greater difference between the transit of the moon (Greenwich meridian) and the heaviest ice-pressures there than farther south; but the periods of the pressures were not well marked at that time, and there are too few observations.

After that time, when the ship had drifted farther towards the inner regions of the deep North Polar Basin, no distinctly tidal pressures were observed, and it seemed as if the pressures were more influenced by the winds.

The mean difference between the transit of the moon across the Greenwich meridian and the ice-pressures obtained by all our observations from October to December, 1893, is 20 hours and 38 minutes.

If we assume that in this region as well as in the region about 83° N. and 12° E. of June 1896, the ice-pressures occurred at the same phase of tidal wave, the latter should thus need about 6 hours and 27 minutes to travel the distance of about 980 naut. miles (1800 kilometres) between the two regions. This gives a velocity of about 152 miles an hour, which would indicate an average depth of the sea of about 624 metres. The soundings taken during the drift of the Fram across this sea, give, however, a depth of between 3000 and 3850 metres. With an average depth of the sea of 3400 metres the tidal wave ought to travel the above distance in 2 hours and 46 minutes (with a velocity of 355 miles an hour), it is 3 hours and 41 minutes less than found above.

According to the cotidal lines on Mr. R. A. Harris's chart [1911] the tidal wave should need about $3^1/_2$ hours across the above mentioned region.

But the velocity of the wave does not only depend on the depth of the sea, it also depends on the shape of the deep basin. We do not know the width of the deep North Polar Basin nor the configuration of its sides.

In 1913 Capt. Vilkitskij made the important discovery of land (Nicholaus II's Land), extending towards the north-west from the region north of Cape Chelyuskin. For several oceanographic reasons I thought it probable that the broad Siberian Continental Shelf had an extension towards the north in that region, as indicated on my bathymetrical chart of the North Polar Basin [1904, Pl. I]. Capt. Vilkitskij followed the coast of the new islands as far north as beyond 80^0 4′ N. Lat., and 97^0 12′ E. Long., and in 81^0 N, 96^0 E the sea was still shallow, between 16 and 100 fathoms. There may probably be more unknown land; during the Fram-expedition we saw a number of new islands far west of us in the sea west of the Cape Chelyuskin Peninsula. The continental shelf may thus have a wide extension, also towards the north, in this region. This would naturally retard somewhat the progress of the tidal wave.

The width of the deep polar basin is perfectly unknown, as we know nothing of its side-slope on the Greenland American side. But it is hardly probable that it can be so narrow as to account for the above retardation of the tidal wave, even considering that the latter may be much hindered by the broken boundaries of the basin.

According to the observations of the Jeanette Expedition, during July 30th to August 6th, 1881, high-water on Bennett Island (74^0 41′ N, 149^0 5′ E) should occur on the average 6^h 37^m after the transit of the moon across the Greenwich meridian [se HARRIS, 1911, p. 79]. The distance between the region of the Fram in October to November 1893 and Bennett Island is about 170 naut. miles. If the mean depth of the sea be 40 metres, the tidal wave would travel this distance in 4^h 12^m. This added to 20^h 38^m gives 24^h 50^m, or if we take the next transit of the moon it would correspond to a tidal hour of 12^h 25^m, *i. e.* 5^h 48^m more than given by the observations on Bennett Island.

If the shortest distance between Bennett Island and the edge of the continental shelf to the north of it, is much shorter than the distance between the island and the region of the Fram in the autumn of 1893, the tidal wave may spend less time *e. g.* 2 hours less in reaching the island. Its tidal hour might then be $22^h\ 50^m$, or $10^h\ 25^m$. But this would be about $3^h\ 48^m$ later than found by the observations of 1881 on the island, — or also would it be $8^h\ 37^m$ earlier, but in that case we would have to assume that the tidal wave reaches Bennett Island one semidiurnal period later than given by Harris's chart, and that seems hardly possible.

At present it seems difficult to find a feasible explanation of these great discrepancies.

The Extension and Shape of the North Polar Basin.

As the results of the investigations described in this paper, especially the salinity of the deep-water of the North Polar Basin, may have some modifying effect upon the views previously held by the writer, as to the extension and shape of the deep North Polar Basin, it might be appropriate to take up this subject for new discussion here.

In 1902 and 1904 the writer held the view that the deep North Polar Basin had a wide extension, and probably covered the greater part of the still unknown North Polar region [1902, pp. 399 *et seq.*; 1904 pp. 227 *et seq.*]. This view was chiefly based upon the nature of the cold deep-water or bottom-water of this basin. As, according to the investigations during the Fram-Expedition, this water should differ entirely from the deep-water of the Norwegian Sea, it was thought to be formed in the North Polar Basin itself; but if so, this formation seemed impossible to account for unless the basin had a wide extension.

After having found by new investigations that, by a special process, cold bottom-water with a comparatively very high salinity may be formed in the Barents Sea [1906], the writers views as to the extension of the North Polar Basin were much modified [1907], and he no more considered it necessary to assume that the North Polar Basin had such a wide extension as he had thought before. His view was now, "that the known geographical and geomorphological features of the Arctic regions do not exclude the possibility of a wide extension of the continental shelf beyond the northernmost known islands of the American Arctic archipelago and Greenland, and there may be lands on this shelf in the Unknown North. It is also possible that the Siberian continental shelf may have northward extensions with land in the region between the New Siberian islands and Alaska".

Later explorations have not disproved the correctness of this view, neither the one way nor the other. Mikkelsen and Leffingwell found comparatively deep water (620 metres (339 fathoms) with no bottom) to the north of Alaska (north of 71° 20′ N), indicating a narrow continental shelf in that region, as assumed by the writer, and they saw no indications of land. The Stephanson Expedition to Bank Land, and the drift of his ship have given no indication of extensive unknown land in that region. Peary found no land north of Grant Land (Ellesmere Land) and Greenland. The continental shelf was observed as far north as Latitude 83° 53′. He found a deep sea near the North Pole, the soundings of his party giving no bottom at 1260 fathoms (2304 metres) in 87° 15′ N, and no bottom at 1500 fathoms (2743 metres) about five miles from the Pole. The existence of Crocker Land, that Peary thought he had seen to the north of Axel Heiberg Land, has not been verified.

All this does not prove, however, that there may not be a wide continental shelf, with unknown lands to the north of the American Arctic archipelago, on the contrary I consider this probable.

As was mentioned before, new islands have been found in the region north-west of Cape Chelyuskin, and the continental shelf is there extending far north, beyond 81° N. As to the vast regions between the New Siberian Islands (or Bennett Island), Parry Islands and Alaska we know nothing, but the possibility that there may be a wide extension of the continental shelves, also with unknown lands, is not excluded.

According to the investigations described above we have arrived at the conclusion that the salinity of the deep-water of the North Polar Basin is about 34.91 ‰. This also agrees well with the salinities of the water-samples (from 300 and 350 metres) collected by Admiral Makaroff in the sea east and south-east of Franz Joseph Land [NANSEN, 1906, p. 51].

According to the determinations in the writers laboratory, Makaroff's observations and samples gave the following values:

N. Lat	E. Long.	Depth	Temp.	Salinity	σ_t
78° 21′	61° 15′	300 Metres	—0.1 °C.	34.88 ‰	28.04
79° 45′	65° 9′	300 „	0.7 „	.92 „	.025
		350 „	0.5 „	.92 „	.035

It seems probable that the depths where these samples were taken communicate directly with the deep North Polar Basin, and this water at Makaroff's stations was evidently very simular to that which the writer found in 1912 at Stat. 36, at 580 metres (0.4° C. and 34.91 ‰), in 80° 36′ N, north of Spitsbergen.

If it be thus correct that the deep-water of the North Polar Basin is of the same kind as that of the Norwegian Sea and has come from the latter, as assumed above (p. 39), this deep-water cannot prove anything as to the extension of the deep North Polar Basin because it, might then just as well be carried over the low threshold into a narrow basin, like a big and very deep fjord, as into a wide basin. Thus far there is still less necessity of assuming that the North Polar Basin has a wide extension, than the writer thougt in 1907.

The one reason which especially seems to the writer to idicate that the deep basin may not have such a wide extension into the unknown north as he at first thought probable, is the drift of the Fram 1893 to 1896.

Although the drift of the ice was chiefly caused by the winds, we would expect that, owing to the deflecting effect of the Earth's rotation, the moving ice would be deflected towards the right until it met with resistance from a coast or continental shelf, and would then follow along this coast or shelf, keeping it on its right hand side. This would be in full accordance with what is always the case with currents and drifting ice everywhere else in the Northern hemisphere.

The writer has shown [1902. pp. 365 *et seq.*] that during the Fram-Expedition (1893 to 1896) the directions of the drift of the ice for shorter periods, only with few exceptions, deviated to the right of the directions of the shifting winds, and generally the angle of deviation was considerable. But nevertheless the direction of the resultant of the whole drift of the Fram nearly coincided with the direction of the wind-resultant for the same period, or it even deviated a little (1°) to the left of the latter.

This proves that the ice, drifting before the wind, must have met with more resistance whenever it was carried towards the right — *i. e.* towards the north and north-east — of the average direction of the drifting of the Fram, than when it was carried towards the left of the latter. Two explanations are then possible: there may either have been land (or a shallow sea) to the right of the Fram's track, which offered resistance to the drift of the ice, — or there may have been a permanent surface-current, directed west- and south-westwards towards the left of the Fram's track, and sufficiently strong to counterbalance the deviation of the ice towards the right of the resultant of the winds during the whole drift.

Let us first consider the latter possibility. As the writer has pointed out before [1907, p. 483], such a directon of a surface-current would be difficult to explain. Whatever the cause and origin of the current might be, we would expect it to be deflected towards the right till it met with resistance near the edge of the continental shelf or against land, and then it would follow along the shelf or the land. In a wide North Polar Basin we wold thus get a cyclonic movement of the currents.

A current deviating much to the left of the average direction of the Fram's drift, as our observations might seem to indicate [see 1902, pp. 358 *et seq.*], cannot, however, follow the direction of any land or of any edge of a continental shelf to the north, for if the edge of the shelf (or land) had such a direction, the Fram would have approached it rapidly, and must have met with it at last; but she was the whole time drifting in a deep sea. Moreover a current with such a direction would be directed towards the edge of the continental shelf on the other side of the basin, north of Franz Joseph Land and Spitsbergen, and that is not probable.

It seems therefore hardly possible that the permanent surface-current of the North Polar Basin along the track of the Fram, may have had such a direction as the writer previously [1902] thought was proved by the observations of the expedition.

The fact that the average direction of the whole drift of the Fram did not deviate to the right of the resultant of the wind, but instead slightly to the left, might therefore more simply be explained by the existence of land, or at least shallow sea, with the edge of the continental shelf, to the north of the Fram's track. In this namer there might have been offered resistance to the drift of the ice in that direction. As has elsewhere been pointed out, even a continental shelf which does not rise to the sea-surface, offers resistance to sea-currents and to the drift of the ice. Not considering the periodical tidal currents, there is comparatively little motion of the water and ice over the shelves and the banks of the sea, the currents will greatly follow their edges and side-slopes.

The existence of a shallow sea, perhaps even with land, somewhere to the north of the Fram's track, might thus seem probable. If the drift of the Jeanette be also taken into consideration, the probability of such land or shallow sea to the north might seem to be strengthened; for if we assume the deep North Polar Basin to have a wide or roundish shape, bounded by the Siberian coast and the known American Arctic archipelago, it would indeed be difficult to explain why the ice is carried in an anticyclonic direction westwards along the Siberian side of this basin. The effect of the Earth's rotation would then seem to make it necessary that the ice should be carried, by wind as well as by current, along the American side of the basin.

During his sledge-expedition from Greenland to the North Pole, Peary found, however, no land in that region, and near the Pole he found a deep sea. Unless we assume that there may be land somewhere between the tracks of Peary and the Fram, there cannot be any land (or shallow sea) in this region north of the Fram's track so near that it could have had an appreciable effect upon the direction of the drift of the ice. It is then a question whether land or shallow sea might exist to the north of the Fram's track farther east.

Mr. Rollin A. Harris has by a careful study of the tidal observations on the coasts of the North Polar Sea [1911] come to the conclusion that there must be an extensive land or a shallow sea in the still unknown region of the North Polar Sea, north of Alaska and the American Arctic archipelago.

The writer does not feel competent to decide whether Mr. Harri's arguments are based upon perfectly sound principles; Mr. Harris operates, however, with many quantities, that owing to the meagerness of observations could not be exactly computed, and may therefor be considered as more or less uncertain, as Mr. Harris himself states. The writer does not therefore think that too much faith ougth to be placed in his conclusions. Although the observations of the latest expeditions do not actually disprove the correctnes of Mr. Harris views as to a hypothetical land north of Alaska, west of Bank Land, and North of Axel Heiberg Land (Crocker Land?), they show at any rate that such lands cannot be so near the known coasts as originally assumed by Mr. Harris.

What we learn as to the tidal wave in the North Polar Basin from our current-measurements and the occurrence of ice-pressures during the Fram-Expedition (see above pp. 83 *et seq.*) may warn us that there are possibly irregularities in the high-waters etc., and these would have to be studied before any reliable conclusions as to unknown land in the north could be based upon the tidal observations.

The other arguments, outside his tidal speculations, advanced by Mr. Harris in favour of his hypothetical land in the north, can hardly be said to carry much weight.

He says: "The decided westward drift observed by Mikkelsen and Leffingwell off the northern coast of Alaska is alone strong evidence against Nansen's hypothesis of an unobstructed polar basin".[1] Why so is

[1] Mr. Harris is mistaken in his views of what is "Nansen's hypothesis". The writer's paper of 1907, which Harris quotes, shows that the writer does not believe in the probability of an "unobstructed polar basin" in the sense Mr. Harris mentions. On the contrary the writer thought "the possibility of a wide extension of the continental shelf" from the American side, etc., into the Unknown North, was not excluded, and he thought that "there may be unknown lands on this shelf", etc.

not stated. It seems difficult to understand that the strength of this evidence should be much greater than that of Mr. Harris's evidence on an earlier occasion [1904] when he thought that the current north of Alaska runs in the opposite direction, eastwards, and that this proved land to the north. There are several observations of the drift of the ice to the north of Alaska, by ships that have been enclosed in it, but none of them seem to prove anything with regard to unknown land to the north, neither in the negative nor in the affirmative. They chiefly prove that the drift of the ice in this region much depends on the local winds.

Mr. Harris also says: "The time required by casks deposited off Point Barrow and off Cape Bathurst to reach their destinations on the north-eastern coast of Iceland and the northern coast of Norway, *viz.*, about five and one-half and eight and one-fourth years, respectively, while not disproving, certainly do not favour the hypothesis in question" (*i. e.* of an unobstructed polar basin). The observed time required by the casks to drift across the North Polar Basin is, however, not longer than might be expected if this basin were unobstructed. We do not know what time was actually required for this drift, as it is impossible to say how long time has elapsed before the casks were found, after they had left the North Polar Basin, between Spitsbergen and Greenland. They may have had a very complicated drift in the Norwegian Sea, where there are several systems of vortex-movements [cf. HELLAND-HANSEN and NANSEN, 1909], and they may have spent a long time there before they were thrown ashore. This may especially have been the case with the cask found on the northern coast of Norway. And then we do not know how long the casks may have been lying on the shore before they were found.

We know, however, that at least the one cask cannot have required *more* than five years to drift across the polar basin from Alaska to the opening between Spitsbergen and Greenland, for it cannot have spent less than half a year on its way from this region and till it was found in Iceland.

But now a drift of five years across the North Polar Basin from Alaska to the opening between Greenland and Spitsbergen is remarkably short for such a cask. Judging from the drift of the Jeanette and the Fram, the writer had calculated that a ship, that worked its way as far as possible into the ice north-east of Bering Strait, would require five years to drift across an unobstructed polar basin, before it could work its way out of the ice again on the Spitsbergen and Greenland side, like the Fram in 1906.

The above-mentioned drift of the cask, in five years, is much shorter, considering that the cask was deposited on a floe off Point Barrow, and that its drift could not be shortened, like that of a ship, by working its way out of the ice on the Greenland side. The cask had consequently a longer and more time-wasting distance to travel. If anything, the drift of this cask would thus rather favour the existence of an unobstructed polar basin. But of course we do not know by which way the casks may have travelled, whether near to the routes of the Jeanette and the Fram, or much farther north. These casks cannot therefore tell us anything as to the possible existence of land or shallow sea in the unknown north.

Mr. Harris also mentions that "the westerly direction taken by the Jeanette, especially during the last five months of her drifting, does not suggest unobstructed deep water to the northward of eastern Siberia". In accordance with what has already been said before (pp. 94 *et seq.*), this evidence seems to the writer to be of somewhat more value than the others stated by Mr. Harris. But before any conclusions of weight could be drawn from it, it would be necessary to know the velocities and directions of the winds during the drifting of the Jeanette, in order to see whether the drifting ice met with any special resistance towards the north which prevented its course from being deflected towards the right of the wind. As far as I know, however, there is not sufficient observation-material for such an investigation. We cannot therefore conclude anything of much importance in the above respect from the drifting of the Jeanette.

It may perhaps only be pointed out that the cask that required less than five years to drift across the North Polar Basin from Alaska, cannot possibly have come by the same way as the Jeanette and the relics from the Jeanette, found off the south-west coast of Greenland; for if so the cask would necessarily have required a much longer time for its drifting; it would require a very long time to reach the starting point of the Jeanette-drift from the place where it was deposited off Point Barrow.

Hence it follows that the cask must have travelled along a much quicker route across the unknown sea, somewhere far to the north of the track of the Jeanette, where the ice drifted more freely. This circumstance may just indicate the probability of more unobstructed and deeper water there than along the track of the Jeanette.

Investigations on the Amount of Oxygen in the Spitsbergen Waters.

Some determinations of the quantity of oxygen in the sea-water at different depths were made at a number of stations. The results are given in Table III.

The ordinary Winkler method was used for the determinations in the following manner: the glass-bottles containing about 300 cc., and provided with carefully ground glass-stoppers, were filled by means of a narrow rubber tube passing from the outlet of the water-bottle to the bottom of the glass-bottle. The water is let in gently and not allowed to form air-bubbles, and when the bottle is full an ample quantity of water is allowed to flow out over the top of the bottle, in order that all water is washed out, which first ran in and came in contact with the air in the bottle. Now solutions of sodium hydrate (with potassium iodide) and manganous chloride are added with pipettes with long stems in the ordinary way. Then the glass-stopper is gently pressed down into the neck of the bottle, while the remaining of any air-bubble is carefully avoided. After the bottle had been inverted several times, the stopper was tied down tightly by string round the neck of the bottle and over the stopper; and after the bottle had been numbered, it was carefully stowed away in a drawer on board. After our return to Bergen in September the final titrations of the water-samples and the exact determinations of the volumes of the bottles were kindly made by Mr. THORBJØRN GAARDER.

The bottles with the samples were not kept in boxes or bigger bottles filled with sea-water, in order to avoid the absorption of air, as recommended by Bjerrum [1904] and Palitzsch [1912]. It might therefore seem possible that the results are not quite trustworthy. But the same method of keeping the samples in glass-bottles with ground glass-stoppers, simply secured by string tied over them, have also been used by Prof. B. Helland-Hansen [1907, p. 13, Note 3] and by Mr. Gaarder for years, and if the stoppers closed tightly, they have never noticed that oxygen was absorbed from the air, although the bottles were not kept in water.

The degrees of saturation of the absorbed oxygen, given in the fifth column of Table III, indicates the relation, expressed in per cent, between the observed quantity of oxygen and the quantity which sea-water with the same *salinity* and *temperature* could absorb at the pressure of one atmosphere, if fully saturated. If the former value be called O_2^1 and the latter value O_2^2 the percentage of saturation will be $\frac{100\ O_2^1}{O_2^2}$. The values are computed by means of Prof. Chas. J. J. Fox's table [1907].

The observations are not sufficiently numerous to give a general view of the distribution of oxygen in the different depths of the sea in the Spitsbergen region; but some general features are demonstrated.

The greatest quantities of oxygen always occurred in the upper layers of the sea, at depths of 10 and 20 metres, with amounts mostly between 8.19 and 8.34 cc. of oxygen per liter of sea-water, and there was a supersaturation of 104 and 105 % or even as much as 109 %.

This supersaturation with oxygen in the uppermost layers of the sea was already distinctly observed by Mr. H. TORNØE [1880, p. 19] "in the surface-water of the northern tracts of the sea" investigated during the Norwegian North-Atlantic Expedition 1876 to 1878, and he throught that it must be the effect "of one or more causes as yet unknown". Similar observations were also made by DITTMAR during the Challenger-Expedition but he suspected that they might be due to observational errors.

As was first pointed out by Prof. MARTIN KNUDSEN [1899, pp. 155 *et seq.*], the supersaturation is the result of the action of phyto-plankton, that occurs in greatest quantities in the layers near the surface of the sea and, below a certain level, rapidly decreases with increasing depth.

Our observations give supersaturation with oxygen at 20 (and 10) metres both in the fjords (Stats. 10, 45, and 50), in July and August, and in the sea outside the coast, even where it was covered by drifting ice as at Stat. 41 c; but the water at 20 metres at this station with a comparatively high temperature (2.11° C.) had evidently come from the region south of the ice.

At the depth of 20 metres at Stat. 53, outside Bell Sound, the quantity of oxygen (7.98 cc.) and the super-saturation (101.7 %) were less than at the same depth at the other stations farther north. This difference may chiefly be due to the phyto-plankton.

The fact that the water at the surface at Stat. 50, and at 5 metres at Stat. 41 c was not saturated with oxygen (showing only 98 % of saturation) was probably due to cooling of the water. Mr. Gaarder has always found similar conditions in the fjords of western Norway in the autumn and winter. There is, however, a characteristic difference in this respect between the surface-waters at Stat. 50, in the sheltered, quiet Bay, where the surface was not stirred by wind and was much cooled, and at Stat. 53 outside Bell Sound where the surface has evidently been stirred by wind and waves, that would have effect here where the sea was not sheltered by land or ice; the surface-water was therefore just saturated with oxygen (100.4 %) in spite of the cooling.

On the whole the quantity of oxygen seems to be considerably greater, or at least somewhat greater, in water with salinities less than 34.3 ‰ than in water with salinities higher than 34.3 ‰.

At 50 metres there was as a rule considerably less oxygen (between 6 99 and 7 49 cc. per liter) than at 20 metres, and the percentage of saturation was comparatively low, between 89.6 and 92.7 %. The amount of oxygen at 50 metres was on the whole less at the more northern stations, both in the fjord (Cross Bay, Stat. 13) and in the sea to the north (Stats. 37, 41 c and 43), than farther south in Ice Fjord, Bell Sound etc. (Stats. 45, 50, 53, 56). The lowest amount of oxygen at 50 metres (6.99 cc. and 90 %) was observed at our northernmost station, Stat. 37, north of Spitsbergen. The temperature was there comparatively high (1.50° C.). At the Stations 41 c and 43, north of western Spitsbergen, the lowest amount of oxygen at 50 metres was found in the water with the lowest temperature and salinity, at Stat. 43.

At Stat. 45, in Ice Fjord, the quantity of oxygen at 50 metres (8.13 cc.) was considerably higher than at the same depth at the stations farther north. But the water observed at 50 metres at Stat. 45, with a low salinity of 33.68 ‰ and a comparatively high temperature of 0.85° C., evidently originated from some higher water-layer that had been depressed to this lower level at Stat. 45 (see Fig. 26, p. 25). If compared with Stat. 10 of July 21st, in the mouth of Ice Fjord, it is noticed that the water at 75 metres, at the latter station, is of the same type, as to temperature and salinity, as the water at 100 metres at Stat. 45, and contains also very nearly the same quantity of oxygen, while the water at 50 metres at Stat. 45 has even a lower salinity than the water at 20 metres at Stat. 10.

It has also to be considered that the observations at Stat 45 were taken much later in the season (Aug. 26th), when more oxygen may have been produced by the action of phyto-plankton in the deeper layers, whose salinity may also have been somewhat reduced by admixture of fresh-water. But this increase of oxygen in the end of August is uncertain, as the light penetrating to the deeper layers has already been much reduced at this time, owing to the lower situation of the sun.

On the other hand it is noteworthy that the cold water at 50 metres in Cross Bay, at Stat. 13, had a considerably smaller amount of oxygen (7.42 cc. and 91 %). This cold water, with a temperature of — 0.25° C., is probably winter-water, originated by the vertical circulation during the cooling, when there was very little phyto-plankton, and into which the sun could not penetrate, even in the spring, as the sea was covered by ice and snow. In this water there may moreover have been a slow oxidation by the animal plankton.

It seems to be the same type of cold water, with temperatures below 0^{0} C., salinities between 34.35 and 34.65 ‰, quantities of oxygen between 7.3 and 7.5 cc., and saturation between 90 and 92 %, that forms the intermediate cold layer in Ice Fjord (se above pp. 23 *et seq.*) as well as in Cross Bay. It was this water with the above mentioned amount of oxygen that was observed at 75 metres at Stat. 10, at 100 and 170 metres at Stat. 45, and at 140 metres at Stat. 46, in Ice Fjord. It was evidently also the same type of water, with similar amounts of oxygen, that was observed in the intermediate cold layers, at 50 metres, in the sea north of western Spitsbergen, at Stats. 41 c and 43.

At 50 metres at Stat. 50, in Van Mijen Bay, and at Stat. 53, outside Bell Sound, where the temperatures were above 0^{0} C., the quantities of oxygen (7.99 and 7.77 cc., 98.4 and 96.3 %) were considerably greater than in the cold intermediate layer just mentioned, though not as great as at 50 metres at Stat. 45, in Ice Fjord, where the water evidently belonged to higher levels.

At Stat. 50 our observations gave more oxygen at 70 metres (8.08 cc.) than at 50 metres (7.99 cc.). If this is not the result of some observational error it seems somewhat difficult to account for.

At Stat. 56, in the Atlantic Current south-west of Spitsbergen, there was supersaturation of oxygen at 50 metres (102.8 %), evidently due to the action of phyto-plankton, but as the temperature was comparatively high (5.45^{0} C.) the actual quantity of oxygen (7.26 cc.) was smaller than at the same depth at the stations farther north.

At depths greater than 50 metres, the amount of oxygen decreases as a rule fairly regularly with increasing depth, as far as our observations go, and so does also as a rule the percentage of saturation. There are, however, exceptions. *E. g.* at Stat. 43 the amount of oxygen decreases very regularly with increasing depth from 100 metres downwards. The decrease is at first 0.09 cc. for hundred metres (between 100 and 200 metres), and then, between 200 and 400 metres, 0.09 cc. for 200 metres, and between 400 and 540 metres about 0.036 cc. per 100 metres. But at 50 metres the cold water contained less oxygen than the warmer water at 100 metres, and the percentage of saturation (89.6 %) was lower than at any greater depth where observations of the oxygen were taken.

This cold water at 50 metres evidently differs in its origin from the warmer waters of the underlying strata. It belongs to the cold intermediate layer mentioned above, and is polar water that has taken part in the vertical circulation during the winter and has been cooled by the radiation of heat from the surface, and by contact with ice. This cold polar water cannot therefore be expected to contain comparatively much oxygen, because in the winter, when this water was near the surface, there is little light, and where the sea is covered by ice (and snow) the sun is hindered from penetrating into the underlying water-layers and consequently very little phyto-plankton can be developed, even in the summer, as was proved during the Fram-Expedition 1893 to 1896. Where the water-layers receive admixture of water formed by the melting of ice we must also expect that their amounts of oxygen are somewhat reduced, because ice, and consequently also its melting-water, contain comparatively little oxygen.

At Stats. 56 and 57 the percentage of saturation was decreasing with increasing depth as far as our observations go, but the actual amount of oxygen in the sea-water was greater at 500 and 700 metres at Stat. 57 than at 100 metres at Stat. 56, although, to judge from the temperatures and salinities, there seemed to be approximately the same kind of water at the different levels at both stations (see Fig. 11). It seems therefore probable that in this region the actual amount of oxygen was distinctly greater at 500 metres, and even somewhat greater at 700 metres, than at 100 metres. But the temperature (4.47^0 C.) was much higher at the latter depth, and the water there (with salinity 35.02 $^0/_{00}$) had evidently been carried from the south by the Atlantic Current, while the water at 700 metres belonged to the upper layers of the regular deep-water of the Norwegian Sea, having the usual salinity of 34.91 $^0/_{00}$ and a temperature of 0.08^0 C.

The water at 500 meters, with a temperature of 1.22^0 C., might be expected to have been formed to some extent by an intermixture of the overlying Atlantic water with the underlying deep-water; but this is hardly possible, because its amount of oxygen (7.23 cc.) is considerably greater than those found both at 100 metres (6.75 cc.) and at 700 metres (6.96 cc.). It must evidently have come from some other part of the sea where it has been more or less intermixed with the upper layers, nearer the sea-surface.

The correctness of this view seems to be supported by the observations at Stat. 43 (80^0 20′ N.) north-west of Spitsbergen, where waters of much the same type, with temperatures between 1.36^0 C. and 1.83^0 C. and salinities between 34.83 $^0/_{00}$ and 34.92 $^0/_{00}$, were found at all depths between 100 and 540 metres, with amounts of oxygen decreasing from 7.35 to 7.12 cc. per liter. It is evidently also the same type of water that was observed at Stat. 18 (80° 2′ N.) at 210 metres (with 18.2° C., 39.91 ‰, and 7.14 cc.), and at Stat. 42 (80° 26′ N.) at 300 metres (1.87° C., 34.92 ‰, and 7.22 cc.).

This kind of water may probably be carried down to considerable depths by the vertical circulation during the winter in regions of the sea where conditions similar to those observed between 100 and 540 metres, at Stat. 43, also exist in the upper layers near the sea-surface, and the sea is not covered by ice, but has surface-temperatures above 1.5° C. in the winter. This water sinks to form extensive intermediate layers, with temperatures between 1° und 2° C. and salinities about 34.9 ‰, and is also carried in under the warmer water of the Atlantic Current (containing less oxygen) by the slant convection currents, that occur so universally in the sea [cf. Nansen, 1913, p. 19]. It is thus formed in the same manner as the underlying cold deep-water with much the same salinity, but with lower temperatures, mostly below 0° C.

As it was winter and little phyto-plankton when this water was near the sea-surface, its amount of oxygen was probably not very great, though it may certainly have been a good deal more than 7.35 cc. per liter, given by our observation at 100 metres, at Stat. 43. In the course of time the amount of oxygen is, however, gradually reduced by the animal plankton, and also by the oxidation occurring during the decomposition of the dead plankton sinking from above. In the same manner the amount of oxygen of the underlying colder *deep-water* is evidently also gradually diminished, and therefore we find that the amount of oxygen is decreasing very regularly with increasing depth in these intermediate and deep layers; and we found that the water of the typical deep-water, observed at Stat. 57 at 700 metres, had only 6.96 cc. of oxygen per liter.

According to our Table III, the minimum of oxygen given by our observations was 6.23 cc., found at Stat. 19 at 510 metres, where the degree of saturation was 80.0 %. It seems strange that the amount of oxygen should be so much smaller here than at 540 metres at Stat. 43 only a very short distance off, where it was 7.12 cc. (and 91.8 %), although the water seems to have been of the same kind at both places, with the same salinity (34.92 ‰) and similar temperatures (1.29° C. and 1.51° C.). At Stat. 57, at 500 metres, the water was also of exactly the same nature, with 1.22° C. and 34.92 ‰, but the amount of oxygen found was still greater, 7.23 cc. (92 6 %). These discrepancies may be due to errors in our results, and Mr. Gaarder, who made the determinations of oxygen, thinks it possible that 6.23 cc. for Stat. 19 (510 metres) is a slip of the pen for 7.23 cc. But unfortunately he cannot find the original journal of these titrations, and thus we cannot arrive at any certainty on this point.

Otherwise the lowest amounts of oxygen found by our observations were 6.79 cc. at Stat. 14 in Cross Bay, at 250 metres (1.35° C., 34.84 ‰), 6.93 cc. at Stat. 37 at 200 metres (1.71° C., 34.88 ‰), far north of Spitsbergen, and 6.96 cc. in the deep-water at Stat. 57 at 700 metres, besides 6.75 cc. in the warm water of the Atlantic Current at Stat. 56, at 100 metres (4.47° C., 35.02 ‰).

It seems a striking feature that the most north-eastern station is the one that gives, on the whole, the lowest amounts of oxygen (6.99 cc. at 50 metres, and 6.93 cc. at 200 metres). The explanation may possibly be that the water of these layers, examined at this station, has not for a long time been near the surface, which is covered by lighter water, and during a great part of the year also by ice. The water has probably come from the west and south, it may to some extent be intermixed with the warmer water of the Atlantic Current, and its oxygen may gradually have been reduced by the action of animal plankton and by oxidation due to the decomposition of sinking dead plankton.

Some Observations of the Hydrogen Ion Concentration in the Northern Sea-Water.

During the cruise with the Veslemöy in 1912, a number of measurements of the Hydrogen Ion concentration were also made at different stations by the colorimetric method of Sørensen and Palitzsch [see Palitzsch, 1911]. In most cases α-naphtolphtalein was used as indicator, giving blue reactions. When the value of the hydrogen ion exponent p_H was above 8.07, phenolphtalein was also used as indicator, giving red reaction.

The results of the observations are given in Table IV. The values of the hydrogen ion exponent, p_H, given in the 4th column, were found in the manner described by Mr. S. Palitzsch, and have been corrected for what he calls "the salt error".

As Mr. Gaarder has suggested, and Mr. Palitzsch has accepted, it would, however, be preferable in Oceanography to introduce, as expression for the reaction of the sea-water, not the value of p_H but the value of the concentration of hydroxyl ions, that increases with the alkalinity of the sea-water.

The values of $C_{OH'}$, *i. e.* the number of gram-equivalents of hydroxyl ions (OH') per liter of sea-water, corresponding to the values found for p_H, are therefore given in the 5th column of Table III; but for the sake of convenience the real values have been multiplied by 10^7.

As the writer had no experience in this colorimetric method before the cruise, and as some accidents happened to the apparatus during the cruise, the results ought not to be considered as very trustworthy, especially as the method in itself is not very accurate.

Mr. PALITZSCH found [1912a, p. 252] that the condition at some of the stations of the Danish expeditions 1908—1910 suggested a relation between the quantity of oxygen in the sea-water and its hydroxyl ion concentration (*i. e.* alkalinity), in this manner that a greater quantity of oxygen is accompanied by a higher hydroxyl ion concentration (or a lower hydrogen ion concentration). Similar conditions have been found by Mr. GAARDER by his numerous investigations in Norwegian fjords near Bergen, and by Prof. B. HELLAND-HANSEN in the northern Atlantic in 1913 [1914].

Our observations may seem to agree with these results, in so far that the hydroxyl ion concentration found shows, on the whole, a tendency to decrease with increasing depth from the surface downwards; but this does not seem always to coincide with the variations in the relative amount of oxygen. The latter was found to be specially great, with supersaturation, at 20 metres, and less near the surface. Our observations gave, however, in most cases a distinctly higher value of the hydroxyl ion concentration at the surface than at 20 metres.

It seems also strange that at Stat. 19 the hydroxyl ion concentration decreases gradually from the surface and down to 310 metres, but below that level it again increases with increasing depth.

The much lower values of the hydroxyl ion concentration given by our observations in the inner end of Cross Bay, at the Lilliehöök Glacier (in Porte Signe and at Stat. 13), as compared with those obtained at Stat. 14 half way out the fjord, are somewhat puzzling, and seem difficult to account for, if the differences may not be due to some observational error; but they are rather big for such a possibility.

TABLE I

gives the observations of the **Temperature, Salinity**, and **Density**, taken on board the Veslemöy, between July 10th and September 4th, 1912.

The heading for each Station gives the Number of the Station, the Date, the Latitude and Longitude, or in some cases a description of the locality.

1st Column. The Hour of the Observation, Central European Time.

2nd Column. Depth in Metres. A line under the number indicates bottom.

3rd Column. Instrument used. **B** = Bucket used for Surface-Water. **A** = The Automatic Insulating Water-Bottle. **I** = Stop-Cock Water-Bottle with the Richter reversing thermometers No. P.T.R. 37552 and No. 316 (where two temperatures are given the second one was taken with the latter thermometer). **II** = Stop-Cock Water-Bottle with the Richter reversing thermometers No. P.T.R. 37551 and P.T.R. 37544 (where two temperatures are given the second one was taken with the latter thermometer). **E.** An Ekman Reversing Water-Bottle with the Richter reversing thermometers No. P.T.R. 37546 and P.T.R 37548. Where two temperatures are given the second one was taken with the latter thermometer till July 29th, and later with the Richter reversing thermometer No. P.T.R. 37547. **RB** = The Reversing Stop-Cock Water-Bottle with the Richter reversing thermometer No. P.T.R. 37549. **PN** = The Pettersson Nansen Insulating Water-Bottle with the Nansen thermometer No. P.T.R. 37554 and the Richter reversing thermometer No. P.T.R. 37547 till July 29th, and later the Richter reversing thermometer No. P.T.R. 37548. When two temperatures are given with this water-bottle the second one was taken with the Richter thermometers, otherwise the temperatures were taken with the Nansen thermometer.

4th Column, $t°$ C. The corrected Temperature (Centigrade) of the Sea-Wa'er *in situ*, referred to the hygrogen thermometer.

5th Column, $S\,^0/_{00}$. Salinity in per mille. An asterisk after the number indicates that the salinity of the sample was determined (with the Interferometer) both by Mr. J. Helland, and by Mr. A. Øyan.

6th Column, σ_t. Density (*i. e.* 1000 $(S\frac{t}{0}-1)$) of the Sea-Water at the temperature *in situ* when the pressure is reduced to one atmosphere.

Stat. 1. July 10, 1912. 73° 57′ N, 20° 26′ E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
2.30 p. m.	0.5	A	3.25	34.51*	27.49
2.15 »	20	»	3.1	.54*	.53
2.00 »	47	»	0.3	.67*	.84
2.20 »	75	»	0.2	.74*	.90

Stat. 2. July 11, 1912. 74° 46′ N, 19° 3′ E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
5.45 p. m.	0.5	A	2.2	34.59*	27.65
5.30 »	26.5	»	1.3	.60*	.73
5.35 »	66	»	0.8	.69*	.83
6.55 »	ca. 90?	»	2.4	.90*	.88
6.45 »	ca. 100?	»	2.0	.86*	.88
6.35 »	[130]	»	[1.5]	[.69*]	[.78]
6.00 »	145				

Stat. 3. July 11, 1912. 74° 59′ N, 18° 47′ E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
9.15 p. m.	1	A	0.9	34.38*	27.58
9.0 »	20	»	0.7	.50*	.68
9.05 »	50	»	0.7	.53*	.71
0.10 »	60	»	0.7	.51*	.69

Stat. 4. July 12, 1912. 75° 13′ N, 18° 31′ E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
0.30 a. m.	1	A	0.8	34.42*	27.61
0.0 »	20	»	0.7	.50*	.68
0.05 »	50	»	0.75	.52*	.70

Stat. 5. July 16, 1912. At the mouth of the Ice Fjord, between Dödmanden and Cape Staratchin, much nearer the former. Depth, first 175 metres, later 150 metres.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
6.30 p. m.	0.5	A	2.8	31.34	25.00
5.55 »	20	»	3.1	33.52	27.20
6.0 »	50	»	0.6	.90*	26.72
6.05 »	100	»	−0.5	34.22*?	.53?
6.20 »	150	»	−0.45	.15*	.47

Stat. 6. July 18, 1912. Green Harbour, midway between the Telegraph Station and the western shore.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
12.35 p. m.	0.5	E	4.20	29.24	23.23
12.45 »	20	RB	2.81	33.49	26.27
12.00 noon	50	E	{ 0.28 / 0.28	34.27*	27.52
» »	75	II	−0.24	.40*	.66
» »	100	I	−0.56	.53*	.78
» »	140	RB	−0.73	.56*	.81
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Stat. 7. July 18, 1912. The mouth of Ice Fjord; near its southern side, just north of "Festningen".

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
3.40 p. m.	0.5	E	{ 4.09 / 4.09	30.44	24.18
» »	25	II	1.85	34.04*	27.30
» »	50	I	0.48	.32*	.55
» »	75	RB	−0.32	.43*	.69
3.00 »	100	E	{ −0.50 / −0.59	.43*	.70
» »	150	II	−0.53	.51*	.76
» »	200	I	−0.25	.62*	.83
	240				

Stat. 8. July 18, 1812. The mouth of Ice Fjord; about midway between "Festningen" and the shore between Alk Point and Dödmanden.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
5.35 p. m	0.5	E	{ 3.76 / 3.75		
» »	20	II	1.37		
» »	50	I	0.18	34.36*	27.60
4.50 »	100	E	{ −0.35 / −0.35		
» »	200	II	−0.93	.59*	.84
» »	300	I	0.78	.76*	.89
» »	380	RB	1.22	.83	.92
	400				

Stat. 9. July 18, 1912. The mouth of Ice Fjord; near the northern side (near Alk Point).

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
7.30 p. m.	0.5	I	2.98	32.93*	26.26
» »	50	RB	0.24	34.30*	27.55
6.40 »	100	E	{ −0.96 / −0.96	.50*	.77
» »	150	II	−0.85	.52	.78
» »	200	I	−0.93	.58*	.84
» »	400	RB	1.43	.86*	.92
	420				

Stat. 10. July 21, 1912. The mouth of Ice Fjord; midway between northern and southern side.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
3.15 p. m.	0	B	4.8	29.05	23.01
» »	20	E	{ 0.74 / 0.76	34.16	27.40
» »	50	II	−0.55	*	
» »	75	I	−0.41	.54	27.78
1.50 »	100	E	{ −0.42 / −0.43	.53	.77
» »	200	I	0.37	.71*	.87
» »	300	II	1.03	.78*	.89
4.25 »	400	PN	{ 1.08 / 1.09	.83	.92
	425				

* Lever stopper of glass-bottle broken.

Stat. 11. July 21, 1912. Near the northern side of the mouth of Ice Fjord.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
5.40 p. m	0	B	4.7	29.34	23.25
» »	50	E	{ 0.63 0.64	34.28	27.51
» »	100	II	−0.70	.45	.72
» »	200	I	0.61	.75	.89
» »	290	PN	0.82	.78	.90
	320				

Stat. 12. July 27, 1912. 78° 58′ N, 10° 0′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
9.45 p.m.	0	B	3.1	33.92	27.04
9.30 »	50	E	{ −0.10 −0.10	34.50	.73
» »	100	II	−0.20	.63	.84
» »	200	I	0.72	.77	.90
» »	240	PN	1.23	.84	.92
	250				

Stat. 13. July 29, 1912. Inner end of Cross Bay (Lilliehöök Bay). About 200 metres, and at last only 100 metres, from the vertical ice-wall of the Lilliehöök Glacier. Depth, first 114 metres, and nearer the glacier wall 140 metres.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
12.30 p. m.	0	B	0.3	34.20	27.46
» »	20	E	{ −0.04 −0.04	34.475	.70
» »	50	II	−0.25	.55	.78
» »	75	I	−0.20	.59	.81
» »	100	PN	0.32	.67	.84
1.30 »	130	PN	{ 1.03 1.05	.76	.87
	140				

Stat. 14. July 29, 1913. Cross Bay, just south of King Haakon Peninsula.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
4.00 p. m.	0	B	0.9	33.71	27.04
» »	50	E	{ −1.01 −1.02	34.51	.78
» »	100	II	−0.68	.59	.83
» »	200	I	1.12	.80	.90
» »	250	RB	1.35	.84	.91
» »	300	PN	{ 1.52 1.54	.90	.95
	314				

Stat. 15. July 29, 1912. 79° 5′ N, 10° 56′ E. Outside Cross Bay, off Cape Mitra.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
7.30 p. m.	0	B	2.5	32.75	26.16
» »	20	RB	−0.03	34.44	27.68
» »	50	E	{ −0.52 −0.55	.52	.77
» »	75	II	0.37	[.69][1]	[.85
» »	100	I	0.07	.66	.85
	135	PN	0.05	[2]	

[1] The India-rubber washer was broken.
[2] Bottle was broken.

Stat. 16. July 30, 1912. 79° 10′ N, 8° 34′ B.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
0.45 a. m.	0	B	2.9	33.98	27.11
» »	40	II	−0.03	34.51	.73
» »	90	I	1.07	.74	.85
» »	175	PN	{ 1.65 1.66	.88	.92
	185				

Stat. 17. July 30, 1912. 79° 13 N, 7° 1′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
4.40 a. m.	0	B	3.2	34.06*	27.14
» »	300	II	1.69	.95*	.97
» »	500	I	1.00	.906*	.99
» »	700	E	−0.16	.895*	28.05
» »	1100	PN	{ [−0.91] −1.07	{ .895 .895	[.085] .09
	1210				

Stat. 18. Aug. 3, 1912. 80° 2′ N, 11° 20′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
11.50 a. m	0	B	1.8	34.33	27.52
» »	60	II	1.56	.79	.86
» »	110	I	1.69	.82	.87
» »	210	E	1.82	.91	.93
» »	240	RB	1.83	.91	.93
	247				

Stat. 19. Aug. 3, 1912. 80° 18′ N, 10° 45′ E. In the ice.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
6.30 p. m.	0	B	0.8	33.06	26.52
7.50 »	0	B	0.75	33.06	26.52
» »	20	II	1.17	.56*	.89
» »	50	I	0.75	34.57*	27.74
» »	100	E	1.91	.86*	.89
» »	200	RB	1.90	.895*	.92
6.30 »	310	II	1.80	34.92*	27.94
» »	410	I	1.55	.93*	.97
» »	510	E	{ 1.29 1.30	[.98][1]	
» »	610	RB	0.90	{ .916* .90*	28.006 27.99
	623				

[1] The bottle was cracked.

Stat. 19 a. Aug. 3, 1912. Same place as Stat. 19. The ship was moored to an ice-floe.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	S ‰	σ_t
10.45 p. m.	0	B	0.8	33.09	26.55
11.00 »	10	E	1.15 1.17	.50	.85
10.45 »	20	II	1.28	.66*	.96
» »	50	I	1.27	34.58*	27.71
» »	75	E	0.99 0.99	.72*	.84

Stat. 19 b. Aug. 4, 1912. Moored to the same ice-floe.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	S ‰	σ_t
1.10 a. m.	10	E	1.16 1.17	33.48	26.83
1.00 »	20	E	1.16 1.18	.61*	.94
0.40 »	50	E	−0.41 −0.41	34.48*	27.73
0.50 »	75	E	0.48 0.49	.65*	.82
3.30 »	50	E	−0.89 −0.87	.43*	.71
2.00 »	626				

Stat. 19 c. Aug. 4, 1912. Mored to the same ice-floe.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	S ‰	σ_t
11.50 a. m.	0	B	0.1	32.59	26.19
» »	10	II	1.02	33.38	.76
» »	20	I	1.41	.70*	.99
» »	30	E	1.17 1.18	34.02*	27.27
0.15 p. m.	40	II	0.06	.05*	.35
11.00 a. m.	50	E	−1.48 −1.47	.38*	.71
0.15 p. m.	60	I	−1.56	.375*	.71
» »	80	E	0.27 0.28	.60*	.79
0.40 »	100	II	1.14	.73*	.84
» »	120	I	1.81	.82*	.86
» »	150	E	2.03 2.05	.90*	.91
1.45 »	620				

Stat. 19 d. Aug. 4, 1912. Moored to the same ice-floe.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	S ‰	σ_t
5.35 p. m.	0	B	−0.1	32.39	26.03
.55 »	20	E	1.42 1.44	33.88*	27.14
6.05 »	30	II	1.54	34.19[1]	.38
5.35 »	40	II	−1.45	.29	.63
6.05 »	50	I	−1.51	.38*	.71
5.35 »	60[2]	I	−1.04?	[.12*][2]	
6.05 »	70	E	0.19 0.21	.52*	.73
5.35 »	80[2]	E	−0.82? [−0.64]	[.36*][2]	[.66]

[1] Mr. Öyan got 34.45 ‰ and later 34.50 ‰, but the glass-bottle was then (February 1915) cracked.

[2] There has evidently been something wrong with these observations at 60 and 80 metres, taken by the same haul, at 5.35 p. m. The water-bottles may probably not have been released and closed in the proper depths but during the hauling up. In that case the temperatures at these two depths are also doubtful, and this may be the explanation of the considerable disagreement between the readings of the two thermometers of the Ekman Water-bottle at 80 metres, the thermometers did not get time to take the temperature at the depth where they happened to be reversed during the hauling up.

Stat. 19 e. Aug. 4, 1912. Moored to the same ice-floe.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	S ‰	σ_t
10.05 p. m.	40	II	−1.25	34.26*	27.60
» »	60	I	−0.74	.49*	.76
» »	80	E	0.78 0.79	.69*	.83
10.50 »	40	II	−1.25	.15*	.50
» »	60	I	−0.85	.48*	.75
» »	80	E	0.73 0.74	.69*	.83

Stat. 20. Aug. 5, 1912. Moored to another ice-floe, after having had to move about 5 miles towards ENE (magn.) from Stat. 19 e. We should then be in 80° 21′ N, 11° 10′ E, if we had not drifted in a south-westerly direction while a Stat. 19.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	S ‰	σ_t
11.30 a. m.	0	B	0.2	32.87	26.40
10.40 »	40	II	0.36	34.53*	27.73
» »	60	I	0.52	.66*	.82
» »	80	E	1.43 1.44	.79*	.87
» »	100	R. B.	1.83	.87*	.90
0.18 p. m.	572				

Stat. 20 a. Aug. 5, 1912. Moored to the same ice-floe.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
3.30 p. m.	40	II	0.72	34.60	27.76
» »	60	I	0.88	.71	.84
» »	80	E	1.62 1.65	.82	.87
» »	100	R. B.	1.86[1]	.88	.90
4.30 »	150	I	2.16	.91	.91
6.20 »	0	B	0.8	33.16	26.60
» »	5	II	0.86	.22	.70
» »	10	I	1.34	.76	27.04
» »	20	E	1.61 1.62	34.13	.32
» »	30	R. B.	1.06	.58	.73
5.40 »	50	R. B.	0.59	.69	.84
5.55 »	200	R. B.	2.12	.92	.92
3.10 »	575				
6.40 »	587				

[1] The journal gives 0.86° C., but that is probably a mistake for 1.86°.

Stat. 21. Aug. 6, 1912. 80° 4' N, 11° 30' E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
11.30 a. m.	0	B	1.7	33.97	27.19
0.20 »	10	A	1.8	34.08	.27
11.50 »	30	»	1.7	.72	.79
11.25 »	50	R. B.	1.70	.80	.86
11.55 »	100	A	2.1	.86	.87
0.11 »	140	II	1.86	.86	.89
0.20 »	200	E	1.63 1.66	[.75]	
	242				

Stat. 22. Aug. 6, 1912. 79° 58' N, 12° 13' E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
5.00 p. m.	0	B	2.0	34.25	27.29
» »	50	E	1.58 1.60	.39	.54
4.45 »	100	II	1.56	.47	.60
» »	150	E	1.57 1.57	.54	.66
	160				

Stat. 23. Aug. 6, 1912. 79° 56' N, 12° 45' E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
7.30 p. m.	0	B	1.9	34.32	27.46
.25 »	10	E	1.58 1.59	.34	.50
.20 »	20	E	1.57 1.59	.35	.51
.15 »	30	E	1.58 1.58	.35	.51
	32				

Stat. 24. Aug. 9, 1912. The mouth of Wood Bay; near the western side (Reindeer Land) 79° 44' N, 14° 8' E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
12.0 noon	0	B	3.1	31.94	25.46
» »	20	II	1.77	[34.50][1]	
0.20 p. m.	50	II	1.62	34.40	27.54
» »	100	E	1.13 1.13	.64	.77
» »	150	R. B.	1.35	.75	.84
	168				

[1] The bottle was cracked.

Stat. 25. Aug. 9, 1912. The mouth of Wood Bay; midway between western and eastern side. 79° 43' N, 14° 13' E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
1.05 p. m.	0	B	4.0	32.20	25.58
1.15 »	10	II	2.47	.60	26.04
» »	20	E	1.74 1.75	.82	.27
0.55 »	50	II	0.38	34.38	27.60
1.15 »	75	R. B.	0.85	.57	.73
0.55 »	100	E	1.31 1.33	.65	.76
» »	150	R. B.	1.12	.70	.82
	170				

Stat. 26. Aug. 9, 1912. The mouth of Wood Bay; near the eastern side.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
1.45 p. m.	0	B	3.2	31.97	25.48
1.50 »	10	II	2.78	32.59	26.00
» »	20	I	1.39	33.98	27.22
» »	50	E	0.65 0.65	34.43	.63
» »	75	R. B.	0.80	.56	.73
	90				

Stat. 27. Aug. 10, 1912. Wijde Bay; near western shore; outside Lake Valley. 79° 39½' N, 15° 25' E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
3.50 p. m.	0	B	1.7	32.60	26.10
4.15 »	10	E	1.71 [−0.61]	.90	.33
3.50 »	20	II	1.36	34.03	27.26
» »	50	I	1.14 1.15	.46	.62
4.15 »	75	R. B.	0.76	.48	.66
3.50 »	100	E	0.78 [−0.86]	.55	.72
» »	130	R. B.	0.73	.61	[illegible]
	143				

Stat. 28. Aug. 10, 1912. Wijde Bay; midway between Lake Valley and Steyle Hook. 79° 40½' N, 15° 32' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
5.00 p. m.	0	B	1.95	32.59	26.07
» »	20	E	1.75 [−0.57]	33.09	26.49
» »	50	II	1.31	34.31	27.49
» »	100	I	0.64	.57*	.74
» »	125	R. B.	0.82	.63	.78
	138				

Stat. 29. Aug. 10, 1912. Wijde Bay, near Steyle Hook on the western side. 79° 41½' N, 15° 40' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
6.00 p. m.	0	B	1.9	32.49*	26.00
6.10 »	20	II	1.58	33.20*	.59
» »	50	I	0.46	34.40	27.62
» »	100	E	−0.12 −0.12	.52*	.75
» »	130	R. B.	−0.10	.56*	.78
	147				

Stat. 30. Aug. 11, 1912. Outside mouth of Hinlopen Strait. 80° 7' N, 17° 8' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
1.15 a. m.	0	B	−1.0	33.27*	26.78
2.00 »	20	II	−0.75	.77*	27.16
» »	50	I	−0.60	34.00*	.35
» »	100	E	0.61 [−1.72]	.37	.58
» »	150	R. B.	1.21	.72*	.83
1.15 »	200	II	1.64	.85*	.90
» »	300	I	1.75	.86*	.90
» »	400	E	1.61 [−0.52]	.893* .893*	.94 .94
» »	440	R. B.	1.62	.89 .895*	.93 .94
	456				

Stat. 31. Aug. 13, 1912. 3 miles NNE (magn.) of Verlegen Hook. 80° 6' N, 16° 34' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
10.15 a. m	0	B	0.8	33.02*	26.49
» »	10	II	0.81	.25*	.68
» »	20	I	0.21	34.10*	27.39
» »	40	R. B.	1.25	.33	.51
	48				

Stat. 32. Aug. 13, 1912. 80° 11' N, 16° 40' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
0.15 p. m.	0	B	0.90	32.93*	26.41
» »	20	II	0.87	33.25*	.67
» »	50	I	1.19	34.54	27.68
» »	100	E	1.48 [−1.54]	.76*	.84
» »	210	R. B.	1.69	.90*	.94
	238				

Stat. 33. Aug. 13, 1912. 80° 15' N, 16° 48' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
1.50 p. m.	0	B	1.8	33.05	26.45
2.00 »	50	II	1.28	34.40*	27.56
» »	100	I	1.45	.73*	.82
» »	200	E	1.69 [−1.53]	.85*	.90
» »	260	R. B.	1.69	.875*	.92
	274				

Stat. 34. Aug. 13, 1912. 80° 23' N, 16° 50' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
4.20 p. m.	0	B	0.3	33.14	26.62
4.45 »	50	II	−0.45	.87*	27.23
» »	100	I	0.96	34.57*	.72
» »	200	E	1.25 1.23		
	240				

Stat. 35. Aug. 13, 1912. 80° 39' N, 17° 14' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
9.00 p. m.	0	B	0.6	32.79*	26.32
» »	50	R. B.	0.07	33.97	27.29
9.05 »	100	R. B.	0.81	34.64*	.79
9.10 »	150	R. B.	1.30	.79	.88
	160				

Stat. 36. Aug. 13 & 14, 1912. 80° 36' N, 16° 17' E.

Hour	Depth in Metres	Instrument	Corr. t° C.	S ‰	σ_t
11.45 p. m.	0	B	−0.7	32.25	25.94
11.50 »	20	R. B.	0.40	33.11	26.58
0.45 a. m.	50	II	1.23	34.27*	27.46
» »	100	I	1 37	.795*	.88
» »	150	E	1.46 1.49	.82*	.89
» »	200	R. B.	1.71	.89*	.93
0.15 »	300	II	1.72	.90*	.93
» »	400	I	1.68	.91* .91*	.95
» »	500	E	1.41 1.40	.93* .925*	.98
» »	580	R. B.	0.43	.906* .904*	28.026 .024
	620				

Stat. 37. Aug. 14, 1[illegible]2. 80° 24′ N., 15° 32′ E.

Hour	Depth in Metres	Instrumen[illegible]	Corr. t° C.	$S\,^0/_{00}$	σ_t
1.15 p. m.	0	E	—0.9	31.98	25.73
2.15 »	20	I	1.12	33.65*	26.97
1.00 »	50	I[illegible]	1.50	34.64	27.74
» »	100	[illegible]	1.67	.82	.87
» »	200	[illegible]	1.71 1.72	.88	.92
» »	230	R.[illegible]	1.70	.895	.93
	246				

Stat. 38. Aug. 14, 1912. 80° 11′ N., 15° 40′ E.

Hour	Depth in Metres	Instrument	Corr. t° C.	$S\,^0/_{00}$	σ_t
8.10 p. m.	0	B	0.2	32.25	25.90
» »	20	II	1.37	33.41*	26.81
» »	50	I	1.56	34.53	27.65
» »	75	E	1.47 1.49		
8.30 »	75	E	1.52 1.53		
8.10 »	100	R. B.	1.61		
8.30 »	100	R. B.	1.62	34.84	27.89
	107				

Stat. 39. Aug. 15, 1912. 80° 5′ N., 15° 33′ E.

Hour	Depth in Metres	Instrument	Corr. t° C.	$S\,^0/_{00}$	σ_t
6.30 p. m.	0	B	1.0	32.72	26.24
» »	10	II	1.03	33.60	.94
» »	40	I	1.28	34.19	27.40
» »	90	E	1.41 1.42	[.20][1]	[.40]
» »	130	[illegible]. B.	1.46	.68	.78
	150				

[1] The sample [illegible]t trustworthy, as the water-bottle was [illegible] perfectly closed when it came up.

Stat. 40. Aug. 17, 1912. 80° 23.5′ N., 11° 58′ E.

Hour	Depth in Metres	Instrument	Corr. t° C.	$S\,^0/_{00}$	σ_t
9.45 p. m.	0	B	2.9	34.01*	27.13
» »	20	R. B.	2.73	.04*	.16
» »	50	II	1.05	.55*	.70
» »	100	I	1.29	.73*	.83
» »	150	E	1.45 1.48	.81*	.88
	455				

Stat. 41. Aug. 17, 1912. 80° 29′ N., 12° 00′ E. In the ice.

Hour	Depth in Metres	Instrument	Corr. t° C.	$S\,^0/_{00}$	σ_t
11.30 p. m.	0	B	—0.7	31.91	25.67
» »	200	R. B.	2.22	34.92*	27.91
» »	300	II	2.02	.94*	.94
» »	400	I	1.54	.93*	.97
» »	530	E	1.08 1.08	.91*	.99
11.00 »	540				

Stat. 41 a. Aug. 18, 1912. 80° 27′ N., 12° 00′ E. Moored to an ice-floe.

Hour	Depth in Metres	Instrument	Corr. t° C.	$S\,^0/_{00}$	σ_t
1.15 a. m.	0	B	—0.1	32.14	25.82
» »	10	R. B.	0.12	32.25	.90
» »	20	II	1.11	34.11*	27.34
» »	50	I	0.85	.60*	.76
» »	100	E	2.89 2.92	.92*	.85
0.45 »	498				

Stat. 41 b. Aug. 19, 1912. Moored to the same ice-floe as at Stat. 41 a.

Hour	Depth in Metres	Instrument	Corr. t° C.	$S\,^0/_{00}$	σ_t
10.00 a. m.	0	B	—0.5	31.89	25.64
» »	50	R. B.	2.21	34.815	27.83
» »	100	II	2.85	.95*	.88
» »	200	I	1.80	.90*	.93
» »	330	E	1.67 1.71	.94*	.97
8.30 »	375				

Stat. 41 c. Aug. 19, 1912. Moored to the same ice-floe as at Stat. 41 a.

Hour	Depth in Metres	Instrument	Corr. t° C.	$S\,^0/_{00}$	σ_t
2.55 p. m.	0	B	0.3	32.22	25.88
3.20 »	5	R. B.	0.54	.32	.94
» »	10	II	2.36	33.35	26.65
» »	20	I	1.54	.99	27.22
» »	50	E	0.83 0.82	34.65	.80
2.55 »	100	R. B.	2.87	.95*	.88
» »	200	II	2.19	.93*	.92
» »	300	I	1.89	.94*	.95
» »	400	E	1.48 1.47	.92*	.97
1.00 »	436				
4.45 »	5	P. N.	1.82 1.72		
5.00 »	10	»	1.91		
5.15 »	20	»	2.15 2.11		
5.30 »	50	»	—0.13 —0.09		
5.50 »	100	»	3.11 3.12		

Stat. 42. Aug. 19, 1912. In the open sea a few hundred metres outside the ice-edge where the observations at Stat. 41 c were taken.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,°/_{00}$	σ_t
7.40 p. m.	20	R. B.	3.80	34.08	27.10
„ „	50	II	2.82	.71	.69
„ „	75	I	3.14	.89	.80
„ „	100[1]	E	2.27? 2.28?	[.57]	
„ „	200[1]	P. N.	2.17? 2.47?	.89*?	.89?
7.00 „	300	P. N.	1.87 1.87	.92*	.94

[1] The messenger-lead was not heard to strike deeper than at 75 metres. The line was then several times hauled up a few metres and let down again, but the striking of the messenger at 100 and 200 metres was not heard. Thus it is possible that the water-bottles at 100 and 200 metres may have been closed at some higher level during the hauling up.

Stat. 43. Aug. 20, 1912. 80° 20′ N., 10° 4′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,°/_{00}$	σ_t
1.00 p. m.	0	B	−0.6	31.13	25.03
„ „	50	R. B.	−0.39	34.43	27.69
„ „	100	II	1.79	.83*	.87
„ „	200	I	1.83	.90	.93
„ „	400	E	1.35 1.38	.91*	.97
„ „	540	P. N.	1.51[1]	.916*	.96
	565				

[1] The reversing thermometer did not register, and this temperature, given by the Nansen thermometer, is evidently too high, giving too low density. The hauling up of the water-bottle may have lasted so long that its insulation was spoilt, or it may have been closed at some higher level, but this seems less probable.

Stat. 44. Aug. 24, 1912. The mouth of the Ice-Fjord; about midway between northern and southern side. The fjord full of ice, the vessel was lying between the floes.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,°/_{00}$	σ_t
9.50 a. m.	0	B	0.8	31.88	25.58
10.20 „	5	II	1.02	.99	.70
„ „	10	I	1.59	32.16	.75
„ „	20	P. N.	[0.79] 0.89	.75	26.28
9.50 „	20	R. B.	1.45	.77	.25
„ „	50	II	0.62	33.94*	27.23
„ „	100	I	−0.16	34.40	.65
„ „	200	E	−0.12	.62	.82
„ „	380	P. N.	0.74 0.76	.76*	.89
	418				

Stat. 45. Aug. 26, 1912 In Ice Fjord; near the southern side, just east of Green Harbour.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,°/_{00}$	σ_t
0.45 p. m.	0	B	1.2	31.31	25.10
„ „	10	R. B.	2.07	32.32*	.84
„ „	20	II	1.64	.88*	26.32
„ „	50	I	0.85	33.68	27.01
„ „	100	E	−0.26 −0.26	34.47	.71
„ „	170	P. N.	−0.12 −0.12	.62	.83
	194				

Stat. 46. Aug. 26, 1912. In Ice-Fjord; outside the mouth of Advent Bay.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,°/_{00}$	σ_t
3.50 p. m.	0	B	3.1	32.44*	25.85
„ „	10	R. B.	2.22	33.36	26.67
„ „	20	II	0.81	.84	27.14
„ „	50	I	0.25	34.24	.50
„ „	100	E	−0.46 [−1.09]	.51	.76
„ „	140	P. N.	−0.74 −0.74	.56	.81
	159				

Stat. 47. Aug. 29, 1912. The mouth of Ice Fjord, near its southern side, just north of „Festningen" (cf. Stat. 7).

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\,°/_{00}$	σ_t
8.15 a. m.	0	B	1.1	32.39	25.97
„ „	10	R. B.	0.51	.61	26.17
„ „	20	II	0.53 0.52	33.17*	.62
„ „	50	I	0.85 0.84	.95*	27.23
„ „	100	E	−0.24 −0.25	34.43	27.68
„ „	230[1]	P. N.	[0.97][1] 0.57[1]	.59*[1]	.76[1]
	256				

[1] The observations at this depth seem doubtful. It is strange that the readings of the Nansen thermometer and the reversing thermometer do not agree, which might indicate that the water-bottle has not been closed properly at 230 metres, but during the hauling up. The salinity (and density) is also remarkably low.

Stat. 48. Aug. 29, 1912. The mouth of Ice Fjord, about midway between „Festningen“ and Dødmanden, somewhat nearer the latter.

Hour	Depth in metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
9.30 a. m.	0	B	2.1	32.17	25.72
" "	20	R. B.	0.10	33.25	26.68
9.45 "	50	E	0.49	34.12	27.39
" "	100	II	−0.33 −0.34	.45*	.70
" "	200	I	−0.22 −0.23	.64*	.85
10.30 "	250	E	0.58 0.62	.72*	.87
" "	300	II	0.82 0.81	.75*	.88
" "	350	I	0.88 0.87	.77*	.89
" "	380	P. N.	1.00	.79*	.90
9.45 "	400[1]	P. N.	[−0.19] [−0.11]	[.65*]	[.85]
	426				

[1] Temperature and salinity prove that this depth must be wrong. It was not heard that the water-bottle was closed when the messenger was sent down. The bottle may either have been lying on the bottom, or there may have been some other irregularity, and the bottle has been closed during the hauling up, probably somewhere near 200 metres.

Stat. 49. Aug. 29, 1912. Outside the mouth of Ice Fjord. 78° 5′ N., 13° 12′ E.

Hour	Depth in metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
2.40 p. m.	0	B	2.2	32.12	25.68
2.45 "	20	E	1.10 1.12	33.04	26.49
" "	50	II	2.47 2.46	34.03*	27.18
" "	100	I	−0.22 −0.23	.38	.64
" "	200	R. B.	0.30	.67	.84
	242				

Stat. 50. Aug. 30, 1912. Bell Sound (Van Mijen Bay), inside Axel Island, a little north of midway between northern and southern side. 74° 44′ N., 15° E.

Hour	Depth in metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
2.00 p. m.	0	B	0.2	32.45	26.06
2.30 "	10	II	0.38 0.37	.53	.12
2.00 "	20	E	0.62	.85	.37
2.30 "	50	E	0.19 0.19	33.25	.71
2.00 "	70	I	0.04 0.03	.42	.85
" "	90	R. B.	−1.06	34.25	27.58
2.30 "	90	I	−0.53 −0.54		
" "	100	R. B.	−1.24	.25	.59
	110				

Stat. 51. Aug. 31, 1912. Bell Sound (Van Mijen Bay), midway between northern and southern side, farther in than Stat. 50. 77° 46′ N., 15° 25′ E.

Hour	Depth in metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
2.50 p. m.	0	B	0.1	31.67	25.45
" "	20	E	0.03 0.03	32.73	26.30
" "	50	II	0.18 0.17	33.21	.67
" "	70	I	−0.22 −0.22	.67	27.06
" "	95	R. B.	−1.20	34.24	.58
	105				

Stat. 52. Aug. 31, 1912. Bell Sound, outside Axel Island. 77° 41′ N., 14° 34′ E.

Hour	Depth in metres	Instrument	Corr. $t°$ C.	$S\,^0/_{00}$	σ_t
5.30 p. m.	0	B	−0.1	32.77	26.33
" "	20	E	0.36 [0.20]	33.38	.80
" "	50	II	0.18 0.16	34.25	27.51
" "	70	I	−0.09 −0.09	.43	.67
" "	110	R. B.	0.21	.64	.82
	120				

Stat. 53. Aug. 31, 1912. Outside Bell Sound, west of Cape Lyell. 77° 33′ N., 13° 28′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
9.00 p. m.	0	B	−0.3	32.17	25.86
" "	20	E	1.65 1.64	[34.38]	
9.30 "	20	II	1.11 1.03?		
9.00 "	50	II	0.09 0.07	34.16	27.44
9.30 "	50	I	−0.02 −0.03		
9.00 "	100	I	1.04 1.03	.61	.75
9.30 "	100	R. B.	1.03		
9.00 "	130	R. B.	0.67	.68	.83
	146				

Sept. 1, 1912. 77° 18′ N., 13° 51′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
0.00 a. m.	0	B	0.2	33.51	26.92

Stat. 54. Sept. 1, 1912. Outside Horn Sound. 76° 57′ N., 15° E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
4.35 a. m.	0	B	−0.5	33.07	26.59
" "	20	E	−0.24 −0.23	.27	.74
" "	50	II	−1.07 −1.08	34.25	27.58
" "	85	I	−1.19 −1.18	.46	.75
" "	110	R. B.	−0.98	.54	.81
	125				

76° 52′ N., 14° 50′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
6.00 a. m.	0	B	−0.3	32.52	26.14

Stat. 55. Sept. 1, 1912. 76° 40′ N., 14° 25′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
8.10 a. m.	0	B	−0.6	32.96	26.51
" "	20	E	−0.54 −0.55	.99	.53
" "	50	II	−1.25 −1.26	34.36	27.68
" "	100	I	0.57 0.57	.76	.90
" "	130	R. B.	0.54	.80	.94
	146				

76° 31′ N., 14° 7′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
10.00 a. m.	0	B	−0.3	32.88	26.43

Stat. 56. Sept. 1, 1912. 76° 22′ N., 13° 25′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
0.15 p. m.	0	B	2.8	33.76	26.94
1.00 "	20	E	4.28 4.31	34.43	27.32
" "	50	II	5.45 5.46	.90	.56
" "	100	I	4.48 4.46	35.02	.77
1.40 "	200	E	3.37 3.38	.01	.88
" "	300	E	2.72 2.73	34.97*	.91
0.15 "	500	II	1.63 1.61	.91*	.95
" "	[700][1]	I	[5.38] [5.37]	[.95]	
1.40 "	[700][1]	II	[2.86] [2.86]	[35.00]	
0.15 "	[900][1]	R. B.	[3.43]	[0.1*]	
	1020				

76° 12′ N., 13° 31′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
4.20 p. m.	0	B	5.0	34.93	27.64

76° 3′ N., 13° 14′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
6.10 p. m.	0	B	4.4	34.62	27.46

[1] These observations are wrong. The messenger was not heard striking at these depths, and the water-bottles have evidently been released during the hauling up at depths between 50 and 300 metres as is proved by the temperatures and salinities.

Stat. 57. Sept. 1, 1912. 75° 58′ N., 13° 5′ E.

Hour	Depth in Metres	Instrument	Corr. $t°$ C.	$S\ ^0/_{00}$	σ_t
7.00 p. m.	0	B	5.1	34.94	27.64
" "	50	E	5.24 5.28	.96	.64
" "	100	II	3.92 3.92	35.04*	.85
" "	200	I	3.06 3.06	.02*	.91
" "	300	R. B.	2.28	.00	.97
7.45 "	400	E	1.68 1.71	[.18][1]	
" "	500	II	1.22 1.21	34.92*	.99
" "	700	I	0.09 0.07	.91*	.05
" "	900	R. B.	−0.84	.896* .894*	.08

[1] The glass-bottle was cracked.

SURFACE OBSERVATIONS

Date and Hour	Lat. N	Long. E	$t°$ C.	$S^0/_{00}$	σ_t
Sept. 1					
9.30 p. m.	75° 51′ N	13° 9′ E	4.8	34.93*	27.66
11.00 „	41′	14′	5.3	.98*	.64
Sept. 2					
4.30 a. m.	75° 9′	13° 36′	5.6	35.02*	27.64
8.00 „	74° 49′	47′	5.3	.02*	.68
1.00 p. m.	20′	14° 3′	5.9	.01*	.60
4.00 „	1′	12′	6.0	.01*	.58
10.00 „	73° 27′	28′	6.0	.02*	.59
Sept. 3					
6.00 a. m.	72° 43′	14° 50′	6.8	34.99*	27.46
1.00 p. m.	14′	15° 4′	8.0	.85*	.18
3.00 „	71° 59′	11′	7.9	.89	.22
8.30 „	36′	21′	7.2	.70	.17
Sept. 4					
0.00 a. m.	71° 19′	15° 28′	7.6	34.89*	27.27
5.00 „	70° 58′	36′	8.5	.85*	.10
8.00 „	44′	41′	8.9	.80*	.00
0.00 p. m.	24′	49′	9.0	.45	26.71
4.00 „	4′	57′	8.8	.89*	27.08
8.00 „	69° 48′	16° 3′	8.8	.56	26.83
Sept. 5					
8.00 a. m.	69° 28′	16° 20′ E	8.0	34.32	26.76

TABLE II

gives the **Current-Measurements**, taken on board the Veslemøy, in August, 1912.

1st Column. Date, Hour, and Duration of the measurements. Central European Time.

2nd Column. Depth in Metres. A line under the number indicates bottom.

3rd Column. Number of Current-meter used.

4th Column. Number of Revolutions of the Propellor registered.

5th Column. Velocity, in cm. per second, of the Relative Movement, computed from the reading of the instrument.

6th Column. Number of Balls fallen in the Compass Box, and Directions (magnetic) registered, *from* which the water moved relatively to the ship.

7th Column. Depth in Metres of the Real Current (or Drift) observed.

8th Column. Velocity, in cm. per second, of the Real Current, computed from the measurements.

9th Column. Direction (true) *towards* which the Real Current moved, as computed from the measurements.

Date and Hour 1912	Depth in Metres	Instru-ment	Revol-utions	cm./sec.	Number of Balls, and Direction	Current: Depth in Metres	Current: Velocity cm./sec.	Current: True Direction (towards)
4 August								
1.42—1.52 a. m.	20[1]	49	295	13.8	1 N 20° E 7 N 30° E			
2.00 »	626							
2.30—2.50 »	560	49	620	14.3	2 N 10° W 2 N 3 N 10° E 2 N 20° E	0	14	N 7° W
» » »	50	52	10	1	0	50	14	N 7° W
11.25—11.35 a. m.	50	49	0	0	0			
» » »	50	52	0	0	0			
0.19—0.39 p. m.	50	49	0	0	0			
0.46—1.06 »	100	49	134	4	3 S 60° W 1 N 80° W[2] 2 N 60° W[2]			
1.45 »	620[3]							
2.00—2.30 »	600	49	816	12.7	1 S 20° W 3 S 30° W 3 S 70° W 7 S 80° W	0	12.7	S 50° W
» » »	50	52	819	12.9	4 S 30° W 6 S 40° W 3 S 50° W	50	5.1	N 39° W
3.13—3.23 »	50	49	300	13.9	1 S 50° E? 4 S 20° W 5 S 30° W			
» » »	20[4]	52	501	23	9 S 10° W 3 S 20° W			
3.41—3.51 »	50	49	192	9.2	3 S 20° W 1 S 30° W 1 S 50° W			
» » »	20	52	314	14.7	3 S 50° W 5 S 60° W			
4.06—5.06 »	50	49	740	6.3	1 S 20° W 2 S 30° W 1 S 40° W 6 S 50° W 2 S 60° W 2 S 70° W			
» » »	10	52	1920	15	1 S 12 S 20° W			
5.27—5.37 »	100	49	180[5]	8.7	2 S 30° E 1 S 20° E 1 S 10° E			
6.20—6.40 »	560	49	10	1.1	1 S 30° W	0	1.1	S 17° W
» » »	50	52	74	2.5	1 S	50	1.6	N 32° W
7.09—7.19 »	20	49	256	12	4 S 30° E 3 S 20° E			

1 This depth may possibly have been 50 metres instead of 20 metres.
2 These balls may be doubtful as by an accident the propellor was turned by the wind about 60 revolutions after the instrument came on deck.
3 The sounding-line was deflected towards NE by E (magnetic).
4 This depth may possibly have been 10 metres instead of 20 metres.
5 The instrument registered 920 revolutions, giving a velocity of 40.9 cm. per second, which is evidently much too high and does not agree with the four balls fallen in the compass box. It had probably been forgotten to adjust the registration of the instrument after the previous observation (at 4.06—5.06 p. m.), and 740 has therefore to be substracted, giving 180 revolutions, which also agrees with the number of balls (4) fallen in the compass box.

Date and Hour 1912	Depth in Metres	Instru-ment	Revol-utions	cm./sec.	Number of Balls, and Direction	Current		
						Depth in Metres	Velocity cm./sec.	True Direction (towards)
4 August								
7.09—7.19 p. m.	10	52	386	17.7	5 S 90° E 7 S 80° E			
9.20—9.30 »	560	49	146	7.3	3 S 1 S 10° W	0	7.3	S 11° E
» »	50	52	73	4	1 S 80° E	50	7.8	S 19° W
5 August								
0.18 p. m.	572							
0.28 »	613	m. line paid out			sounding-line deflected towards N 39° E	0	36.7	S 26° W
0.38 »	658	» » » »				0	17.2	»
0.48 »	723	» » » »				0	19.5	»
0.58 »	782	» » » »				0	15.0	»
1.08 »	905	» » » »				0	27.2	»
1.18 »	1001	» » » »				0	20.17	»
						Mean	22.6	
0.28—0.38 »	50	49	221	10.4	2 S 80° W 1 S 90° W 1 N 70° W 1 N 60° W 2 N 10° W	50	15.4	S 6° E
0.56—1.06 »	10	49	240	11.2	2 S 90° E 3 S 80° E 2 S 60° E			
1.13—1.25 »	20	49	370	14.3	2 N 40° E 1 N 50° E 1 N 60° E 2 N 70° E 1 N 80° E 3 S 90° E 1 S 60° E			
1.31½—2.12 »	50	49	428	5.6	3 N 90° W 6 N 80° W 1 N 50° E 1 N 60° E 2 N 70° E			
3.02—3.12 »	10	49	0	0	0			
3.16—3.26 »	20	49	0	0	0			
3.29—3.39 »	50	49	0	0	0			
3.45—3.55 »	100	49	0	0	0			
4.11—4.21 »	540	49	0	0	0	0	0	0
4.58—5.30 »	200	49	1226	17.5	4 S 10° W 6 S 20° W 1 S 30° W			
3.10 »	575							
3.20 »	591	m. line paid out			sounding-line deflected towards N 34° E	0	21.3	S 21° W
3.30 »	700	» » » »				0	44.92	»
3.40 »	785	» » » »				0	22.5	»
3.50 »	880	» » » »				0	21.7	»
4.00 »	1025	» » » »				0	30.4	»
4.10 »	1100	» » » »				0	15.0	»
4.20 »	1220	» » » »				0	23.4	»
						Mean	25.6	
5.57—6.02½ »[1]	20	49	290	23.8	5 S 30° W 2 S 40° W			
6.19—6.29¼ »	520	49	342	15.3	6 S 20° W 4 S 30° W	0	15.3	S 11° W

[1] The wind increased and became SSW after having been W by S (magn.) earlier in the day. It increased probably to about 5 or 6 metres per second.

Date and Hour 1912	Depth in Metres	Instrument	Revolutions	cm./sec.	Number of Balls, and Direction	Current: Depth in Metres	Current: Velocity cm./sec.	Current: True Direction (towards)
5 August								
6.40 p. m.	587[1]							
6.50 »	[682] m. line paid out, but too much therefore hauled in again till tight.				Sounding-line deflected towards N 39° E			
7.05 »	661 m. line paid out					0	20.1	S 26° W
7.10 »	672 » » » »					0	7.7	»
7.20 »	703 » » » »						10.0	»
7.30 »	732 » » » »						8.8	»
7.40 »	767 » » » »						8.8	»
7.50 »	783 The lead has evidently been dragged along the bottom[2]						3.0?	»
8.00 »	783							
8.10 »	783							
8.20 »	783							
7.25—·735 »	50	49	515	23.2	3 S 70° W 12 S 80° W			
» » »	20	53	300	14.7	7 N 80° W			
7.47—7.52 »	100	49	204	18.6	5 S 70° W			
» » »	10	53	153	15	3 N 40° W 2 N 30° W			
8.15½—8.22 »	20	49	206	14.6	3 N 2 N 10° E 1 S 40° W?			
» » »[3]	5	53	265	19.3	1 N 1 N 30° E 6 N 40° E			
8.46—8.56 »	200	49	126	6.4	1 S 30° W 2 S 40° W 1 S 60° W			
8.47—8.57 »	20	53	130	7.2	1 N 10° W 1 N 40° E 1 N 50° E 1 N 60° E			
9.16—10.01 »	520	49	1060	11.2	4 S 60° W 8 S 70° W 1 S 80° W	0	11.2	S 55° W
» » »[4]	50	53	1662	17.7	5 N 50° W 4 N 40° W 4 N 30° W 1 N 20° W	50	16.7	S 20° E
10.31—10.41 »	20	49	545	24.4	1 N 40° E 8 N 50° E 3 N 60° E			
» » »	20	53	510	24	7 N 40° E 6 N 50° E			
11.01—11.34½ »	520	49	732	10.4	2 S 30° E 1 S 20° E 5 S 10° E 2 S 1 S 30° W 1 S 40° W	0	10.4	S 18° E

[1] This sounding and measurement of surface-drift was made with a lead of 20 kilogram and single steel-wire (piano-wire).
[2] During the hauling up, the steel-wire snapped, and the lead was lost.
[3] The ice became closer by this time.
[4] The ice was fairly open.

Date and Hour 1912	Depth in Metres	Instrument	Revolutions	cm./sec.	Number of Balls, and Direction	Current		
						Depth in Metres	Velocity cm./sec.	True Direction (towards)
5 August								
11.01-11.34½ p. m.	200	53	674	10.2	4 S 60° E	200	7.2	S 50° W
					4 S 50° E			
					2 S 40° E			
					1 S 30° E			
					1 S			
					1 N 60° W			
6 August								
0.41—0.46 a. m.	50	49	275	24.8	6 S 50° E			
					1 S 30° E			
» » »	10	53	330	30.6	1 S 80° E			
					4 S 70° E			
					3 S 60° E			
18 August								
0.45 a. m.	498[1]							
1.45—1.55 »	470	49	582[2]	26	1 N 40° E	0	26	N 33° E
					1 N 50° E			
» » »	20	53	664	31	3 N 40° E	20	5.3	S 52° W
					12 N 50° E			
2.31—2.41 »	470	49	480	21	14 N 90° E	0	21	N 78° E
» » »	50	53	189	10	4 S 90° E	50	11	N 76° E
					1 S 80° E			
3.04—3.14 »	450	49	522	23.5	13 S 70° E	0	23.5	S 82° E
» » »	100	53	255	13	6 S 50° E	100	12.2	N 76° E
					1 S 40° E			
3.37—3.47 »	450	49	430	19.5	6 S 60° E	0	19	S 64° E
					4 S 50° E			
					1 S 10° E			
» » »	20	53	586	27.5	13 S 30° E	20	12.5	N 4° W
					1 S 20° E			
3.58—4.08 »	10	53	380	18	7 S	10	7.5	N 24° E
					3 S 10° W			
4.14—4.24 »[3]	450	49	301	14	1 S 60° E	0	11	S 2° E
					1 S 30° E			
					2 S 10° E			
					2 S 10° W			
					1 S 20° W			
					1 S 30° W			
					1 S 40° W			
					1 N 80° W			
» » »	50	53	232	12	4 S 80° E	50	15.5	S 48° W
					3 S 70° E			

1 During the following 10 minutes 37 metres line more had to be paid out (so that 535 metres line was out). This would correspond to a drift of about 35 cm. per second, provided that the line was kept perfectly straight between the ship and the lead lying on the bottom, which, however, could not be the case. The direction of the deflection of the line could not be seen for the ice.

2 This high number of revolutions does not agree with the fact that two balls only had fallen in the compass box, which correspond to about 82 revolutions. If we assume that something has unduely increased the registered number of revolutions, and that the number given by the balls is more correct, we would obtain a velocity of 4.7 cm. per second. It might, however, seem more probable that something has happened to the balls, preventing more balls from falling.

3 The ice now became slacker.

Date and Hour 1912	Depth in Metres	Instru-ment	Revol-utions	cm./sec.	Number of Balls, and Direction	Current: Depth in Metres	Current: Velocity cm./sec.	Current: True Direction (towards)
18 August								
7.00—7.10 a. m.	340[1]	49	340(?)	16 (?)	[1 N 20° W][1]	0	16 (?)	S 33° W (?)
» » »	20	53	1054	48.5	2 S	20	32	N 28° W
					5 S 10° W			
					7 S 20° W			
7.15 »	340							
7.21—7.31 »	10	53	710	28.5	1 N 40° W			
					1 N 30° E			
					1 N 80° E			
					1 S 60° E			
7.48—7.58 »	300	49	852	38	6 S 60° W	0	38	S 53° W
					7 S 70° W			
» » »	50	53	578	27	4 S 50° W	50	13.8	S 84° W
8.52—8.57 »	300	49	364	32.5	10 S 80° W	0	32.5	S 68° W
» » »	100	53	392	36	1 S 10° W[2]	100	10.6	N 17° W
					1 S 20° W[2]			
					1 S 60° W			
					2 S 70° W			
					5 S 80° W			
9.09—9.13½ »	10	53	420	43	10 N 80° W	10	13.7	S 54° E
9.22—9.27 »[3]	300	49	370	33	11 S 90° W	0	33	S 78° W
» » »	20	53	460	42	13 S 70° W	20	15.6	N 12° E
12 noon	400							
0.20—0.25 p. m.	350	49	220	20	4 N 60° W	0	19.9	N 68° W
					3 N 50° W			
» » »	20	53	322	30	3 N 50° W	20	11.3	S 32° E
					4 N 40° W			
					1 N 30° W			
1.33—1.38 »	350	49	280	25	7 N 50° W	0	24.9	N 60° W
					1 N 30° W			
» » »	50	53	388	35.5	1 N 60° W	50	10.5	S 64 E
					9 N 50° W			
					2 N 40° W			
2.35—2.40 »	350	49	145[4]	13.4	2 N 50° W	0	13.4	N 57° W
					2 N 40° W			
» » »	100	53	214	20	4 N 40° W	100	7.0	S 27° E
					1 N 30° W			
					1 N 20° W			
2.51—3.01 »	10	53	250	12.5	1 N 10° W	10	11.1	S 64° W
					6 N			
					1 N 30° E			

[1] 450 metres of line were run out, but the line was much deflected towards NE (magn.) and a sounding taken afterwards at 7.15 a. m. gave a depth of 340 metres only. Hence the current-meter had been dragged along the bottom, and the registered direction is erroneous as the deflection of the line indicated a rapid drift of the ship towards SW (magn.) that also agrees well with the observations taken at 4.14—24 a. m. and at 7.48—58 a. m. The registered number of revolutions of the propellor is probally also too low.

[2] After the first messenger had released the propellor, the current-meter was hauled up some 20 metres, by a mistake, and then lowered to 100 metres again. It is therefore possible that the first registered directions are not trustworthy.

[3] At this time and also earlier in the morning and night the wind was NE by N (magn.).

[4] The registered number of revolutions was 425 (giving a velocity of 38 cm./sec.) that is too high as compared with the number of balls fallen in the compass box. It seems probable that the registration of the instrument had not been adjusted after the previous observation, and 280 would then have to be substracted from 425 giving 145 revolutions, that agrees well with four balls fallen.

Date and Hour 1912	Depth in Metres	Instru-ment	Revol-utions	cm./sec.	Number of Balls, and Direction	Current		
						Depth in Metres	Velocity cm./sec.	True Direction (towards)
18 August								
3.04—3.09 p. m.[1]	350	49	152	14	4 N 50° W	0	14	N 62° W
»	20	53	143	14	4 N 10° E	20	14	S 58° W
3.26—3.31 »	350	49	100	9.5	2 N 50° W	0	9.4	N 59° W
					1 N 40° W			
» » »	50	53	146	14.5	4 N 30° W	50	6.1	S 15° E
4.30 »	510[2]							
4.41—4.46 »	450	49	0	0		0	0	
» » »	20	53	334	28	8 S 10° W	20	28	N
					2 S 20° W			
4.57—5.07 »	10	53	418	20	5 S 40° W	10	20	N 34° E
					8 S 50° W			
5.12—5.17 »	430	49	0	0		0	0	
	50	53	141	14	2 S 20° W	50	14	N 13° E
					2 S 30° W			
5.27—5.37 »	20	53	750	34.5	15 S 10° W	20	32.8	N 1° W
5.42—5.47 »	400	49	100	9.5	1 S 20° W	0	9.5	S 15° W
					2 S 30° W			
» » »	50	53	164	16	2 S 10° W	50	7	N 19° W
					1 S 20° W			
5.59—6.04 »	100	53	196	18.5	1 S 40° W	100	6.7	N 77° E
					4 S 50° W			
					[1 N 50° E ?]			
6.12—6.17 »	420	49	168	15.5	5 S 30° W	0	15.5	S 18° W
	200	53	145	14	1 S 10° W	200	2.5	S 67° W
					2 S 20° W			
					2 S 30° W			
8.30 »	520[3]							
8.30—8.35 »	450	49	147	13.7	5 S 70° W	0	13.7	S 58° W
» » »	10	53	48	5.7	1 S 90° W	10	8.5	S 45° W
9.35—9.40 »[4]	400	49	200	18.5	3 S 50° W	0	18	S 43° W
					3 S 60° W			
» » »	50	53	468	43	12 S 70° W	50	26	N 72° E
					1 S 80° W			
					1 S 90° W			
9.51—9.56 »	10	53	296	28	8 S 80° W	10	10.2	N 82° E
10.05—10.10 »	400	49	202	18.4	3 S 80° W	0	18.2	S 72° W
					2 S 90° W			
» » »	100	53	335	31	1 S 70° W	100	13	N 61° E
					9 S 80° W			
10.20—10.25 »	20	53	385	35	3 N 90° W	20	16.4	N 83° E
					7 N 80° W			
					2 N 70° W			
10.34—10.39 »[5]	400	49	201	18.4	4 N 70° W	0	18.2	N 79° W
					2 N 60° W			
» » »	200	53	242	22.7	5 N 90° W	200	8.4	N 31° E
					2 N 80° W			
19 August								
1.15 a. m.	502[6]							
1.22—1.28 »	450	49	6	1.5	1 N 70° W	0	1.5	N 82° W
» » »	50	53	55	5.5	1 S 90° W	50	4	N 72° E

1 At this time the ice was moderately tight.
2 The sounding-line was hanging vertically till it was hauled up. The ice was very tight.
3 The sounding-line was much deflected towards NE indicating a rapid drift of the ship towards SW (magn). The ice was very open.
4 The ice was unusually open, with big open lanes.
5 The ice was still open.
6 The sounding-line remained vertical. No wind; earlier there had been a northerly and north-north-easterly wind.

Date and Hour 1912	Depth in Metres	Instru-ment	Revol-utions	cm./sec.	Number of Balls, and Direction	Current		
						Depth in Metres	Velocity cm./sec.	True Direction (towards)
19 August								
1.59—2.04 a. m.	20	53	126	12.5	1 N 70° E 2 N 80° E 1 N 90° E	20	14	S 65° W
2.03—2.08 »	10	53	172	16.5	5 S 50° W	10	15.2	N 42° E
2.13—2.18 »	400	49	29	3.5	0	0	3.5	?
»	100	53	0	0		100	3.5	S 10° W?
2.28—3.33 »	200	53	0	0		200	4	S?
2.42—2.47 »	20	53	205	19.5	4 S 50° E 2 S 40° E	20	17.6	N 79° W
2.52—2.57 » [1]	10	53	170	16.5	4 S 70° W 1 S 20° E (?)	10	11.9	N 68° E
6.00 »	424							
6.11—6.16 »	350	49	245	22	2 S 20° W 6 S 30° W	0	21.9	S 16° W
» » »	50	53	288	27	3 S 6 S 10° W	50	10.4	N 56° W
6.26—6.31 »	20	53	383	35	1 S 30° W [2] 1 S 40° W	20	12.7	N 31° E
6.36—6.41 »	350	49	258	23	6 S 30° W 2 S 40° W	0	22.9	S 21° W
» » »	100	53	286	26.5	1 S 1 S 10° W 1 S 20° W 5 S 30° W	100	5	N 48° W
6.51—6.56 »	10	53	344	32	[3]			
7.01½ 7.06 »	10	53	325	33	1 S 50° W 7 S 60° W	10	13.2	N 82° E
8.30 »	375							
8.56—9.01 »	320	49	282	25	7 S 70° W 1 S 80° W	0	25	S 59° W
» » »	50	53	400	37	10 S 80° W 1 S 90° W	50	12.9	N 88° E
9.10—9.15 »	20	53	400	37	7 S 70° W 3 S 80° W 1 S 90° W 1 N 70° W	20	10.5	N 79° E
9.21—9.26 »	10	53	243	23	3 S 80° W 3 S 90° W 2 N 80° W	10	10.5	S 40° W
9.31—9.36 »	320	49	365 [4]	33	2 S 70° W 7 S 80° W 2 S 90° W	0	32.8	S 68° W
» » »	100	53	379	35	9 S 80° W 1 S 90° W	100	2.2	N 79° E
10.04—10.09 »	320	49	396	35	5 N 90° W 7 N 80° W	0	34.8	S 84° W
1.00 »	436 [5]							
1.10—1.15 »	400	49	186	17	5 S 70° W	0	17	S 58° W
» » »	50	53	246	23	5 S 70° W 2 S 80° W	50	6.1	N 70° E

[1] The ice fairly open. We have approached the open sea at the ice-edge.

[2] Why only two balls had fallen is uncertain, it may either be some mistake in the journal, or there may have been some fault in the registration of the balls.

[3] The magnetic needle of the compass-box was out of place.

[4] The registered number of revolutions was 647, but that is evidently erroneous as only 11 balls had fallen. It had probably been forgotten to adjust the registration of the instrument after the previous observation and 282 has to be substracted. We then obtain 365, which is a probable value.

[5] The sounding-line was deflected towards E by N. The wind was W.

Date and Hour 1912	Depth in Metres	Instrument	Revolutions	cm./sec.	Number of Balls, and Direction	Current		
						Depth in Metres	Velocity cm./sec.	True Direction (towards)
19 August								
1.25—1.30 p. m.	20	53	0	0	0	20	9.5	S 73° W
1.39—1.44 »	400	49	37	4	1 N 80° W	0	4	S 88° W
	100	53	128	13	3 S 80° W	100	9.4	N 60° E
1.57—2.02 »	10	53	48	5.6	1 S 90° E (?) 1 S 10° E			
6.15—6.20 »	330	49	140[1]	13	2 S 1 S 10° W 1 S 20° W	0	13	S 4° E
» » »	50	53	203	19.5	4 S 1 S 10° W	50	6.7	N 22° W

[1] This observation was made just as the ice-floes began to tighten round the vessel, and in order to avoid being nipped, we had to make our way out of the ice as soon as we got our instruments hauled up. In the hurry the current-meter No. 49 was then placed on deck before read off, and unfortunately its propellor was turned backward by the wind, and the registration was spoilt. But according to the number of balls (4) fallen, it ought to have been about 140, giving a velocity of about 13 cm./sec.

TABLE III

gives the measurements of the **Oxygen** in the Sea-Water, taken during the cruise with the Veslemöy, in July to September 1912.

1st Column. Depth in Metres.

2nd Column, $t°$ C. Temperature (Centigrade) of the Sea-Water *in situ.*

3rd Column, $S ‰$. Salinity (in per mille) of the Sea-Water.

4th Column, O_2 *cc.* Quantity of Oxygen observed, expressed in cc. per liter of Sea-Water.

5th Column, O_2 %. Percentage of Saturation, *i. e.* the relation, expressed in per cents, between the observed quantity of Oxygen and the quantity which the same sea-water could absorb at the same temperature and at the pressure of one atmosphere, if fully saturated, according to Chas. J. J. Fox's Table.

Depth in Metres	$t°$ C. *in situ*	S ‰	O_2 cc. per 1000 cc. of Sea-Water	O_2 % of Saturation

Stat. 10. July 21, 1912. At the mouth of Ice Fjord.

20	0.75	34.16	8.34	105.0
75	−0.41	.54	7.47	91.6
300	1.03	.78	7.17	91.2

Stat. 13. July 29, 1912. Inner end of Cross Bay, at Lilliehöök Glacier.

50	−0.25	34.55	7.42	91.4
100	0.32	.67	7.29	90.8

Stat. 14. July 14, 1912. Midway in Cross Bay.

250	1.35	34.84	6.79	87.3

Stat. 18. Aug. 3, 1912. 80° 2′ N., 11° 20′ E.

210	1.82	34.91	7.14	92.8

Stat. 19. Aug. 3, 1912. 80° 18′ N., 10° 45′ E.

510	1.29	(34.92)	6.23 (?)	80.0 (?)

Stat. 37. Aug. 14, 1912. 80° 24′ N., 15° 32′ E.

50	(1.50)	(34.64)	6.99	90.0
200	(1.71)	(.88)	6.93	89.9

Stat. 41 c. Aug. 19, 1912. 80° 26′ N., 12° 00′ E.

5	1.72	(32.32)	7.71	98.1
20	2.11	(33.99)	8.37	108.7
50	−0.09	(34.65)	7.49	92.7
100	3.12	(.95)	7.13	95.7

Stat. 42. Aug. 19, 1912. Near Stat. 41 c.

200?	2.47	34.89	7.03	92.8
300	1.87	.92	7.22	91.8

Stat. 43. Aug 20, 1912. 80° 20′ N., 10° 4′ E.

50	−0.39	34.43	7.31	89.6
100	1.79	.83	7.35	95.5
200	1.83	.90	7.26	94.4
400	1.36	.91	7.17	92.2
540	1.51?	.92	7.12	91.8

Stat. 45. Aug. 26, 1912. In Ice Fjord.

20	1.64	32.88	8.19	104.3
50	0.85	33.68	8.13	102.3
100	−0.26	34.47	7.49	92.2
170	−0.12	.62	7.26	89.8

Stat. 46. Aug. 26, 1912. In Ice Fjord.

140	−0.74	34.56	7.51	91.2

Stat. 50. Aug. 30, 1912. Van Mijen Bay (Bell Sound).

0	0.2	32.45	8.04	98.4
10	0.38	.53	8.25	101.6
50	0.19	33.25	7.99	98.4
70	0.04	.42	8.08	99.3

Stat. 53. Aug. 31, 1912. Outside Bell Sound. 77° 33′ N., 13° 28′ E.

0	−0.3	32.17	8.32	100.4
20	1.65		7.98	101.7
50	0.08	34.16	7.77	96.3
100	1.03	.61	7.41	94.3
130	0.67	.68	7.23	91.3

Stat. 56. Sept. 1, 1912. 76° 22′ N., 13° 52′ E.

50	5.45	34.90	7.26	102.8
100	4.47	35.02	6.75	93.5

Stat. 57. Sept. 1, 1912. 75° 58′ N., 13° 5′ E.

500	1.22	34.92	7.23	92.6
700	0.08	.91	6.96	86.7

TABLE IV

gives the measurements of the **Hydrogen Ion Concentration** (and the **Hydroxyl Ion Concentration**) of the Sea-Water, taken during the cruise of the Veslemöy, in July and August 1912.

1st Column. Depth in Metres.

2nd Column, $t°$ C. Temperature (Centigrade) of the Sea-Water *in situ.*

3rd Column, $S\ ^0/_{00}$. Salinity (in per mille) of the Sea-Water.

4th Column, p_H. The Hydrogen Ion Exponent, p_H, given by the observations.

5th Column, $C_{OH'} \cdot 10^7$. The Hydroxyl Ion Concentration, expressed in gram-equivalents of hydroxyl ions per liter of sea-water, multiplied by 10^7.

6th Column, O_2 *cc.* Cc. of Oxygen per liter of Sea-Water.

7th Column, $O_2\ ^0/_0$. Percentage of Saturation of Oxygen.

Green Harbour, at our anchorage. July 20, 1912.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0			8.25	12.9		

Stat. 10. July 21, 1912. In the mouth of Ice Fjord.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0	4.8	29.05	8.08	8.7		
20	0.75	34.16	.04	.1	8.34	105
50	−0.55		7.92	6.0		
75	−0.41	.54	.95	.5	7.47	91.6
100	−0.42	.53	.93	.0		
200	0.37	.71	.93	.0		
300	1.03	.78	8.01	7.0	7.17	91.2
400	1.09	.83	7.92	6.0		

Poole Point, Foreland Sound. July 23, 1912.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0			8.05	8.1		

Port Signe, Lilliehöök Bay. July 29, 1912.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0			7.93	6.0		

Stat. 13. At Lilliehöök Glacier. July 29, 1912.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
20	−0.04	34.48	7.94	6.5		
75	−0.20	.59	.95	.5		
100	0.32	.67	.95	.5	7.29	90.8

Stat. 14. Cross Bay. July 29, 1912.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
50	−1.01	34.51	8.04	8.1		
100	−0.68	.59	.05	.1		
200	1.12	.80	.10	9.2		
250	1.35	.84	.01	7.0	6.79	87.3

Stat. 15. July 29, 1912. 7.00 p. m. 79° 5' N., 10° 56' E.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0	(2.5)	(32.75)	8.07	8.7		

Stat. 18. Aug. 3, 1912. 80° 2' N., 11° 20' E.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0	1.8	34.33	8.07	8.7		
60	1.56	.79	.03	7.6		
110	1.69	.82	.06	8.1		
210	1.82	.91	.04	7.6	7.14	92.8
240	1.83	.91	.04	.6		

Stat. 19. Aug. 3, 1912. 6.30 to 7.50 p. m. 80° 18' N., 10° 45' E.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0	0.8	33.06	8.24	12.7		
20	1.17	.56	.19	11.0		
50	0.75	34.57	.07	8.1		
100	1.91	.86	.05	.1		
200	1.90	.90	.05	.1		
310	1.80	.92	.02	7.6		
410	1.55	.93	.05	8.1		
510	1.29	(.92)	.08	.7	6.23?	80.0?

Stat. 19 a. Aug. 3, 1912. Same place as Stat. 19.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
10	1.15	33.50	8.24	12.7		
20	1.28	.66	.22	.1		
50	1.27	34.58	.19	11.6		

Verlegen Hook. Aug. 12, 1912. 1.30 p. m.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0	1.3		8.24	12.7		

Stat. 37. Aug. 14, 1912. 80° 24' N., 15° 32' E.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
50	1.50	34.64	8.10	9.2	6.99	90.0
230	1.70	.90	.07	8.7	(6.93)	(89.9)

Stat. 39. Aug. 15, 1912. 80° 5' N., 15° 33' E.

Depth in Metres	$t°$ C. *in situ*	S ‰	p_H	$C_{OH'} \cdot 10^7$	O_2 *cc.*	O_2 %
0	1.0	32.72	8.19	11.6		
10	1.03	33.60	.11	9.2		
40	1.28	34.19	.04	8.1		
90	1.41		.04	.1		
130	1.46	.68	.01	7.0		

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