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POUR L'EXPLORATION DE LA MER

# BULLETIN PLANKTONIQUE

POUR L'ANNÉE 1912

(CONTINUATION DU BULLETIN TRIMESTRIEL DES RÉSULTATS ACQUIS PENDANT LES CROISIÈRES  
PÉRIODIQUES ET DANS LES PÉRIODES INTERMÉDIAIRES, PARTIE D)

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AVEC L'ASSISTANCE DE

C. H. OSTENFELD,  
CHARGÉ DU SERVICE PLANKTONIQUE



H. H. GRAN: THE PLANKTON PRODUCTION IN THE NORTH EUROPEAN  
WATERS IN THE SPRING OF 1912

ORIGINAL  
siehe BUCH

EN COMMISSION CHEZ  
ANDR. FRED. HØST ET FILS  
COPENHAGUE

IMPRIMERIE BIANCO LUNO  
1915

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## PREFACE

At the sittings of the Plankton Section during the meeting of the International Council in April 1912, the question of future plankton work was thoroughly discussed, and the plankton specialists present agreed upon the importance of the quantitative study of the micro- and nannoplankton according to a method recently proposed by Professor H. H. GRAN (Public. de Circonstance No. 62). The discussion resulted in the following considerations (Rapp. et Proc. Verb. XIV, p. 94):

"It is urgently desired that quantitative determinations of the Microplankton and Nannoplankton should be carried out on all opportunities when trustworthy results of general importance can be expected. It is recommended that the centrifugal method should be applied to samples taken at different depths with the waterbottle. As Prof. GRAN has shown in Publication de Circonstance No. 62, such water samples can be preserved with Flemming's solution for future examination of many of the most important species.

It is particularly desirable that the opportunity should be taken of the cruises in May 1912 to make the most complete collection possible of material by this method at all stations and at depths of 0, 5, 10, 20, 30, 40, 50, 60, 80 and 100 meters and greater depths. Prof. GRAN has expressed his willingness, for this occasion, to work out any portion of the material which cannot be examined by other investigators".

According to these considerations the Council passed the following resolution (ibid. XIV, p. 32):

### Resolution 15.

That it is extremely desirable, that quantitative investigation should be made of the Microplankton on the method proposed by Prof. GRAN (cf. Public. de circonst. 62).

## VORWORT

Während der Zusammenkunft des internationalen Zentralkomitees im April 1912 wurde in den Sitzungen der Planktonabteilung die Frage der zukünftigen Planktonarbeiten gründlich erörtert, und die anwesenden Planktonspezialisten einigten sich über die Wichtigkeit quantitativer Untersuchungen des Micro- und Nannoplanktons nach der kürzlich von Prof. H. H. GRAN (Public. de Circonstance No. 62) vorgeschlagenen Methode. Die Discussion zeitigte die folgenden Schlüsse (Rapp. et Proc. Verb. XIV, p. 95):

»Es ist dringend erwünscht, quantitative Bestimmungen über das Mikroplankton und Nannoplankton bei solchen Gelegenheiten auszuführen, wo zuverlässige Resultate von allgemeiner Bedeutung zu erwarten sind. Es wird empfohlen die Centrifugenmethode auf Proben, die mit Wasserschöpfer aus verschiedenen Tiefen gewonnen sind, anzuwenden. Wie Prof. GRAN in Publ. de Circonst. No. 62 gezeigt hat, können solche Wasserproben für die Untersuchung vieler der wichtigsten Arten mit Flemmings Flüssigkeit für spätere Bearbeitung konserviert werden.

Es wäre besonders zu wünschen, dass die Gelegenheit benutzt werde, im Mai 1912 ein möglichst vollständiges Material während der Terminfahrten nach dieser Methode von allen Stationen aus den Tiefen 0, 5, 10, 20, 30, 40, 50, 60, 80 und 100 m bzw. aus grösseren Tiefen zu sammeln. Prof. GRAN erklärt sich bereit, bei dieser Gelegenheit diejenigen Teile des Materials zu bearbeiten, die nicht von anderen Forschern untersucht werden können.

Auf Grund dieser Schlüsse nahm der Zentralkomitee folgende Resolution an (ibid. XIV, p. 33):

### Resolution 15.

Es ist dringend erwünscht, quantitative Bestimmungen über das Mikroplankton auszuführen unter Anwendung des von Prof. GRAN benutzten Verfahrens (cf. Public. de circonst. 62).

The investigations alluded to in the above considerations and resolution were carried out in May and June 1912 by Denmark, England, Holland, Norway, Scotland and Sweden, and the material collected was sent to Prof. GRAN (the Scottish material excepted) for examination. He has now, assisted by Miss OGILVIE as regards the Scottish material, completed his task, and the important memoir published in the following pages is the result of this arduous work for the accomplishment of which the International co-operation of the study of the sea is greatly indebted to him.

Die in obigen Schlüssen und Resolutionen angeführten Untersuchungen wurden im Mai und Juni 1912 von dänischer, englischer, holländischer, norwegischer, schottischer und schwedischer Seite ausgeführt, und das gesammelte Material mit Ausnahme des schottischen wurde Herrn Prof. GRAN zur Untersuchung eingesandt. Dieser unterstützt durch Miss OGILVIE soweit es das schottische Material betrifft, hat sich jetzt seiner Aufgabe erledigt, und die in den folgenden Seiten veröffentlichte wichtige Abhandlung ist das Resultat seiner grossen Arbeit, für deren Vollendung die internationale Meeresforschung ihm zu grossem Dank verpflichtet ist.

THE PLANKTON PRODUCTION  
OF THE NORTH EUROPEAN WATERS IN THE SPRING OF 1912

BY

A. S. OGILVIE and H. H. GRAN

INTRODUCTION

THE International Investigation of the Sea has, from the commencement of the work in 1900-01, included in its programme an examination of the production of the sea by quantitative determinations of the plankton at different places and at different seasons.

A method for this examination had already been worked out several years before by HENSEN (1887), who was also the first to bring forward the question of the production of the sea for systematic scientific investigation. A water column of a certain length and base is filtered, a net of fine miller's gauze with a certain accurately determined diameter being drawn vertically a certain distance through the water. The quantity of water actually filtered is equal to the product of the distance and the diameter of opening plane of the net multiplied by a filtration-coefficient previously determined by experiment for the net-model employed.

The samples collected are examined quantitatively, partly by volume- or weight-determinations of the total amount of plankton obtained, partly by counting the individuals of the different species in accurately measured parts of the sample.

The more important sources of error, of which HENSEN himself was aware from the beginning, are 1), the escape of a number of organisms through the mesh of the net, some species being probably not caught at all and others not in proportion to the number present, and 2), the inconstancy of the filtration-coefficient, which is very considerably diminished when the plankton contains an abundance of slimy algæ such as *Phaeocystis* and certain diatoms, a variation which cannot be accurately determined.

The existence of the first of these sources of error especially has been proved by actual experiment by LOHMANN (1901, 1902, 1903), who found it considerably greater than had hitherto been expected. On the one hand, it was found that a whole series of economically more or less important small forms (Nanno-plankton) were not caught at all, while, on the other hand, the proportion even of such large organisms as *Ceratium furca* and *fuscus* which passed through the meshes was surprisingly great.

Another objection raised against HENSEN's method, in particular by HÆCKEL (1890), was that the small samples, taken thus locally with a net, could not be representative of any great part of the sea, owing to the fact that the character of the plankton may differ from place to place at short intervals. This objection has, however, been found to be of no practical importance. All later investigations have proved, that the plankton under equal conditions of life is evenly distributed over great areas, so that even quite small samples are sufficient to give a picture of its character, both as regards quality and quantity. This particularly applies to the smaller forms, with which it is reasonable to begin the examination (cfr. LOHMANN 1908).

Investigations on the plankton of the sea, according to HENSEN's method, have been carried out by a series of workers, and have given great and important results. In the course of HENSEN's great

Atlantic expedition in 1889, it was recorded, that the total quantity of plankton in the open sea in the tropics is considerably smaller than in temperate waters, such as the North European coastal water. By investigations carried on throughout the year in the Baltic (BRANDT), in the Mediterranean near Naples (SCHÜTT 1892), in the Karajakfjord in the north-west of Greenland (VANHÖFFEN 1897) it has been proved, that the quantity of plankton changes periodically in the course of the year. The maximum does not always appear at the warmest season, but on the contrary, often in the autumn and the spring. The investigations by KRAEMER on the remarkably poor plankton round the coral reefs must also be mentioned.

There was already sufficient material to form a basis for BRANDT's well known theories respecting the decided importance of dissolved nutritive substance and especially of the nitrogen-compounds for the production of plankton<sup>1</sup> and for further investigations as to the occurrence and physiological activity of the denitrifying bacteria<sup>2</sup> and the presence of the soluble nitrogen-, phosphorus and silica-compounds<sup>3</sup>.

These important results were already attained by determinations, in themselves more or less rough and inaccurate, of the volume of the total quantity of plankton. The only method of examination allowing of really quantitative analysis of the plankton, viz. determination by actual counting of the occurrence of the separate species, was, on the other hand, of smaller importance, as long as the material consisted of the samples caught by net according to HENSEN's method. There exists, it is true, a number of observations, especially from the "National" expedition in 1889 (HENSEN 1911); but the results are disproportionate to the enormous amount of work involved, which occupied a long period of years. Moreover, the value of the results is lessened by the uncertainty in the determination of the species, which it is impossible to avoid, when, owing to the extent of the work, it is necessary to employ untrained assistants.

The quantitative method of counting as applied to net samples has, however, not prevailed to any extent outside the Kiel school. During the International Investigations it has been employed by APSTEIN (1905) for the material from the German quarterly cruises in the North Sea and the Baltic in 1903, by DRIVER (1907) for similar material from the Baltic in 1905, by MERKLE (1910) for investigations in the Baltic in July—August 1907, by MIELCK (1911) for the North Sea cruises in February and May 1906 and by LÜCKE (1912) for investigations throughout the year 1910 from the Borkum Riff lightship in the Baltic. In the other countries, apart from the countings of the Copepoda recognizable when slightly magnified, the determinations have been restricted to the roughly estimated occurrence of the different species, according to CLEVE's method. A large and valuable amount of material relating to the biology of the separate species has been collected, and dealt with by a series of authors specially qualified to deal with the separate groups<sup>4</sup>.

The development of the investigations along these lines is due to the fact that the object of the research was not so clearly stated as to warrant the expectation of results proportionate to the great amount of work involved by the counting. HENSEN's main object was to examine the whole of the plant-producing water column collectively from the surface to the bottom, or to a depth limit of 200 m. Since, however, the point of the investigation is to determine the laws governing the production of plankton by studying the conditions of development and the whole biology of the most productive species, it becomes necessary to carry the analysis a step further. A vertical water column can never offer to the organisms quite equal conditions of life, even if water layers do not, as at most places in the Baltic, the Kattegat, the Skagerak and the North Sea, appear one above the other, and present widely different hydrographical characters. The intensity of the light will at any rate vary so much with the

<sup>1</sup> BRANDT 1899, 1902.

<sup>2</sup> BAER 1901, GRAN 1902 a, FEITEL 1903.

<sup>3</sup> RADEN 1904, 1905, 1910.

<sup>4</sup> Résumé des observations sur le plankton des mers explorées par le conseil pendant les années 1902—1908 I—III. Copenhague 1910—13.

depth as to render it absolutely necessary to determine the character of the plankton, qualitatively and quantitatively, at stated depths, where all the conditions of life can be precisely determined.

It was thus already a considerable advance, when PETERSSON commenced to fix plankton bags at different depths on rheometer-apparatus, and to compute, from the velocity of the current, the approximate quantity of the water mass filtered through each net. Samples thus taken, quantitatively determined by BROCH, have already given valuable results. Still more important was LOHMANN's demonstration of the fact that small water samples taken in water bottles, furnished when centrifuged, a sufficiently exact determination of the quantity of plankton for a whole series of species. In his important work on the yearly periodicity of the plankton at Laboe, near Kiel (1908), LOHMANN has carefully worked out this method and used it for a series of exceedingly valuable determinations on the fluctuations of the separate species and the aggregate amount of plankton taken in the course of a year. He also furnishes, on the basis of some accurate observations at certain depths, calculation of the mean values for the whole of the water column from the surface to the bottom. The value of these calculations rests chiefly on the fact, that the results can be compared with the results of the investigations by means of vertical hauls. For our purpose, however, i. e. analysis of the occurrence and conditions of life of the most important species, such calculations and comparison are of no great value, and LOHMANN himself has also in his later works come to the conclusion, that „Wollen wir hier eine exakte Analyse der Planktonieren und ihrer Existenzbedingungen haben, so müssen wir also unbedingt auf die Abfischung vertikaler Wassersäulen von solcher Länge, dass verschiedene hydrographische Zonen durchschnitten werden, verzichten, und werden nur dann sicher gehen können, wenn wir jeden Fang einer ganz bestimmten Wasserschicht entnehmen, die zugleich hydrographisch untersucht wird“<sup>1</sup>.

HENSEN (1912) and BRANDT, however, insist that the whole of the water column should be examined, and recommend for this purpose the employment of a rubber tube, immersed in a vertical position at a certain depth and thereafter emptied into a reservoir on deck, so that one can get an evenly mixed sample of water from all depths between the surface and the lower end of the tube. This would, in my opinion, only retard the progress of the investigations, the average of the total amount of organisms in the water column being far less valuable than precise information in a single instance as to the conditions at a certain depth. On the other hand, given a series of observations from different depths, it is possible from these to form an opinion as to the extent to which averages for the occurrence within a certain water layer can be profitably calculated. The investigations described in the following pages furnish illustrations both of great vertical variations in the character of the plankton even at very short distances, and of cases where it is so equally distributed throughout the whole the water mass, that a calculation of average values may be perfectly justifiable.

LOHMANN's centrifugal investigations near Laboe were based exclusively on living material in fresh samples. The same applies to my own investigations on the Atlantic expedition with the "Michael Sars", where the plankton was often so poor, that water samples of 300 cc were necessary in order to obtain values representative of the quantity of the plankton (MURRAY and HJORT, 1912, p. 362). The same method was also employed by LOHMANN in his important and valuable investigations in the Atlantic on board the "Deutschland" in 1911 (LOHMANN 1912 a, b). We had here the advantage of being able to determine a series of species, which it is difficult to preserve in a recognizable state, and out in the open sea these forms play a particularly prominent part in the plankton. The method, however, had this serious disadvantage, that it was only possible to examine a relatively small number of samples from each station. A more perfect method would be to get a closer series of observations from the surface downwards, from which curves might be drawn showing the vertical occurrence of the separate species, enabling us pos-

<sup>1</sup> LOHMANN 1912 b, p. 192.

sibly also gradually to acquire data for the study of their dependence on various conditions such as light, temperature, salinity and the occurrence of nutritive matter.

This could not be done unless some means were found to preserve the water samples for later examination. Such a means, thoroughly satisfactory for many forms, I have found in FLEMING's fluid (the stronger solution), added to the water samples immediately after they are taken, in the proportion of 1:20 (GRAN 1912). An experiment with water samples collected according to this method in the Norwegian Sea during May 1911 ("Michael Sars") and in the Skager Rak in May 1911 and February 1912 (by the courtesy of Professor O. PETTERSSON), was successful. At the meeting of the International Council in Copenhagen it was thereafter decided, that in May--June 1912 samples should be collected according to this method throughout the whole of the International area, and a sum for assistance in dealing with the entire material was placed at my disposal.

The collection was satisfactorily carried out, save for the fact that observations from the German area in the south-eastern corner of the North Sea are unfortunately lacking. The absence of these observations can only partly be made up for by using for comparison APSTEIN's (1905) and MIELCK's (1911) quantitative investigations from this area in May 1903 and 1906.

During these investigations I have been assisted by Miss CAROLINE LEEGAARD, who together with me examined the Danish, Swedish, English, Dutch and Norwegian material, and a portion of the Scottish. In addition, Miss HELEN S. OGILVIE, of Dundee, has independently worked out the greater part of the Scottish material, dealt with by her in a special chapter with accompanying tables.

In the course of these investigations we obtained our first impressions of the advantages and restrictions of the method. It is hoped that the following account will demonstrate how the method may be of service in throwing light upon various conditions not previously open to a scientific examination, or of which but vague conceptions could be formed. In such cases as at the Danish station Da. 1860 in the Kattegat, the hydrographical conditions varying greatly with the depth, and the hydrographical observations being exceptionally complete, the quantitative determination of the plankton in the water samples from certain depths may, for convincing clearness, almost be compared to a biological titration. In other cases the conditions are less evident, but even where no decisive conclusions can be formed, the results still furnish suggestions for further investigations.

The restrictions of the method are also distinctly evident. It is not, and cannot more than any other, become a universal method. All larger and all rarer forms are excluded from examination, particularly where the plankton is so rich, that it becomes impossible to collect the contents of the larger water samples under a cover-glass. On the other hand, we find, in a well preserved state, a series of smaller forms, which in the net samples are either not caught or not satisfactorily preserved, such as the *Laboca*-species and other ciliate Infusoria, *Mesodinium*, the *Gymnodinium*-species, *Prorocentrum* and the smallest *Dinophysis*-species. The method is, however, less fit for the true Nanno-plankton; even the *Exuviaella*-species easily elude observation and the small Flagellata are, no doubt, generally passed over in the examination of the samples, unless very high magnifying powers are used. These are, however, less suitable for the purpose; because small forms like the above-mentioned do not, at least as a rule, play such an important part in our waters as to make it worth while to spend four times the amount of time over the examination and thereby restrict the scope of the whole work<sup>1</sup>. For the present, at any rate, our aim

<sup>1</sup> The counting is generally carried out with ZEISS's achromatic lens C., giving a field of view of somewhat more than 0.8 mm. The object-slide used as a counting plate, has diagonal lines at intervals of 0.4 mm. In more difficult cases the achromatic lens E. is used, the diameter of the field of view being then rather more than the distance between two lines (0.4 mm).

is to get a general view. And, with this object now before us, the important point is not first of all to learn the total sum of all the organisms in our water samples, but to follow from sample to sample the quantitative variations of a series of accurately determined species, which illustrate the laws for the production and destruction of organic substance in the ocean. We therefore choose as many as possible of such species which are found, be it in few or many of the samples, in sufficient numbers to furnish adequate material for a reliable determination. Those species, on the other hand, which always occur sparsely, are of less importance to us. It is in the determination of the common species that the value of the investigations rests. This does not, however, prevent our reporting everything observed, even such forms as we are for the present unable to determine. We have found it right to do so, since we may safely conclude that observations now considered unimportant may turn out to be of more value later on.

In the tables containing the results of our observations, all records are given in numbers of individuals (cells) pr. litre. Below the hydrographical data in each column is given the quantity of each water sample examined, thus enabling the reader to judge to what extent the figures can be considered reliable. Where two values are given, as for instance 50 (10), this indicates that a few species which occur very abundantly have been enumerated in a sample of 10 cc, while all the others have been enumerated in a sample of 50 cc. Generally samples of 50 cc, but sometimes of 100 cc, are used, an extra determination of 50 cc being usually made in the case of the *Ceratium*-species, and added to the first, so that the water sample in question may be stated as 100 cc.

According to HENSEN, the investigation ought at any rate to be so far exact as to render the number observed at least the square root of the number reported in the table.

For 100 cc examined, with a multiplication factor of 10, the corresponding minimum value will thus be 100

- 50 -	-	-	-	20	-	-	-	400
- 10 -	-	-	-	100	-	-	-	10000

Many of the figures in the tables do not fulfil these conditions. They give, however, at any rate, some information, and can sometimes also be used for calculating mean values which are serviceable, even if the separate figures are not. They can especially serve as a basis on which to calculate the average occurrence in regard to depth of relatively rare species, as has frequently been attempted in the following pages. Where the hydrographical conditions are more or less constant, such a calculation may be of some value, at any rate as a preliminary.

The following description has been arranged thus:

#### I. Special part.

1. The Danish, Swedish, Dutch, English and Norwegian Investigations. By H. H. GRAN.
2. The Scottish Investigations. By HELEN S. OGILVIE.

#### II. General part. By H. H. GRAN.

1. Remarks on the separate species.
2. On the general conditions of life of the plankton production.
  - A. The variation of the quantity of plankton according to the depth.
  - B. Horizontal quantitative variations in the plankton.
  - C. Seasonal variation in the quantity of plankton.

obvious result in the vertical distribution, we almost invariably find an abrupt transition at certain depths between the rich plankton of the surface layers and the lower water masses with poorer vegetation. This limit is not situated at a uniform depth throughout. At the stations N 5, 6, 8, 11, 12, 13, 14, 15 and 17 it lies between 30 and 50 m, at N 4 and N 16 between 50 and 75 m, at N 10 between 75 and 100 m, and at N 7 between 150 and 200 m.

This limit corresponds in all cases to a hydrographical limit, indicated by a fall of at least half a degree in temperature, while the water layer above is relatively homogeneous, apart from the fact that several stations exhibit varying conditions at the actual surface. The algae-bearing water layer above these limits is also in biological respects remarkably homogeneous. The variations in the quantity of plankton are at any rate far from being so regular as to suggest that they are determined by the decrease in intensity of the light occasioned by the increasing depth. The maximum lies, however, almost everywhere below the surface. We are thus forced to conclude that a considerable vertical mixture has taken place, either of the whole water layer or at any rate of the diatoms, by vertical movements within the water layer. These questions will be treated more particularly in the chapter on vertical distribution.

The great variations in the position of the depth limit, or, in other words, in the volume of the algae-bearing surface layer, may perhaps be most correctly explained as due to the fact that this layer, normally appearing to be a little more than 30 m deep, may sometimes extend to greater depths, owing to hydrographical conditions. A point which immediately suggests itself in this connection is the occurrence of the submarine waves first observed by HELLAND-HANSEN<sup>1</sup> in this very water, and also found by LEA on the same voyage during which the plankton samples here dealt with were collected.

## 2. THE SCOTTISH INVESTIGATIONS

BY

HELEN S. OGILVIE, M. A., B. Sc.

During May and the early part of June 1912, an extensive collection of plankton samples was made by the Scottish "Goldseeker" off the east and north coasts of Scotland and in the Faeroe-Shetland Channel. The material thus obtained may conveniently be dealt with in four sections according to the locality in which it was collected:

- I Faeroe-Shetland Channel, Southern Section.
- II — — — — — , Northern —
- III North Sea, Northern Section.
- IV — — — — — , Southern —

The first and second sections extend from the south-west of the Shetland Islands to the south-east of the Faeroes and from the north of the Shetlands to the east of the Faeroes respectively. The third section comprises a line of stations in Lat.  $61\frac{1}{2}^{\circ}$  N. between Long.  $2^{\circ}$  W. and  $4^{\circ}$  E. reaching very nearly

<sup>1</sup> HELLAND-HANSEN and NANSEN 1909, p. 87.

to the Norwegian coast. The fourth heading comprises three sections, one between the Moray Firth and the Utsire Light on the coast of Norway, another between that point and the east of the Shetland Islands, while the third extends from there southwards to meet the first opposite Kinnaird Head.

## I. Faeroe-Shetland Channel — Southern Section.

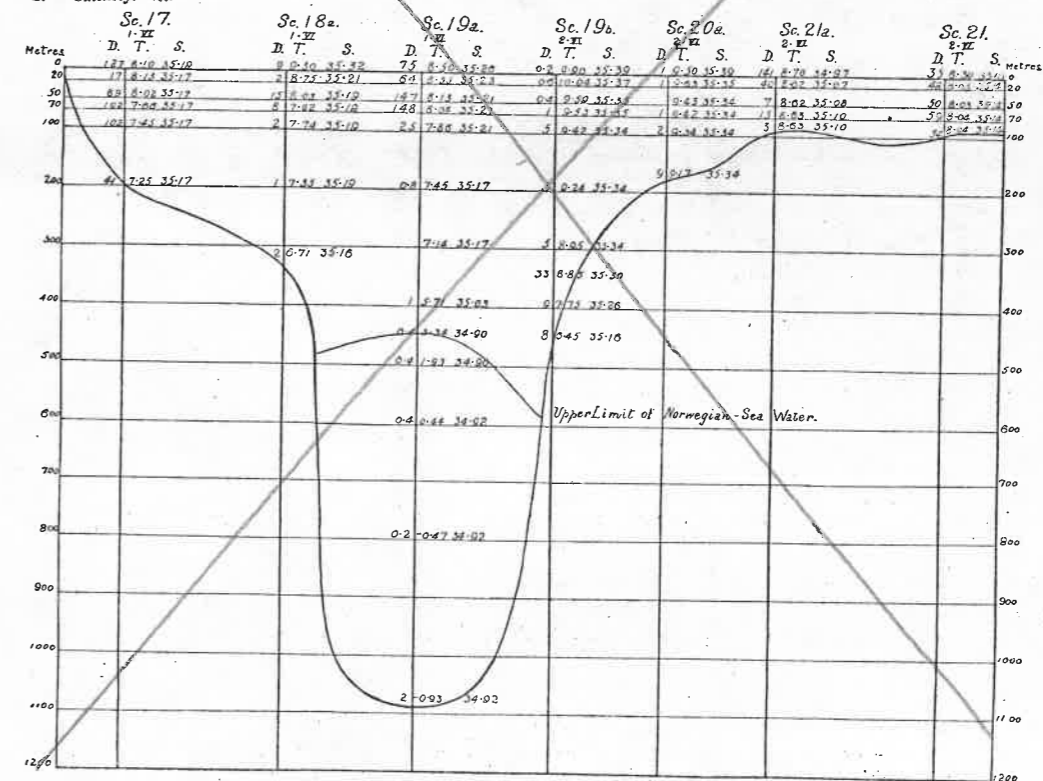
Table VIII<sup>1</sup>.

The plankton of this section, and of the Northern section as well, exhibits great irregularity in its distribution, both vertically and horizontally. The most abundant plankton is found at station Sc. 17, that nearest the Faeroes and at station Sc. 19a the next but one to it, but at neither of these stations are

### Faeroe-Shetland Channel — Southern Section.

D. = Number of diatoms (in hundreds) per litre.  
T. = Temperature, °C.  
S. = Salinity, ‰.

June 1912.



<sup>1</sup> By HELEN S. OGILVIE.

These observations agree in the main with the results of previous investigations. According to the tables given for May and June in the "Bulletins" *Chaetoceras debile* occurs frequently at all stations in the Channel except Sc. 19b, Sc. 19a and Sc. 15b, and is usually given as "cc". In 1912 it presented a similar occurrence. The records for the three other species of *Chaetoceras* which occurred plentifully in 1912 are somewhat incomplete. *Chaetoceras compressum*, which in 1912 was abundant at the Faeroe side and was also present in considerable numbers at the Shetlands, does not seem to be so regular a constituent of the plankton of this region as *Ch. debile*, as, between 1903 and 1910, only two records ("c") are given, which occurred in 1904 at stations Sc. 16 and Sc. 17 near the Faeroes. In May 1910 *Ch. lacinosum* was present ("cc") at stations Sc. 13a and Sc. 14a, and was also found ("c") at Sc. 20a in 1908, but for further records of its occurrence we have to go back to 1903 when it was again found abundantly at the same stations and also at Sc. 19b. At the same time there are no records of this species from the more westerly stations and this agrees with the results of 1912. The previous records of *Ch. constrictum* which occurs with fair regularity from 1903 to 1908 are, with the exception of one record ("c") at Sc. 19a, confined to stations Sc. 12, Sc. 13a, Sc. 14, Sc. 21 and Sc. 20a, all on the Shetland side. In May 1912 on the contrary it was only present at stations Sc. 16 and Sc. 17, close to the Faeroes. A more complete series of observations would throw further light on these points.

### III. North Sea — Northern Section.

Table X<sup>1</sup>.

This section lies approximately across the entrance from the North Sea to the Norwegian Sea, and comprises eight stations, the two most westerly of which lie directly to the north of the eastern end of the Northern Section of the Faeroe-Shetland Channel. The four eastern stations are situated within short distances of one another, the most westerly of the group lying about 120 miles from the Norwegian coast.

In hydrographical respects the conditions at the four westerly stations are very similar to those found in the Faeroe-Shetland Channel. From the records of salinity and temperature, it is evident that the Atlantic stream in its northward course, after leaving the Channel, crosses that part of the section in which stations Sc. 11 and Sc. 10 are situated, and the water at station Sc. 11a and at station Sc. 9, the stations on either side of those, is still so saline that it must have originated in large measure in the Atlantic stream also. The influence of the less saline water from the Norwegian coast is first seen at station Sc. 9 and there only at the actual surface. To the east of this, however, an abrupt decrease in the salinity of the surface layers takes place, the surface reading at station Sc. 9 being 35.07 ‰ while that at Sc. 8 is only 33.10 ‰. The lowest surface record of salinity, viz. 32.79 ‰ occurs at Sc. 8b, the record at Sc. 8c, which is situated nearer the coast, being 33.04 ‰. That this fresher water only floods the surface while the salt Atlantic water persists below it and extends to the bottom is shown by the fact that at all these stations the salinity increases with great regularity to an average record of 35.08 ‰ at the bottom, the greatest increase taking place in all cases between 20 m. and 50 m. At station Sc. 11a, the most westerly of the section, and the only station at which sufficient depth is attained, the deeper regions are filled, as in the Channel, with Norwegian-Sea bottom water, the surface limit of which is reached at 300 m.

Returning to the westerly group of stations we find at Sc. 11a a diatom-flora which, except for the large quantities of *Nitzschia delicatissima* present to a depth of 30 m., is remarkably poor. Of other species *Chaetoceras lacinosum* and *Ch. contortum* may be mentioned though occurring in small numbers, as these are among the species found plentifully in the neighbourhood of the Shetlands. *Peridinales* are

<sup>1</sup> By HELEN S. OGILVIE.

scarce except *Gymnodinium Lohmanni* and of *Protozoa* the most abundant are the small *Laboea* spp. and *Cyrtarocyclus norvegica*. By far the greater proportion of the plankton is found at and above 30 m., the numbers of organisms occurring below this depth being quite inconsiderable.

Station Sc. 11 and the following station Sc. 10 are the two situated most directly in the path of the current from the Atlantic. The high salinity is very constant at all depths only showing a very slight fall below 70 m. Diatoms are abundant, particularly *Nitzschia delicatissima*, but several species of *Chaetoceras* are also well represented notably *Ch. lacinosum* and *Ch. compressum*, while *Ch. constrictum* and *Ch. decipiens* are also present in smaller numbers. *Thalassiosira gravida* is also rather plentiful and a fair amount of *Nitzschia seriata* occurs along with *N. delicatissima*. The maximum for several of the species, and in particular for *Nitzschia delicatissima* occurs at a depth of 50 m. *Peridinales* are on the whole scarce and the *Protozoa* are again dominated by the small species of *Laboea*, while *Cyrtarocyclus norvegica* is in this case less plentiful than *C. denticulata*.

At station Sc. 10, although the records for temperature and salinity are nearly as high as at the last station, diatoms show a great falling off both in numbers of species and individuals. *Nitzschia delicatissima* is again the only abundant species. *Thalassiosira gravida* is the most plentiful of those remaining, and several species of *Chaetoceras* are recorded, but all in small numbers. *Peridinales* are rather more numerous at this station especially *Gymnodinium Lohmanni*, and *Protozoa* much more so, the numbers being made up chiefly of the same species as at the preceding station.

At station Sc. 9, the last of the group, the plankton is richer than at any other point in the section. The salinity record viz. 35.25 ‰ remains constant from 10 m. to 300 m., but the surface reading falls to 35.07 ‰ indicating that the influence of the water from the Norwegian coast is beginning to make itself felt. Biologically also this point is clearly shown. At the surface the species of diatoms recorded are considerably fewer than in the deeper layers, while the reverse is the case with the *Peridinales* which reach an undoubted maximum in this same surface water. This layer appears to offer specially favourable conditions to the *Protozoa* also. Of the *Chaetoceras* species *Ch. scolopendra* is the most abundant, then *Ch. compressum* and *Ch. constrictum*. *Ch. lacinosum* is also present but in small quantities and *Thalassiosira gravida* is plentiful. The *Peridinales*, as has been mentioned, are chiefly confined to the surface and the *Ceratia* entirely so. *Gonyaulax spinifera* heads the list with a record of 3520 cells per l. and is followed by *Gymnodinium Lohmanni*. Of the *Ceratia*, *C. longipes* is, as is usually the case in these northern waters, the most abundant species. In all 8260 cells of *Peridinales* per l. are found at the surface, a number much in excess of any recorded at the preceding stations, while at 10 m. only 1200 per l., about the average number, are present. The *Protozoa* consist for the most part of the usual species of *Laboea*, *L. conica* being particularly numerous, but *Cyrtarocyclus denticulata* and *C. norvegica* are both abundant also.

The character of the plankton at all the stations in this group is distinctly that of the Faeroe-Shetland Channel, and in particular of the Shetland side, but again irregularities occur in its distribution for which it is difficult to account. The great similarity of the plankton at station Sc. 11 to that at Sc. 12 has already been noted and is easily understood as both stations lie well within the course of the Atlantic current. The plankton at the neighbouring stations on either side is by no means so rich, *Nitzschia delicatissima* being the only abundant diatom-species, but again the same was found to be the case at station Sc. 14a to the west of the Shetlands. The remarkable abundance of the plankton at station Sc. 9, which is situated a considerable distance to the east, is not so easily explained. As however it consists in all essential respects of the same species as are found at the stations close to the Shetlands, it seems probable that, if it has not been actually carried from that neighbourhood in such quantities, although owing to the easterly direction in which the current flows when entering the Norwegian Sea this is not altogether impossible, the organisms from which it has developed had their origin there and continued to reproduce

themselves as they were borne onwards by the stream. Moreover, the salinity at this station is still so high as to indicate that the Atlantic water has only been slightly influenced by the fresher water from the eastward.

The four stations (viz. Sc. 8, Sc. 8a, Sc. 8b and Sc. 8c) which form the next group are so similar that they may be treated together. The salinity is in all cases low (cf. p. 44), but increases towards the bottom, and the temperature also is considerably lower than at the preceding stations, the average record at the surface for the four stations being 7°.5 compared with 8°.9 for the western group. The most striking feature of the plankton is the almost complete absence of diatoms. Only a few scattered individuals are found and at two of the stations the total number of diatom-cells collected from all depths only amounts to 160 per l. The *Peridinales* on the contrary are strongly developed, particularly the *Ceratia*, but are found almost exclusively at and above 30 m. Within these limits their distribution is regular at least to a depth of 20 m. They are most plentiful at stations Sc. 8 and Sc. 8a, the most westerly of the stations, and *Ceratium longipes* is in all cases the most abundant species. *Protozoa* are on the whole scarce at these stations with the exception of Sc. 8c, the station nearest the coast, and this fact may be correlated with the comparatively low temperatures obtaining. The predominance of *Peridinales* is characteristic of the Norwegian coastal water and will be referred to again when the Norwegian stations to the north of this section are dealt with.

It is thus evident that the stations of this section fall naturally into two groups, a western group comprising stations Sc. 11a—9, in the plankton of which diatoms play the most important part and the stations of which resemble in biological respects those of the Faeroe-Shetland Channel, and an eastern group comprising stations Sc. 8—8c, in the plankton of which *Peridinales* and particularly the *Ceratium* spp. are predominant, and which lie within the range of the Norwegian coastal water. In this particular section, the transition from the predominantly Atlantic water of the western part, to the shore water of low salinity with which the eastern part of the section is flooded, is exceedingly well marked, the boundary line between the two waters, each with its characteristic plankton being found between stations Sc. 9 and Sc. 8, that is considerably to the east of the centre of the section.

#### IV. North Sea — Southern Section.

Table XI<sup>1</sup>.

Three sections are included in this division, the first reaching from the Moray Firth to Utsire on the coast of Norway. Along this line, during the course of the cruise carried out in May 1912, collections were made at ten stations situated at fairly regular intervals. The second section extends from Utsire in a north-westerly direction to the Shetland Islands, and the third from there southwards to a point somewhat to the south of the line of the first, which it cuts in the neighbourhood of station Sc. 32. This section comprises six stations, while the second, excluding the two terminal stations which may be taken as belonging to the first and third sections, comprises five.

The hydrographical conditions may be briefly summarised as follows. Within the Moray Firth the water is, as might be expected, comparatively fresh. At station Sc. 28, the station nearest the shore, the salinity recorded at the surface is 34.38 ‰. A gradual but regular increase is observed to the eastward until station Sc. 36 is reached, where the surface record is 35.17 ‰. The high salinity of the central region of the section at this season is due to the presence of Atlantic water derived from the off-shoots of the Atlantic stream in its passage through the Faeroe-Shetland Channel which flows into the North Sea

<sup>1</sup> Station Sc. 28, 34, 38, 38 b, 38 c, 38 e, 38 g and 38 i by Caroline Leegaard, the rest by Helen S. Ogilvie.

round the north and south of the Shetland Islands. These off-shoots usually unite before reaching the line of the section, their greatest influence being observed in the neighbourhood of station Sc. 36. At this time, however (May 1912), the salinity is found to be equally high, indeed slightly higher, at station Sc. 38b, while at the two interjacent stations Sc. 38 and Sc. 38a it is comparatively low. This would appear to indicate that the northern branch has assumed a more easterly direction than usual and that its influence is still apparent in the section as far to the east as Sc. 38b.

At the two remaining stations of the section the conditions are altogether different. There, as was found to be the case with the most easterly stations of the Northern Section, the surface layers consist of water of low salinity originating from the Norwegian coast. The salinity increases downwards, however, the water of the deeper layers being similar to that found at all depths at the more westerly stations. Following the line of the second section from this point westwards, we find that the coastal water is again strongly in evidence at station Sc. 38e, but considerably less so at the two next stations Sc. 38f and Sc. 38g. In this section, then, the transition from the coastal water of the eastern part to the Atlantic water of the western is much more gradual than in the first. The next station, Sc. 38h, however, exhibits strong Atlantic influence, the surface record being 35.08 ‰, while at Sc. 38i the salinity is the highest recorded at any point in the three sections, and is due to the influence of the more northerly branch of the Atlantic stream already referred to, which probably also accounts for the records at station Sc. 5a, the first station of the third section, which are equally high except from the surface to 20 m.

At the two following stations the salinity falls somewhat, but is again found to be high at station Sc. 3, which is evidently situated within the range of the branch which flows round the south of the Shetlands. Still further south, at stations Sc. 2 and Sc. 26, the influence of the Scottish coastal water again makes itself felt, and the salinity is consequently on the decrease. It may be noted, however, that the records from this region are by no means so low as those from the vicinity of the Norwegian coast, there being a difference of 1.3 ‰ between the lowest readings in the two cases.

The range of temperature recorded is on the whole slight. At the stations of the first section, from Sc. 28 to Sc. 38b, as well as at Sc. 38i and all the stations of the third section, the temperature is highest at the surface and with few exceptions falls gradually and more or less regularly to the bottom. At the remaining stations, which are influenced by the Norwegian coastal water, the surface temperatures are much lower than at the other stations. A decrease usually takes place from the surface to a depth of about 50 m., when the temperature again rises rather quickly, the surface limit of the underlying Atlantic water being reached at about this depth.

With regard to the biological features of the sections, station Sc. 28, the most westerly of the stations, is situated within the Moray Firth not far from the shore. The depth recorded is only 20 m. The diatom-plankton is poor, *Thalassiosira gravida* being the only abundant species. There is, however, rather a strong development of such small *Peridinales* as *Exuviaella baltica*, *Gymnodinium Lohmanni*, *G. sp.* and *Dinophysis acuminata*. Among the *Protozoa*, too, the small species of *Laboea*, *Mesodinium* and *Tintinnopsis beroidea* are fairly abundant.

The next two stations present an increasingly plentiful diatom-flora, which at station Sc. 32, the more easterly of the two, may be described as very abundant. The outstanding feature is the predominance of *Thalassiosira gravida*, which occurs here in very large numbers, accompanied at station Sc. 32 by almost equal numbers of *Th. Nordenskiöldii*<sup>1</sup>. Some species of *Chaetoceras* are also plentiful, especially *Ch. debile* and *Ch. decipiens*, and at station Sc. 30 *Ch. compressum*. Other species, all fairly abundant, are *Leptocylindrus danicus*, *Skeletonema costatum*, *Nitzschia delicatissima*, *Rhizosolenia fragilissima* and *Rh. semis-*

<sup>1</sup> I am not quite certain as to the relative numbers of *Th. gravida* and *Th. Nordenskiöldii* at this station. There is, however, no doubt that the diatoms enumerated belong to one or other of these species.



*pina* and *Thalassiothrix nitzschioides*. *Paralia sulcata* is rather plentiful to the surface at both stations. *Peridinales* on the other hand are on the decrease compared with station Sc. 28, but *Gymnodinium Lohmanni*, and *G. sp.* are still abundant, while *Protozoa* are scarce with the exception of the small species of *Laboea*.

At the next station, Sc. 34, the plankton is much poorer in quantity. *Thalassiosira gravida* is present, but no longer in great numbers. Of *Peridinales*, *Exuviaella baltica* is abundant, but all others are scarce, and the records of *Protozoa* are very scanty.

Station Sc. 36 is one of those at which, according to the salinity records, the influence of the Atlantic water is strongly marked. The plankton also differs somewhat in character from that of the preceding stations and is much more plentiful than at station Sc. 34. The dominant diatom-species is here *Nitzschia delicatissima* along with which there are found relatively large numbers of *N. Closterium*. *Rhizosolenia semispina* is also abundant and *Rh. fragilissima* and *Rh. faeroensis* are present in considerable numbers. Other species occurring rather abundantly are *Lauderia borealis*, *Thalassiosira gravida*, but in much smaller numbers than at stations Sc. 30 and Sc. 32, *Chaetoceras debile* and *Ch. decipiens*. Among the *Peridinales*, *Gymnodinium Lohmanni* is the most plentiful, but various species of *Ceratium* and *Peridinium* are present though not in large numbers. In the surface collections the species of *Laboea* are very abundant, otherwise *Protozoa* are scarce.

At the next two stations, which are very similar in hydrographical respects, the salinity again shows a considerable decrease. The diatom-plankton of the one, however, differs distinctly from that of the other. At station Sc. 30a, where the species present are few, these are mostly rich in individuals, while at Sc. 38a the number of species recorded is much greater, but the total number of cells present is considerably less. The plankton of station Sc. 38 is dominated by *Chaetoceras debile*, which occurs in large numbers to a depth of 30 m. *Nitzschia seriata* is also abundant and to a less degree *Rhizosolenia semispina* and *Leptocylindrus danicus*. At station Sc. 38a, on the other hand, *Chaetoceras debile*, though still abundant, is exceeded in amount by *Nitzschia delicatissima*, along with which considerable numbers of both *N. seriata* and *N. Closterium* are found. *Rhizosolenia semispina* is again rather plentiful, as is also *Thalassiosira gravida* which is quite absent at station Sc. 38. At both stations *Peridinales* and *Protozoa* are scarce, except for a slight development of the species of *Laboea* at station Sc. 38.

At station Sc. 38b the high salinity again indicates strong Atlantic influence. The plankton is here very abundant. Diatoms are plentiful, both as regards species and individuals, *Thalassiosira gravida* being once more the dominant species, while *Chaetoceras debile* also occurs in great numbers. Other abundant species are *Leptocylindrus danicus*, *Rhizosolenia semispina* and *Nitzschia seriata*, which is here more plentiful than *N. delicatissima*. *Peridinales* are remarkable for the large number of species present, the most abundant being the small forms such as *Gymnodinium Lohmanni*, *G. sp.*, *Exuviaella sp.* and *Glenodinium sp.*, though *Ceratia* and *Peridinia* are also represented. Among *Protozoa* the small species of *Laboea* and *Mesodinium* are very abundant.

The plankton of the two following stations is altogether different in character, a fact doubtless correlated with the presence of Norwegian coastal water in the upper layers. This water, the influence of which is very marked to a depth of 30 m., is remarkably poor in diatoms, only two species, *Leptocylindrus danicus* and *Rhizosolenia faeroensis* being recorded from it, the former occurring, however, very abundantly. Below this depth the salinity gradually increases to the bottom, where the record is about the average for the preceding stations. In this water other species of diatoms occur, but all in quite small numbers. At station Sc. 38d the conditions are very similar, *Leptocylindrus danicus* being again very abundant to 30 m. and other species being very scarce. Among the *Peridinales*, the *Ceratia*, as is characteristic of this water, are well developed, the most abundant species being *C. longipes*, as are also *Dinophysis acuminata* and *D.*

*norvegica*, and at station Sc. 38d *Diplopsalis lenticula*. These organisms occur for the most part only in the surface water to a depth of 20 m., while the small forms such as *Gymnodinium Lohmanni*, *Exuviaella sp.*, etc., found at the preceding stations, are here confined mostly to the deeper layers, further evidence that it is the same water as was found at the stations further west which persists here under the fresher surface layers. *Protozoa* are not very abundant, but are rather more so at station Sc. 38d than at Sc. 38c, *Laboea conica*, *L. sp.* and *Mesodinium* being the most plentiful.

Station Sc. 38e, situated to the north-west of the last, may be considered as the first station of the second section, the stations of which will be dealt with in order from east to west. The hydrographical conditions are similar to those at station Sc. 38c and Sc. 38d and the transition from the fresher coastal water to the more saline lower layers is here particularly well marked, there being a difference of 1.53 ‰ between the salinity records at 30 m. and at 50 m. Diatoms, including *Leptocylindrus danicus*, are particularly scarce, but even from the small records at our disposal, it is evident that two distinct floras are present, which occur above and below 50 m. respectively. The *Ceratia* are again well represented, but are confined to the surface waters, and other *Peridinales* are only present in small numbers. *Protozoa*, too, are not abundant.

The two following stations exhibit no remarkable features. The salinity gradually rises as we pass westwards. Diatoms are very scarce, in fact nearly absent at station Sc. 38g the more westerly of the two. *Ceratia* are still fairly numerous, especially at the second of the stations, but the records obtained of other *Peridinales* and of *Protozoa* are scanty.

At station Sc. 38h the influence of the continental coastal water has almost disappeared, the surface record for salinity being 35.08 ‰. The character of the plankton has again undergone a change. Here we have a fairly abundant diatom-flora, rather rich in species, but somewhat poor in individuals. *Thalassiosira gravida*, *Nitzschia delicatissima*, *Chaetoceras densum* and *Ch. debile* are the most abundant species. *Leptocylindrus danicus*, *Rhizosolenia semispina*, and *Rh. fragilissima* are present but not plentiful. *Peridinales* are fairly numerous, still chiefly represented by *Ceratia*, though these are not so abundant as at some of the stations previously dealt with. *Protozoa* are rather plentiful, consisting for the most part of *Laboea conica* and *Mesodinium*.

At the next station, Sc. 38i, where the maximum salinity for the section is recorded, diatoms are rather abundant, but by no means so numerous as they were found to be at the stations where the highest salinities are recorded in the more southerly section. *Rhizosolenia faeroensis* is the most abundant species, and along with it are found *Rh. fragilissima* and *Rh. semispina*. In addition *Chaetoceras densum*, *Ch. debile* and *Thalassiosira bioculata* are rather plentiful. The species of *Peridinales* which occur are many but the individuals are few. *Ceratia* are still present, but now only in small numbers. *Protozoa* are on the whole scarce, *Mesodinium* being the only species at all abundant.

Station Sc. 5a is the turning point from which the third section extends southwards. The salinity is high, but less so near the surface and the plankton of all kinds is conspicuously poor. Diatoms are most abundant at the bottom, and there a considerable proportion of the whole number consists of *Paralia sulcata*. Both *Peridinales* and *Protozoa* are very scarce, more so indeed than at any other point in the three sections.

The diatom-floras found at the three following stations are remarkably similar. Practically the same species are present in each and the numerical variations from station to station are slight. The only species which occurs at all abundantly is *Rhizosolenia faeroensis*, and it is most numerous at station Sc. 5. A considerable development of *Peridinales* and particularly of *Ceratia* occurs at station Sc. 4 and Sc. 3, the two following stations, but at station Sc. 5 these organisms are almost entirely absent. The

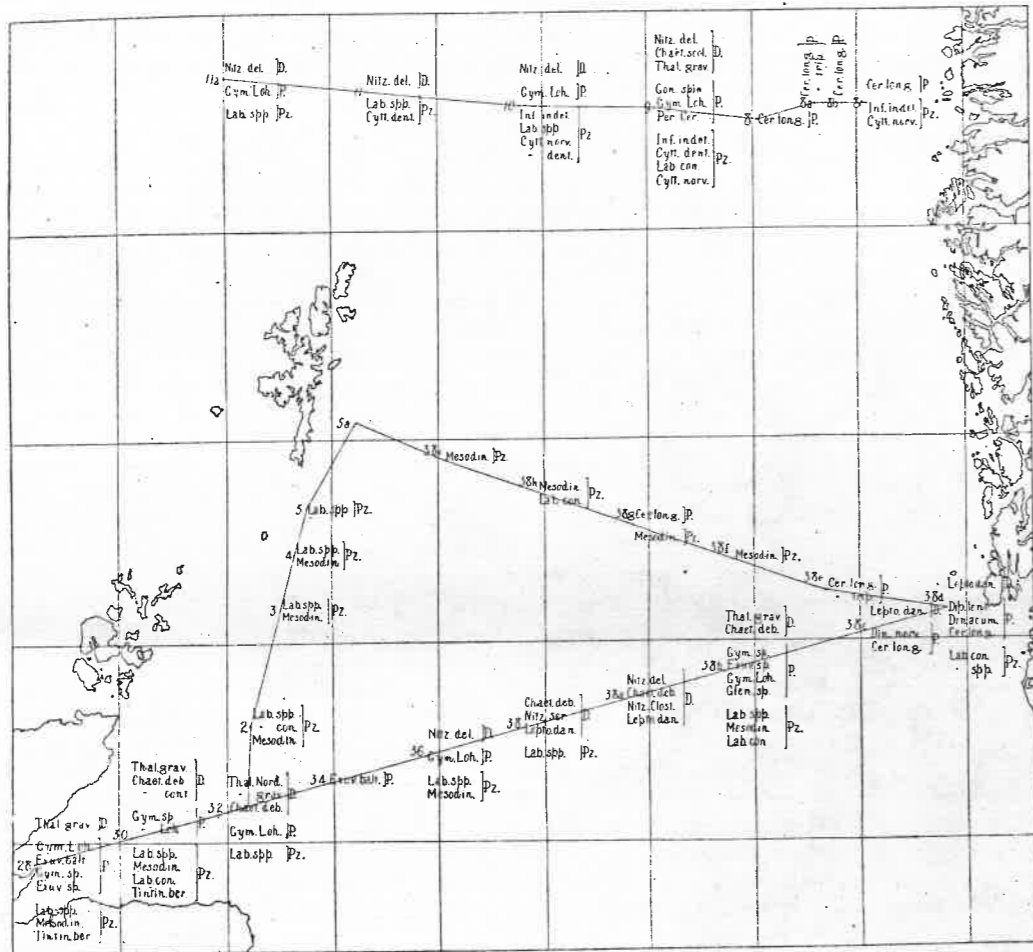


Diagram showing the distribution of the most abundant plankton-species at certain stations in the northern part of the North Sea in May and June 1912.

Diatoms are mentioned when an average of over 2000 per litre occurs at depths of from 0 m. to 50 m.  
 Peridiniales and Protozoa are mentioned when an average of over 200 per litre occurs at depths of from 0 m. to 30 m.  
 The organisms are noted in each case in order of frequency of occurrence.

List of Abbreviations.

D. = Diatoms.	Thal. Nord. = Thalassiosira Nordenskiöldii.	Gym. Loh = Gymnodinium Lohmanni.
P. = Peridiniales.	Cer. (C.) long. = Ceratium longipes.	Per. Cer. = Peridinium Cerasus.
Pz. = Protozoa.	Diu. acum. = Dinophysis acuminata.	Cytl. dent. = Cyttarocyclus denticulata.
Chaet. cont. = Chaetoceros compressum.	Dip. lent. = Diplopsalis lenticula.	norv. = norvegica.
deb. = debilis.	Exuv. balt. = Exuviaella baltica.	Lab. con. = Laboea conica.
scol. = scolopendra.	sp. = species.	spp. = species.
Lepto. dan. = Leptocyclus danicus.	Glen. sp. = Glenodinium species.	Mesodin. = Mesodinium.
Nitz. Glost. = Nitzschia Glosterium.	Gon. spina. = Gonyaulax spinifera.	Tintin. ber. = Tintinnopsis herodea.
del. = delenticissima.		Inf. indet. = Infusoria indeterminata.
ser. = serjata.		
Thal. grav. = Thalassiosira gravida.		

same applies to the species of *Laboea* and to *Mesodinium*, which are found at station Sc. 4 and Sc. 3 in great numbers.

At the two remaining stations, where the salinity has fallen somewhat owing to the influence of the fresher water from the Moray Firth, diatoms are very poorly represented; at station Sc. 26 indeed they are entirely absent above 50 m. and the highest records are those of *Paralia sulcata*. *Peridiniales* are very scarce at both stations. At station Sc. 2 *Protozoa*, chiefly the small *Laboea*-spp., are remarkably abundant, but at station Sc. 26 they are present only in small numbers.

Considered generally, the plankton of this group of stations consists of two kinds, one in which diatoms predominate and in which numbers of small forms of *Peridiniales* are also to be found, and another characterised by the presence of the larger *Peridiniales*, chiefly the *Ceratia*. The first is exemplified with a few exceptions by the stations of the first section from the Moray Firth to station Sc. 38b, and it is at certain of these stations that the plankton is found to be most richly developed. The second is met with typically at the two most easterly stations of the same section and along the line of the second section from station Sc. 38e to Sc. 38h. Beyond this a further change occurs and the plankton at station Sc. 38i again resembles that of the western stations of the first section. The plankton of the third section is throughout so poor that it is difficult to characterise it. Diatoms are at all stations very scarce, but in the central part of the section, the *Ceratia* are again fairly numerous and the more southerly stations show a rich development of the small species of *Laboea*.

Some curious points with regard to the distribution of certain species of diatoms, especially along the line of the first section, may also be noted. *Thalassiosira gravida* is, as has been observed on previous occasions, very plentiful in the vicinity of the Moray Firth. At this particular season it is found in increasing numbers at stations Sc. 28, Sc. 30 and Sc. 32, with a distinct maximum at the last mentioned station. Thereafter a sudden falling-off takes place until at station Sc. 33 it is not recorded at all. It reappears at the next station and at the next, Sc. 38b, it occurs again in large numbers, but throughout the remainder of the sections the records of this species are quite inconsiderable. The occurrence in large numbers of *Leptocyclus danicus* (with a maximum of 407,800 cells per l.) at stations Sc. 38 and Sc. 38d may also be mentioned. At these stations the diatom-flora is otherwise particularly scanty. This diatom is present at several stations to the west of Sc. 38c, but is not specially abundant there, and is very scarce at Sc. 38e, the station immediately to the west of Sc. 38d, where the hydrographical conditions are almost exactly similar. Further west in the second section it disappears entirely from the flora.

Another remarkable feature is the occurrence at stations Sc. 2 and Sc. 26 of a plankton unusually poor in all respects save for the large numbers of the small species of *Laboea* found at station Sc. 2. Station Sc. 32, on the other hand, which lies almost midway between them, presents an abundant diatom-plankton and is also the station at which *Thalassiosira gravida* has its maximum. This species is practically absent at the two other stations. In addition it may be noted that at station Sc. 32 the species of *Laboea* are by no means plentiful.

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Table VI. North Sea (English Investigations), June 1912.

Table VI. North Sea (English Investigations).

E 53. S. VI. 12. 56°58' N. 1°21' E.											E 51. S. VI. 12. 56°26' N. 2°47' E.											E 50. S. VI. 12. 55°41' N. 3°28' E.											E 49. S. VI. 12. 56°54' N. 4°6' E.											E 48. S. VI. 12. 57°9' N. 4°48' E.											E 47. S. VI. 12. 57°22' N. 5°28' E.											Station										
0	5	10	15	20	25	30	35	40	45	50	0	5	10	15	20	25	30	35	40	45	50	0	5	10	15	20	25	30	35	40	45	50	0	5	10	15	20	25	30	35	40	45	50	0	5	10	15	20	25	30	35	40	45	50	0	5	10	15	20	25	30	35	40	45	50		Depth (Metres). Temperature (° C). Salinity (‰). Quantity (cc) examined.									
40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240											
40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	40	60	80	100	120	140	160	180	200	220	240	10.32	10.12	10.05	9.75	8.67	8.47	8.33	8.28	8.28	8.28	8.28

1. Cerataulina Bergonii E 52, S. VI, 75 m. 10. 7. Chaetoceros cinctum E 52, S. VI, 0 m. 180.  
 2. Coccinella polychorda E 52, S. VI, 40 m. 60. 14. Lauderia borealis E 55, S. VI, 30 m. 20.  
 22. Rhizosolenia laevis E 52, S. VI, 30 m. 20. 26. Rhizosolenia styliiformis E 55, S. VI, 50 m. 20.  
 54. Peridinium conoides E 52, S. VI, 40 m. 20. 58. Peridinium oceanicum E 52, S. VI, 15 m. 20. 61. Peridinium parvum E 51, S. VI, 40 m. 20.  
 31. Distephanus speculum E 56 S. VI, 75 m. 20.

Table VI. North Sea (English Investigations).

Table VI. North Sea (English Investigations), June 1912.

Station.....	E 56. 4. VI. 12. 55°15' N. 0°43' W.								E 55. 5. VI. 12. 55°29' N. 0°23' W.								E 54. 8. VI. 12. 55°40' N. 0°29' E.								E 53. 8. VI. 12. 55°55' N. 1°21' E.								E 52. 8. VI. 12. 56°13' N. 2°21' E.								E 51. 8. VI. 12. 56°26' N. 2°47' E.								E 50. 8. VI. 12. 56°															
	5	10	15	20	30	40	50	75	0	5	10	15	20	30	40	50	5	10	15	20	30	40	50	5	10	15	20	30	40	50	5	10	15	20	30	40	50	5	10	15	20	30	40	50	5	10	15	20	30	40	50	5	10	15	20	30	40	50	5	10	15	20	30	40
Depth (Metres).....	10.05	10.20	10.20	9.1	8.1	6.95	7.2	6.7	10.	10.	10.	10.	9.5	8.3	6.6	6.55	10.33	10.0	9.95	9.65	8.7	8.7	6.65	6.65	6.65	10.34	10.25	10.07	9.80	8.95	6.50	6.45	6.45	10.19	10.20	10.15	9.82	9.50	9.16	7.66	6.42	6.40	9.61	9.62	9.69	9.40	9.25	8.55	6.97	6.25	6.25	9.70	9.70	9.55	9.30	6.65	6.65	6.65	6.65	6.65	6.65	6.65		
Temperature (° C).....	34.515	34.515	34.63	34.67	34.75	34.58	34.75	34.58	34.65	34.72	34.785	34.84	34.965	34.70	34.80	34.8	34.85	34.965	35.01	35.06	35.06	35.07	35.06	35.02	35.04	34.94	34.92	34.89	34.90	34.92	34.965	34.965	34.94	34.99	35.02	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99	34.99											
Salinity (‰).....	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50								
Quantity (cc) examined.....	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50								
<b>Diatomaceae.</b>																																																																
1. Actinocyclus Ehrenbergii.....																																																																
2. Actinocyclus undulatus.....																																																																
3. Chaetoceras atlanticum.....																																																																
4. — boreale.....																																																																
5. — decipiens.....																																																																
6. — sp.....																																																																
10. Coscinodiscus lineatus.....																																																																
11. Guinardia flaccida.....																																																																
13. Navicula distans.....																																																																
15. — sp.....																																																																
16. Nitzschia Closterium.....																																																																
17. — sp.....																																																																
19. Paralia sulcata.....																																																																
20. Pleurosigma sp.....																																																																
21. Rhizosolenia alata.....																																																																
23. — semispina.....																																																																
24. — Shrubsolei.....																																																																
25. — Stolterothii.....																																																																
27. Thalassiosira decipiens.....																																																																
28. — sp.....																																																																
29. Thalassiothrix nitzschoides.....																																																																
<b>Pterospmataceae.</b>																																																																
30. Pterosperma Vanhöffenii.....																																																																
<b>Peridinales.</b>																																																																
32. Ceratium bucephalum.....																																																																
33. — furca.....																																																																
34. — finus.....																																																																
35. — intermedium.....																																																																
36. — lineatum.....																																																																
37. — longipes.....																																																																
38. — macroceros.....																																																																
39. — tripos.....																																																																
40. Dinophysis acuminata.....																																																																
41. — acuta.....																																																																
42. — norvegica.....																																																																
43. — rotundata.....																																																																
44. Diplopelta bomba.....																																																																
45. Diplopsalis lenticula.....																																																																
46. Exuviaella periorata.....																																																																
47. — baltica.....																																																																
48. Glenodinium bipes.....																																																																
49. — sp.....																																																																
50. Gonyaulax spinifera.....																																																																
51. — triaenantha.....																																																																
52. Gymnodinium Lohmanni.....																																																																
53. — sp.....																																																																
55. Peridinium conicum.....																																																																
56. — crassipes.....																																																																
57. — depressum.....																																																																
59. — ovatum.....																																																																
60. — pallidum.....																																																																
62. — pellucidum.....																																																																
63. — pyriforme.....																																																																
64. — Steirii.....																																																																
65. — sp.....																																																																
66. Pouchetia nigra.....																																																																
67. — sp.....																																																																
68. Protocestrum reticulatum.....																																																																
69. Pyrocystis lunula.....																																																																
70. Pollen of firs.....																																																																
<b>Protozoa.</b>																																																																
71. Laboea conica.....																																																																
72. — strobila.....																																																																
73. Laboea setacea.....																																																																
74. Mesodinium rubrum.....																																																																
75. Tintinnopsis beridea.....																																																																
76. Tintinnus acuminatus.....																																																																
77. Infusoria indeterminata.....																																																																
78. Foraminifera.....																																																																
79. Cystae.....																																																																
<b>Metazoa.</b>																																																																
80. Ova.....																																																																
81. Nauplii of Copepods.....																																																																
82. Acartia sp.....																																																																
83. Copepoda indeterminata.....																																																																
84. Eudae sp.....																																																																
85. Larvae of Annelids.....																																																																
86. Other Larvae.....																																																																
87. Fritillaria borealis.....																																																																
88. Not determined cells.....																																																																

Also observed: 3. Asteromphalus atlanticus E 49, 9. VI, 40 m. 20. 4. Cerataulina Bergonii E 52, 8. VI, 75 m. 10. 7. Chaetoceras cinctum E 52, 8. VI, 0 m. 180. 9. Chaetoceras densum E 55, 5. VI, 50 m. 20. 12. Coscinosira polychorda E 52, 8. VI, 40 m. 60. 14. Lauderia borealis E 55, 5. VI, 30 m. 20.

22. Rhizosolenia taeroensis E 52, 8. VI, 50 m. 20. 26. Rhizosolenia 54. Peridinium conicoideum E 52, 8. VI, 40 m. 20. 58. Peridinium oceanum



















