REPORT

ON

HYDROGRAPHICAL INVESTIGATIONS

IN THE

FAEROE-SHETLAND CHANNEL AND THE NORTHERN PART OF THE NORTH SEA IN 1902,

BY

B. HELLAND-HANSEN.

CONTENTS.

I

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BY

B. HELLAND-HANSEN.

1. INTRODUCTION.

In the beginning of August, 1902, when the first quarterly cruises under the International Programme took place, Professor *D'Arcy W. Thompson* asked me to come to Scotland and inaugurate the Scottish part of the hydrographic work. The investigations were carried out on board H.M.S. *Jackal*, Lieutenant and Commander *H. E. Sharp*, R.N. In December, 1902, the second cruise was made by Lieutenant-Commander *Sharp*, and I was afterwards entrusted with the material from this second expedition, to be studied together with the August observations. The results of these investigations are given in the present memoir.

THE CRUISES.

The first Scottish cruise in connection with the International Investigations was made in 1902 from August 25th to September 1st. The course lay from the Moray Firth to Shetland, thence in a north-easterly direction nearly to the Norwegian Coast, then westwards to the Faeroes, thence by Fair Isle between Shetland and the Orkneys into the North Sea, and westward again to the Moray Firth. Assisted by Mr. *F. Pearcey* I worked 26 stations, and surface observations were made every hour during the cruise. By means of this course we got two almost parallel section-lines across the most important areas, the lines being in their leading features the same as those laid down by Mr. *H. N. Dickson* for his investigations on board the *Jackal* in 1893–94.* The next expedition was made with the *Jackal* in December, from the 4th to the 16th. The weather then was extraordinarily bad, but nevertheless Commander *Sharp*, assisted by Mr. *Lyon*, managed to work successfully 20 stations along the same section-lines as had been followed on the August cruise.

24

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* XIIth Annual Report of the Fishery Board for Scotland (1893), Pt. iii., p. 336, 1894.

The Chart, Fig. 1, shows the stations and the lines followed on these expeditions. The latitude and longitude of each station will be found in Table 1.*

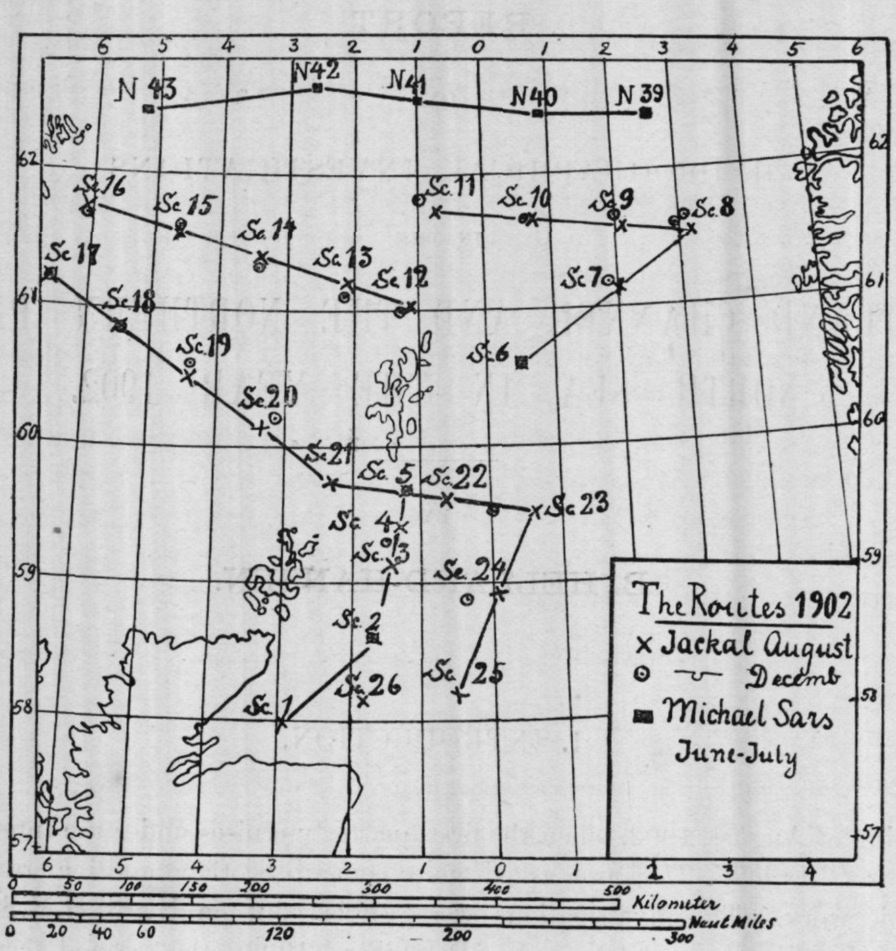

FIG. 1.

METHODS AND INSTRUMENTS.

The hydrographical work at sea was limited to observations of temperature and to the collection of samples for analysis ashore. For taking water samples from different depths the Pettersson insulating water bottle was used, the small pattern of it in all cases except one (August cruise, Station Sc. 14, 1000 metres), when the large Pettersson-Nansen insulating water bottle was employed.† This is too heavy to work by hand, and as the *Jackal* had at that time no steam winch for sounding purposes the large instrument could not be used any more. The releasing mechanism of the water bottles was altered from propeller-wings to a messenger arrangement. The depth was determined by an ordinary meter-wheel. The deep-sea temperatures were generally determined by means of Nansen-Richter thermometers, fixed in the lid of the water bottle.‡ On account of faults in the manufacture three of them were broken during the August cruise, so that at some stations we were obliged to use good ordinary

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* Preliminary notes on these cruises were published in "Nature," vol. 66, p. 654, and vol. 67, p. 246.

† See Dr. *H. R. Mill*: "The Pettersson-Nansen Isolating Water Bottle" (Geographical Journal, October, 1900).

‡ *Fridtjof Nansen*: "Some Oceanographical Results of the Expedition with the 'Michael Sars,' headed by Dr. Hjort, in the Summer of 1900" ("Nyt Magazin for Naturvidenskab," Vol. 39, No. 2, Christiania 1901).

thermometers (with milk glass scale), which were put into the water bottle after it had come up on deck. As the temperature of the air did not differ very much from that of the water we may neglect the errors caused by this method. After the temperature had been read, a portion of the water was poured for subsequent analysis into a glass bottle holding about 230 cc. (8 ounces), the bottle always being carefully corked. Water from the surface was collected in an ordinary bucket and the temperature read off with a thermometer graduated in $\frac{1}{5}$°C.

The water samples were examined for Chlorine by means of Mohr's method. The titrations were made in Professor *Walker's* Laboratory in University College, Dundee, most of them (from both cruises) being repeated in the hydrographical laboratory of the "Norges Fiskeristyrelse," Bergen. The August samples were examined by myself, the December samples by Mr. *Foggie* and Mr. *A. J. Robertson.* The burettes used for these determinations were provided with a bulb between the 0-mark and the divisions of the stem, in order to diminish the errors caused by slow drainage of the silver solution along the inner side of the burette. The stem of one of the burettes was graduated from 32 to 36, the strength of the silver solution being such that the total amount of salts could be read off at once, almost exactly. The stem of another burette was graduated from 17·5 to 20, in order to read off the approximate amount of chlorine. Knudsen's pipette, containing about 15 cc., was used. For every fifteenth titration, on an average, a comparative titration of "standard water" supplied by the International Bureau was made.

THE TABLES AND PLATES.

Table 1 (p. 25) contains the results of the station observations from both cruises. In this table are to be found the numbers of the stations, the positions, dates, and hours when the observations were made. The column headed "Depth" gives the depths from which the samples were taken, in metres as well as in fathoms. The next column, "t°C." contains the temperatures at the several depths in degrees centigrade, referred to the Hydrogen thermometer. The temperature readings are corrected for instrumental error, and in order to get the temperatures *in situ* a correction for the pressure of the water is added according to Lord *Kelvin's* formula.* I think the temperatures generally are exact to some few hundredth parts of a degree centigrade. The column headed "$S^\circ/_{\circ\circ}$" contains the total amounts of salts *per mille* according to Martin Knudsen's definition, the numbers being calculated from Knudsen's "Hydrographical Tables" (Copenhagen 1901). From a great many double titrations I have found that the errors generally do not exceed $0{\cdot}02^\circ/_{\circ\circ}$; in most cases they are less.† The densities *in situ* (though without allowance for the compression of the water) are found in the column "σ_t." Only the second and following decimal places are recorded; thus for instance 26·65 means "density = 1·02665." The densities are in most cases exact to about 2 units in the fifth decimal place.‡ The column "$v—v^1$" gives the specific volume *in situ* minus the specific volume of water of 0°C and $35^\circ/_{\circ\circ}$ salinity, all through; allowance is here made for compression. Lastly, the column "$E—E^1$" contains the values of the integral $\int vdp$ (p = pressure) from the surface to a certain depth at the station minus the values of the corresponding integral for a water column containing only water of 0°C and $35^\circ/_{\circ\circ}$ salinity. These numbers are used for the

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* See *Fridtjof Nansen:* "Some Oceanographical Results," *l.c.* p. 136; and the same author: "The Oceanography of the North Polar Basin," p. 4 (the Norwegian North Polar Expedition, 1893–96. Scientific Results, Vol. III., No. 9).

† *B. Helland-Hansen:* "Einige hydrographische Hauptresultate" (Petermann's Geographische Mitteilungen, April, 1901).

‡ Tables containing the observations of temperature, salinity and density have been already published in the "Bulletin des résultats acquis pendant les courses périodiques, publié par le Bureau du Conseil. Année 1902–1903" (Copenhagen).

hydrodynamical calculations as described below; they are calculated from the tables in *J. W. Sandström* and *B. Helland-Hansen:* "On the Mathematical Investigation of Ocean Currents," printed below.

Table 2 (p. 40) contains the surface observations from the August cruise (A) and the December cruise (B); "t°C" means temperature in degrees centigrade referred to the Hydrogen thermometer, and $S^{\circ}/_{\circ\circ}$ means salinity *per mille* according to *Knudsen's* tables.

The distribution of temperatures and salinities is graphically represented on the surface chart, Fig. 2, and in the sections, *Plates* I.—III. These are easily understood without further explanation here. Even small variations of the salinity above $35^{\circ}/_{\circ\circ}$ are important for the waters in question; therefore the waterlayers containing between 35·0–35·15, 35·15–35·20, 35·20–35·25, and above $35{\cdot}25^{\circ}/_{\circ\circ}$ salinity are distinguished by different colours. The stations are on an average only about 40 nautical miles apart, but we nevertheless often find very great and important differences between the phenomena at adjacent ones. The distance between the stations ought, indeed, to be not more than 20 miles, or even less; hence the sections are perhaps not absolutely correct, the isotherms and isohalines being in important places drawn hypothetically.

THE HYDRODYNAMICAL CALCULATIONS.

The oceanic currents are chiefly determined by the following factors: by the distribution of pressure and density in the water, by the rotation of the earth, by the friction of the water, and by the action of winds. We are not yet able to calculate the currents exactly, because we do not know sufficiently the quantitative influence of all these different factors; nevertheless we shall in this paper attempt an approximate calculation of the currents from the hydrographical observations.

It must at the outset be remarked that the influence of the wind can not be fully taken into account. The local winds quickly provoke superficial currents, but their effect upon the deeper layers is not so great and has often been over-estimated by oceanographers.*

The influence of the several factors mentioned is expressed for a closed curve in the ocean by Professor *Bjerknes's* formula† :—

$$\frac{dC}{dt} = -\int v\,dp - 2\omega\frac{dS}{dt} - R \qquad (1)$$

where C is the *circulation* of the closed curve according to Lord *Kelvin's* definition, and $\frac{dC}{dt}$ the variation of this circulation in time, *i.e.*, the acceleration of the circulation. The first term to the right side of the equation gives the influence of the pressure (p) and the specific volume (v), v thus being the reciprocal of the density. The next term to the right represents the effect of the rotation of the Earth, ω being the angular velocity of the Earth and S the projection of the curve on the Equator: $\frac{dS}{dt}$ is thus the variation of this projection in time. R indicates the influence of friction. Everything is referred to c.g.s. units.

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* *V. Walfr. Ekman:* "Om jordrotationens inverkan på vindströmmar i hafvet" (Nyt Magazin for Naturvidenskab, Vol. 40, 1, Christiania, 1902), and *Fridtjof Nansen:* "The Oceanography of the North Polar Basin" (*l.c.*). See also *P. Hoffman:* "Zur Mechanik der Meeresströmungen an der Oberfläche der Oceane" Berlin, 1884, p. 92.

† *V. Bjerknes:* "Cirkulation relativ zu der Erde." Ofversigt af Kongl. Vet. Akad. Handl., Stockholm, 1901, No. 10.

As an approximation, I will suppose that $\frac{dC}{dt}$ and R may be neglected, because the acceleration of the circulation—at least under stationary circumstances—and the internal friction of the water may generally both be regarded as relatively small quantities. Thus, when $-\int vdp$ is replaced by A,

$$A = 2\omega\frac{dS}{dt} \qquad (2)$$

i.e., the effect of the distribution of pressure and density is then equivalent to the effect of the deflecting force of the rotation. For the sake of argument I shall suppose that we have to deal with a closed curve from a vertical section through a current* the velocities of which are decreasing downwards. All the particles of this curve will, then, have a tendency to be deflected to the right on account of the rotation of the Earth. This tendency is proportional to the velocity of the particle, and thus greater in the upper part of the curve where the velocities are supposed to be greater than in the deeper parts. Consequently the whole curve will move in the direction of the *resultant*, *i.e.*, in the upper part to the right and in the lower part to the left, the right-hand motion here being overcome by the stronger tendency from the other parts of the curve. This movement will under stationary current-conditions generally be checked by other factors and especially by the distribution of densities and pressures. The distribution will in this case be such that the lightest water is found to the right side of the current and the heaviest water to the left, the curve in this way acquiring a tendency to move in a direction opposite to that provoked by the rotation of the Earth. In the same manner it will readily be understood that the deflecting force of the rotation of the Earth will tend to move the particles of the closed curve in the upper part to the left if the velocities of the mass of water are increasing from the surface downwards, and that this influence may be checked if the lightest water is found on the left side of the current. The formula (2), given above, expresses the fact that these influences in opposite directions are equally great under the assumptions made.

It is convenient for practical purposes to choose such curves as consist of two vertical lines at different stations and two horizontal lines between these stations, one at the surface and the other at a given depth. For such curves the value of A in equation (2) is easily calculated from the Tables to be found in the above-mentioned paper by Mr. *Sandström* and myself. In Table 1 of the present paper is found a column headed $E - E^1$. In order to find A for a closed curve, limiting the water between two station-verticals from the surface to a certain depth, we have to subtract the value of $E - E^1$ at this depth for one of the stations from the corresponding value for the same depth at the other station,

$$A = [E - E^1]_a - [E - E^1]_b,$$

the small letters indicating two different stations, a and b.† Thus, *e.g.*, the value of A between the stations Sc. 13 and Sc. 14 of the August cruise from the surface down to 500 metres depth is

$$36367 - 23913 = 12454.$$

The term $2\omega\frac{dS}{dt}$, equation (2), is equal to a term $2\omega\frac{d\sigma}{dt}\sin\lambda$, σ being the projection of the curve on the sea-surface, $\frac{d\sigma}{dt}$ the variation of this projection by the time ; λ is the geographical latitude.‡ In order to find the value of $\frac{d\sigma}{dt}$ we shall suppose that the vertical velocities of the water particles may be neglected, being small compared with the horizontal ones. Let the mean velocity between the stations *a* and *b* be c_0 at

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* Currents in the Northern Hemisphere only are considered here.

† For all further particulars the reader is referred to the paper "On the Mathematical Investigation of Ocean-currents," *infra*, p. 135.

‡ Ibid., p. 160.

the surface and at a certain depth be c_1 centimetres per second, in the same horizontal direction perpendicularly to the line between the stations. In a unit of time the projection on the sea-surface of the curve, consisting of the vertical lines at a and b and the horizontal lines at the surface and at that depth, will have increased by $(c_0 - c_1)$ L, L being the distance between the stations (expressed in centimetres). Then is $\frac{d\sigma}{dt} = (c_0 - c_1)\, L$; and L being l. 10^5 kilometres (where l. is the distance between the stations expressed in kilometres) we get

$$A = 2\omega \sin \lambda \, (c_0 - c_1) \, l.\, 10^5,$$

$$i.e., \; c_0 - c_1 = \frac{A}{2\omega 10^5 \, l. \sin \lambda} \qquad (3)$$

From the following Table the values of $2\omega 10^5 \sin \lambda$ are found for latitudes between 50° and 69° N.

$$2\omega 10^5 \sin \lambda = \kappa.$$

λ	κ	λ	κ	λ	κ	λ	κ
50° N.	11·17	55° N.	11·95	60° N.	12·63	65° N.	13·22
51° N.	11·33	56° N.	12·09	61° N.	12·75	66° N.	13·32
52° N.	11·49	57° N.	12·23	62° N.	12·87	67° N.	13·42
53° N.	11·65	58° N.	12·37	63° N.	12·99	68° N.	13·52
54° N.	11·80	59° N.	12·50	64° N.	13·11	69° N.	13·61

Between the stations Sc. 13 and Sc. 14, 0 and 500 metres, August, 1902, l was about 74, $\kappa = 12{\cdot}8$, and $A = 12454$; *i.e.*,

$$c_0 - c_1 = \frac{12454}{12{\cdot}8 \cdot 74} = 13{\cdot}15 \frac{\text{cm}}{\text{sec}}.$$

The light water is found to the east, the velocities are decreasing downwards, and the water is moving northwards. The mean surface-velocity in the direction N.E. between those stations is then approximately about 13 centimetres per second greater than the mean velocity in the same direction at 500 metres depth.

At our present stage, in calculating the oceanic movements, I think equation (3) will give valuable results, until *Bjerknes's* complete equation may some day be practically used with all its factors.

2. THE FAEROE-SHETLAND CHANNEL.

The hydrography of the Faeroe-Shetland Channel is extremely complicated. We have to deal with waters of very different origin : viz., a current originating in the Atlantic Ocean, commonly called "The Gulf Stream," or, as Mr. *H. N. Dickson* has proposed to call it, "The Norwegian branch of the European Stream"*; water from the central and western parts of the Norwegian Sea ; water, of Arctic origin, that may enter the Channel as an offshoot from the East-Icelandic Polar current ; and, lastly, to some extent, water from the North Sea and the British coasts. Mr. *H. N. Dickson* has in different papers on this subject† clearly shown that the quantities of these different masses of water, and as a consequence the currents themselves, vary from season to season. I shall in the following pages try to describe the

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* Phil. Trans., Vol. 196, p. 113.

† Phil. Trans., Vol. 196 ; XIIth and XVth Ann. Rep. of the Fishery Board for Scotland ; Geographical Journal, Vol. XXI., No. 4 (April, 1903).

hydrographical situation in August and December, 1902, and the variations then indicated. The problem of the primary causes of these variations I shall leave aside. This difficult and important problem will, it is to be hoped, be ripe for solution after the International Investigations have been continued for a somewhat longer time.

AUGUST, 1902.

The Tables 1 and 2, the surface chart, Fig. 2, and the sections from August, 1902, Pl. I., 1, 2, show clearly the different masses of water in the Channel at this epoch :—I. The eastern part of the Channel from the surface down to 400–500 metres is occupied by the warmest and saltest water, forming the main body of the Norwegian branch of the European stream. II. In the deepest part of the Channel a wedge-shaped mass of cold water rises up, with salinities below $35{\cdot}0\,^{\circ}/_{\circ\circ}$. III. In the middle and western parts towards the Faeroes large masses of mixed water are seen, mostly of salinities between $35{\cdot}1\,^{\circ}/_{\circ\circ}$ and $35{\cdot}2\,^{\circ}/_{\circ\circ}$. IV. At the surface, in the central part of the Channel, there is a surface " flake " with rather low salinities, the minimum salinity being $34{\cdot}86\,^{\circ}/_{\circ\circ}$.

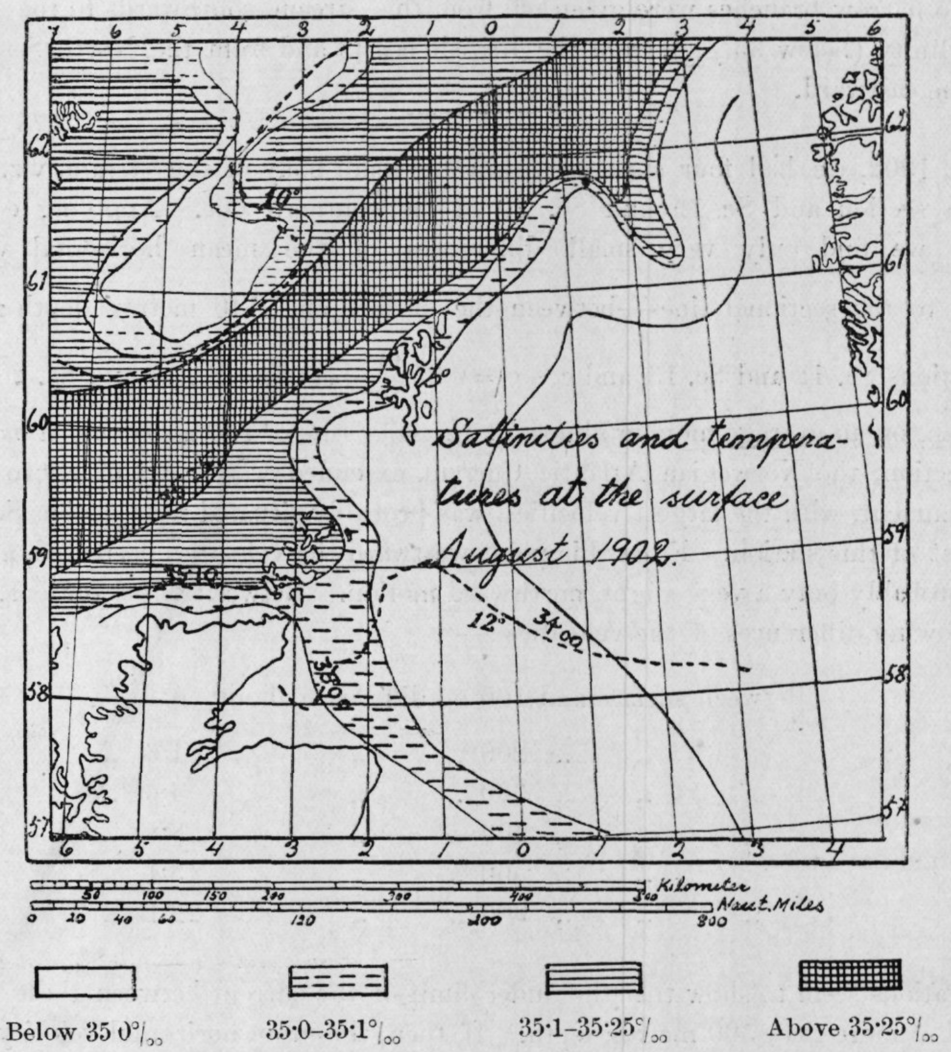

FIG. 2.

1. The " Norwegian branch of the European Stream," or, as we may better name it, the *Norwegian Atlantic Current*, had its centre in the eastern part of the Channel along the Shetland banks. The stream comes from the Atlantic Ocean with a more or less strong component motion towards the east, an effect

of the rotation of the Earth; in the Channel itself the current is impelled in a more northerly direction on account of the configuration of the land; when leaving the Channel to the north-west of Shetland the direction becomes more easterly again, nearly following the contour lines of the bottom. In August, 1902, the maximum temperature of the stream in the Channel was about 11½° C., the maximum salinity almost $35{\cdot}5\,{}^{\circ}/_{\circ\circ}$. The temperatures were found upon the whole to decrease from the surface downwards, the maximum temperature being found at the surface or at some few metres depth. The salinities were more or less uniform throughout the upper 400 metres, with a slight maximum at about 150–200 metres. The densities were almost everywhere increasing downwards, forming a stable equilibrium. It is, however, worth noticing that the density was not infrequently greater at the very surface than some metres below it; this phenomenon is in part due to a lowering of the surface temperature, heat being given off to the atmosphere, and in part due to an increase, amounting to some hundredths *per mille*, of the surface salinity, as a result of evaporation. In such cases the equilibrium was unstable and such as to induce vertical currents. The same phenomenon was found also in other parts of the sea, and not only at the surface of the Norwegian Stream. The density at the surface of the Norwegian Stream was slightly above 1·0270, slowly increasing northwards. Near the Orkneys and between Shetland and Norway two narrow branches were given off from this stream southwards to the North Sea. Water of rather low salinity (below $35\,{}^{\circ}/_{\circ\circ}$), from the British coasts and from the North Sea, was seen to limit the stream to the eastward.

In August, 1902, we had four stations within the main body of the stream, viz., Sc. 12 and Sc. 13 of the northern section and Sc. 19 and Sc. 20 of the southern one. Applying equation (3) to the observed data, we find only very small differences of the mean horizontal velocities—reckoned perpendicularly to the sectional lines—between the surface and 140 metres' depth; thus $c_0 - c_1 = 0\,\frac{\text{cm}}{\text{sec}}$ between the stations Sc. 12 and Sc. 13, and $c_0 - c_1 = 0{\cdot}25\,\frac{\text{cm}}{\text{sec}}$ between Sc. 19 and Sc. 20. This part of the current was, then, on an average moving almost at *the same rate at 140 metres depth as at the surface.* In the northern section, the Norwegian Atlantic Current extended westwards nearly to station Sc. 14, and the axis of the current, with the largest velocities, was probably situated near station Sc. 13 and perhaps a little to the east of this station. From this point westward the velocities decreased, and at station Sc. 14 the water had probably only a very slight northward motion. Between these stations, Sc. 13 and Sc. 14, we find the following differences of the velocities:—

Between surface and 100 m. difference about $0{\cdot}4\,\frac{\text{cm}}{\text{sec}}$.
" " " 200 " " " 1·6 "
" " " 300 " " " 4·6 "
" " " 400 " " " 8·8 "
" " " 500 " " " 13·1 "
" " " 900 " " " 22·1 "

The observations seem to show that the under limit of the current between these stations was on an average situated at more than 500 metres depth. If, then, the mean horizontal velocity perpendicularly to the line between the stations (*i.e.*, in the true direction N. 17° E.) was 0 at, say, 600 metres, the mean velocity at the surface was about 16–17 centimetres per second in the same direction. The stream was, however, probably flowing in a more easterly direction at the surface, forming an angle of about 30° with the direction mentioned. *The mean surface velocity of the current was then about 20 centimetres per second, or about 10 miles in 24 hours.* At station Sc. 13 the velocity was evidently still greater and at station

Sc. 14 much less (perhaps not moving at all northwards). We lack observations for calculating the currents by our method in greater detail. Fig. 3 is a graphical representation of the values recorded above, as well as of those found for the same locality six months later, in December, 1902. The vertical lines, or abscissæ, indicate the differences of the velocities, and the horizontal lines, or ordinates, indicate the differences of depth.

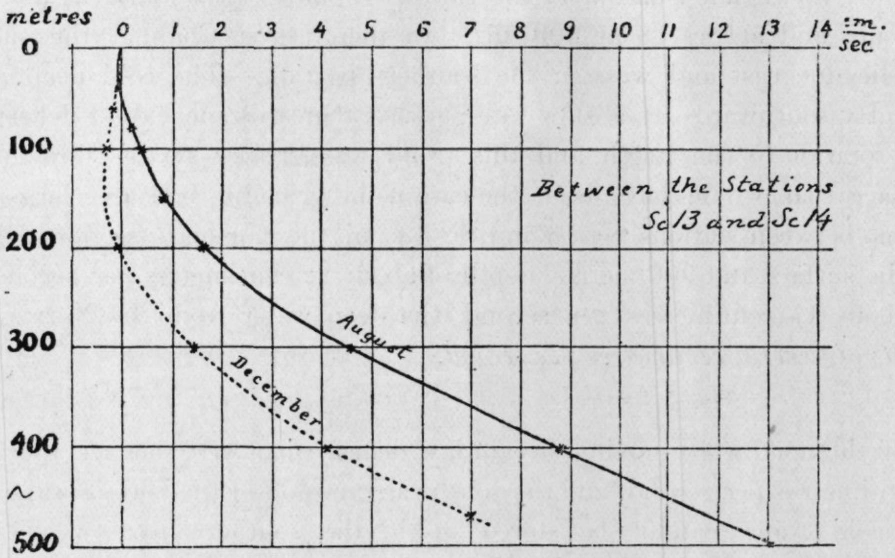

FIG. 3.

It is evident from the figure and the numbers shown that in August *the velocities decrease at first slowly in the upper layers of water, then more quickly at greater depths until we reach a condition of rest.* The decrease in the upper 200 metres is only 1·6 centimetres per second, but in the next 200 metres the decrease is 7·2 centimetres. This seems to be a common rule for oceanic currents, the curve of the velocities forming approximately part of some conic section, with its apex at varying depths.

These results are of great importance for our knowledge of the stream. When the velocities decrease so slowly in the upper water layer of 200 metres thickness, and not rectilinearly throughout the whole body of the stream, the masses of water transported by the current may be enormous.* Tidal currents and casual wind currents may then be disregarded. As will be shown later on, the velocity is sometimes larger at some intermediate depth than at the surface. The Norwegian Atlantic Current seems often to have a maximal velocity at 80–100 metres in the Norwegian Sea ; at that depth the isohalines have a tongue-formed shape in the longitudinal direction of the current, indicating a maximum of salinity.†

II. The deep, cold wedge is highly interesting. The salinities are very uniform indeed, being between 34·9 and 35·0 pro mille in the deeper part of the wedge : at 1000 m. 34·92,—temperature 0·5°C. (Station Sc. 14). South of the Wyville Thomson Ridge, the depth of which is about 500 m., water of such low temperature and salinity is not found. The water in question must have

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* From a rough calculation I have found that the Norwegian Atlantic Current in the Channel, in August, 1902, carried away about 4 million cubic metres of water per second.

† *Cf. Helland-Hansen:* "Einige Hydrographische Hauptresultate" (Petermanns Mitteilungen, 1901, Heft 5 and 6), and *Fridtjof Nansen:* "Some Oceanographical Results" (*l.c.*).

come from the Norwegian Sea, and the salinity 34·92 is the very same as that found by the Norwegian steamer *Michael Sars* all over the Norwegian Sea from 800 metres depth downwards, where the temperatures are below zero.* On Pl. III., fig. 1, a section from the *Michael Sars* investigations in June–July, 1902, north of the Faeroe Channel, is reproduced (see the Station-chart, Fig. 1). When comparing this section with the two *Jackal* sections from the Channel we find that the summit of the 35·0 isohaline in the summer of 1902 was met with deeper and deeper as we trace it farther and farther to the southward. At the Norwegian Station 42 the salinity of 35·0°/$_{00}$ is found at about 50 metres depth; at Sc. 14 at 300 m., and at Sc. 18 at 400 m. In the Faeroe Channel the summit of the 35°/$_{00}$ isohaline came to lie due east and west in the southern portion. The cold deep water was evidently moving independently southwards at a slow rate; it was then to some extent deflected towards the west on account of the rotation of the Earth, and this trend was greater at the slow movement which was actually taking place than would have been the case if the velocities had been larger.† An approximate calculation of c_0—c_1 between stations Sc. 13 and Sc. 14 (in the northern section) shows a difference of velocity between the surface and 900 metres' depth of about 22 centimetres per second. If the velocity at the surface was about 17 centimetres per second, the deep water from the Norwegian Sea was *moving southwards at a rate of several centimetres per second.*

If the limit of the northward moving stream lay deeper than 600 metres, the surface velocity was greater than 17 centimetres per second, and the southward motion of the bottom water was correspondingly slower. As this cold water cannot be stored up in the southern part of the Channel, the upper parts of it must be driven away by the Norwegian Atlantic Current, with which it is partially intermingled. The mixed water below the main body of the Norwegian Stream, with salinities between 35·0 and 35·25°/$_{00}$, and parts of the cold water, with salinities below 35·0°/$_{00}$, were thus moving northwards.

If the average velocity of this cold water that filled the deeper parts of the Channel was 5 cm. per second, the whole bulk of it would have been renewed in about three months—this, that is to say, would be the time taken by the water in passing from one end to the other of the Channel.

III. In the middle and western part of the Channel above the cold bottom-water (II.), was Atlantic water mixed with water from the Norwegian Sea (and partially from the East Icelandic Polar Current), marked by salinities between 35·0 and 35·25°/$_{00}$. The mixing processes had taken place partly to the north of the Faeroes and partly in the Channel itself. In the western part of the Channel near the Faeroes we find higher salinities than in the central part; this is clearly seen from the northern section, where a nucleus of water containing more than 35·2°/$_{00}$ is met with. The Atlantic water here then was less diluted than the other mixed water in the Channel. The *Michael Sars* made investigations N. and N.E. of the Faeroes in August.‡ In the following table certain results from these investigations will be found, together with observations by the *Jackal* from the western part of the Channel.

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* *Nansen:* "Some Oceanographical Results," *loc. cit.* If the salinities recorded in that memoir are calculated by means of *Knudsen's* Tables the salinities of the bottom water of the Norwegian Sea are found to be 34·92–34·94 all over.

† See *P. Hoffmann:* "Zur Mechanik der Meeresströmungen," *l.c.*, and *Nansen:* "Oceanography of North Polar Basin," *l.c.*, p. 369.

‡ Recorded in the August Bulletin, 1892, of the International Bureau (*l.c.*).

Depth.	N. 102. 63° 6′ N. Lat. 6° 19′ W. Long.		Sc. 16. 61° 47′ N. Lat. 6° 4′ W. Long.		Sc. 17. 61° 13′ N. Lat. 6° 34′ W. Long.	
m.	‰	° C.	‰	° C.	‰	° C.
0	35·21	9·20	35·20	9·00	35·13	8·80
10	—	—	35·18	8·79	35·15	8·78
20	—	—	35·19	8·66	35·17	8·55
25	35·18	9·24	—	—	—	—
40	—	—	35·18	8·53	35·17	8·48
50	35·25	8·45	—	—	—	—
60	—	—	35·19	8·52	35·17	8·49
75	35·26	8·20	—	—	—	—
80	—	—	35·21	8·42	35·17	8·48
100	35·26	7·86	35·20	8·35	35·18	8·43

The results given in this Table are quite comparable, the methods employed by the Norwegian and the Scottish investigations being precisely the same; the Norwegian station was worked one day (29th August) before the Scottish stations.

When the different latitudes of the three stations are taken into account, the following facts are quite evident:—1. The salinities are decreasing *southwards*. 2. The temperatures are growing more and more uniform southwards, the average temperature of the three stations from the surface down to 100 metres decreasing, though very slightly. As far as the salinities are concerned, we may compare the *Michael Sars* section (Pl. III., Fig. 1) for June–July with the *Jackal* sections for August (Pl. I., Figs. 1, 2); the salinities north-east of the Faeroes had altered to an insignificant extent during the months of July and August. We see, then, how the salinities are decreasing: on the Faeroe side of the sections we find water of above 35·25‰ salinity in the northernmost one, salinities in some cases slightly above 35·20 but always less than 35·25‰ in the middle section, and salinities all below 35·20‰ in the southernmost one. Water of such low salinities was not found south of the Faeroes and of the Wyville Thomson ridge in August, according to the *Michael Sars* observations.

These facts, I think, indicate that *the water east of the Faeroes was in August, 1902, moving towards the south.*[*] Water from the Atlantic Ocean was on its way northward to the west of the Faeroes, but bent off eastwards north of the Islands, some of it coming through the fiords between them and passing with a southerly component into the Channel. On its way this Atlantic water was mixed up and became intermingled with water of less salinity from the East Icelandic Polar current and with other water from the Norwegian Sea. The *Michael Sars* found—in accordance with these results drawn from the August observations—that the average drift of the water at Station 43, north-east of the Faeroes (*see* Chart, Fig. 1), in the beginning of July had a south-easterly direction. The Faeroes have only a very small

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[*] In the preliminary note in "Nature" (for October 30, 1902) I supposed that this water was moving northwards, parallel with the Norwegian Stream. I had not then, however, been able to examine all the material completely.

influence upon the concentration of the water; the influence of land is barely to be traced in the salinities.*

Calculations made from the observations at stations Sc. 15 and Sc. 16 (of the northern section) show that the average velocities there were pretty much the same at the surface and at 150 metres, a maximum velocity southwards being found at 50–60 metres depth (about 0·5 centimetres per second more than at the surface). The maximum velocity was found at a deeper level in the southern section between stations Sc. 17 and Sc. 18, viz., at about 80 metres depth, the difference from the surface velocity here being 1·2 centimetres per second. The southward movement seemed to be checked by the masses of water to the south in a relatively greater degree at the surface than in the deeper layers.

The masses of water between stations Sc. 14 and Sc. 15 (northern section) were probably moving southwards, attaining a maximum velocity at nearly 150 metres depth; the average difference from the surface velocity is here found—from the calculations—to be 1·5 centimetres per second. As we lack sufficient observations from depths greater than 400 metres we cannot say definitely anything about the absolute velocities, which seem, however, to have been somewhat large in the upper water layers. Fig. 4 is a graphic representation of the values found by the hydrodynamical calculations.

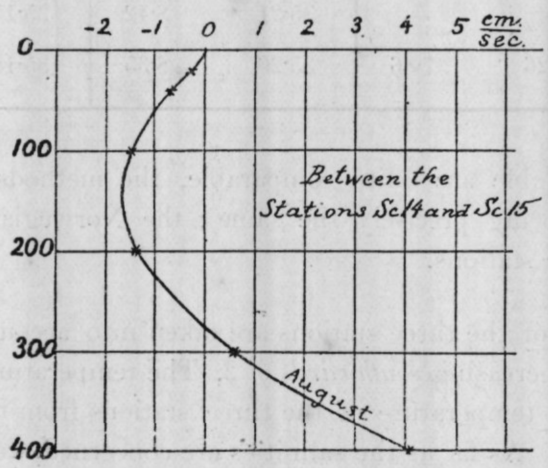

FIG. 4.

Station Sc. 19 (in the southern section) is situated within the main, saltest, part of the Norwegian Atlantic Current. The water at this station was all through lighter than the water at Station Sc. 18 to the west. The masses of water in the upper layer, several hundred metres thick, moved on the whole northwards, with their mean maximum velocity at the surface and with velocities gradually decreasing downwards until the direction changed to a southerly one. The calculations give the following results:—

Difference of velocity between surface and 60 metres $= 0\cdot3\ \frac{\text{cm}}{\text{sec}}$.
" " " " " 100 " $= 1\cdot0$ "
" " " " " 150 " $= 1\cdot9$ "
" " " " " 200 " $= 2\cdot5$ "
" " " " " 300 " $= 4\cdot0$ "
" " " " " 400 " $= 5\cdot2$ "

From the above account it appears that *the layers of water east of the summit of the deep wedge were, in August 1902, upon the whole moving northwards, and those west of the summit southwards.*

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* *C. H. Ostenfeld* states in his paper on the "Phytoplankton from the Sea around the Faeroes" (Botany of the Faeroes, II., Copenhagen, 1903, p. 610) that he has found only 37 species of neritic phytoplankton at the Faeroes, but 47 oceanic species, while Dr. *Gran* ("Das Plankton des norwegischen Nordmeeres," Bergen, 1902) has found 57 and 51 species respectively from the Norwegian Sea. The small proportion of neritic forms is still much more evident from quantitative plankton investigations. Arctic species are quite absent around the Faeroes.

IV. The central part of the surface of the Channel was covered, in August. 1902, with water of remarkably low salinities, even considerably less than 35·0 pro mille. Water of such low salinities was not at the time found south of the Channel, as we may conclude with certainty from the *Michael Sars* observations ; and this curious "flake" of water of low salinity was separated from the North Sea by the Norwegian Atlantic Current. To the west towards the Faeroes the water was salter again. At a relatively short distance north of the *Jackal* line between stations Sc. 14 and Sc. 15 the *Michael Sars* in the same days found much salter and warmer water at the surface,[*] except in a narrow belt some 40 nautical miles north of Station Sc. 15; where the surface salinity was only 34·52°/$_{oo}$ and the temperature as low as 7·9° C., indicating an Arctic origin. The area which the *Jackal* found to be covered with water of less than 35·0°/$_{oo}$ or 35·1°/$_{oo}$ was thus surrounded by salter water except at that narrow interval, and the less saline water formed, so to speak, a "flake" in the middle of the surface of the Channel : the depth of this flake was not more than about 50 metres. The only probable explanation of the phenomenon is that *this thin layer of water had come from the north, and had expanded somewhat over a larger area in the central part of the Channel, its centre remaining almost motionless for some time longer.* It is also possible that it may have originated from the North Sea, having got past the Norwegian Atlantic Current at an earlier period ; but the comparatively low temperatures seem to indicate that its origin was from the East Icelandic Polar Current, and that it had been warmed a little at the surface during its period of quiescence after its southward motion had been arrested in the Channel. The explanation here given is in apparent harmony with what is said above concerning the movement of the Atlantic water masses. If the stream along the Shetland side of the Channel be moving northwards and the water at the Faeroe side be moving southwards we may expect to find a sort of "eddy," *with a cyclonic motion at its circumference,* between those two contrary streams.

From what has been said above it is plain that the salinities reached a distinct maximum in the central part of the Channel below the surface "flake." As to the general relative distribution of salinities and temperatures it is noteworthy that for the deeper water layers, especially in the central and western parts of the Channel, a temperature of 6° C. corresponded approximately to 35·1 *per mille* of salts and 4° C. corresponded to 35·0°/$_{oo}$. In the eastern part below the Norwegian Atlantic Current, the same temperatures were accompanied by higher salinities.

The current system in the summer of 1902 seems, then, to be quite intelligible. Atlantic water streamed northwards in the eastern part only of the Channel (*i.e.*, the Norwegian Atlantic Current) ;

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[*] The *Michael Sars* had the following observations :—

Time.	Position.		t.°C.	S.°/$_{oo}$
	Latitude N.	Longitude W.		
30/viii 1.0 a.m.	62° 43′	5° 36′	9·14	35·18
„ 2.0 „	62° 36′	5° 23′	8·9	35·10
„ 3.0 „	62° 29′	5° 10′	9·14	35·20
„ 4.0 „	62° 23′	4° 55′	9·14	35·17
„ 6.10 „	62° 18′	4° 36′	8·98	35·18
„ 9.0 „	62° 20′	4° 27′	7·91	34·52
„ 10.0 „	62° 17′	4° 24′	9·14	35·01
„ 11.0 „	62° 9′	4° 13′	10·14	35·17
„ 12·0 noon	62° 0′	4° 2′	10·2	35·20
„ 1.0 p.m.	61° 50′	3° 52′	10·21	35·17
„ 2.0 „	61° 41′	3° 41′	10·2	35·23
„ 3.0 „	61° 32′	3° 30′	10·16	35·14
„ 4.0 „	61° 22′	3° 19′	10·3	35·15
„ 5.0 „	61° 13′	3° 9′	11·7	35·48
„ 6.0 „	61° 4′	2° 58′	11·54	35·48
„ 8.0 „	60° 45′	2° 36′	11·04	35·47 ?
„ 9.0 „	60° 35′	2° 25′	10·9	35·33
„ 10.0 „	60° 26′	2° 22′	10·6	35·20
„ 11.0 „	60° 19′	2° 22′	10·7	—
„ 12.0 „	60° 11′	2° 26′	10·5	35·18

the mean surface velocity of this current was about 10 nautical miles in 24 hours. The western part was filled with water that moved southwards from the Norwegian Sea and consisted of mixed water, the constituents of which originated partly from the Atlantic stream west of the Faeroes and partly from the East Icelandic Polar Current. These southward-moving water masses changed their course in the southern part of the Channel, and, turning round, joined the Norwegian Atlantic Current. On account of the opposite movements in the eastern and western parts of the Channel an eddy was formed in the central part, where an offshoot from the Polar Current was found as a thin surface layer of relatively low temperature and salinity. Just below this surface layer the water masses had higher salinities, the Polar water there being to a greater extent mixed with Atlantic water; the process of mixing had taken place for the most part in the Channel itself, partially also in the Norwegian Sea. Below these several masses of water the Channel was filled down to the bottom with relatively cold water, of salinity less than $35{\cdot}0^{\circ}/_{\circ\circ}$, derived from the bottom layers of the Norwegian sea and the under parts of the East Icelandic Polar Current. This mass of water had the shape of an inverted wedge and had an independent motion to the southward.

December, 1902.

The December observations from the Channel are recorded in the Tables and graphically represented in two sections, Plate I., Fig. 3, 4. They show the same four bodies of water as we found in August, but their range of distribution and other conditions had altered considerably. Still more than was the case in August we feel the want of more numerous observations from this area in December; I think that, for instance, important phenomena west of station Sc. 14 and east of station Sc. 18 are missed out altogether. The station observations differ much from each other and show peculiarities that cannot be completely explained, for want of observations from the parts of the Channel north and south of the *Jackal's* course. Thus no observations exist from the southern part of the Norwegian Sea nor from the Channel near the Wyville Thomson ridge in December. At that time the weather was very stormy and greatly hindered the observations; moreover, the winds affected the surface movements in such a manner that these were probably irregular and inconstant.

The changes which had taken place from August to December were of two kinds: *the limits between the different water strata had altered their position, mainly because the movements had themselves altered, and the conditions within the different water layers themselves were other than three months before.*

The salt and warm nucleus of the Norwegian Atlantic Current was again in December situated along the Shetland Bank in the eastern part of the Channel. There are some striking differences between the two sections. For one thing, *the saltest part of the Norwegian Atlantic Current, with salinities above* $35{\cdot}25^{\circ}/_{\circ\circ}$, *was considerably narrower in the southern section than in the northern one.* In the southern section the depth of the "35·25-water" was about 300 metres and it was about 50 miles broad at the surface; in the northern one the depth was more than 500 metres and the breadth about 80 nautical miles at the surface. Consequently it is probable that *the current was considerably narrower and the velocity of the stream correspondingly greater in the southern part of the Channel than farther to the north.* In August the southern part of the stream in this area extended farther westwards than in December, but the opposite is the case in the northern part, where the current extended much more to the westward in December. To the north of Shetland (station Sc. 12) we found water of above $35{\cdot}3^{\circ}/_{\circ\circ}$ all through in August, but in December only salinities below $35{\cdot}2^{\circ}/_{\circ\circ}$; in the middle of the Channel (Sc. 14) on the other hand, the maximum salinity in August was $35{\cdot}15^{\circ}/_{\circ\circ}$, in December $35{\cdot}30^{\circ}/_{\circ\circ}$. It is thus evident that the nucleus of the stream in December was pressed more to the eastward against the Shetland Bank in the south, and then diverged to a greater distance from land in the north than it had done in August. We shall come back to this point in the sequel. From equation (3) we find between stations Sc. 13 and Sc. 14 the following differences of the average velocities :—

Between the surface and 100 m. difference about $-0{\cdot}3\ \frac{\text{cm}}{\text{sec}}$.
„ „ „ 200 „ „ „ $-0{\cdot}1$ „
„ „ „ 300 „ „ „ 1·4 „
„ „ „ 400 „ „ „ 4·1 „
„ „ „ 470 „ „ „ 7·0 „

These numbers are represented in Fig. 3 (p. 9). At 100 metres the velocity was greater by about 0·3 centimetres per second than at the surface, and even at 200 metres depth the stream was moving a little faster northwards than at the surface. We lack material to determine the absolute velocities in December. In August the velocity at 470 metres was 12 cm. per second less than at the surface; in December the difference was 7 centimetres. If, then, the velocities at greater depths were the same in both months, the surface velocity seems to have been about 5 centimetres per second (2–3 nautical miles in 24 hours) less in December than three months before.

The average densities at the surface within the "35·25-water" are found to be :—

—	August.	December.
Southern part	1·02704	1·02741
Northern „	1·02705	1·02733

In August the densities were very slightly less in the southern part of the Channel than in the northern one, but in December the opposite was the case; the densities were considerably higher in the north than in the south. This distribution of the densities must tend to counteract the northward movement of the surface water, and thus to decrease the velocity. It is hence very probable that *the surface velocity of the Norwegian Atlantic Current was greater in the summer of* 1902 *than in the winter*—in complete agreement with *Dickson's* statement that "northward movement of water originating as a *stream* current is strongest in summer."* On account of convection currents, and as a result of gradual mixing, the temperatures grew more uniform northwards; in the southern section the temperatures of the "35·25-water" ranged between 7° and 10° C. (with a maximum at about 100 metres); in the northern section between 8° and 9½° C. (with a maximum at the surface). During the time between the two cruises the temperatures were upon the whole lowered by about 1½° C.

The deep cold wedge had undergone important alterations from summer to winter in 1902. In August the summit of the 35·0 isohaline was met with deeper and deeper as we traced it southwards and became level from east to west. In December the opposite was the case—the summit of the "35·0 water" was in the northern section found at about 400 metres depth, in the southern section nearer to the surface at about 350 metres, and it was southwardly directed towards the eastern (Shetland) side of the Channel. We find, thus, great variations from summer to winter at depths of some hundred metres in

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* "Geographical Journ.," April, 1903, p. 431.

the different stations. The following table, which contains the temperature observations from 400 metres, will illustrate this :—

Station.	Northern Section.		Southern Section.	
	Sc. 15.	Sc. 14.	Sc. 18.	Sc. 19.
Temperature, August	6°·35	About 2°·5	4°·27	5°·70
„ December	3°·17	5°·59	6°·93	0°·49

We have supposed that the water in the eastern part of the Channel down to 600 metres was in August moving on an average northwards, and that the velocity was almost nil at that depth. From the distribution of the salinities in December it seems likely that the depth of the northward-moving waters in the northern part of the Channel was nearly the same. The temperature at about 600 metres was approximately the same in both months, as can be seen from the following extract from the tables containing some of the observations from station Sc. 14 :—

Depth.	300 m.	500 m.	600 m.	700 m.	1000 m.
Temperature, August	3°·60	1°·24	...	0°·15	–0°·52
„ December	7°·62	2°·14	0°·33	–0°·24	–0°·70

From these data it is also seen that *the temperatures of the bottom water had changed even down to the greatest depths.* At 700 metres the temperature was lowered by 0°39 C. and at 1000 metres by 0°18 C. from August to December. A decrease of temperature at these depths within three months cannot be explained without assuming that the bottom water was actually in motion and not stagnant.

It is probable that *the upper water layers in the Channel had a cyclonic movement in December as well as in August.* At the eastern border the Norwegian Atlantic Current was moving northwards ; in the northern part of the Channel the surface layer of the stream extended partially westwards. Along the Faeroe side a part of this water, and also water from the Norwegian Sea, streamed southwards and joined farther to the south a body of Atlantic water that was proceeding straight eastwards to the south of the Faeroes. This Atlantic water is partially seen at station Sc. 17 ; the temperatures between 20 and 60 metres depth were here higher in December than in the warmer month of August, apparently because the water now came more directly from the west, without having passed round the Faeroes and being cooled on the way. The eastward-moving water masses in the southern part of the Channel caused the wedge to keep near to the eastern border without being deflected to the west as in August. The under part of the Norwegian Atlantic Current got much intermingled to the northward with the cold water of the wedge ; the belt of water containing 35·0–35·25°/$_{\circ\circ}$ that lies between these water masses was much larger in the northern section than in the southern one. In the mixed water at some hundred metres depth we find almost the same coincidence of isotherms and isohalines as in August : 6° C. corresponded nearly to 35·1°/$_{\circ\circ}$ and 3° C. to 35·0°/$_{\circ\circ}$. The temperatures were a little lowered compared with the salinities.

The cyclonic movement of the upper water layers of the Channel explains, again, the presence of a layer of relatively fresh water of low temperature in the centre of the surface. It was only found along the southern track and was evidently of less extent than in the summer.

SOME PREVIOUS INVESTIGATIONS.

The results of earlier expeditions are in many cases not directly comparable with our material from 1902. The difficulties of such a comparison arise partially from the very great variations to which the hydrographical state of the Channel is evidently subject, and partially also from differences of method and even from errors of procedure. It is quite obvious that the temperatures and salinities vary largely within short distances and within short intervals of time. It is, therefore, impossible to draw from isolated stations conclusions as to the hydrographical conditions throughout the whole Channel; and it is generally not permissible to combine stations investigated at different epochs one with another. Most of the older determinations of temperature are probably correct; but the determinations of salinity or of specific gravity are evidently in many cases very doubtful. Besides constant corrections originating in the use of different factors for the relation between chlorine, salts and specific gravity, there are often other great and more irregular errors in the older results. These are due to imperfect water-bottles, also to alterations in the samples (from evaporation, &c.) but in most cases to the methods used for determining the characteristics of the samples.

Mohn found from his study of the Norwegian Sea that the water of this sea, from a depth below the "Gulf Stream," passes southwards along the bottom and along the north-western border of the Faeroe Channel and turns at the Wyville Thomson Ridge.* As to the surface movements, *Mohn* says: † "Between the Faeroes and Scotland the Atlantic water finds direct ingress into the Northern Ocean, after bending from N.N.E. to E. and E.S.E. Between Scotland and the Faeroe-Shetland Channel the velocity is 0·16 m. per second to 0·23 m. per second." We have for August, 1902, found the very same velocities of the Norwegian Atlantic Current (0·2 m. per second), but, on the other hand, somewhat different directions of the circulating water masses. Then the water at the Shetland side was moving with less of an easterly component, and the water in the neighbourhood of the Faeroes was moving from the Norwegian Sea more nearly due south than had been supposed by *Mohn*. In December, however, our results as to the directions seem to agree fairly well, except in the northern part of the Channel, where the stream then had a trend westwards; and except that the velocities of the Norwegian Atlantic Current were then smaller than the values given by *Mohn*.

The first special and extensive hydrographical survey of the Channel between Shetland and the Faeroes was made by *Dickson* in 1893, on board the *Jackal*,‡ at which time he made a great many temperature observations, but relatively few determinations of specific gravity or of salinity. Moreover, the methods and tables in use at the time for the determination of salinity were unsatisfactory; and, upon the whole, it is probable that the salinities recorded in his paper are too high.§

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* *Mohn*: "The North Ocean: Its Depths, Temperature and Circulation" (The Norwegian North Atlantic Expedition, 1876–78, Christiania, 1887), p. 181. See also *Dickson* in XIIth Fishery Board Report, p. 350. *Mohn's* sections are now of little value as they include stations worked at very different times by different ships (*Porcupine*, *Knight Errant*, *Triton* and *Vöringen*); no contemporary investigations of importance were made at the time between Shetland and the Faeroes.

† *l.c.* p. 168, Pl. XLIII.

‡ XIIth Scottish Fishery Board Report (1893), Pt. iii., p. 336, 1894.

§ *Dickson's* calculations of the salinities are partially based upon *Pettersson's* tables. I have found that these give the salinities higher by about 0·08 ‰ than *Knudsen's* tables. *Dickson* has thus found for the bottom-water (732 metres depth with temperature −0°4C.) a salinity=35·06 ‰ ($\sigma_t=28{\cdot}23$); whereas I have never found in the southern part of the Norwegian Sea higher salinities than 34·96 ‰ for the deep water at temperatures below zero (maximum value of $\sigma_t=28{\cdot}10$); they are certainly not higher in the Channel. In the central and western part, at 200 fathoms, *Dickson* found salinities generally above 35·2 ‰, when the temperatures were about 6°; whereas it seems probable that the salinities there ought to be about 35·1 ‰, as they were found to be in 1902.

It is evident that the salinities in the eastern part of the Channel (in the main part of the Norwegian Atlantic Current) were rather lower in 1893 than in 1902; in the western part they seem to have been approximately the same and in the central part higher. In 1893 "the cold bottom water, which shows no marked tendency to rise towards the surface, was entirely cut off from a thin layer of relatively fresh surface water (salinity below 35·3°), which covered the whole surface of the Channel to a depth of a few fathoms."* The temperature observations in 1893 seem to show that the deep wedge then approached more to the surface in the southern part of the Channel than farther north.† Thus 1°C. was met with at about 700 metres depth in the northern part of the Channel, but at 460 metres in the southern. When the observations from 1893 are summed up it seems permissible to draw the following conclusions, as *Dickson* himself has, in part, done: The Norwegian Atlantic Current extended in August, 1893, below the surface over the greater part of the Channel. The bottom-water was drawn up from below as a sort of undertow (*Ekman's* 'Reaction-current'); and this deep water from the Norwegian Sea had but a very slow independent motion. The Norwegian Atlantic Current was, in the surface-layer, counteracted or antagonised by water from the Norwegian Sea, and it got mixed with this latter water which had then a rather high temperature owing to the fact that the East Icelandic Polar Current did not in 1893 bring much cold water towards the Faeroes. Especially in the western part of the surface of the Channel the northward motion was overcome and turned into a movement straight towards the south. This would partially explain the fact that the *Jackal* was involved in a somewhat strong southerly drift in the Channel, a striking phenomenon that could not at the time be adequately explained.

Dickson has lately published, in his article in the "Geographical Journal" for April, 1903, which we have several times mentioned and quoted, a good many observations made by Dr. *Wolfenden* in the Channel during the years 1899 to 1902. It is rendered more than ever clear from these observations that the hydrographical characteristics in the Channel may vary very considerably within short distances and within a few weeks.

General Statements.

From the observations made up to the present time in the Channel, the following general conclusions may be drawn:—

Atlantic water is always moving northwards through the Channel to the Norwegian Sea, in the southern part of which sea the maximum salinity always exceeds 35·25°/₀₀.‡ This Norwegian Atlantic Current comes, as it were, in irregular pulsations, varying much in velocity and extent within short periods. The stream sometimes occupies the whole breadth of the Channel, but as a rule it is limited to the eastern side. Its velocity is often greatest at some intermediate depth; at the surface it is more or less checked by bodies of water from the Norwegian Sea.

Water from the Norwegian Sea is always entering the Channel in a wedge-shaped mass, extending from some hundred metres depth down to the bottom: and it often enters also in the upper layers in the western and central parts of the Channel. The velocity and quantity of this southward-moving water also vary largely. The wedge generally, but not always, extends throughout the whole Channel. It may be lifted nearer to the surface towards the south, especially when the Atlantic Current is broad and of relatively great velocity.

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* Geogr. Journ., Apr. 1903, p. 422, 423.

† *Dickson* had only one deep station from the southern part of the Channel.

‡ According to *Knudsen's* Tables.

When the Norwegian Atlantic Current is limited to the eastern part of the Channel, the western part is filled with water from the north. Under these circumstances, the upper layers get a cyclonic movement with a still or stagnant part in the centre. This is generally noticeable at the surface, where an eddy is formed containing water of relatively low salinity from the Norwegian Sea.

Extensive processes of mixing take place in the Channel; and, as a result of this mixing, the hydrographical characteristics of the water in the southern part of the Norwegian Sea tend to a somewhat uniform distribution.*

3. THE NORTHERN PART OF THE NORTH SEA.

The Scottish observations for August and November, 1902, are not extensive enough to make it possible to draw final conclusions as to the complex hydrographical features of the North Sea. In comparison with the observations made before 1902, and still more in comparison with all the material which is now being collected under the International Scheme, the material dealt with here is small. The following discussion deals only with some of the more important problems.

The variations of the hydrographical conditions within short distances and during short periods are even greater in the North Sea than in the Faeroe-Shetland Channel. Hence the sections, shown on Plates II. and III., are largely hypothetical, and do not permit of minute conclusions being drawn. From most parts of the North Sea and the Norwegian Sea the differences of salinities, of temperatures, and speaking generally, of densities, are usually so great that an enormous amount of material is necessary in order to arrive at the true conditions. This fact has not hitherto been taken sufficiently into account by oceanographers. The usual method of discussing the current, &c., from sectional observations of temperature and salinity has, in consequence, often been misleading.

August, 1902.

Dr. *Fulton* has from his drift-bottle investigations† found that the *surface-layer* of the North Sea generally has a cyclonic movement. This was also the case in August, 1902: Atlantic water of 35·0 °/₀₀ and about 12° C. entered the North Sea along the north-eastern coast of Scotland (*see* Surface-chart, Fig. 2), and proceeded south-eastwards to the Doggerbank. This highly saline water, of 35·0°/₀₀, lay *close to the northern part of the Scottish Coast*; it penetrated the Pentland Firth and the Sounds of the Orkneys, but did not, to any significant extent, pass through the opening between the Orkneys and Shetland, where water from the North Sea prevailed. Midway between Shetland and Norway another short tongue of 35°/₀₀ water is seen (between stations Sc. 7 and Sc. 8, Pl. II., Fig. 2, and the Surface-chart Fig. 2); it is a continuation of the salt water near station Sc. 9. This water was moving southwards as an offshoot from the Norwegian stream, and got quickly intermingled with the fresher water from the North Sea. North Sea water made a bend northwards, E. of Shetland. The directions of the surface movements seemed to be south-westerly to the E. of Shetland, changing into south along the eastern Scottish coast, and afterwards more and more eastwards, passing over the Doggerbank; then northwards along the Norwegian Channel, the waters at about 59°–60° N. latitude being divided into two branches, one proceeding towards the north-west (E. of Shetland), the other one joining the Baltic current and running further northwards along the Norwegian coast.

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* The problems of the Faeroe-Shetland Channel are closely connected with those of the Norwegian Sea. For further particulars on this point, the reader may be referred to a paper, by Professor Fridtjof Nansen and myself, "On the Physical Oceanography of the Norwegian Sea," which is about to be published (Report on Norwegian Fishery and Marine Investigations, Vol. II., No. 3).

† Fifteenth Annual Report of Scottish Fishery Board (1896), Pt. iii., p. 334, 1897.

Looking now at *the deeper water layers* we first notice that large areas of the bottom of the northern part of the North Sea were covered with remarkably cold and remarkably salt water. The bottom-layer at about 100 metres, seen in Pl. III., fig. 3, had temperatures below 7° C. (about 5° C. lower than at the surface), and salinities above 35·2°/$_{00}$ (considerably higher than anywhere at the surface of the North Sea). At station Sc. 24 the temperature at 120 metres depth was 6°·70 C., the same as the bottom temperature at the German station D. Nordsee 4, in the centre of the North Sea.* Most of the bottom north of a line from Scarborough to the Skagerrack was covered with this cold water, *i.e.*, practically the part of the North Sea where the depths are greater than 50 metres. The line then skirted the northern border of the Doggerbank, where the bottom temperatures were considerably higher. *The low temperatures below 7° were, however, not found along the route from the Moray Firth to Shetland* (Pl. III., fig. 2). Here the cold water was limited by warmer and less salt water. Along the English coasts the temperatures were in all probability higher too. The isotherm of 7° C. was met with in August, 1902: at station Sc. 24, at about 60 metres; at the German station D. Nordsee 4 (in the central part of the North Sea), at 45 metres; and still more to the south at the station D. Nordsee 3, at 35 metres (a little north of the Doggerbank). It is thus seen that *these low temperatures were found nearer to the surface in the southern part of the area in question than further to the north.* And a similar investigation shows that in the eastern part of the area—towards the Norwegian Channel—the isotherm of 7° C. lay deeper than in the central part of the North Sea. It seems, then, as if *this cold bottom water were banked up in the central part of the North Sea, north of the Doggerbank*, the whole bottom south of this bank being covered with water of much higher temperatures. Thus the North Sea was divided into two distinctly different parts, corresponding to the configuration of the bottom.

These two different areas were first observed by Dr. *Meyer* during the *Pommerania* expedition in the summer of 1872, and have since then been studied by various oceanographers.† It is quite plain and certain that the low temperatures are always (or nearly always) to be found in the northern half of the North Sea during summer and autumn.

The salinity of this cold bottom water is, as already mentioned, remarkably high, even above 35·25°/$_{00}$. In August this cold water was cut off from the Norwegian Atlantic Current in the Faeroe-Shetland Channel by water layers of considerably less salinity, but it had a direct communication with that salt current north and north-east of Shetland (Pl. II., sections 2 and 3). Here, however, north and north-east of Shetland, the corresponding temperatures were 1°–2° C. higher.

The bottom-layer had much higher densities than the upper layer. In the former the densities were 1·0273 – 1·0275 or more; in the surface-layer they were considerably below 1·0270. These two layers were in August distinctly separated from each other, and there is a sudden and large increase of the densities at the transition plane, caused by the sudden decrease of temperature and increase of salinity. The limit is found at various depths in the different parts of the sea; at station Sc. 24 the limit was situated at about 50 metres depth in August, 1902.

DECEMBER, 1902.

In order to further understand these conditions it is necessary to discuss the conditions observed in December, 1902. The *surface observations* made at that date show some significant differences from those made in August. The temperatures are, of course, considerably lower, ranging from 6·5° and 9·5° C. in the northern part of the North Sea; but the salinities are, upon the whole, much higher. It is probable that

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* August Bulletin, 1902, of the International Council.

† See, *e.g.*, *John Gibson:* Report on Observations relating to the Physics and Chemistry of the North Sea during 1888 and 1889 (Seventh Scottish Fishery Board Report). See also *H. N. Dickson's* memoir in the Twelfth Scottish Fishery Board Report.

35°/₀₀ water entered the North Sea near the Scottish coast in December, as we have shewn that it did in August, but in December most of the salt water came round Shetland, passing southwards east of the islands. One band of 35 °/₀₀ water was found close to Shetland with salinities up to 35·20 °/₀₀, and another band of it was distributed midway between Shetland and Norway (salinities up to 35·28 °/₀₀ in the neighbourhood of station Sc. 7). Between those bands the salinities were much lower than 35 °/₀₀ (viz., 34·38 and 34·52 °/₀₀ between stations Sc. 6 and Sc. 7), indicating a drift from the south. Along the route from the Moray Firth to Lerwick only small quantities of 35 °/₀₀ water were found (maximum salinity 35·05 °/₀₀ between stations Sc. 3 and Sc. 4). Quite near Lerwick considerably higher salinities were observed in a narrow space; but further eastwards (corresponding to the section line 2, stations Sc. 23 and 24) much 35·2°/₀₀ water was met with, and in two localities even water of 35·34–35·35 °/₀₀. The salinities were here much higher than in August. An important question is: Did this very salt water come directly with a surface current southwards from the Norwegian Sea, or was it formed *in situ* by a transference of the salt bottom-water to the surface through the operation of vertical currents? In order to determine this point we must examine the vertical distribution of temperatures and salinities.

It is seen, then, that *the vertical distribution* of temperatures and of salinities, and hence of densities, was much more uniform in December than in August. In many places the density was perfectly uniform through many metres depth, and the slightest increase of density in the upper part would, under such circumstances, induce vertical currents. These vertical currents seem to be interrupted in many places: in one part of a vertical column of water such a current system goes on, carrying the colder water downwards and thus cooling the upper end of the next part of the column, where another "current" is set up. In this way several separate vertical "currents" may be developed; and within each of them the density is almost uniform (*e.g.*, station Sc. 23*). In other places, the vertical current system is continuous from surface to bottom (*e.g.*, stations Sc. 2, 4, 6), so that there is no sudden increase of the densities; under these circumstances the two layers observed in August become intermingled with each other. In many cases the total amount of salts from surface to bottom was not the same in December as in August, sometimes larger, sometimes smaller. Thus the total amount of salts was less at stations Sc. 2 and Sc. 5 (between the Moray Firth and Shetland) in December than in August, but greater in the more easterly stations Sc. 23 and Sc. 24. The reason of this change must be either a greater influx of Atlantic water or a less influx of fresh water in the western part of the North Sea (above the Norwegian Channel). When we examine the salinities of the Baltic Current, we find that they are considerably lower in December than in August (*see e.g.* station Sc. 7 and the German and Swedish stations in the Norwegian Channel); the supply of fresh water was thus apparently greater in November–December than in August.† It follows, as the only probable conclusion, that the *supply of salt Atlantic water to the northern part of the North Sea had increased during the autumn.* And, from the distribution of salinities, it is evident that *this influx of Atlantic water took place southwards from the Norwegian Sea, and not to any important extent between Shetland and the Orkneys from the Faeroe-Shetland Channel.* This influx of salt water is illustrated by the sections 1 and 2, pl. II. In the northern section (Fig. 1) for August we see much water of 35·25 °/₀₀ and above 8° C.; in the more southern one (Fig. 2) 35·25 °/₀₀ water is hardly to be found save in the deeper layers, being overlaid by fresher water from the North Sea. This very salt bottom-water was continuous with the bottom-water of section 3, pl. III., the temperatures decreasing by about 1°·5 C. The vertical extension of this water decreased southwards along Shetland. It spread over the whole area southwards to the Doggerbank, being—as already mentioned—lifted up in the central part of the sea. In

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* *See* also the German station D.L.N. Nordsee 4 in the November Bulletin, 1902.

† I have not taken into consideration the rainfall, evaporation, &c., but think that these factors are of less importance than the above-named.

the northern December section (Pl. II., 3) we see again vast quantities of 35·25 °/$_{oo}$ water of temperatures above 8° C.; in the more southern section (Pl. II., 4) the water-masses near Shetland are mixed with fresher water, forming water of a mean salinity of almost 35·2 °/$_{oo}$. The bottom-layer containing 35·25°/$_{oo}$ water in August has grown less salt, the upper layers however considerably salter. Midway between Shetland and Norway a mass of 35·25 °/$_{oo}$ water is still seen. The waters evidently moved southwards almost all over, *e.g.* from between stations Sc. 9 and Sc. 10 to station Sc. 7, except in the small space between the stations Sc. 6 and Sc. 7 where water from the North Sea made a bend towards the north-west. This North Sea water probably turned and passed southwards nearer to Shetland along with the Atlantic water. It was, however, only found at the surface, and it is probable that the deeper layers of salt water passed unbroken southwards. Still more to the southward at the stations Sc. 23 and Sc. 24 most of the salinities are 35·1–35·2 °/$_{oo}$, a little less than further to the north, the temperatures having decreased by about 1° C. Thus in December, too, the salt waters from the north are continued into the salt waters further south.

This very salt water is not of Arctic origin, that is to say, it does not form a continuation of the East Icelandic Polar current, nor of the bottom water of the Norwegian Sea. In August, as well as in December, 1902, the depth of the Norwegian Atlantic Current was about 400 metres, and it was not penetrated by the Polar current but passed unbroken northwards. It is also seen from the sections on Pl. II. that the salt water in question was found east of Shetland, where the depths are about 150 metres. Further, it is not to any important extent drawn up on to the North Sea bank from the deep parts of the Norwegian Channel, where deep water from the Norwegian Sea may partially enter. *Almost all of it is an offshoot from the Atlantic Stream in the Norwegian Sea, owing its low temperature to the effect of the winter in the North Sea itself* by convection currents. It is, moreover, evident that the salinities are considerably higher than those of real Arctic water. It has been supposed, especially by the Swedish oceanographers, that "Arctic water" periodically enters the Skagerrack,* but I think the cold and salt water found there is the same kind of cold *Atlantic* water that covers the northern area of the North Sea, and which has here been still more cooled (and diluted): and that water from the East Icelandic Polar current is never found in the Skagerrack, except perhaps sometimes partially at the bottom, where the Atlantic water may possibly be found somewhat diluted with bottom water that has come from the Norwegian Sea and has traversed the Norwegian Channel.

The result of this discussion is, then, to shew that *the salt water at the surface of the northern part of the North Sea in December had two sources; the chief source was an increased influx of water from the Atlantic stream in the Norwegian Sea and the other source was a transference of salt water from the bottom by vertical currents.* This latter cause may be sufficient to reduce the salinities of the bottom-layer for some time.

The temperatures are relatively much reduced southwards, so much that the southward movement of the water-masses must be slow, and slower in summer time than during the autumn and winter. The low temperatures of the bottom-layer in August could not exist were the movement not very slow.

The cold bottom-water is a reminiscence of the foregoing winter, and the low temperatures at the bottom are due chiefly to vertical currents, but also to some extent to the effect of "temperature-waves" slowly transmitted downwards in the same way as has been found, *e.g.*, by Prof. *Mohn*, in the Norwegian fjords.

On account of the vertical currents the temperatures fall more and more until the spring. If the vertical current does not extend quite through the water masses from surface to bottom—if, in

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* See the different papers by Prof^{r} *Pettersson* on this subject.

other words, very cold and relatively light water superpose warmer and denser water—a slow "temperature wave" will proceed downwards and reduce the bottom temperature still more during spring and summer. The temperature reached in this way depends upon the depth of the water; at 150 metres depth the minimum temperature will be found considerably later than at 100 metres.

GENERAL STATEMENTS.

From what has been said above we may sum up as follows:—In August, as well as in December, 1902, the surface water of the North Sea moved cyclonically. The deeper layers had in August an extremely slow motion; in December these layers moved more quickly southwards from the Norwegian Sea. As these water masses could not be stored up north of the Doggerbank it is possible that they bent off towards the Norwegian Channel, thus *forming part of a slow cyclonic movement in the bottom layer also.* It is worth noticing that the movements in the North Sea resemble those described from the Faeroe-Shetland Channel in the foregoing chapter. It is very probable that there was an "eddy" formed in the North Sea similar to that found in the central part of the Channel between Shetland and the Faeroes, but there is not sufficient material available for a definite conclusion on this point. If it be the case, we should expect to find that, in such an eddy, eggs and fry of various fishes (and also other plankton-organisms) keep there for some time without being carried away by currents, and it is probable that, other circumstances being favourable, the amount of fry found in such localities will be greater than in other parts of the sea.

Our observations are not yet extensive enough for more detailed conclusions, and the description of the currents here given refers only to the main system; it is very probable that there are many smaller local systems.

It is at present impossible to calculate the absolute velocities of the currents in the North Sea, as we do not know where these velocities are nil, and as we also lack data for introducing the influence of friction (including the effect of the winds) into the hydrodynamical formula. I shall here only give two instances of hydrodynamical calculations to illustrate the phenomena.

In the part of the North Sea S.S.E. of Shetland we find the following differences between the mean velocities at the surface (c_0) and at different depths (c_1):—

—	Between Sc. 3 and Sc. 24 in August.	Between Sc. 4 and Sc. 24 in December.
	$c_0 - c_1$	$c_0 - c_1$
Between the surface and 20 m. ...	$-1{\cdot}1 \frac{\text{cm.}}{\text{sec.}}$	—
„ „ 30 „ ...	—	$0{\cdot}8 \frac{\text{cm.}}{\text{sec.}}$
„ „ 40 „ ...	$-1{\cdot}3$ „	—
„ „ 60 „ ...	$-0{\cdot}5$ „	$1{\cdot}4$ „
„ „ 80 „ ...	$0{\cdot}3$ „	—
„ „ 100 „ ...	$1{\cdot}0$ „	$2{\cdot}6$ „

In August the lighter water was found at Sc. 24 in the upper layers, at Sc. 23 in the deeper. Supposing that all the water between these two stations was, on an average, moving southwards, then the movement had a maximum velocity at 30–40 metres depth. At about 70 metres the velocity was the same as at the surface ; still deeper it was less. In December the velocities were gradually decreasing from the surface to the bottom. Between Shetland and Norway (Pl. II., 2, 4.) we notice that the lightest water was found all through at the eastern station Sc. 7 ($c_0 - c_1$ between Sc. 6 and Sc. 7, 0 and 100 meters, is $= 2\frac{\text{cm}}{\text{sec}}$). This indicates that the surface water was moving slowly towards the north-west, forming the bend or offshoot of North Sea water east of Shetland as suggested above. In December there was almost no difference of density at all between the same stations. In the northern section, the maximum densities were found at station Sc. 9, with lighter water at the eastern station Sc. 8 as well as at the more westerly station Sc. 10. The water between Sc. 9 and Sc. 10 was, on an average, moving southwards all through in August as well as in December. Near station Sc. 8 the water was moving northwards in both months, the surface water evidently more quickly in December than in August. The following numbers are found by calculation :—

—	$c_0 - c_1$ between Sc. 8 and Sc. 9.	
	In August.	In December.
Between the surface and 100 m. ...	$4·7\ \frac{\text{cm.}}{\text{sec.}}$	$11·5\ \frac{\text{cm.}}{\text{sec.}}$
„ „ 200 „ ...	5·6 „	13·4 „
„ „ 300 „ ...	—	20·0 „

It is probable that at least the water below 200 metres at Sc. 8 in December was moving southwards into the Norwegian Channel ; this water was, however, Atlantic water from the Norwegian Atlantic Current and not water from the East Icelandic Polar Current, as the salinities as well as the temperatures were considerably higher than they would have been had there been an overflow of Arctic water.

I have tried in these pages to describe the hydrographical conditions in the last half-year of 1902. They vary considerably from year to year and may sometimes be found to be quite different. The periodic phenomena discovered by *Pettersson and Ekman** I have not been able to discuss from our material, but the future work of the International Council will doubtless throw more light upon these variations.

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* See, *e.g.*, "Ytvattnets tillstånd i Nordsjön och Skagerack," Bihang til Kungl. svenska Vettenskaps Akademiens Handlingar, Vol. 25, Part II., No. 1 (Stockholm, 1899).

TABLE 1.

(The explanation of this table is found above, page 3.)

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/oo	σ_t	v—v^1	E—E^1	t.°C.	S.°/oo	σ_t	v—v^1	E—E^1
		STATION SC. 1.									
—		Latitude, N. 58° 0′; Longitude, W. 2° 54′. 26/viii, 3h. 40m. a.m.—4h. 30m. a.m.					—				
0	0	11·71	34·97	26·65	*141*	*0*	—	—	—	—	—
10	5	11·50	34·97	26·685	*137*	*1390*	—	—	—	—	—
20	11	10·86	34·98	26·81	*125*	*2700*	—	—	—	—	—
30	16	10·53	34·99	26·875	*120·5*	*3925*	—	—	—	—	—
40	22	10·52	34·99	26·875	*120*	*5127*	—	—	—	—	—
		STATION SC. 2.									
—		Latitude, N. 58° 36′; Longitude, W. 1° 46′. 26/viii, 10h. a.m.—10h. 40m. a.m.					Latitude, N. 58° 36′; Longitude, W. 1° 46′. 4/xii, 2h. p.m.				
0	0	12·10	34·79	26·43	*161*	*0*	8·15	34·97	27·265	*81·5*	*0*
10	5	11·64	34·84	26·55	*148*	*1545*	8·55	—	—	—	—
20	11	11·12	34·85	26·65	*139*	*2980*	—	—	—	—	—
30	16	—	—	—	—	—	8·55	34·97	27·19	*89*	*2556*
40	22	9·81	35·07	27·055	*102*	*5490*	—	—	—	—	—
60	33	9 47	35·14	27·17	*91*	*7420*	8·66	34·97	27·175	*92*	*5271*
75	41	—	—	—	—	—	8·76	34·99	27·17	*92*	*6651*
80	44	9·14	35·15	27·23	*86·5*	*9234*	—	—	—	—	—
95	52	9·13	35·16	27·235	*86*	*10527*	—	—	—	—	—
100	55	—	—	—	—	—	8·76	—	—	—	—
		STATION SC. 3.									
—		Latitude, N. 59° 10′; Longitude, W. 1° 27′. 26/viii, 3h. 10m. p.m.—4h. p.m.					—				
0	0	11·71	34·59	26·375	*169·5*	*0*	—	—	—	—	—
10	5	11·15	34·60	26·455	*158*	*1637*	—	—	—	—	—
20	11	10·87	34·62	26·535	*151·5*	*3184*	—	—	—	—	—
40	22	9·73	34·97	27·000	*108·5*	*5784*	—	—	—	—	—
60	33	9·29	35·09	27·16	*98*	*7848*	—	—	—	—	—
80	44	9·12	35·10	27·20	*90*	*9728*	—	—	—	—	—
100	55	9·01	35·14	27·245	*85*	*11478*	—	—	—	—	—

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.‰	σ_t	$v-v^1$	$E-E^1$	t.°C.	S.‰	σ_t	$v-v^1$	$E-E^1$

STATION SC. 4.

—		Latitude, N. 59° 26′; Longitude, W. 1° 20′. 26/viii, 7h. 10m. p.m.—7h. 40m. p.m.					Latitude, N. 59° 17′; Longitude, W. 1° 30′. 4/xii, 8h. p.m.				
0	0	10·81	34·96	26·795	*126*	*0*	8·75	—	—	—	—
10	5	10·43	34·94	26·85	*120·5*	*1230*	8·75	35·00	27·18	*90*	*0*
20	11	9·74	35·00	27·02	*105·5*	*2360*	8·85	35·00	27·165	*92*	*1820*
40	22	9·69	35·00	27·025	*106*	*4474*	8·95	34·99	27·14	*95*	*3690*
60	33	9·67	35·02	27·045	*100*	*6534*	8·86	34·99	27·155	*94*	*5580*
80	44	9·67	35·00	27·03	*106*	*8594*	9·06	35·00	27·13	*96*	*7480*
100	55	—	—	—	—	—	8·96	35·00	27·15	*95*	*9390*
105	57	8·89	35·14	27·265	*84*	*10969*	—	—	—	—	—

STATION SC. 5.

—		Latitude, N. 59° 40′; Longitude, W. 1° 14′. 26/viii, 11h. 20m. p.m.—27/viii, 12h. 5m. a.m.					Latitude, N. 59° 40′; Longitude, W. 1° 15′. 15/xii, 1h. p.m.				
0	0	10·71	34·83	26·725	*134*	*0*	7·95	33·86	26·40	*164·5*	*0*
10	5	10·51	34·81	26·74	*131*	*1325*	—	—	—	—	—
20	11	9·97	34·97	26·95	*111·5*	*2537*	—	—	—	—	—
30	16	—	—	—	—	—	8·45	35·09	27·295	*79*	*3651*
40	22	9·20	35·14	27·215	*87*	*4521*	—	—	—	—	—
60	33	8·63	35·24	27·38	*71*	*6101*	8·46	35·09	27·295	*80*	*6036*
85	46	7·83	35·26	27·525	*59·5*	*7731*	—	—	—	—	—
100	55	—	—	—	—	—	8·56	35 08	27·27	*83*	*9296*

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.‰	σ_t	v—v^1	E—E^1	t.°C.	S.‰	σ_t	v—v^1	E—E^1
STATION SC. 6.											
—		Latitude, N. 60° 37′; Longitude, E. 0° 30′. 27/viii, 10h. 40m. p.m.—11h. 40m. p.m.					Latitude, N. 60° 37′; Longitude, E. 0° 30′. 8/xii, 3h. p.m.				
0	0	11·61	34·36	26·185	*184*	*0*	8·45	35·18	27·37	*72·5*	*0*
10	5	11·18	34·63	26·475	*156·5*	*1702*	—	—	—	—	—
20	11	10·37	—	—	—	—	8·10	35·17	27·42	*68*	*1404*
40	22	9·00	35·26	27·345	*75*	*5173*	8·15	35·17	27·41	*69*	*2774*
60	33	8·70	35·20	27·42	*68*	*6603*	8·21	35·18	27·415	*69·5*	*4158*
80	44	8·57	35·32	27·45	*65*	*7933*	8·11	35·19	27·425	*68*	*5532*
100	55	8·22	35·31	27·50	*60·5*	*9187*	8·11	35·18	27·42	*68·5*	*6896*
130	71	—	—	—	—	—	8·16	35·20	27·43	*68·5*	*8951*
140	77	8·05	35·34	27·55	*57·5*	*11547*	—	—	—	—	—
STATION SC. 7.											
—		Latitude, N. 61° 9′; Longitude, E. 2° 0′. 28/viii, 6h. a.m.—7h. a.m.					Latitude, N. 61° 12′; Longitude, E. 1° 52′. 8/xii, 11h. p.m.				
0	0	11·58	34·20	26·05	*195·5*	*0*	8·85	35·26	27·37	*72*	*0*
10	5	11·19	34·17	26·115	*191*	*1932*	—	—	—	—	—
20	11	11·10	34·45	26·345	*168·5*	*3729*	8·55	35·28	27·425	*66*	*1380*
40	22	10·21	35·14	27·045	*103*	*6443*	8·70	35·29	27·41	*69*	*2730*
60	33	9·38	34·95	27·035	*104·5*	*8517*	8·81	35·29	27·395	*70*	*4120*
80	44	9·35	35·13	27·18	*91*	*10471*	8·71	35·27	27·395	*71*	*5530*
100	55	8·28	35·30	27·49	*62*	*12001*	8·76	35·27	27·39	*72*	*6960*
120	66	—	—	—	—	—	8·71	—	—	—	—
140	77	7·45	—	—	—	—	8·62	35·26	27·405	*71*	*9820*

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/₀₀	σ_t	v—v¹	E—E¹	t.°C.	S.°/₀₀	σ_t	v—v¹	E—E¹

STATION SC. 8A.

—		—					Latitude, N. 61° 36′·5 ; Longitude, E. 2° 57′. 9/xii, 4h. a.m.				
0	0	—	—	—	—	—	6·55	32·74	25·715	*228*	*0*
274	150	—	—	—	—	—	5·90	35·11	27·675	*47·5*	*37757*

STATION SC. 8.

—		Latitude, N. 61° 32′ ; Longitude, E. 3° 10′. 28/viii, 12h. noon—1h. 50m. p.m.					Latitude, N. 61° 40′ ; Longitude, E. 3° 4′. 9/xii, 6h. a.m.				
0	0	10·58	34·07	26·145	*188*	*0*	6·65	32·77	25·73	*227*	*0*
10	5	9·98	34·07	26·255	*178*	*1830*	—	—	—	—	—
20	11	9·39	34·16	26·42	*162*	*3530*	6·04	33·04	26·025	*198*	*4250*
40	22	8·63	34·46	26·77	*128*	*6430*	6·07	33·43	26·33	*169*	*8020*
60	33	8·22	34·69	27·01	*106*	*8770*	7·50	34·15	26·70	*136*	*11070*
30	44	8·47	34·80	27 07	*102·5*	*10854*	8·01	34·56	26·945	*114*	*13570*
100	55	8·35	34·91	27·17	*93*	*12808*	8·26	34·88	27·16	*93*	*15640*
125	68	8·19	35·01	27·275	*83·5*	*15013*	—	—	—	—	—
150	82	7·92	35·04	27·335	*77·5*	*17026*	—	—	—	—	—
200	109	7·15	35·14	27·53	*60*	*20461*	8·67	35·26	27·395	*73*	*23940*
250	137	7·01	35·15	27·555	*59*	*23436*	—	—	—	—	—
300	164	6·27	35·14	27·65	*50·5*	*26171*	7·44	35·17	27·515	*64·5*	*30810*
350	191	5·93	35·12	27·675	*47·5*	*28621*	—	—	—	—	—
380	208	—	—	—	—	—	6·03	35·07	27·62	*53*	*35506*
390	213	5·99	—	—	—	—	—	—	—	—	—

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.‰	σ_t	v—v¹	E—E¹	t.°C.	S.‰	σ_t	v—v¹	E—E¹
STATION SC. 9.											
—		Latitude, N. 61° 34′ ; Longitude, E. 2° 5′. 28/viii, 5h. 15m. p.m.—6h. 20m. p.m.					Latitude, N. 61° 39′ ; Longitude, E. 2° 0′. 9/xii, 11h. a.m.				
0	0	10·98	35·01	26·815	*125*	*0*	9·15	35·29	27·34	*75*	*0*
10	5	10·80	35·15	26·945	*111·5*	*1182*	—	—	—	—	—
20	11	10·72	35·28	27·06	*101*	*2249*	8·55	35·28	27·425	*66*	*1410*
40	22	10·50	35·28	27·10	*97·5*	*4233*	8·55	35·27	27·42	*67·5*	*2744*
60	33	9·43	35·30	27·30	*79*	*5977*	8·45	—	—	—	—
80	44	9·83	35·32	27·245	*85*	*7617*	8·45	35·28	27·44	*66·5*	*5424*
100	55	8·92	35·32	27·395	*70·5*	*9171*	8·35	35·26	27·445	*66·5*	*6754*
125	68	8·88	35·31	27·40	*71·5*	*10946*	—	—	—	—	—
150	82	8·73	35·31	27·42	*69*	*12701*	—	—	—	—	—
200	109	8·51	35·29	27·44	*69·5*	*16161*	7·86	35·13	27·415	*71*	*13624*
240	131	8·00	35·25	27·48	*65*	*18849*	—	—	—	—	—
300	164	—	—	—	—	—	6·93	35·15	27·565	*59*	*20124*
STATION SC. 10.											
—		Latitude, N. 61° 38′ ; Longitude, E. 0° 43′. 28/viii, 11h. p.m.—12h. p.m.					Latitude, N. 61° 38′ ; Longitude, E. 0° 33′. 9/xii, 4h. p.m.				
0	0	10·98	35·03	26·82	*123·5*	*0*	9·55	35·30	27·28	*80*	*0*
10	5	11·00	35·07	26·845	*121*	*1222*	—	—	—	—	—
20	11	10·92	35·08	26·87	*119*	*2422*	8·75	35·31	27·42	*66·5*	*1464*
40	22	10·53	35·22	27·05	*102·5*	*4626*	8·85	35·28	27·38	*71*	*2838*
60	33	9·86	—	—	—	—	8·86	35·29	27·385	*71*	*4258*
80	44	9·80	35·27	27·215	*88*	*8434*	8·86	35·28	27·375	*72*	*5688*
100	55	9·58	35·28	27·26	*84·5*	*10158*	8·76	35·29	27·40	*70·5*	*7112*
125	68	9·12	35·30	27·355	*75·5*	*12158*	—	—	—	—	—
150	82	9·03	35·30	27·37	*75*	*14038*	—	—	—	—	—
170	93	—	—	—	—	—	8·77	35·27	27·385	*74*	*12166*
200	109	8·07	35·28	27·50	*62·5*	*17448*	—	—	—	—	—

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/$_{oo}$	σ_t	v—v^1	E—E^1	t.°C.	S.°/$_{oo}$	σ_t	v—v^1	E—E^1
		STATION SC. 11.									
—		Latitude, N. 61° 43′; Longitude, W. 0° 43′. 29/viii, 4h. 30m. a.m.—6h. a.m.					Latitude, N. 61° 50′; Longitude, W. 1° 0′. 9/xii, 12h. p.m.				
0	0	10·98	35·36	27·085	*99·5*	*0*	9·35	35·34	27·345	*76*	*0*
10	5	11·06	35·32	27·03	*103·5*	*1010*	—	—	—	—	—
20	11	10·77	35·32	27·08	*99*	*2022*	—	—	—	—	—
40	22	10·53	35·34	27·14	*93·5*	*3946*	8·85	35·31	27·405	*69*	*2860*
60	33	10·32	35·34	27·18	*90·5*	*5786*	8·86	35·30	27·395	*70*	*4250*
80	44	10·19	35·35	27·205	*88·5*	*7576*	8·86	35·30	27·395	*71*	*5660*
100	55	9·92	35·35	27·245	*84*	*9300*	8·86	35·31	27·40	*70*	*7070*
125	68	9·32	35·35	27·36	*75·5*	*11292*	—	—	—	—	—
150	82	9·33	35·36	27·37	*76*	*13184*	—	—	—	—	—
200	109	9·03	35·32	27·38	*75*	*16959*	8·57	35·29	27·43	*70*	*14070*
240	131	9·15	35·33	27·37	*77*	*19999*	—	—	—	—	—
300	164	—	—	—	—	—	8·28	35·23	27·43	*72*	*21190*
350	191	—	—	—	—	—	7·82	35·14	27·43	*73*	*24795*
		STATION SC. 12.									
—		Latitude, N. 61° 2′; Longitude, W. 1° 10′. 29/viii, 10h. 10m. a.m.—11h. a.m.					Latitude, N. 61° 0′; Longitude, W. 1° 18′. 10/xii, 6h. a.m.				
0	0	11·08	35·34	27·05	*102·5*	*0*	9·15	35·20	27·27	*80*	*0*
10	5	11·12	35·34	27·035	*103·5*	*1030*	—	—	—	—	—
20	11	11·00	35·35	27·07	*101*	*2052*	8·85	35·15	27·275	*81*	*1610*
40	22	10·80	35·34	27·095	*99*	*4052*	8·75	35·17	27·315	*78*	*3200*
60	33	10·36	35·34	27·175	*92*	*5962*	8·76	35·17	27·315	*78*	*4780*
80	44	9·88	35·34	27·255	*84·5*	*7736*	8·86	35·16	27·28	*82*	*6380*
100	55	9·42	35·33	27·325	*77·5*	*9356*	8·86	35·16	27·28	*82*	*8020*
125	68	9·45	35·33	27·32	*78·5*	*11306*	—	—	—	—	—
140	77	9·18	35·33	27·365	*75*	*12456*	—	—	—	—	—

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/$_{\circ\circ}$	σ_t	v—v^1	E—E^1	t.°C.	S.°/$_{\circ\circ}$	σ_t	v—v^1	E—E^1
STATION SC. 13.											
—		Latitude, N. 61° 12′; Longitude, W. 2° 6′. 29/viii, 2h. p.m.—4h. p.m.					Latitude, N. 61° 10′; Longitude, W. 2° 9′. 10/xii, 10h. a.m.				
0	0	10·98	35·32	27·045	*101*	*0*	9·45	35·37	27·355	*73*	*0*
10	5	11·02	35·31	27·03	*104*	*1025*	—	—	—	—	—
20	11	11·00	35·31	27·035	*104*	*2065*	—	—	—	—	—
30	16	—	—	—	—	—	8·95	35·35	27·38	*71*	*2160*
40	22	10·67	35·33	27·11	*97·5*	*4079*	—	—	—	—	—
60	33	9·99	35·31	27·215	*88*	*5933*	—	—	—	—	—
70	38	—	—	—	—	—	8·86	35·29	27·385	*71*	*5000*
80	44	9·93	35·31	27·225	*87·5*	*7687*	—	—	—	—	—
100	55	9·40	35·32	27·315	*78·5*	*9347*	8·86	35·30	27·395	*71*	*7130*
125	68	9·23	35·35	27·375	*73·5*	*11247*	—	—	—	—	—
150	82	9·33	35·35	27·36	*76·5*	*13122*	—	—	—	—	—
200	109	8·96	35·33	27·40	*73*	*16857*	8·87	35·31	27·40	*73*	*14330*
300	167	8·58	35·34	27·47	*68·5*	*23927*	8·89	35·29	27·38	*78*	*21880*
400	219	—	—	—	—	—	8·70	35·30	27·42	*76*	*29580*
470	257	—	—	—	—	—	7·94	35·21	27·47	*72*	*34760*
500	273	6·66	35·18	27·63	*56*	*36367*	—	—	—	—	—
900	492	0·14	34·97	28·10	*3·5*	*48247*	—	—	—	—	—

TABLE 1—*continued.*

STATION SC. 14.

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/oo	σ_t	v—v^1	E—E^1	t.°C.	S.°/oo	σ_t	v—v^1	E—E^1
—		Latitude, N. 61° 25′; Longitude, W. 3° 24′. 29/viii, 10h. 30m. p.m.—30/viii, 1h. 30m. a.m.					Latitude, N. 61° 23′; Longitude, W. 3° 25′. 10/xii, 6h. a.m.				
0	0	9·49	34·97	27·03	*103·5*	*0*	9·45	35·30	27·30	*78·5*	*0*
20	11	10·04	35·08	27·02	*104·5*	*2080*	—	—	—	—	—
30	16	—	—	—	—	—	8·95	35·29	27·37	*72*	*2256*
40	22	9·81	35·08	27·06	*101·5*	*4140*	—	—	—	—	—
60	33	8·62	35·15	27·315	*78*	*5934*	8·86	35·28	27·375	*74*	*4446*
80	44	8·62	35·15	27·315	*79*	*7504*	—	—	—	—	—
100	55	—	—	—	—	—	8·76	35·27	27·385	*72*	*7366*
150	82	7·05	35·10	27·515	*61·5*	*12418*	—	—	—	—	—
200	109	6·51	35·11	27·59	*54*	*15303*	7·73	35·14	27·445	*69*	*14416*
300	164	3·60	34·97	27·83	*31·5*	*19573*	7·62	—	—	—	—
400	219	—	—	—	—	—	5·59	35·09	27·695	*47*	*26016*
500	273	1·24	34·96	28·01	*13*	*23913*	2·14	34·89	27·895	*25*	*29616*
600	328	—	—	—	—	—	0·33	34·91	28·035	*10*	*31366*
700	383	0·15	34·93	28·06	*6·5*	*25853*	−0·24	34·90	28·06	*6·5*	*32186*
800	437	—	—	—	—	—	−0·45	34·90	28·07	*4·5*	*32736*
900	492	—	—	—	—	—	−0·65	34·92	28·09	*1*	*33006*
1000	547	−0·52	34·92	28·085	*2*	*27113*	−0·70	34·90	28·08	*2*	*33106*
1100	601	—	—	—	—	—	−0·80	34·90	28·085	*1·5*	*33276*

TABLE 1—*continued.*

STATION SC. 15.

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/$_{oo}$	σ_t	v—v^1	E—E^1	t.°C.	S.°/$_{oo}$	σ_t	v—v^1	E—E^1
—		Latitude, N. 61° 35′ ; Longitude, W. 4° 39′. 30/viii, 6h. a.m.—8h. 15m. a.m.					Latitude, N. 61° 38′ ; Longitude, W. 4° 39′. 11/xii, 1h. a.m.				
0	0	8·70	34·99	27·175	*90*	*0*	6·95	35·21	27·615	*48·5*	*0*
10	5	8·80	35·00	27·170	*91*	*905*	—	—	—	—	—
20	11	8·73	34·99	27·175	*90*	*1810*	—	—	—	—	—
30	16	—	—	—	—	—	7·44	35·13	27·475	*62*	*1656*
40	22	8·21	35·12	27·355	*73·5*	*3444*	—	—	—	—	—
60	33	—	—	—	—	—	7·42	—	—	—	—
100	55	8·06	35·21	27·455	*66*	*7626*	7·45	—	—	—	—
200	109	7·66	35·21	27·51	*62·5*	*14046*	7·52	35·13	27·465	*66*	*12536*
300	164	6·92	35·15	27·565	*59*	*20116*	6·83	35·19	27·61	*54*	*18536*
400	219	6·35	35·10	27·61	*55·5*	*25836*	3·17	35·00	27·895	*26*	*22536*
500	273	—	—	—	—	—	1·39	34·96	28·00	*13*	*24486*
600	328	—	—	—	—	—	0·40	34·93	28·045	*8·5*	*25556*
700	383	—	—	—	—	—	−0·02	34·93	28·07	*5·5*	*26256*
800	437	—	—	—	—	—	−0·48	34·92	28·08	*2·5*	*26656*
900	492	—	—	—	—	—	−0·65	34·95	28·115	*−1*	*26726*

TABLE 1—*continued*.

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.‰	σ_t	$v-v^1$	$E-E^1$	t.°C.	S.‰	σ_t	$v-v^1$	$E-E^1$
		STATION SC. 16.									
—		Latitude N. 61° 47′; Longitude, W. 6° 4′. 30/viii, 2h. 10m. p.m.—3h. 5m. p.m.					Latitude, N. 61° 44′; Longitude, W. 6° 3′. 11/xii, 8h. a.m.				
0	0	9·00	35·20	27·295	*79*	*0*	7·85	35·20	27·475	*62*	*0*
10	5	8·79	35·18	27·315	*76·5*	*777*	—	—	—	—	—
20	11	8·66	35·19	27·34	*75*	*1534*	—	—	—	—	—
30	16	—	—	—	—	—	7·59	35·16	27·475	*61*	*1845*
40	22	8·53	35·18	27·355	*74*	*3024*	—	—	—	—	—
60	33	8·52	35·19	27·36	*73*	*4494*	7·56	35·16	27·48	*62*	*3690*
80	44	8·42	35·21	27·395	*71*	*5934*	—	—	—	—	—
100	55	8·35	35·20	27·40	*71*	*7354*	7·60	35·17	27·49	*62·5*	*6178*
125	68	8·21	35·19	27·41	*70·5*	*9121*	—	—	—	—	—
150	82	8·21	35·20	27·42	*70*	*10876*	—	—	—	—	—
		STATION SC. 17.									
—		Latitude, N. 61° 13′; Longitude, W. 6° 34′. 30/viii, 6h. 50m. p.m.—7h. 30m. p.m.					Latitude, N. 61° 13′; Longitude, W. 6° 34′. 11/xii, 1h. p.m.				
0	0	8·80	35·13	27·27	*81*	*0*	7·95	35·28	27·52	*57·5*	*0*
10	5	8·78	35·15	27·285	*79·5*	*802*	—	—	—	—	—
20	11	8·55	35·17	27·35	*74*	*1569*	8·85	35·17	27·30	*79*	*1344*
40	22	8·48	35·17	27·36	*74*	*3049*	8·85	35·17	27·30	*80*	*2934*
60	33	8·49	35·17	27·355	*74·5*	*4533*	8·86	35·17	27·30	*80*	*4534*
80	44	8·48	35·17	27·36	*75*	*6027*	7·90	35·17	27·45	*67*	*6004*
100	55	8·43	35·18	27·37	*74*	*7517*	—	—	—	—	—
135	74	8·43	35·18	27·37	*74·5*	*10114*	—	—	—	—	—

TABLE 1—*continued.*

STATION SC. 18.

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.‰	σ_t	v—v^{1}	E—E^{1}	t.°C.	S.‰	σ_t	v—v^{1}	E—E^{1}
—		Latitude, N. 60° 52′ ; Longitude, W. 5° 31′. 30/viii, 11h. 30m. p.m.—31/viii, 1h. a.m.					Latitude N. 60° 53′ ; Longitude, W. 5° 30′. 11/xii, 6h. p.m.				
0	0	9·30	35·07	27·14	*93*	*0*	7·58	35·22	27·535	*56*	*0*
10	5	9·65	35·03	27·05	*102*	*975*	—	—	—	—	—
20	11	9·07	34·95	27·085	*99*	*1980*	—	—	—	—	—
30	16	—	—	—	—	—	7·55	35·16	27·48	*61*	*1755*
40	22	8·80	35·02	27·185	*90*	*3870*	—	—	—	—	—
60	33	8·68	35·15	27·305	*78·5*	*5560*	—	—	—	—	—
70	38	—	—	—	—	—	7·56	35·15	27·475	*62*	*4215*
80	44	7·66	35·07	27·395	*71*	*7050*	—	—	—	—	—
100	55	8·22	35·18	27·405	*71*	*8470*	7·53	35·13	27·465	*64*	*6105*
125	68	7·73	35·23	27·51	*60*	*10107*	—	—	—	—	—
150	82	7·74	35·19	27·48	*65·5*	*11674*	—	—	—	—	—
200	109	7·31	35·17	27·535	*60·5*	*14824*	7·56	35·15	27·475	*65*	*12555*
300	164	6·36	35·14	27·635	*51*	*20394*	7·61	35·16	27·47	*67*	*19155*
400	219	4·27	35·01	27·80	*36*	*24744*	6·93	35·13	27·55	*62*	*25605*
500	273	—	—	—	—	—	1·63	34·94	27·975	*16*	*29505*
600	328	—	—	—	—	—	1·74	34·92	27·945	*19*	*31255*

TABLE 1—*continued.*

STATION SC. 19.

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.‰	σ_t	v—v^1	E—E^1	t.°C.	S.‰	σ_t	v—v^1	E—E^1
—		Latitude, N. 60° 30′; Longitude, W. 4° 26′. 31/viii, 5h. 30m. a.m.—7h. 10m. a.m.					Latitude, N. 60° 35′; Longitude, W. 4° 26′. 11/xii, 11h. p.m.				
0	0	11·08	35·32	27·025	*104*	*0*	6·85	35·18	27·605	*49·5*	*0*
10	5	11·08	35·32	27·025	*104*	*1040*	—	—	—	—	—
20	11	10·88	35·32	27·06	*100·5*	*2062*	—	—	—	—	—
30	16	—	—	—	—	—	7·71	35·17	27·475	*62*	*1671*
40	22	10·39	35·31	27·145	*94*	*4006*	—	—	—	—	—
60	33	10·16	35·38	27·16	*92·5*	*5870*	7·71	35·16	27·455	*64*	*3561*
80	44	9·73	35·27	27·23	*86·5*	*7660*	—	—	—	—	—
100	55	9·63	35·27	27·245	*84·5*	*9370*	6·69	35·17	27·62	*50·5*	*5849*
125	68	9·36	35·27	27·29	*82·5*	*11457*	—	—	—	—	—
150	82	9·06	35·30	27·365	*75·5*	*13432*	—	—	—	—	—
200	109	8·83	35·31	27·405	*73*	*17142*	6·81	35·17	27·605	*53·5*	*11049*
300	164	8·28	35·30	27·485	*66·5*	*24112*	4·30	—	—	—	—
400	219	5·70	35·31	27·71	*45*	*29682*	0·49	34·94	28·05	*7·5*	*17149*
500	273	3·18	34·98	27·88	*28·5*	*33402*	−0·24	34·92	28·07	*4·5*	*17749*

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.‰	σ_t	$v-v^1$	$E-E^1$	t.°C.	S.‰	σ_t	$v-v^1$	$E-E^1$
		STATION SC. 20.									
—		Latitude, N. 60° 9′; Longitude, W. 3° 20′. 31/viii, 10h. 30m. a.m.—11h. 15m. a.m.					Latitude, N. 60° 13′; Longitude, W. 3° 9′. 12/xii, 6h. a.m.				
0	0	10·78	35·24	27·015	*104·5*	*0*	9·25	35·40	27·41	*68*	*0*
10	5	10·88	35·25	27·00	*106*	*1052*	—	—	—	—	—
20	11	10·91	35·25	26·995	*106*	*2112*	—	—	—	—	—
30	16	—	—	—	—	—	9·65	35·28	27·245	*83*	*2265*
40	22	10·68	35·26	27·06	*102·5*	*4196*	—	—	—	—	—
60	33	9·99	35·29	27·20	*89*	*6110*	9·66	35·30	27·265	*83*	*4755*
80	44	9·99	35·31	27·215	*88·5*	*7884*	—	—	—	—	—
100	55	9·70	35·33	27·275	*82*	*9588*	9·86	35·29	27·22	*86*	*8135*
125	68	9·70	35·33	27·275	*82·5*	*11643*	—	—	—	—	—
144	79	9·58	35·35	27·31	*80*	*13186*	—	—	—	—	—
150	82	—	—	—	—	—	8·97	35·29	27·37	*74·5*	*12145*
		STATION SC. 21.									
—	—	Latitude, N. 59° 46′; Longitude, W. 2° 21′. 31/viii, 3h. 15m. a.m.—3h. 45m. a.m.					—				
0	0	10·58	34·88	26·775	*127*	*0*	—	—	—	—	—
10	5	10·27	34·97	26·91	*116*	*1215*	—	—	—	—	—
20	11	9·81	34·99	26·995	*107*	*2330*	—	—	—	—	—
40	22	9·69	35·06	27·065	*101*	*4410*	—	—	—	—	—
60	33	9·72	35·06	27·06	*101*	*6430*	—	—	—	—	—
85	46	9·85	35·08	27·055	*103·5*	*8975*	—	—	—	—	—

TABLE 1—*continued.*

STATION SC. 22.

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/oo	σ_t	$v-v^1$	$E-E^1$	t.°C.	S.°/oo	σ_t	$v-v^1$	$E-E^1$
—		Latitude, N. 59° 36′; Longitude, W. 0° 41′. 31/viii, 8h. 45m. p.m.—9h. 40m. p.m.					—				
0	0	11·68	33·96	25·86	*215*	*0*	—	—	—	—	—
10	5	11·88	33·96	25·82	*219*	*2170*	—	—	—	—	—
20	11	10·45	34·01	26·12	*190*	*4215*	—	—	—	—	—
40	22	8·85	35·01	27·175	*91·5*	*7029*	—	—	—	—	—
60	33	8·04	35·23	27·465	*63·5*	*8579*	—	—	—	—	—
80	44	7·68	35·26	27·55	*57·5*	*9789*	—	—	—	—	—
100	55	7·54	35·30	27·60	*52·5*	*10889*	—	—	—	—	—

STATION SC. 23.

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/oo	σ_t	$v-v^1$	$E-E^1$	t.°C.	S.°/oo	σ_t	$v-v^1$	$E-E^1$
—		Latitude, N. 59° 31′; Longitude, E. 0° 37′. 1/ix, 2h. 15m. a.m.—3h. 15m. a.m.					Latitude, N. 59° 32′; Longitude, E. 0° 2′. 15/xii, 7h. p.m.				
0	0	11·58	33·48	25·505	*249*	*0*	8·15	35·09	27·34	*74*	*0*
10	5	11·72	33·59	25·57	*243*	*2460*	—	—	—	—	—
20	11	11·77	33·53	25·51	*247·5*	*4912*	8·05	35·07	27·34	*75*	*1490*
40	22	9·44	34·40	26·575	*146*	*8846*	8·05	35·06	27·33	*76*	*3000*
60	33	7·38	35·28	27·59	*51*	*10816*	7·99	35·10	27·375	*72*	*4480*
80	44	6·92	35·26	27·645	*46*	*11786*	7·65	35·17	27·485	*63*	*5830*
100	55	7·01	—	—	—	—	7·54	35·16	27·48	*62·5*	*7084*
120	66	—	—	—	—	—	7·22	35·18	27·535	*57·5*	*8284*
125	68	6·80	—	—	—	—	—	—	—	—	—

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.‰	σ_t	$v-v^1$	$E-E^1$	t.°C.	S.‰	σ_t	$v-v^1$	$E-E^1$
STATION Sc. 24.											
—		Latitude, N. 58° 55′; Longitude, E. 0° 4′. 1/ix, 8h. 15m. a.m.—9h. 15m. a.m.					Latitude, N. 58° 53′; Longitude, W. 0° 25′. 15/xii, 12h. p.m.				
0	0	11·97	33·86	25·72	*228*	*0*	7·75	35·21	27·50	*59·5*	*0*
10	5	11·90	33·84	25·725	*227*	*2275*	—	—	—	—	—
20	11	11·94	34·18	25·985	*203·5*	*4427*	—	—	—	—	—
30	16	—	—	—	—	—	8·05	35·09	27·36	*73*	*1986*
40	22	8·27	35·13	27·355	*74·5*	*7207*	—	—	—	—	—
60	33	6·93	35·22	27·625	*49*	*8441*	8·00	35·10	27·365	*72*	*4161*
80	44	6·78	35·21	27·64	*48*	*9411*	—	—	—	—	—
100	55	6·74	35·23	27·655	*46·5*	*10355*	7·45	35·17	27·515	*61*	*6821*
120	66	6·70	35·23	27·66	*46·5*	*11285*	—	—	—	—	—
STATION Sc. 25.											
—		Latitude, N. 58° 11′; Longitude, W. 0° 32′. 1/ix, 3h. 10m. p.m.—3h. 50m. p.m.					—				
0	0	12·27	34·60	26·24	*178·5*	*0*	—	—	—	—	—
10	5	12·27	34·55	26·21	*182*	*1802*	—	—	—	—	—
20	11	10·16	34·57	26·61	*144*	*3432*	—	—	—	—	—
40	22	8·89	35·18	27·30	*80*	*5672*	—	—	—	—	—
60	33	7·81	35·23	27·50	*60*	*7092*	—	—	—	—	—
80	44	7·68	—	—	—	—	—	—	—	—	—
95	52	7·63	35·25	27·535	*57*	*9119*	—	—	—	—	—

TABLE 1—*continued.*

Depth.		August Cruise, 1902.					December Cruise, 1902.				
m.	f.	t.°C.	S.°/$_{oo}$	σ_t	v—v^1	E—E^1	t.°C.	S.°/$_{oo}$	σ_t	v—v^1	E—E^1

STATION SC. 26.

Depth.		August Cruise, 1902.					December Cruise, 1902.				
—		Latitude, N. 58° 9′; Longitude, W. 1° 50′. 1/ix, 8h. 40m. p.m.—9h. 20m. p.m.					—				
0	0	11·28	35·01	26·755	*130*	*0*	—	—	—	—	—
10	5	11·25	34·99	26·74	*131·5*	*1307*	—	—	—	—	—
20	11	11·20	35·01	26·77	*129·5*	*2612*	—	—	—	—	—
40	22	10·67	35·01	26·865	*121*	*5116*	—	—	—	—	—
60	33	10·37	—	—	—	—	—	—	—	—	—
75	41	9·99	35·11	27·06	*103*	*9036*	—	—	—	—	—

TABLE 2.

SURFACE OBSERVATIONS.

A.—August Cruise, 1902.

Station.	Time.		Locality.		t°C.	S.°/$_{oo}$
	Date.	Hour.	Latitude.	Longitude.		
	25/viii.	12 p.m.	N. 57° 42′	W. 3° 53′	13·1	34·00
	26/viii.	1 a.m.	N. 57° 47′	W. 3° 37′	12·9	34·52
	„	2 „	N. 57° 52′	W. 3° 22′	12·6	35·00
	„	3 „	N. 57° 56′	W. 3° 7′	12·9	34·99
Sc. 1	„	4.30 „	N. 58° 0′	W. 2° 54′	11·7	34·97
	„	5 „	N. 58° 3′	W. 2° 47′	12·0	35·00
	„	6 „	N. 58° 10′	W. 2° 34′	12·0	35·00
	„	7 „	N. 58° 16′	W. 2° 22′	12·0	35·02

TABLE 2—*continued.*

Station.	Time.		Locality.		t°C.	S.°/₀₀
	Date.	Hour.	Latitude.	Longitude.		
	26/viii.	8 a.m.	N. 58° 23′	W. 2° 10′	11·6	35·01
	„	9 „	N. 58° 30′	W. 1° 58′	12·8	35·01
Sc. 2	„	10.40 „	N. 58° 36′	W. 1° 46′	12·1	34·79
	„	11 „	N. 58° 39′	W. 1° 47′	12·7	34·81
	„	12 „	N. 58° 47′	W. 1° 35′	12·7	34·74
	„	1 p.m.	N. 58° 55′	W. 1° 33′	12·1	34·80
	„	2 „	N. 59° 3′	W. 1° 31′	12·5	34·59
	„	3 „	N 59° 10′	W. 1° 29′	12·4	34·49
Sc. 3	„	4 „	N. 59° 10′	W. 1° 27′	11·7	34·59
	„	5 „	N. 59° 16′	W. 1° 24′	11·2	34·79
	„	6 „	N. 59° 21′	W. 1° 22′	10·9	34·965
	„	7 „	N. 59° 26′	W. 1° 20′	10·9	34·88
Sc. 4	„	7.40 „	N. 59° 27′	W. 1° 19′	10·8	34·96
	„	10 „	N. 59° 32′	W. 1° 17′	10·8	34·90
Sc. 5	27/viii.	0·5 a.m.	N. 59° 40′	W. 1° 14′	10·7	34·83
	„	1 „	N. 59° 49′	W. 1° 8′	11·4	34·36
	„	2 „	N. 59° 54′	W. 1° 5′	11·4	34·56
	„	3 „	N. 59° 59′	W. 1° 2′	11·6	34·45
	„	4 „	N. 60° 41′	W. 0° 59′	11·6	34·44
	„	5 „	N. 60° 6′	W. 1° 81′	11·7	34·98
	„	5 p.m.	N. 60° 8′	W. 0° 56′	11·7	34·56
	„	6 „	N. 60° 13′	W. 0° 42′	11·9	34·21
	„	7 „	N. 60° 18′	W. 0° 28′	11·6	34·58
	„	8 „	N. 60° 23′	W. 0° 14′	11·7	34·30
	„	9 „	N. 60° 28′	W. 0° 0′	11·7	34·60
	„	10 „	N. 60° 33′	E. 0° 14′	11·7	34·28
Sc. 6	„	11.40 „	N. 60° 37′	E. 0° 30′	11·6	34·36
	28/viii.	1 a.m.	N. 60° 42′	E. 0° 45′	11·6	34·21
	„	2 „	N. 60° 48′	E. 1° 0′	11·6	33·99
	„	3 „	N. 60° 53′	E. 1° 15′	11·6	34·13
	„	4 „	N. 60° 59′	E 1° 30′	11·5	34·12

TABLE 2—*continued.*

Station.	Time.		Locality.		t°C.	S.°/₀₀
	Date.	Hour.	Latitude.	Longitude.		
	28/viii.	5 a.m.	N. 61° 4′	E. 1° 45′	—	34·73
Sc. 7	,,	7 ,,	N. 61° 9′	E. 2° 0′	11·6	34·20
	,,	8 ,,	N. 61° 13′	E. 2° 11′	11·6	—
	,,	9 ,,	N. 61° 18′	E. 2° 26′	11·1	35·17
	,,	10 ,,	N. 61° 23′	E. 2° 41′	10·3	34·55
	,,	11 ,,	N. 61° 27′	E. 2° 55′	11·0	34·60
	,,	12 ,,	N. 61° 32′	E. 3° 10′	10·7	34·16
Sc. 8	,,	1.50 p.m.	N. 61° 32′	E. 3° 10′	10·6	34·07
	,,	3 ,,	N. 61° 33′	E. 2° 44′	10·4	34·34
	,,	4 ,,	N. 61° 34′	E. 2° 27′	10·5	34·43
	,,	5 ,,	N. 61° 34′	E. 2° 10′	10·5	34·77
Sc. 9	,,	6.20 ,,	N. 61° 34′	E. 2° 5′	11·0	35·01
	,,	7 ,,	N. 61° 36′	E. 1° 45′	10·9	35·18
	,,	8 ,,	N. 61° 36′	E. 1° 30′	10·9	35·30
	,,	9 ,,	N. 61° 37′	E. 1° 16′	11·1	34·93
	,,	10 ,,	N. 61° 37′	E. 1° 1′	11·1	34·67
Sc. 10	,,	12 ,,	N. 61° 38′	E. 0° 43′	11·0	35·03
	29/viii.	1 a.m.	N. 61° 39′	E. 0° 25′	11·0	35·06
	,,	2 ,,	N. 61° 40′	E. 0° 6′	11·1	35·26
	,,	3 ,,	N. 61° 41′	W. 0° 14′	11·0	35·32
	,,	4 ,,	N. 61° 42′	W. 0° 34	11·0	—
Sc. 11	,,	6 ,,	N. 61° 43′	W. 0° 43′	11·0	35·36
	,,	7 ,,	N. 61° 32′	W. 0° 50′	10·9	35·36
	,,	8 ,,	N. 61° 22′	W. 0° 56	11·0	35·35
	,,	9 ,,	N. 61° 13′	W. 1° 2′	11·0	35·34
	,,	10 ,,	N. 61° 4′	W. 1° 8′	11·0	35·35
Sc. 12	,,	11 ,,	N. 61° 2′	W. 1° 10′	11·1	35·34
	,,	12 ,,	N. 61° 5′	W. 1° 28′	11·2	—
	,,	1 p.m.	N. 61° 9′	W. 1° 46′	11·0	—
Sc. 13	,,	4 ,,	N. 61° 12′	W. 2° 6′	11·0	35·32
	,,	5 ,,	N. 61° 16′	W. 2° 25′	10·8	35·26

TABLE 2—*continued.*

Station.	Time.		Locality.		t°C.	S.‰
	Date.	Hour.	Latitude.	Longitude.		
	29/viii.	6 p.m.	N. 61° 19′	W. 2° 44′	10·7	35·26
	„	7 „	N. 61° 22′	W. 3° 3′	10·4	35·18
	„	8 „	N. 61° 25′	W. 3° 22′	9·3	34·86
Sc. 14	30/viii.	1.30 a.m.	N. 61° 25′	W. 3° 24′	9·5	34·97
	„	3 „	N. 61° 29′	W. 3° 44′	9·4	34·99
	„	4 „	N. 61° 31′	W. 4° 2′	9·3	34·99
	„	5 „	N. 61° 33′	W. 4° 20′	8·5	34·77
Sc. 15	„	8.15 „	N. 61° 35′	W. 4° 39′	8·7	34·99
	„	10 „	N. 61° 40′	W. 5° 5′	8·8	34·96
	„	11 „	N. 61° 43′	W. 5° 26′	9·0	35·06
	„	12 „	N. 61° 46′	W. 5° 47′	8·9	35·15
Sc. 16	„	3.5 p.m.	N. 61° 47′	W. 6° 4′	9·0	35·20
	„	4 „	N. 61° 38′	W. 6° 11′	8·8	35·08
	„	5 „	N. 61° 29′	W. 6° 20′	9·1	35·16
	„	6 „	N. 61° 20′	W. 6° 28′	9·1	35·17
Sc. 17	„	7.30 „	N. 61° 13′	W. 6° 34′	8·8	35·13
	„	8 „	N. 61° 11′	W. 6° 31′	8·8	—
	„	9 „	N. 61° 6′	W. 6° 14′	9·2	35·17
	„	10 „	N. 61° 1′	W. 5° 57′	8·7	34·95
	„	11 „	N. 60° 56′	W. 5° 41′	9·1	35·06
Sc. 18	31/viii.	1 a.m.	N. 60° 52′	W. 5° 31′	9·3	35·07
	„	2 „	N. 60° 47′	W. 5° 20′	9·5	35·02
	„	3 „	N. 60° 39′	W. 4° 55′	9·0	34·97
	„	4 „	N. 60° 31′	W. 4° 29′	9·3	35·16
Sc. 19	„	7.10 „	N. 60° 30′	W. 4° 26′	11·1	35·32
	„	8 „	N. 60° 25′	W. 4° 11′	11·0	35·34
	„	9 „	N. 60° 18′	W. 3° 50′	11·3	35·35
	„	10 „	N. 60° 11′	W. 3° 29′	11·0	35·35
Sc. 20	„	11.15 „	N. 60° 9′	W. 3° 20′	10·8	35·24
	„	12 „	N. 60° 4′	W. 3° 7′	11·1	35·14
	„	1 p.m.	N. 59° 58′	W. 2° 53′	10·7	35·08

TABLE 2—*continued.*

Station.	Time.		Locality.		t°C.	S.°/₀₀
	Date.	Hour.	Latitude.	Longitude.		
	31/viii	2 p.m.	N. 59° 33′	W. 2° 39′	10·7	35·09
	„	3 „	N. 59° 47′	W. 2° 24′	10·7	34·88
Sc. 21	„	3.45 „	N. 59° 46′	W. 2° 21′	10·6	34·88
	„	5 „	N. 59° 43′	W. 1° 56′	10·5	34·90
	„	6 „	N. 59° 41′	W. 1° 36′	10·5	34·92
	„	7 „	N. 59° 39′	W. 1° 16′	11·2	34·10
	„	8 „	N. 59° 37′	W. 0° 57′	11·3	34·17
Sc. 22	„	9.40 „	N. 59° 36′	W. 0° 41′	11·7	33·96
	„	11 „	N. 59° 35′	W. 0° 16′	11·7	33·84
	„	12 „	N. 59° 34′	W. 0° 0′	11·8	33·90
	1/ix.	1 a.m.	N. 59° 33′	E. 0° 16′	11·2	33·55
	„	2 „	N. 59° 32′	E. 0° 32′	11·5	33·59
Sc. 23	„	3.15 „	N. 59° 31′	E. 0° 37′	11·6	33·48
	„	4 „	N. 59° 25′	E. 0° 34′	11·8	33·50
	„	5 „	N. 59° 18′	E. 0° 27′	11·7	33·63
	„	6 „	N. 59° 11′	E. 0° 20′	11·8	33·67
	„	7 „	N. 59° 4′	E. 0° 13′	11·8	33·69
	„	8 „	N. 58° 56′	E. 0° 6′	11·9	33·93
Sc. 24	„	9.15 „	N. 58° 55′	E. 0° 4′	12·0	33·86
	„	10 „	N. 58° 51′	E. 0° 0′	12·0	34·11
	„	11 „	N. 58° 43′	W. 0° 6′	12·1	34·19
	„	12 „	N. 58° 35′	W. 0° 12′	12·2	34·27
	„	1 p.m.	N. 58° 28′	W. 0° 18′	12·3	34·36
	„	2 „	N. 58° 20′	W. 0° 24′	12·3	34·45
	„	3 „	N. 58° 12′	W. 0° 30′	12·3	34·49
Sc. 25	„	3.50 „	N. 58° 11′	W. 0° 32′	12·3	34·60
	„	5 „	N. 58° 11′	W. 0° 35′	12·3	34·83
	„	6 „	N. 58° 10′	W. 1° 0′	12·2	34·93
	„	7 „	N. 58° 10′	W. 1° 25′	12·2	34·90
	„	8 „	N. 58° 9′	W. 1° 40′	12·2	34·99
Sc. 26	„	9.20 „	N. 58° 9′	W. 1° 50′	11·3	35·01

TABLE 2—*continued.*

B.—December Cruise, 1902.

Station	Time.		Locality.		t°C.	S.‰
	Date.	Hour.	Latitude.	Longitude.		
	4/xii.	1 p.m.	N. 58° 34′	W. 1° 47′	7·5	35·00
Sc. 2	„	2 „	N. 58° 36′	W. 1° 46′	8·2	34·99
	„	3 „	N. 58° 37°	W. 1° 45′	8·8	34·97
	,	4 „	N. 58° 51′	W. 1° 40′	6·8	35·05
	„	5 „	N. 59° 3′	W. 1° 35′	6·5	34·94
	„	6 „	N. 59° 16′	W. 1° 31′	9·0	35·00
Sc. 4	„	7 „	N. 59° 17′	W. 1° 30′	8·8	34·99
	„	9 „	N. 59° 21′	W. 1° 26′	8·9	34·97
	„	10 „	N. 59° 29′	W. 1° 20′	8·7	34·98
	„	11 „	N. 59° 37′	W. 1° 15′	9·3	34·98
	„	Midnight	N. 59° 41′	W. 1° 9′	8·9	—
	5/xii.	1 a.m.	N. 59° 44′	W. 0° 57′	8·0	35·17
	„	2 „	N. 59° 43′	W. 1° 0′	6·5	35·24
	„	3 „	N. 59° 45′	W. 1° 2′	5·4	—
	„	4 „	N. 59° 52′	W. 1° 3½′	8·4	—
	8/xii.	11 „	N. 60° 17′	W. 0° 32′	8·9	35·19
	„	Noon	N. 60° 23½′	W. 0° 14½′	8·5	35·18
	„	1 p.m.	N. 60° 29′	E. 0° 4′	8·5	35·19
	„	2 „	N. 60° 25′	E. 0° 22′	8·6	35·20
Sc. 6	„	3 „	N. 60° 37′	E. 0° 30′	8·5	35·18
	„	4 „	N. 60° 38′	E. 0° 31′	8·3	35·18
	„	5 „	N. 60° 40′	E. 0° 33′	8·3	34·38
	„	6 „	N. 60° 46′	E. 0° 49′	8·5	34·52
	„	7 „	N. 60° 53′	E. 1° 5′	8·3	35·10
	„	8 „	N. 60° 59′	E. 1° 21′	8·3	—
	„	9 „	N. 61° 6′	E. 1° 36′	8·4	35·16
Sc. 8	„	10 „	N. 61° 12′	E. 1° 52′	8·9	35·26
	„	Midnight	N. 61° 15′	E. 2° 2′	9·3	35·09
	9/xii.	1 a.m.	N. 61° 22′	E. 2° 20′	9·4	—

TABLE 2—*continued.*

Station.	Time.		Locality.		t°C.	S.‰
	Date.	Hour.	Latitude.	Longitude.		
	9/xii.	2 a.m.	N. 61° 28′	E. 2° 36′	9·6	35·28
	„	3 „	N. 61° 35′	E. 2° 52′	6·8	32·49
Sc. 8*a*	„	4 „	N. 61° 36½′	E. 2° 57′	6·4	32·74
	„	5 „	N. 61° 40′	E. 3° 4′	6·8	32·78
Sc. 8	„	6 „	N. 61° 40′	E. 3° 4′	6·7	32·77
	„	7 „	N. 61° 40′	E. 2° 50′	8·2	—
	„	8 „	N. 61° 39½′	E. 2° 8′	9·2	35·28
	„	9 „	N. 61° 39′	E. 2° 6′	8·6	35·28
	„	10 „	N. 61° 39′	E. 1° 55′	9·4	35·30
Sc. 9	„	11 „	N. 61° 39′	E. 2° 0′	9·2	35·29
	„	Noon	N. 61° 39′	E. 1° 52′	9·3	—
	„	1 p.m.	N. 61° 39′	E. 1° 32′	9·5	35·30
	„	2 „	N. 61° 38½′	E. 1° 12′	9·5	35·29
	„	3 „	N. 61° 38½′	E. 0° 52′	9·5	35·29
Sc. 10	„	4 „	N. 61° 38′	E. 0° 33′	9·6	35·30
	„	5 „	N. 61° 38′	E. 0° 31′	9·5	35·34
	,	6 „	N. 61° 38′	E. 0° 15′	9·6	35·36
	„	7 „	N. 61° 37½′	W. 0° 7½′	9·6	35·33
	„	8 „	N. 61° 37½′	W. 0° 30′	9·5	35·34
	„	9 „	N. 61° 38′	W. 0° 45′	9·7	35·40
	„	10 „	N. 61° 46′	W. 0° 54′	9·3	35·32
	„	11 „	N. 61° 50′	W. 1° 0′	9·3	35·32
Sc. 11	„	Midnight	N. 61° 50′	W. 1° 0′	9·4	35·34
	10/xii.	1 a.m.	N. 61° 45′	W. 1° 2′	9·4	35·30
	„	2 „	N. 61° 34′	W. 1° 6′	9·5	35·30
	„	3 „	N. 61° 24′	W. 1° 9′	9·7	35·34
	„	4 „	N. 61° 13′	W. 1° 13′	9·5	35·34
	„	5 „	N. 61° 5′	W. 1° 17′	9·3	35·22
Sc. 12	„	6 „	N. 61° 0′	W. 1° 18′	9·2	35·20
	„	7 „	N. 61° 3′	W. 1° 31′	9·4	35·18
	„	8 „	N. 61° 7′	W. 1° 54′	9·0	35·29

TABLE 2—*continued.*

Station.	Time.		Locality.		t°C.	S ‰
	Date.	Hour.	Latitude.	Longitude.		
	10/xii.	9 a.m.	N. 61° 10′	W. 2° 9′	9·6	35·35
Sc. 13	„	10 „	N. 61° 10′	W. 2° 9′	9·5	35·37
	„	11 „	N. 61° 11′	W. 2° 14′	9·4	35·34
	„	Noon	N. 61° 14′	W. 2° 31′	9·4	35·36
	„	1 p.m.	N. 61° 17′	W. 2° 48′	9·6	35·34
	„	2 „	N. 61° 20′	W. 3° 6′	9·6	35·07
	„	3 „	N. 61° 23′	W. 3° 25′	9·4	35·35
	„	4 „	N. 61° 23′	W. 3° 25′	9·4	—
	„	5 „	N. 61° 23′	W. 3° 25′	9·5	—
Sc. 14	„	6 „	N. 61° 23′	W. 3° 25′	9·5	35·34
	„	7 „	N. 61° 24′	W. 3° 26′	9·1	35·33
	„	8 „	N. 61° 26′	W. 3° 36′	9·3	—
	„	9 „	N. 61° 30′	W. 3° 57′	9·1	—
	„	10 „	N. 61° 34′	W. 4° 18′	8·1	35·25
	„	11 „	N. 61° 37′	W. 4° 36′	7·9	35·16
	„	Midnight	N. 61° 38′	W. 4° 39′	7·5	35·17
Sc. 15	11/xii.	1 a.m.	N. 61° 38′	W. 4° 39′	7·0	35·21
	„	2 „	N. 61° 38′	W. 4° 40′	7·6	35·16
	„	3 „	N. 61° 40′	W. 4° 55′	7·6	35·15
	„	4 „	N. 61° 44′	W. 5° 16′	7·6	35·25
	„	5 „	N. 61° 47′	W. 5° 37′	7·6	35·17
	„	6 „	N. 61° 51′	W. 5° 57′	7·8	35·45
	„	7 „	N. 61° 48′	W. 6° 4′	7·8	—
Sc. 16	„	8 „	N. 61° 44′	W. 6° 3′	7·9	35·20
	„	9 „	N. 61° 42′	W. 6° 4′	7·7	35·17
	„	10 „	N. 61° 34′	W. 6° 12′	7·8	35·16
	„	11 „	N. 61° 25′	W. 6° 21′	7·7	35·20
	11/xii.	Noon	N. 61° 17′	W. 6° 29′	7·8	—
Sc. 17	„	1 p.m.	N. 61° 13′	W. 6° 33′	8·0	35·29
	„	2 „	N. 61° 7′	W. 6° 16′	7·8	35·34
	„	3 „	N. 61° 2′	W. 6° 0′	7·8	35·17

TABLE 2—*continued.*

Station.	Time.		Locality.		t°C.	S.‰
	Date.	Hour.	Latitude.	Longitude.		
	11/xii.	4 p.m.	N. 60° 58′	W. 5° 45′	7·9	35·26
	„	5 „	N. 60° 53	W. 5° 30′	7·9	35·27
Sc. 18	„	6 „	N. 60° 53′	W. 5° 30′	7·6	35·22
	„	7 „	N. 60° 52′	W. 5° 24′	7·5	35·09
	„	8 „	N. 60° 47′	W. 5° 9′	7·8	35·00
	„	9 „	N. 60° 43′	W. 4° 54′	6·8	35·07
	„	10 „	N. 60° 38′	W. 4° 39′	6·6	34·94
Sc. 19	„	11 „	N. 60° 35′	W. 4° 26′	6·9	35·18
	„	Midnight	N. 60° 36′	W. 4° 27′	7·5	35·25
	12/xii.	1 a.m.	N. 60° 32′	W. 4° 19′	7·6	35·24
	„	2 „	N. 60° 30′	W. 4° 6′	6·6	35·01
	„	3 „	N. 60° 25′	W. 3° 58′	8·9	35·41
	„	4 „	N. 60° 20′	W. 3° 34′	9·3	35·42
	„	5 „	N. 60° 15′	W. 3° 19′	9·4	35·38
Sc. 20	„	6 „	N. 60° 13′	W. 3° 9′	9·3	35·40
	„	7 „	N. 60° 12′	W. 3° 3′	9·3	35·44
	„	8 „	N. 60° 8′	W. 2° 50′	9·0	35·27
	„	9 „	N. 60° 5′	W. 2° 38′	9·1	35·17
	„	10 „	N. 60° 2′	W. 2° 25′	8·9	35·18
	„	11 „	N. 59° 58′	W. 2° 10′	9·0	35·08
	„	Noon	N. 59° 55′	W. 1° 55′	9·0	35·15
	„	1 p.m.	N. 59° 53	W. 1° 42′	8·5	35·25
	„	2 „	N. 59° 51′	W. 1° 29′	8·4	35·16
	„	3 „	N. 59° 50′	W. 1° 16′	8·4	35·08
	15/xii.	Noon	N. 59° 49′	W. 1° 10′	8·5	34·87
Sc. 21	„	1 p.m.	N. 59° 40′	W. 1° 15′	8·0	33·86
	„	2 „	N. 59° 40′	W. 1° 10′	8·4	34·89
	„	3 „	N. 59° 41′	W. 1° 0′	8·6	35·06
	„	4 „	N. 59° 40′	W. 0° 42′	8·5	35·07
	„	5 „	N. 59° 37′	W. 0° 23′	8·0	35·15
	„	6 „	N. 59° 34′	W. 0° 4′	8·1	35·15

TABLE 2—*continued.*

Station.	Time.		Locality.		t°C.	S.‰
	Date.	Hour.	Latitude.	Longitude.		
Sc 23	15/xii.	7 p.m.	N. 59° 32′	E. 0° 2′	8·2	35·19
	„	8 „	N. 59° 24′	W. 0° 1′	8·2	35·17
	„	9 „	N. 59° 18′	W. 0° 9′	8·1	35·21
	„	10 „	N. 59° 13′	W. 0° 17′	7·8	35·20
	„	11 „	N. 58° 58′	W. 0° 28′	7·8	35·28
Sc. 24	„	Midnight	N. 58° 53′	W. 0° 25′	7·8	35·21
	16/xii.	1 a.m.	N. 58° 48′	W. 0° 31′	8·2	35·12
	„	2 „	N. 58° 40′	W. 0° 37′	8·2	35·18
	„	3 „	N. 58° 32′	W. 0° 43′	8·3	35·34
	„	4 „	N. 58° 24′	W. 0° 50′	8·3	35·35

PLATES I.—III.

Illustrating Mr. Helland-Hansen's Report on the Hydrography of the Faeroe Channel and Northern Part of the North Sea in 1902.

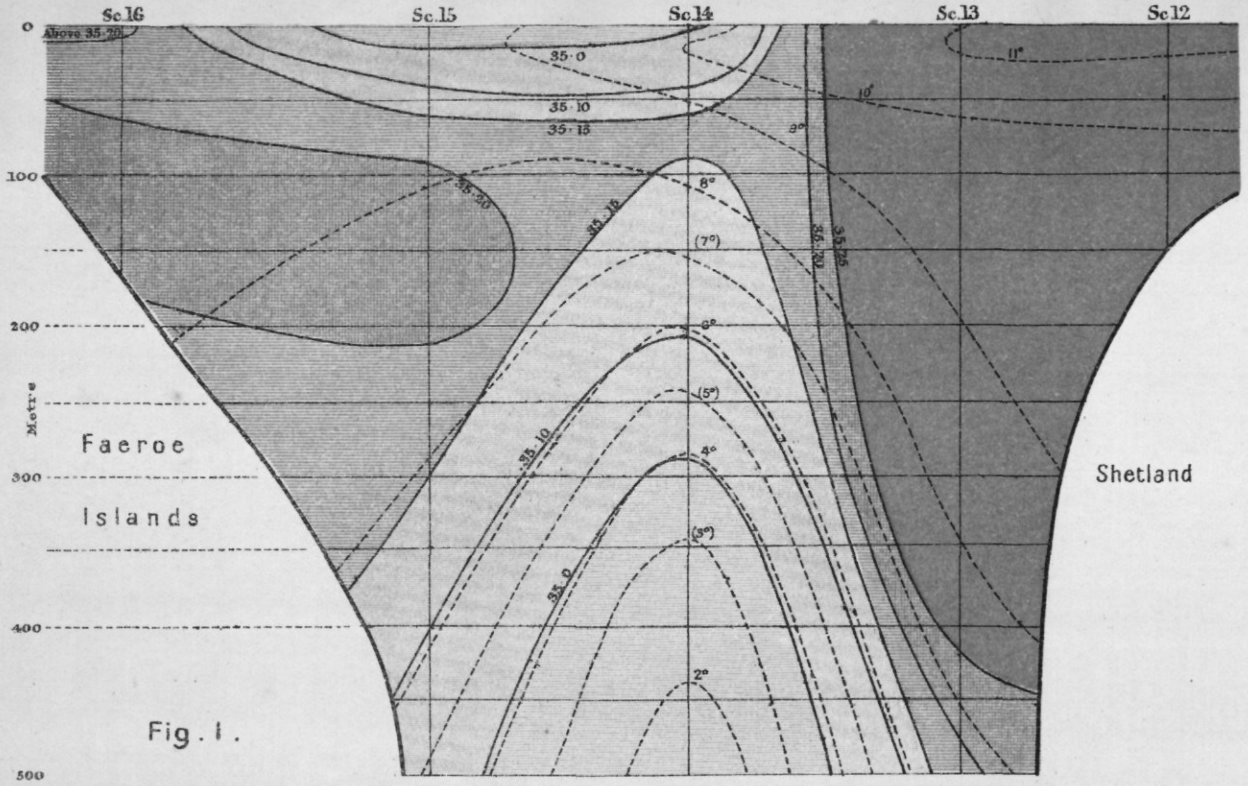

Fig. I.

Faeroe - Shetland Channel - Northern Section, Aug. 1902.

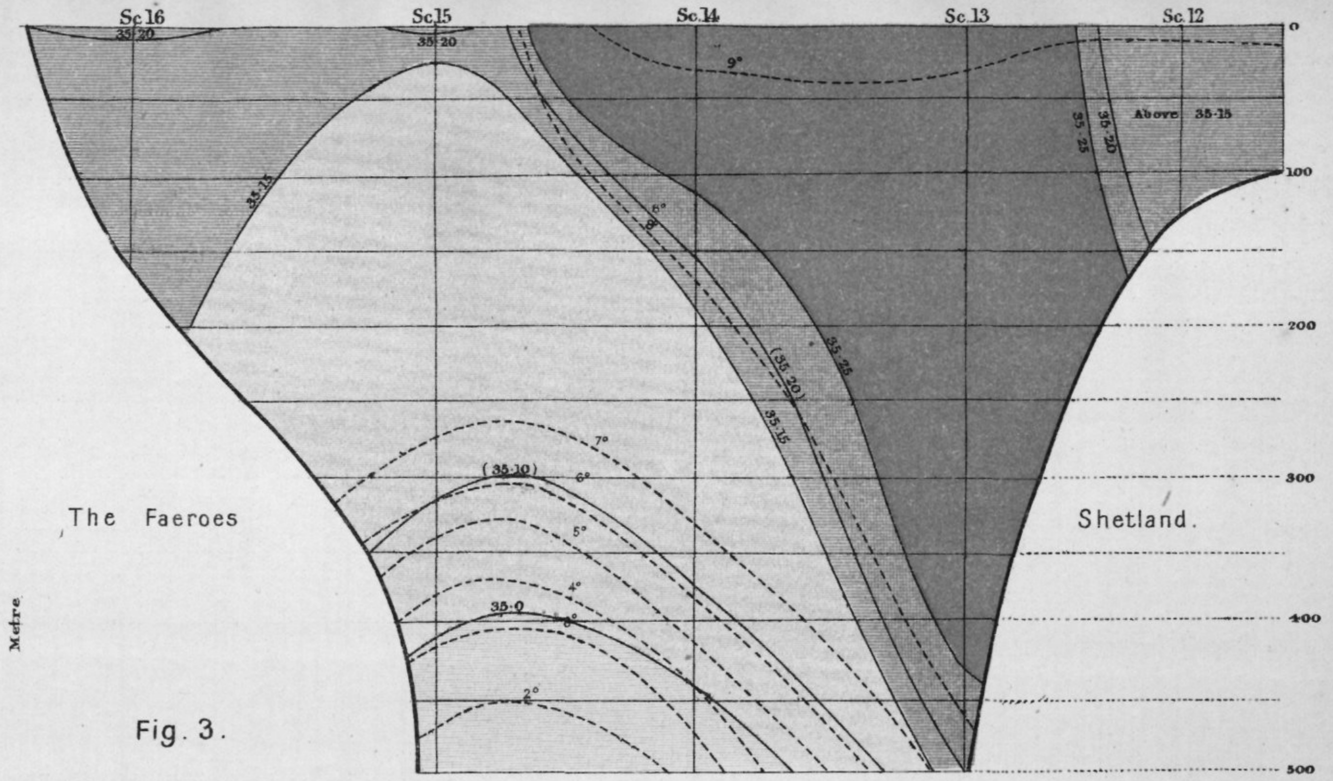

Fig. 3.

Faeroe - Shetland Channel - Northern Section, December 1902.

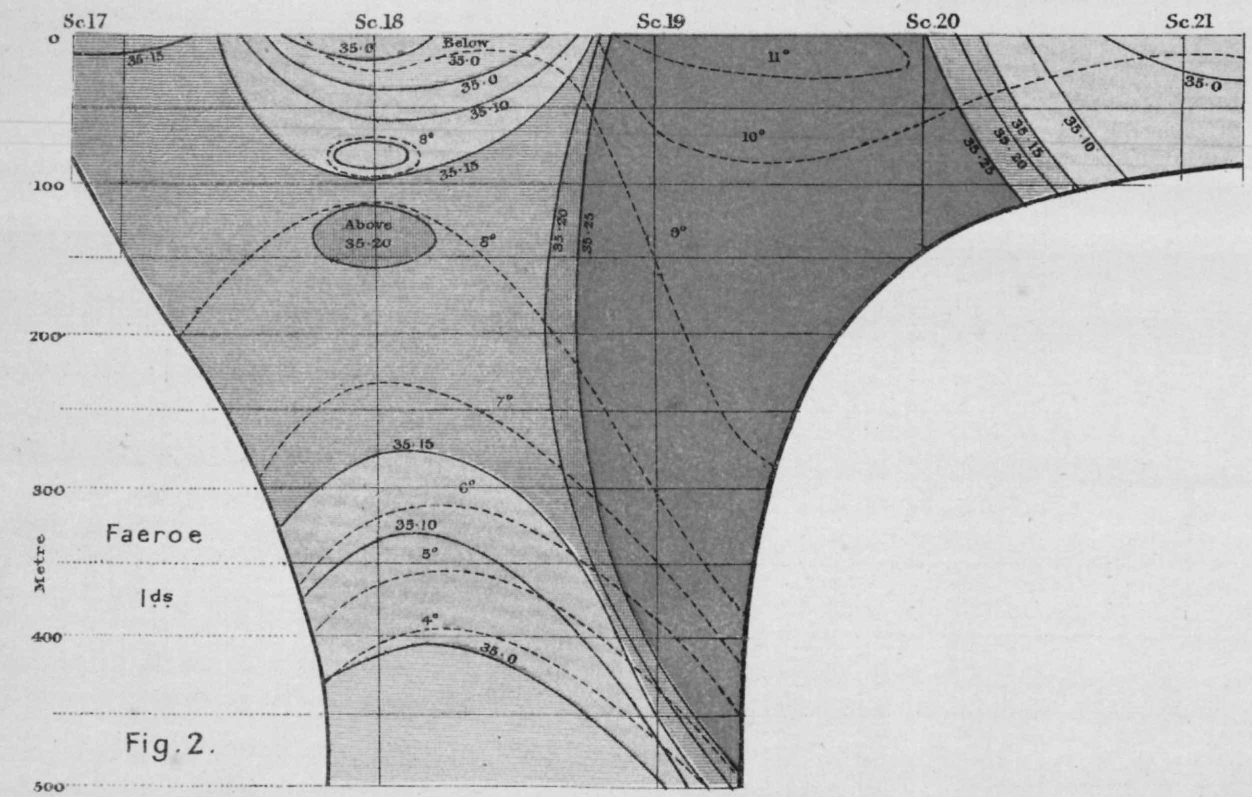

Fig. 2.

Faeroe - Shetland Channel - Southern Section, Aug. 1902.

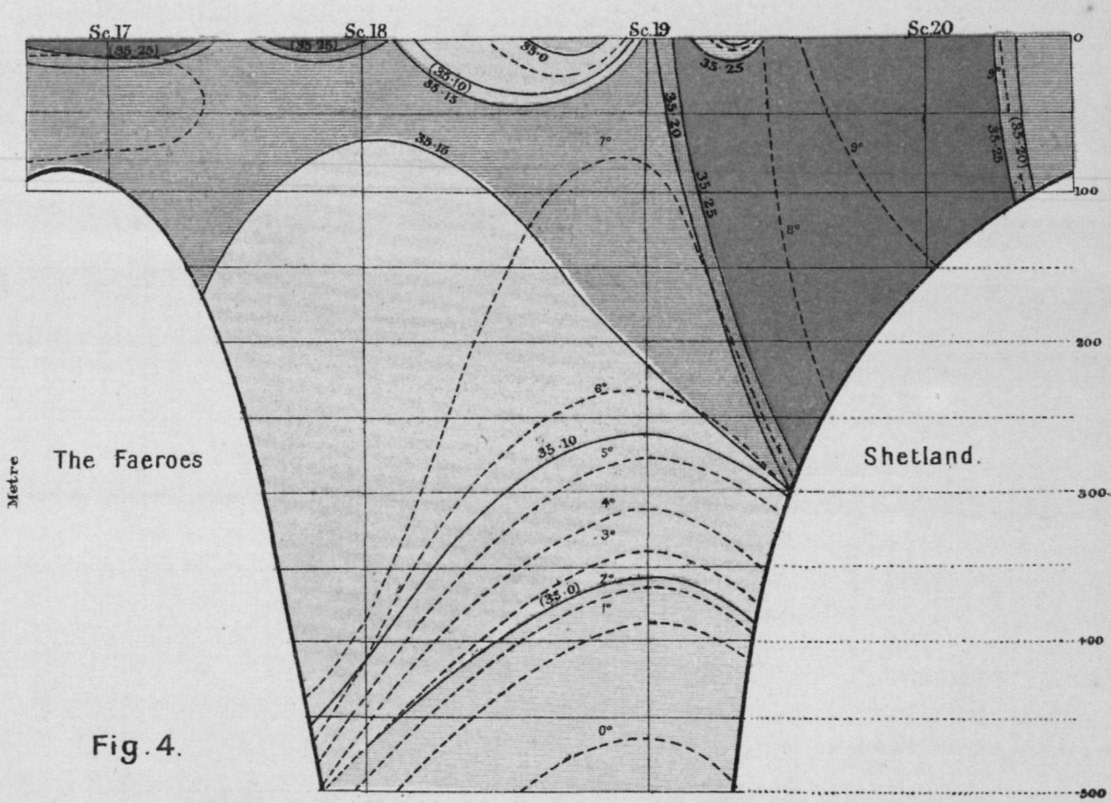

Fig. 4.

Faeroe - Shetland Channel - Southern Section, December 1902.

Horizontal Scale, 1 : 2,000,000,

Vertical Scale, 1 ; 5,000.

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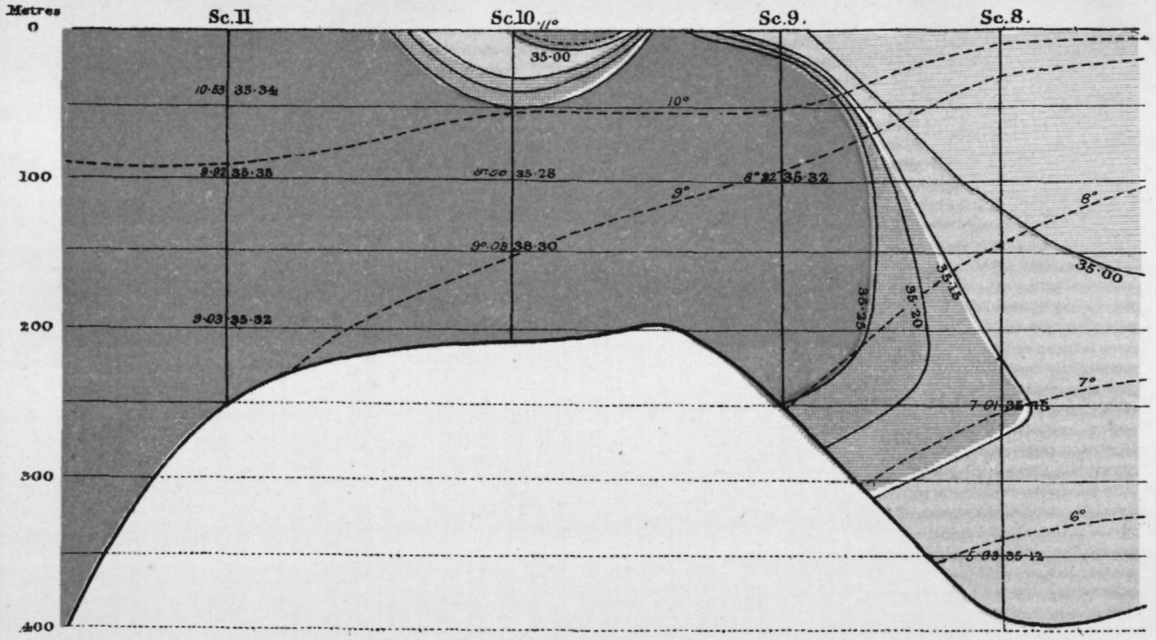


Fig. 1. Entrance from North Sea to Norwegian Sea.
August 1902.

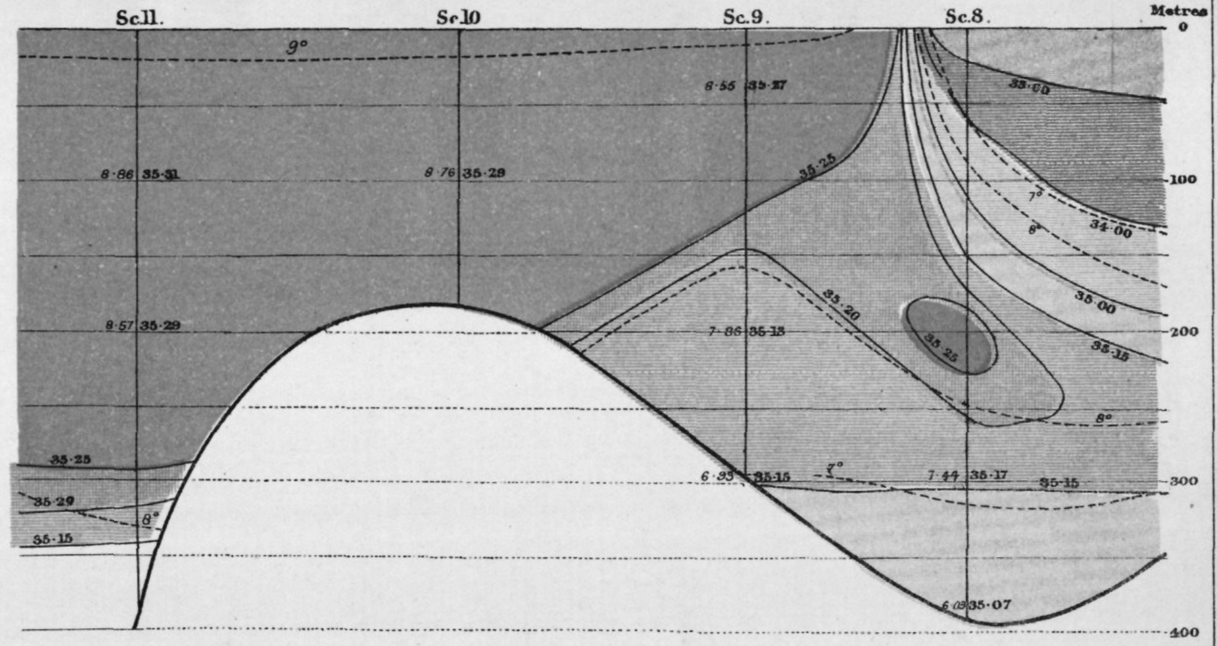
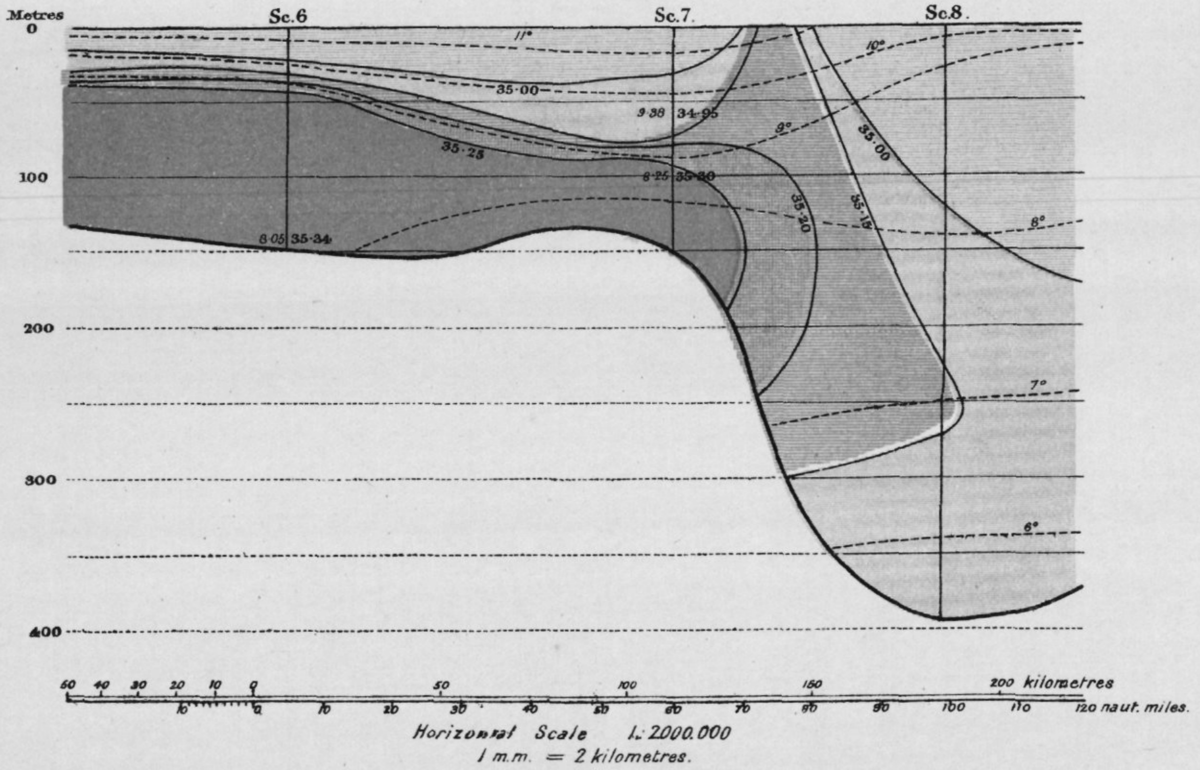
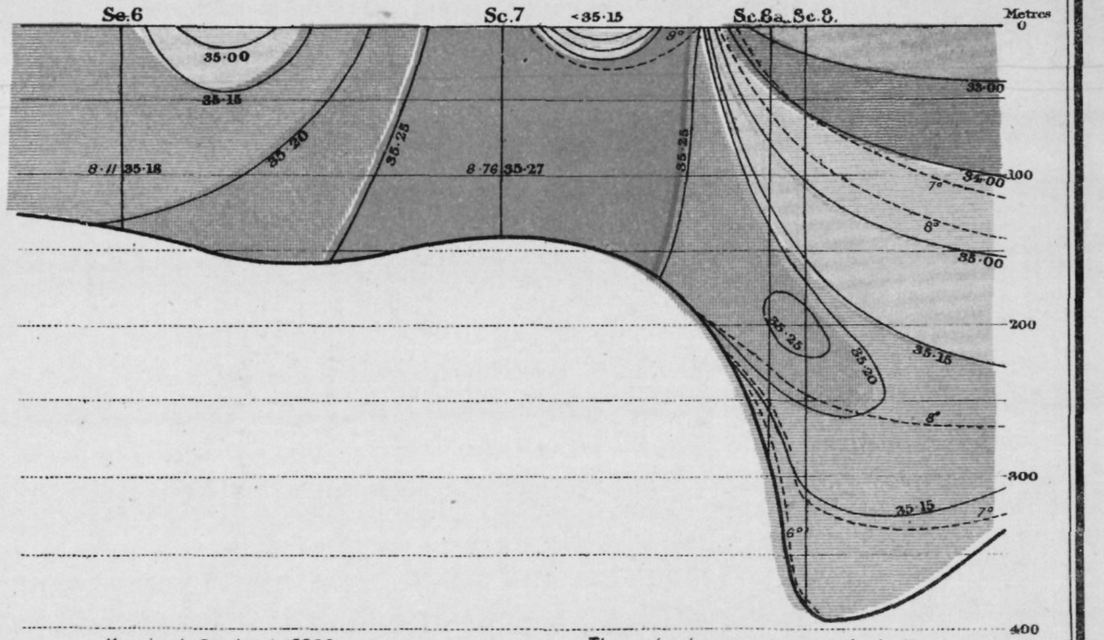


Fig. 3. Entrance from North Sea to Norwegian Sea.
December 1902.



Horizontal Scale 1: 2000.000
1 m.m. = 2 kilometres.

Fig. 2. North Sea between Shetland and Norway.
August 1902.



Vertical Scale 1: 5000
1 mm. rep. 5 metres.

The unbroken curves are isohalines
The broken curves are isotherms.

Fig. 4. North Sea between Shetland and Norway.
December 1902.

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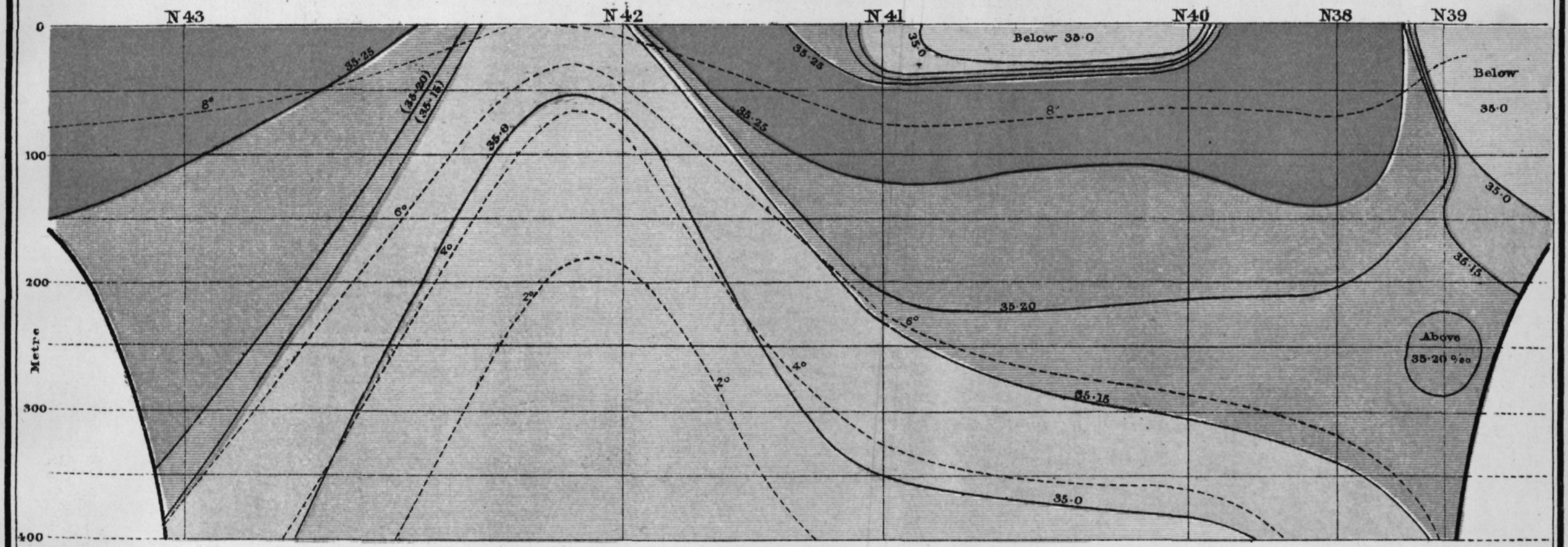
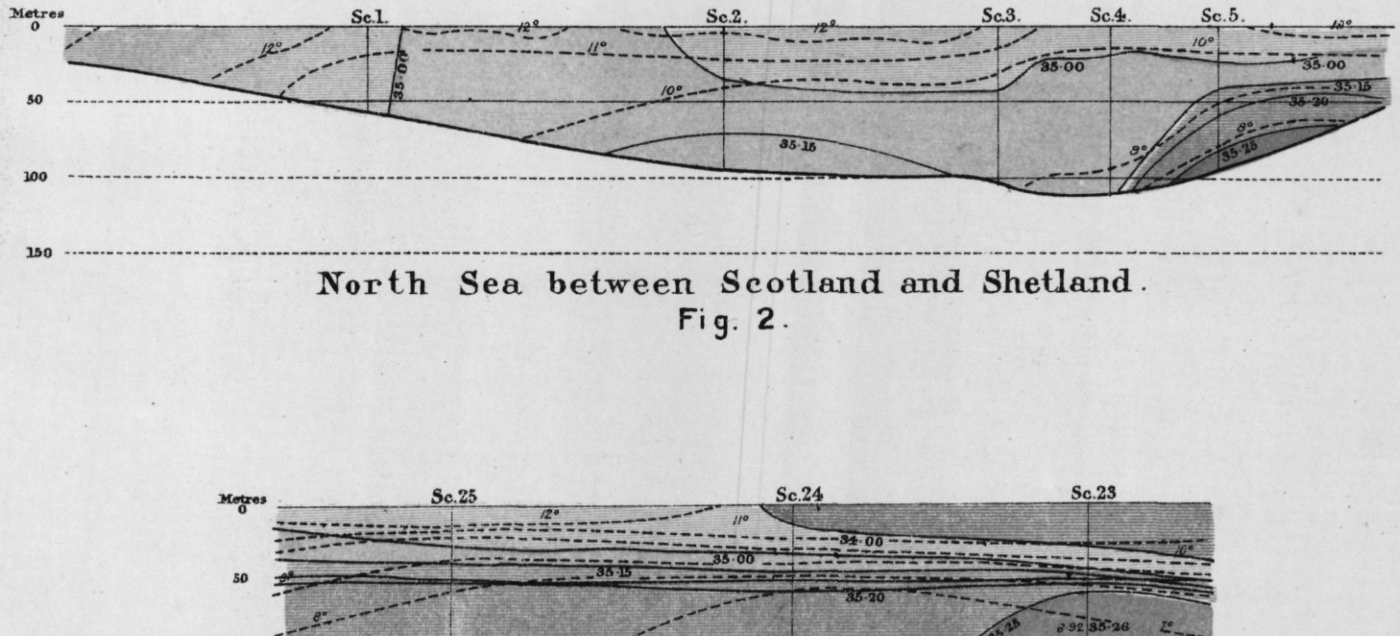


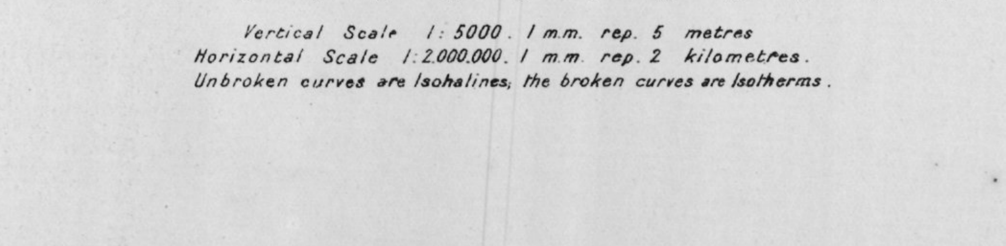
N. of the Faeroe-Shetland Channel, June - July 1902.
(From observations made by S/s "Michael Sars")

Fig. 1.

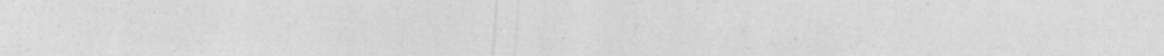
1902, August



North Sea between Scotland and Shetland.
Fig. 2.



North-western area of North Sea.
Fig. 3.



Vertical Scale 1: 5000. 1 m.m. rep. 5 metres
Horizontal Scale 1: 2.000.000. 1 m.m. rep. 2 kilometres.
Unbroken curves are Isohalines; the broken curves are Isotherms.

5151. 2. 05

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