FISKERIDIREKTORATETS SKRIFTER
Serie Havundersøkelser
(*Report on Norwegian Fishery and Marine Investigations*)
Vol. XII. No. 3.

Seasonal Changes in the Phytoplankton at Various Points off the Norwegian West Coast

(Observations at the permanent oceanographic stations, 1945—46.)

By
T. BRAARUD, K. RINGDAL GAARDER and O. NORDLI
(*Institute for Marine Biology, B, University of Oslo*)

1958
A.S JOHN GRIEGS BOKTRYKKERI, BERGEN

FISKERIDIREKTORATETS SKRIFTER
Serie Havundersøkelser
(Report on Norwegian Fishery and Marine Investigations)
Vol. XII. No. 3.

Seasonal Changes in the Phytoplankton at Various Points off the Norwegian West Coast

(Observations at the permanent oceanographic stations, 1945—46.)

By
T. BRAARUD, K. RINGDAL GAARDER and O. NORDLI
(Institute for Marine Biology, B, University of Oslo)

1958
A.S JOHN GRIEGS BOKTRYKKERI, BERGEN

CONTENTS

Preface.

Through the courtesy of Dr. JENS EGGVIN, Institute of Marine Research, Fisheries Directorate, Bergen, samples for quantitative phytoplankton studies were collected in 1945—46 at the permanent oceanographic stations operated by the Institute of Marine Research. Dr. EGGVIN kindly placed hydrographical data from the same period at our disposal. The samples from the stations Utsira, Sognesjøen, Skrova and Eggum were worked up at the Institute for Marine Biology, B, University of Oslo. The microscopical examination of the samples was carried out by Mrs. K. RINGDAL GAARDER, Mr. O. NORDLI and the late Mr. M. AARFLOT.

We wish to express our sincere thanks to Dr. JENS EGGVIN for organizing the collection of phytoplankton material and for supplying hydrographical data. Only through his active cooperation could this survey be undertaken. We are also greatly indebted to Fiskeribedriftenes Forskningsfond for financing the microscopical work; to the Norwegian Research Council for Science and the Humanities which financed the assistance of Mrs. BJØRG PAULSEN for drawing the figures.

I. Introduction.

The foundation of our knowledge of the phytoplankton of Norwegian coastal waters was laid by GRAN in his taxonomical and extensive biogeographical studies in Northern waters (GRAN 1897a, b, 1900a, b, 1901, 1902, 1904, 1905, 1910) and supplemented by the floristic-taxonomical studies of JØRGENSEN (1905). Although net methods were used during these investigations the coarse features of the seasonal changes in the population were brought out, except for the coccolithophorids and other minute forms which pass through the nets. The most striking event was found to be the spring diatom "flowering". In his publications GRAN pointed out the difference between the phytoplankton of the fjords and that of the coastal current outside the archipelago and he raised the question as to the general causes of the seasonal fluctuations in the phytoplankton population.

After the introduction of the centrifuge method GRAN carried out a survey of the spring plankton of the Hardangerfjord and the waters outside in 1922 (GRAN 1927). A more intensive study of the spring phytoplankton was carried out in 1926—29 in the Romsdalsfjord and the coastal waters off Møre, within a section reaching out to the Atlantic current at Storegga. During 1929 observations were also made in the Lofoten area where RUUD FØYN already had made a quantitative study of the plankton of the Vestfjord and the waters outside in 1922—27 (RUUD 1926, RUUD FØYN 1929, GRAN 1929, 1930). The early occurrence of the spring diatom flowering at the stations near the coast and at the outer border of the coastal current towards the Atlantic waters was observed in both areas. The phytoplankton observations were combined with physico-chemical observations which included analyses of nitrate, nitrite, ammonia and phosphate in the Møre region (BRAARUD and KLEM 1931) and phosphate and nitrate analyses by O. SUND in the Lofoten area (GRAN 1929, 1930). These data, obtained by the methods which recently had been introduced by ATKINS (1923), HARVEY (1926) and WATTENBERG (1927), made it possible to gain a far more reliable picture than before of the ecological background for the spring diatom development in the fjords as well as in the offshore coastal waters.

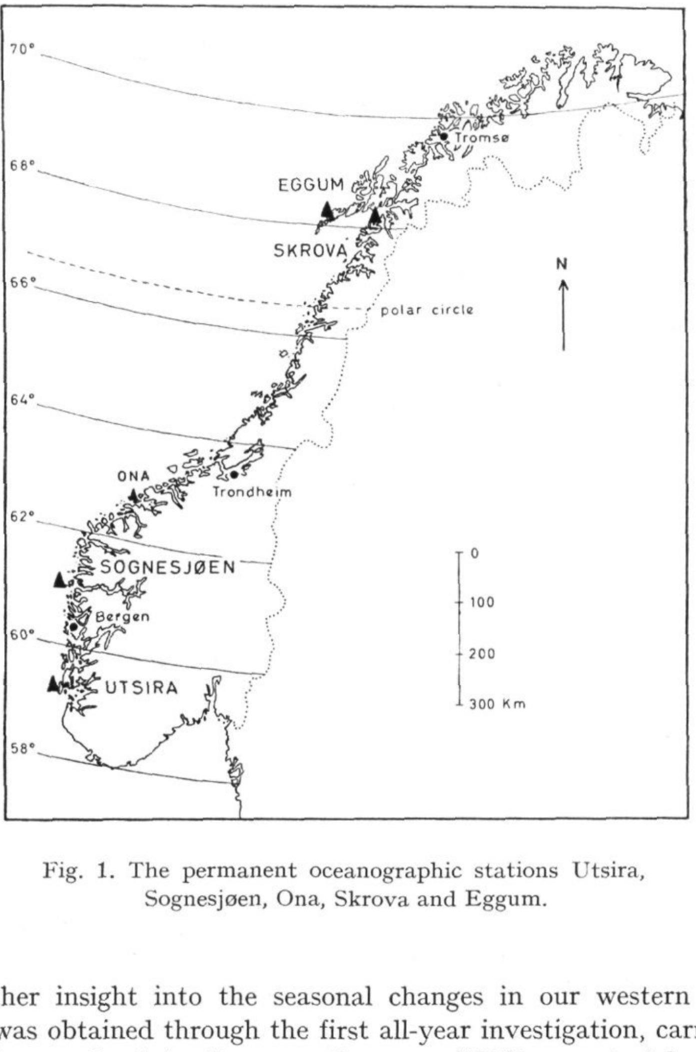

Fig. 1. The permanent oceanographic stations Utsira, Sognesjøen, Ona, Skrova and Eggum.

Further insight into the seasonal changes in our western coastal waters was obtained through the first all-year investigation, carried out in the Tromsø fjords by RINGDAL GAARDER (1938) on material collected by Mr. T. SOOT-RYEN. A similar investigation in the land-locked fjord Nordåsvatn, near Bergen, added new features, partly conditioned by the special hydrographical character of this locality and its ice cover in winter (BRAARUD and HOPE 1952).

Occasional observations in connection with offshore surveys illustrated the effect of offshore hydrographical conditions upon the phytoplankton of the coastal current (BRAARUD 1935, BRAARUD, RINGDAL GAARDER and GRØNTVED 1953, HALLDAL 1953). The problem of the autumnal maximum in phytoplankton was discussed by BRAARUD (1944).

In spite of extensive information gained through these surveys it was obvious that our knowledge of the seasonal changes in the phytoplankton of the coastal waters of our west coast was still most incomplete, both for the fjords proper and for the outer area. The present material was intended to contribute further information on the annual cycle in the waters just outside the archipelago, both in the southern and the northern part of the Norwegian west coast.

Before entering upon a description of the seasonal changes in the phytoplankton population at the four stations: Utsira, Sognesjøen, Skrova and Eggum (see map, Fig. 1), it may be useful to bring to mind certain hydrographical features of the area.

The coastal waters of western Norway consist of: 1) the offshore coastal current, a continuation of the Baltic current of the Skagerrak, passing along the southern coast of Norway, 2) local coastal water at the mouth of the fjords and between the islands outside, 3) the water of the fjords proper. These categories of coastal water can not be considered as well-defined water bodies, but in describing the oceanographic conditions along the coast it is useful to make this distinction on a geographical basis. It must, however, be kept in mind that the water masses encountered are by no means stationary water bodies. On the contrary, there is a continuous in- and outflow and interchange between the waters occupying the various parts of the coastal region. Although this hydrographical feature is of paramount importance for the understanding of the phytoplankton conditions, we are unable to present any detailed picture of the hydrography of the surface layers, which are of special interest in our discussion. We must confine ourselves to a few general statements.

Very complex interchanges take place within the coastal area, conditioned by the varying flow of the coastal current, by the outflow of water from the fjords, which is subject to pronounced seasonal changes, and by wind conditions. Tidal currents add to this intricate pattern. In addition, offshore waters are, at a varying rate, continually being mixed with the outer parts of the coastal waters.

While these interchanges between the various water masses in an area take place, a general northward drift carries water from the southern localities northwards, at a speed which fluctuates and is subject to seasonal variations (MOHN 1887, HELLAND-HANSEN and NANSEN 1909, MARTENS 1929, EGGVIN 1940).

The complexity of the hydrographical situation at any point of the Norwegian coast must be kept in mind when observations from fixed positions are considered. The process of "sequence" (GRAN and BRAARUD 1935): the change in the plankton population in a certain locality due to transport of water masses past the point of observation, confuses the picture of the "succession" of phytoplankton populations which takes place in a certain body of water. Interchange of fjord water with the waters outside does not make easier the analysis of the ecological background for the seasonal changes observed.

On the other hand, since these hydrographical conditions are characteristic of the coastal region as a whole, they form an important part of the interplay of factors determining the productivity of a certain area and the actual phytoplankton populations to be found there at any time.

In each of the four localities which have been chosen the hydrographical conditions have their specific features. The interchange between the local fjord water, the offshore waters and the coastal waters entering the area from the south is not the same. We have tried to deal with this point below. A detailed account of the hydrographical observations from the permanent oceanographical stations is being prepared by Dr. J. EGGVIN for a subsequent publication.

II. Seasonal changes in the phytoplankton population at Utsira, Sognesjøen, Skrova and Eggum in 1945—46.

a) *Utsira.*

Tables I, V—VII, Figs. 2, 4, 5 and 11.

The seasonal variations in 1945—46 may be briefly summarized as follows:

After a poor winter period the spring diatom maximum occurred in the last week of March. The profuse diatom population continued during the first half of April, but then fell off and a poor phytoplankton was recorded in late April to May.

In June *Coccolithus huxleyi* attained abundance (1 million/L). (July observations are missing.) The ceratia also reached their maximum at this time, but they were always rather scarce at Utsira as compared with the other localities (cp. Fig. 11). In late August and early September an increase in the diatom population was recorded, but the population during this small autumnal diatom maximum did not nearly reach that of the spring maximum. It lasted for a short time only; in the middle of September the plankton numbers were again small and gradually the very poor winter population was established.

Apart from the poor winter period *Gymnodiniaceae* was a regular and fairly numerous component of the plankton at all seasons (see Table I).

Below are given some details on the observations, which cover the period 26 March 1945 to 29 March 1946.

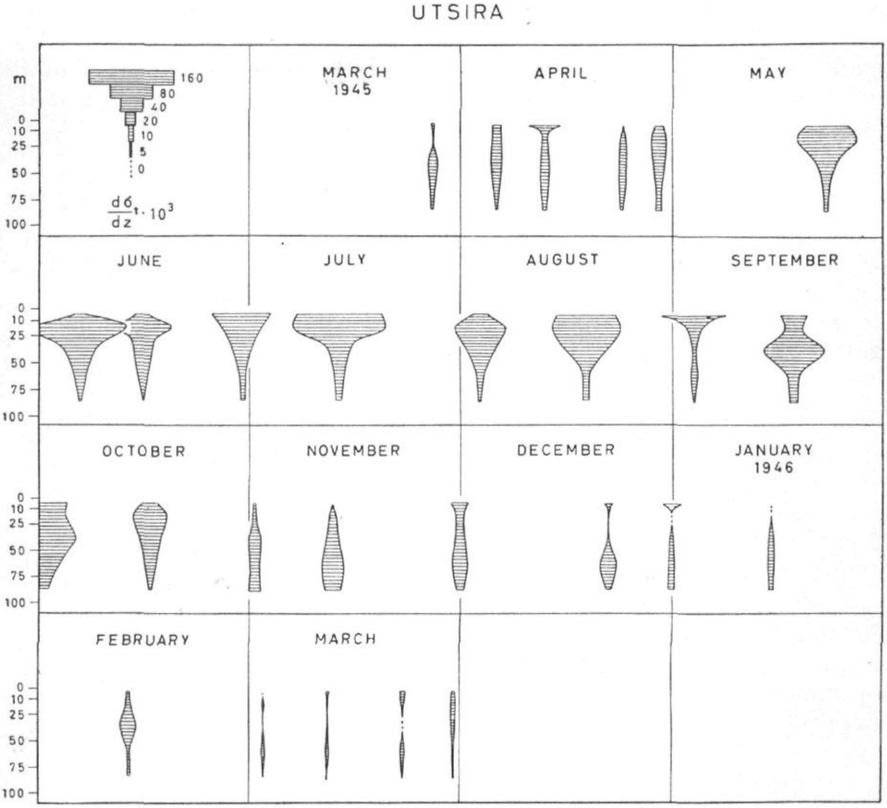

Fig. 2. Stability diagrams for station Utsira during the period of investigation.

26 March 1945. — Table V.

At this time the spring diatom maximum was recorded, the population being dominated by *Sceletonema costatum*, in numbers up to 6.750.000/L. *Chaetoceros* were present in fair numbers and, likewise, *Thalassiosira*, but none of them in populations surpassing 50.000/L for any species. Coccolithophorids were extremely scarce, while dinoflagellates were represented by many species. The society was similar to those previously recorded at this time of the year in Norwegian coastal waters.

5 April 1945.

Sceletonema was not nearly as predominant as 10 days before, while *Thalassiosira* (mainly *nordenskioeldi*) was more abundant, the species mentioned reaching 232.000/L. The *Chaetoceros* population was varied and fairly numerous.

12 April 1945.

The following week observations show a remarkable change in the composition of the diatom population. *Sceletonema* occurred in very small numbers only (max.: 19.500/L at 5m), while *Chaetoceros socialis* was the diatom predominantly numerous. The *Thalassiosira* population was small. The *Ceratium* population was composed of the same species and in similar numbers as that of the preceding week and the whole dinoflagellate society was of a character similar to that of the same week.

23 April 1945.

Observations are only available from 1 and 10 m. The diatom population was extremely poor, while otherwise the composition of the plankton was similar to that of the previous date. It is remarkable that *Sceletonema* was not recorded at all this time while 5 days later it occurred again in numbers of 145.000/L.

28 April 1945.

Apart from *Sceletonema*, the population was practically unchanged from the time of the previous sampling.

22 May 1945.

A noticeable change had taken place during these three weeks. Coccolithophorids had appeared in larger numbers, *Coccolithus huxleyi* and an unidentified species both surpassing 50.000/L. Peridinia were remarkably scarcer, while the *Ceratium* population was varied, although not numerous. *Chilomonas marina* was more abundant than before (max.: 17.500/L).

6 June 1945. — Table VI.

Coccolithus huxleyi had increased to about 1 million/L (10m); otherwise the community was much the same as on the previous date of sampling. *Peridinium trochoideum* was recorded in a number of 14.000/L at 25 m. A similar society was observed on 18 June, only a 1m sample being available.

29 June 1945.

The only sample, from 10m, indicates that the *Coccolithus huxleyi* population had decreased, but otherwise no great change seemed to have taken place.

18 August 1945.

There is a gap in the observations from July through the first half of August. Observations on 18 August from 25m and 50 m show that a much more varied plankton society occurred then than in June. Diatoms were represented by several *Chaetoceros* species and other forms, but the numbers were small. The coccolithophorid component was not very numerous, but both *Anthosphaera robusta* (21.500/L) and *Coccolithus huxleyi* (35.000/L) may have been more abundant in the upper layers. *Peridinium* species were present in considerable numbers and the *Ceratium* population was much the same as during the rest of the summer.

3 September 1945. — Table VII.

The diatom population was now quite large, *Nitzschia delicatissima* and *Sceletonema costatum* both surpassing 100.000/L. *Coccolithus huxleyi* reached 325.000/L, while ceratia were scarce. Among the peridinia the neritic *P. trochoideum* (500/L) was most abundant.

17 September 1945.

Diatoms were now practically absent. *Coccolithus huxleyi* was not recorded at all. Among the dinoflagellates *Peridinium trochoideum* occurred in a number of 5.500/L. *Chilomonas marina* was rather numerous (13.000/L).

1 October 1945.

Observations showed a society similar to that of the preceding date, practically without diatoms, with a fair variety of dinoflagellates and very few coccolithophorids.

The decrease in the population seemed to continue during November, when our observations are incomplete on account of precipitate in the bottles.

21 December 1945.

The only sample, from 1m, was extremely poor in plankton with a few diatoms, dinoflagellates and coccolithophorids present.

31 December 1945, 14 January, 13 February and 2 March 1946.

Through January, February and early March the plankton was extremely poor. At the last date the list of species is, however, somewhat longer than before.

11 March and 22 March 1946.

Although only single samples are available from these dates, they clearly indicate that the population was still small. The main spring increase in the population did not take place until the last week of March.

29 March 1946.

At this date the population had again a composition similar to that recorded a year before. *Sceletonema* was the leading species (1.040.000/L), being accompanied by a varied *Chaetoceros* population with *laciniosus, debilis* and *furcellatus* as predominating species. The *Thalassiosira* population was also numerous, the maximum numbers for *Th. gravida* and *Th. nordenskioeldi* being 102.500/L and 43.500/L respectively.

It is noteworthy that the leading *Chaetoceros* species were not the same in the spring both years. In 1945 *Ch. affinis, compressus, subsecundus* and *socialis* were most numerous, while in 1946 *Ch. laciniosus, debilis* and *furcellatus* predominated.

SOGNESJØEN

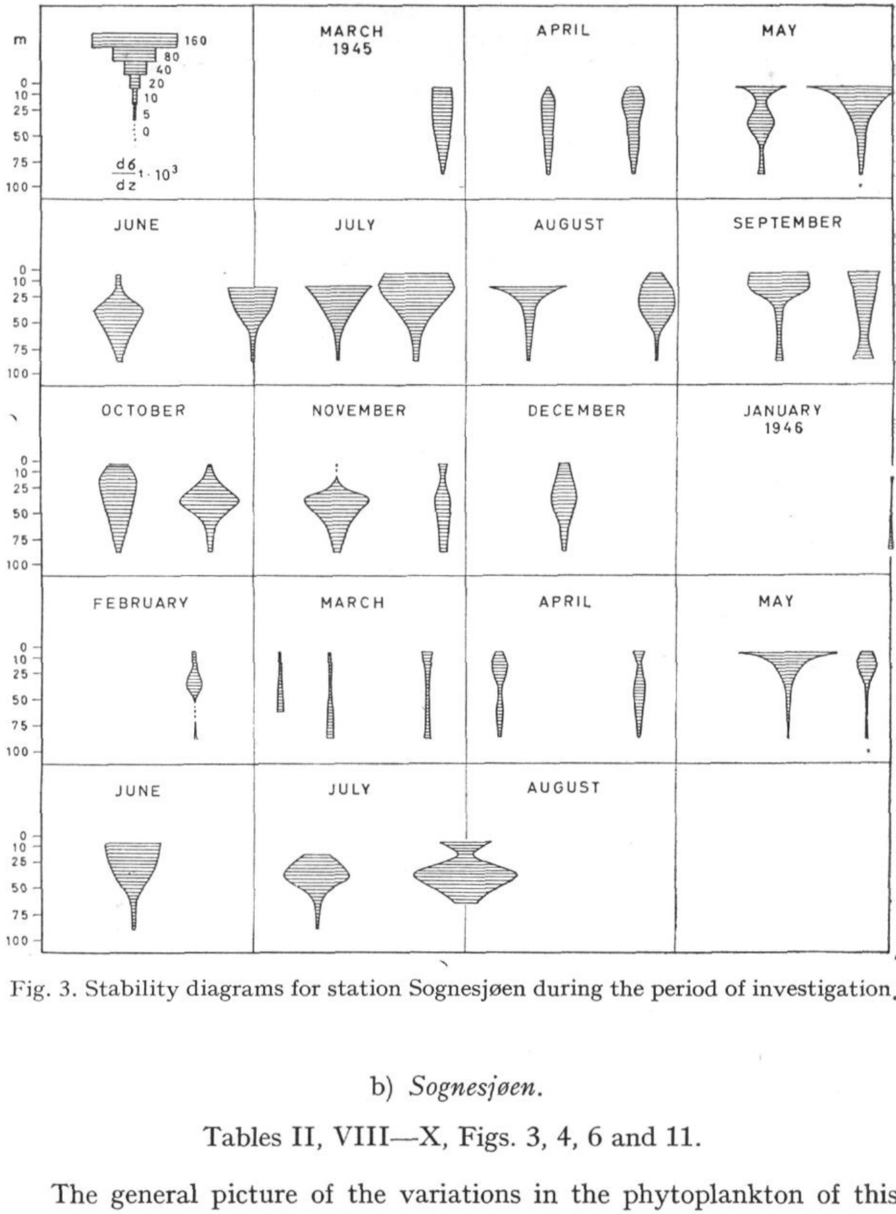

Fig. 3. Stability diagrams for station Sognesjøen during the period of investigation.

b) *Sognesjøen.*

Tables II, VIII—X, Figs. 3, 4, 6 and 11.

The general picture of the variations in the phytoplankton of this locality during the period of investigation may be summarized as follows:

A very poor winter plankton persisted until early March when the spring diatom development was initiated. The peak of the diatom population seemed to be reached at the end of March and was succeeded by later stages in the spring development, dominated by *Chaetoceros* species and other diatoms, but with decreasing numbers of *Sceletonema*. *Nitzschia* species formed an important part of this society. The *Chaetoceros* population which was recorded during April and May changed in composition, the relative importance of the species showing great fluctuations. This is illustrated in Fig. 6.

The summer conditions in 1945 and 1946 were notably different. In 1945 a fairly rich diatom society prevailed during the whole summer, showing an increase at the end of August (observations are lacking for September and October 1945). In 1946 there was no sign of such a diatom population during late summer, the plankton consisting of a dinoflagellate and coccolithophorid component similar to that of the previous summer, but lacking the diatoms which then were quite numerous.

As far as our observations indicate, the phytoplankton during autumn was gradually becoming poorer and changing into the very poor winter plankton.

Also at this locality *Gymnodiniaceae* occurred in fairly large numbers all through the year, except in winter when populations were small.

Below are given some details on the observations, which cover the period 27 March 1945 to 30 September 1946.

27 March 1945. — Table VIII.

The phytoplankton was of the "spring maximum type" with *Sceletonema costatum* numerically predominant (3.180.000/L), accompanied by a fair population of *Thalassiosira* species, *Thalassionema nitzschioides*, *Coscinosira polychorda*, *Nitzschia* spp., *Chaetoceros* spp. (*debilis* most numerous) and a number of other diatoms. Among the dinoflagellates *Exuviaella baltica* (6.500/L) and *Gymnodinium lohmanni* occurred in fair numbers.

12 April 1945.

Diatoms were still numerous, but the population of *Sceletonema* had fallen off so the maximum number was only 262.000/L (50m). The other prominent genera were also more scarce, apart from *Chaetoceros*, which was represented by a great number of species, *curvisetus* and *debilis* being the most numerous ones. Dinoflagellates were more abundant, but no species occurred in large numbers. Coccolithophorids were very scarce, ciliates more abundant than in March.

24 April 1945.

The same late spring society of diatoms, dinoflagellates and coccolithophorids occurred. Only small changes had taken place: an increase in *Leptocylindrus danicus* and a relative increase in *Chaetoceros curvisetus*, but otherwise an impoverishment in diatoms. The *Coccolithus huxleyi* population as well as the ceratia had increased, *C. longipes* being the most numerous species of the last group. The *Peridinium* populations showed the characteristic seasonal increase in the number of species, the heterotrophic *P.globulus* and *P.minusculum* and the autotrophic *P.trochoideum* being the most prominent members of this last genus. *Eutreptia* attained numbers of 13.500/L, while the heterotrophic *Chilomonas marina* occurred in populations similar to those during the previous sampling (18.500/L).

26 May 1945.

Conditions resembled those of a fortnight before. *Chaetoceros compressus* now occurred as an important species of this genus. Another notable change was a definite decline in the populations of *Exuviaella baltica* and *Eutreptia lanowi.*

30 June 1945.

The *Chaetoceros* population had changed in its composition, although *Ch.curvisetus* remained the leading species. *Ch. brevis* was a new member of importance (it may have been overlooked before). Coccolithophorids and dinoflagellates showed changes, but on the whole the picture of their relative importance was the same. Among the flagellates *Dinobryon* occurred in considerable numbers and *Chilomonas marina* attained 33.000/L at a depth of 25 m.

12 July 1945. — Table IX.

Compared with the previous samples the diatom populations were now more varied and numerous. A noticeable increase in *Sceletonema costatum* and the occurrence of large *Nitzschia* populations are outstanding features. Coccolithophorids were still only moderately represented, maximum for *Coccolithus huxleyi* being 43.500/L. The dinoflagellate society was varied, *Exuviaella baltica* being more numerous than before and *Peridinium triquetrum* now occurring in numbers up to 7.000/L. Ciliates played an important part, as during the previous samplings.

The occurrence of the brackish water forms *Ch.danicus* (10.000/L) and *Ch.wighami* (11.500/L) in the 1 m sample is an indication that fjord water from the Sognefjord was present and the exceptionally low salinity of the 1 m sample (18,45‰ as compared with 24,35 and 28,97‰ at the preceding and the following dates) is another sign of a definite admixture of fjord water.

26 July 1945.

During the fortnight which elapsed between observations the diatoms had decreased in numbers, both as to the number of species and as to the populations of the more important species. *Sceletonema* was only recorded in one sample (3.000/L) and the *Nitzschia* population was also much smaller now. Among the coccolithophorids *Anthosphaera robusta* was recorded in the number of 32.500/L (25 m). Dinoflagellates were represented by a great many species, apart from the *Gymnodiniaceae* in small numbers. Among the ceratia *C. longipes* was not recorded, while *C. tripos* was the most numerous one. *Chilomonas marina* still had its maximum at 25 m (48.000/L).

9 August 1945.

The diatom population, even more pronounced than at the previous sampling, had its maximum at 25 m, while at 1 and 10 m only few were recorded. Coccolithophorids and dinoflagellates showed no noteworthy changes from the previous time. *Chilomonas marina* was scarcer now.

27 August 1945.

The *Chaetoceros* population had increased greatly and the same was the case with other diatoms, especially *Sceletonema* and the *Nitzschia* species. Even *Thalassiosira gravida* was recorded together with *Th. decipiens*, but in small numbers only. The diatoms had their maximum abundance in the 25 m sample (10 m lacking). At this time the coccolithophorids were also more numerous than before, reaching their maximum for the year. *Ceratium lineatum* was the most prominent member of this genus.

There is a gap in the observations for the months of September and October and from 12 November only 25 m and 50 m samples are available. At this time the plankton was poor in diatoms and coccolithophorids while the dinoflagellates remained somewhat better represented. The decline in the population continued, the samples of 27 November, 14 December and 20 December all showing a very poor plankton society of diatoms, coccolithophorids and dinoflagellates. After New Year the same was observed on 11 January (1 m and 10 m samples lacking) and on 31 January. On 22 February an indication of change was noticeable, the list of diatoms being longer, but no species attained large populations. Ten days later the situation was, however, completely changed.

4 March 1946.

The spring increase was now evident, with *Sceletonema costatum* as the most predominant species, accompanied by a number of *Chaetoceros* species, *Nitzschia* species, *Thalassionema nitzschioides*, *Thalassiosira gravida* and *decipiens*. Coccolithophorids were also present, *Anthosphaera robusta* with up to 7.000/L and *Coccolithus huxleyi* in similar numbers. Apart from *Gymnodiniaceae*, the dinoflagellate population was scanty.

11 March 1946.

The *Chaetoceros* fraction, as well as the *Sceletonema* and *Thalassiosira* populations had now increased.

25 March 1946.

The spring diatom society had now reached a stage similar to that observed at the end of March in 1945, *Sceletonema* again approaching 3 million/L.

There is a gap in the observations from the end of March to the end of July 1946, when sampling started again and continued until the end of September. The late summer plankton was very poor in diatoms this year. Coccolithophorids were represented by a few species and only in fair numbers, less than 50.000/L, while dinoflagellates predominated in the society. There was no sign of an autumn maximum in diatoms, conditions being decidedly different from those in 1945 when, at the end of August, a fair diatom population was present with *Sceletonema* and *Chaetoceros* as the leading genera.

The coccolithophorids were more numerous at the end of July (*Coccolithus huxleyi* :48.500/L) than in August and September, but the variations were not very pronounced. The same species were recorded and the community seems to have been the same.

c) *A comparison between the phytoplankton of the two southern localities, Utsira and Sognesjøen.*

The outstanding common features in the seasonal cycle of the phytoplankton at these two localities in 1945—46 are: 1) The poor winter plankton and 2) the tremendous increase in the population, mainly in its diatom component, taking place during the last week of March in both localities. In addition, there are also other similarities, but, in view of our previous knowledge the most notable result of this survey is that it demonstrates how varying the phytoplankton society of the outer coastal waters is during the rest of the year, in its qualitative composition as well as in regard to quantities.

The paramount importance of light and stability conditions during late February and early March for growth of the phytoplankton which has survived the winter would seem to offer the general explanation of the coincidence of the spring development at the Utsira and Sognesjøen stations as in the outer coastal waters in general (BRAARUD and KLEM 1931, GAARDER 1938). The further development of the phytoplankton during late spring, summer and autumn seems to be a result of an interaction of factors of various nature, which are not so general in their effect as those responsible for the pronounced spring diatom maximum. This is concluded from the fact that conspicuous differences both from one locality to another and from year to year were clearly demonstrated at these two localities during the period of investigation.

One of the factors to be considered in this connection is the grazing intensity which may vary geographically and from one year to another. However, in addition, the complex of trophic factors determining the quantity of the vegetation at any time of the year, and the group of other factors especially influencing the qualitative composition of the population, seem to be involved. In both cases the hydrographic situation is apt to be the underlying cause of many of the differences which are recorded.

It may facilitate the discussion if we consider separately the following two parts of the problem of the variability of the phytoplankton in the well stabilized coastal waters of the two localities in question during late spring to autumn: 1) The changes in late spring and summer populations

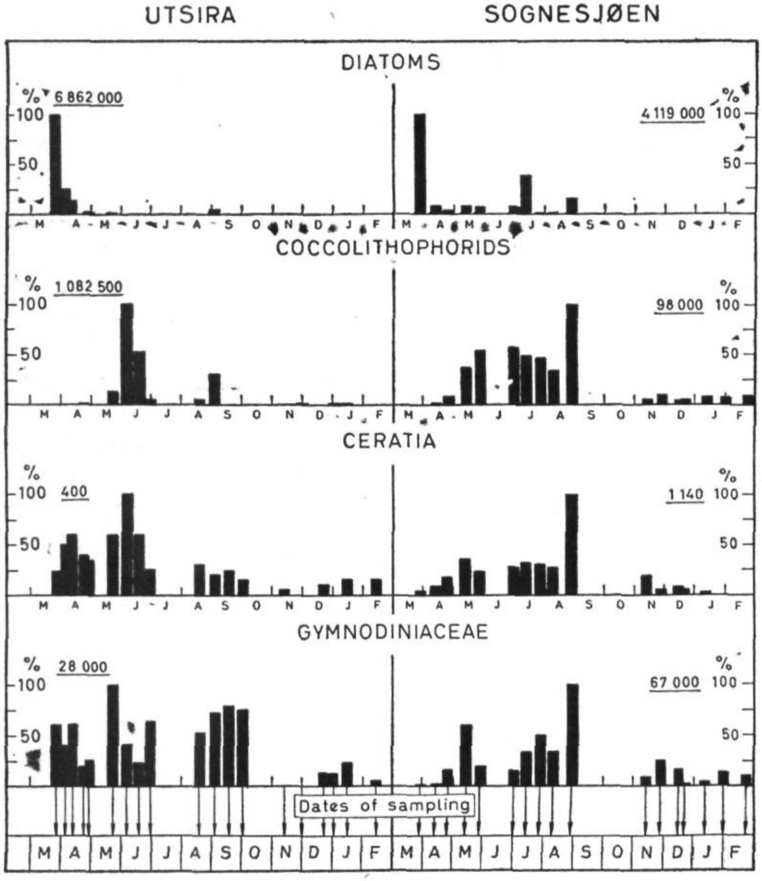

Fig. 4. Seasonal changes in the main components of the phytoplankton at stations Utsira and Sognesjøen in 1945.—For each date the maximum number recorded at the station is represented as percentage of the maximum population of the group during the year.

and 2) the capricious occurrence of the autumn diatom increase. This division does not exclude the possibility of common causes.

1) The irregularity in the composition of the vegetation after the spring diatom maximum.

After the maximum the diatom population falls off very quickly in both localities, a feature which is known from previous investigations in Norwegian coastal waters (GRAN 1927, 1929, 1930). Two processes cooperate in effecting this great reduction in the population: the exhaustion of the winter supply of inorganic N- and P-compounds of the euphotic zone which takes place as stabilization becomes more pronounced (GRAN 1930, BRAARUD and KLEM 1931, GAARDER 1938) and the increase in the grazing intensity which accompanies the seasonal rise in the zooplankton population of these layers. Although we have no zooplankton observations from 1945—46, the investigations by WIBORG (1954) clearly illustrate how during March—April there is a great increase in the plankton volumes of the 0—50 m layer at the stations of the southern part of the Norwegian west coast, Sognesjøen and Ona. As an illustration the average seasonal variations in the net plankton volumes for 1949—51 at these stations are shown in Fig. 10.

During the period after the spring diatom maximum there is a marked change in the qualitative composition of the phytoplankton, but at our two localities these changes are in no way parallel. This may be exemplified by the seasonal variation in the populations of *Chaetoceros* and *Sceletonema* (Figs. 5 and 6, Tables I and II).

In March 1945, during the spring maximum, the *Chaetoceros* populations at the two localities were similar in their composition, although the relative importance of the various species was not the same. Predominant common species were: *compressus, debilis, laciniosus* and *subsecundus*. During April the changes which took place were, however, notably different. At Utsira, *furcellatus* and *socialis* took the lead, while also *constrictus, radicans* and *subsecundus* were prominent members of the society. At Sognesjøen, on the other hand, *curvisetus* gradually became the outstanding species in 1945 (see Figs. 5 and 6).

There is also a striking difference as to the quantitative changes at the two localities. At Utsira there was an extremely quick decline in the *Chaetoceros* population, as in the diatom population as a whole, while at Sognesjøen a fair population was maintained during April, May, June and July. The same was the case with other components of the phytoplankton, for instance *Sceletonema* (see Table I).

Succession alone can not explain the differences in the qualitative composition of the *Chaetoceros* populations of the two localities. The results of the survey would indicate that within the coastal waters sufficiently well-defined bodies of water exist over such a long period of time that specific populations, very different in their detailed composition, may grow up within each water mass.

The North Sea survey of May 1948 (BRAARUD, RINGDAL GAARDER and GRØNTVED 1953) demonstrated how in the Northern North Sea, at that time, vegetation areas occurred with definitely different societies. The predominant components of these were diatom societies which had a markedly different composition in the various areas (cp. BRAARUD et al. 1953, Fig. 5). The local vegetations showed affinities to those of

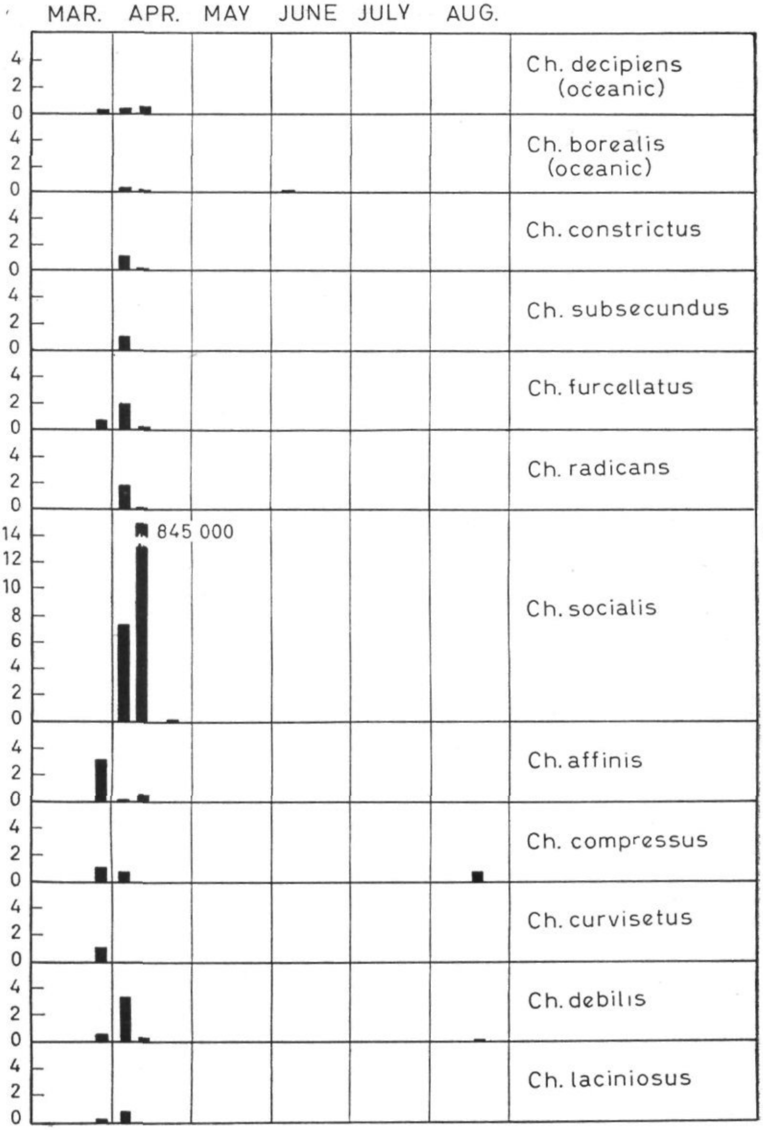

Fig. 5. Seasonal changes at Utsira in the populations of various *Chaetoceros* species during 1945. The figures indicate cell numbers in ten thousands per litre.

neighbouring areas, indicating a mutual admixture whereby initial populations for the future development within the area were supplied.

The Norwegian coastal waters are apt to be constantly influenced by the water masses to the south and west. Along the southern part of the west coast the various parts of the coastal current receive contributions

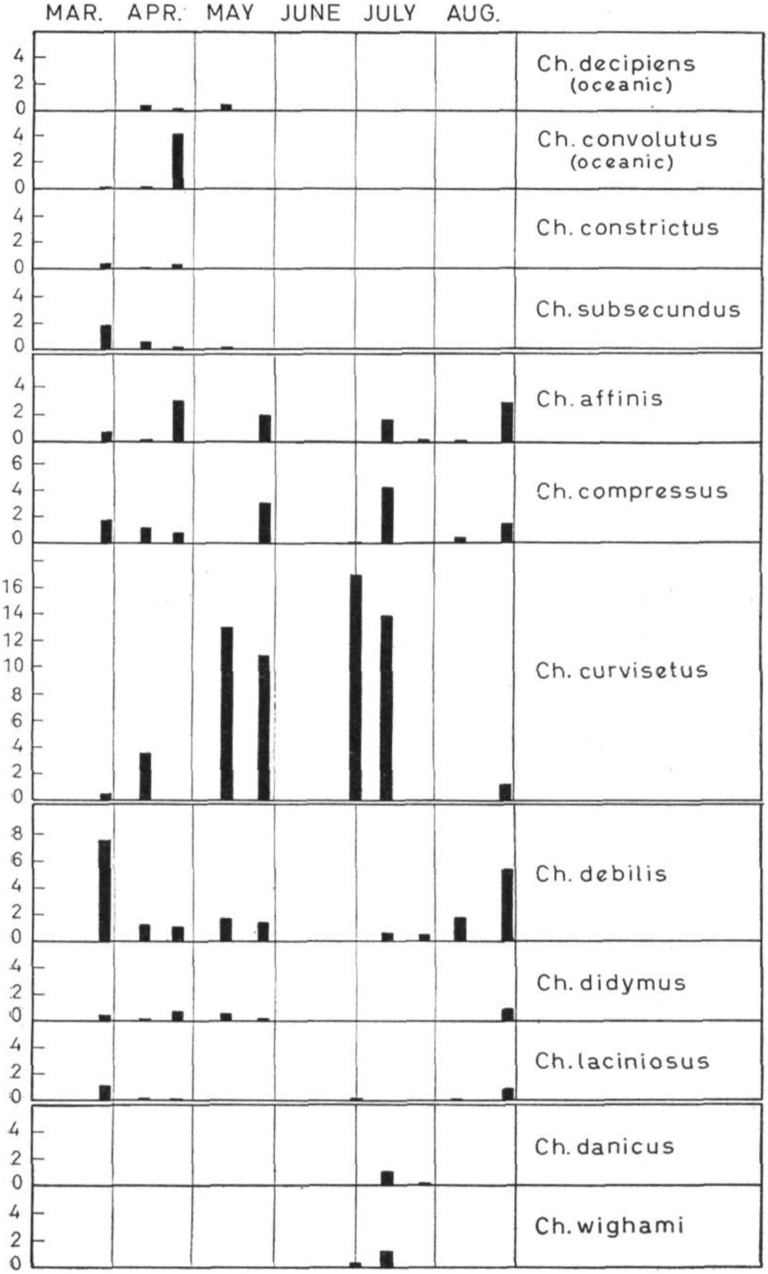

Fig. 6. Seasonal changes at Sognesjøen in the populations of various *Chaetoceros* species during 1945. The figures indicate cell numbers in ten thousands per litre.

from the North Sea waters and it may be assumed that the extent of these contributions varies according to the hydrographical situation, which again is influenced by wind.

If we try to visualize how such an influence from the adjacent water masses may affect the composition of the phytoplankton of the current, the continuous drift of the waters has to be taken into account. It is easy to imagine that in a section along the current a mapping of its phytoplankton communities would give a rather complex picture, partly due to the intermittent supplies of initial populations from neighbouring water masses during the drift. To a certain extent our observations from 1945, taken in two localities, demonstrate such differences. The difference between the societies observed during the spring diatom maximum at Utsira in 1945 and 1946 may have a similar cause.

Additional complications are brought in through the exchange with local fjord water to the east. Although we have no records from the fjords for this period, our observations in July at Sognesjøen indicate that fjord water, at this time of maximum fresh-water supply to the fjord, is brought out to the mouth in such quantities as to lower its salinity so it reaches its minimum for the year, and to introduce definitely brackish forms (*Chaetoceros danicus* and *wighami*).

Besides affecting the qualitative composition of the phytoplankton at various sections of the northbound drift the hydrographical situation may differ from one part to the other in such a manner as to influence the trophic conditions of the waters differently. Unfortunately we are unable to analyze in detail the effect of these hydrographical forces which may for a certain period alter locally the conditions for phytoplankton growth within an area of the coastal waters (cp. also p. 39).

2) The phytoplankton in autumn at Utsira and Sognesjøen.

At Utsira there was in late August to early September 1945 an increase in the diatom population which led to an autumnal maximum, although small. At Sognesjøen observations from this season are available from two years. In 1945 such an increase was also observed at this locality, while in 1946 there were no signs of an autumn maximum in the phytoplankton (see Table II).

Two factors seem to be of special importance and may, in different localities, through their interaction be decisive for the occurrence and non-occurrence of such a maximum: a) A decrease in the grazing intensity in late summer and autumn, which would be favourable for an increase in the standing stock, and b) the seasonal decline in the stability of the upper strata, which may result in an improvement in the supply of nutrients to the euphotic layer by turbulence (Braarud 1944). A third factor which may have to be considered also is the light supply, which may differ from one year to another according to the weather conditions (cloudiness).

If we regard the stability conditions at the two localities in question, we find that at the time of the autumnal increase at Utsira the water masses observed on this occasion had a remarkably low stability as compared with conditions at the preceding and the following dates (see Fig. 2). In this case a hydrographical situation favourable for the supply of nutrients seems to be, at least partly, responsible for the recorded increase in the population.

At Sognesjøen, the notable difference between the late summer and autumn vegetations in 1945 and 1946 may also to some extent be due to differences in the stability conditions in the two years. In 1946 the stability at the end of July was extremely high for the 25—50 m layer, which would seem to be of special interest in this connection. Therefore, this year conditions may have been unfavourable for a seasonal rise in the nutrient supply from the deeper layers with the result that the diatom population remained small.

d) *Skrova.*

Tables III, XI—XIII, Figs. 7, 9 and 11.

In spite of the fact that there are long gaps in the observations, the overlapping of the records from 1945 into 1946 makes it possible to obtain an impression of the seasonal changes at this station.

The winter plankton was extremely poor and prevailed through January, February and March. In the second half of March the first signs of an increase in the diatom component were noticeable, but the spring diatom maximum did not occur until the middle of April and the rich vegetation continued for about two weeks after this time. This is in accordance with previous observations from this locality by FØYN (1929) and GRAN (1930).

From early May there was a society with few diatoms and a dinoflagellate component which first was poor but increased during June and, in July, reached a considerable abundance. Remarkable are the rather large *Ceratium* populations in late July 1945. In late summer and autumn other neritic autotrophic dinoflagellates were also rather numerous. An outstanding feature of this summer plankton is the occurrence of large populations of *Euglenaceae,* from early May, when the maximum was reached in 1946, until the middle of July (1946). In 1945 the population in May was smaller. (For the following period observations are lacking for this year.)

In August dinoflagellates were especially abundant and the ceratia

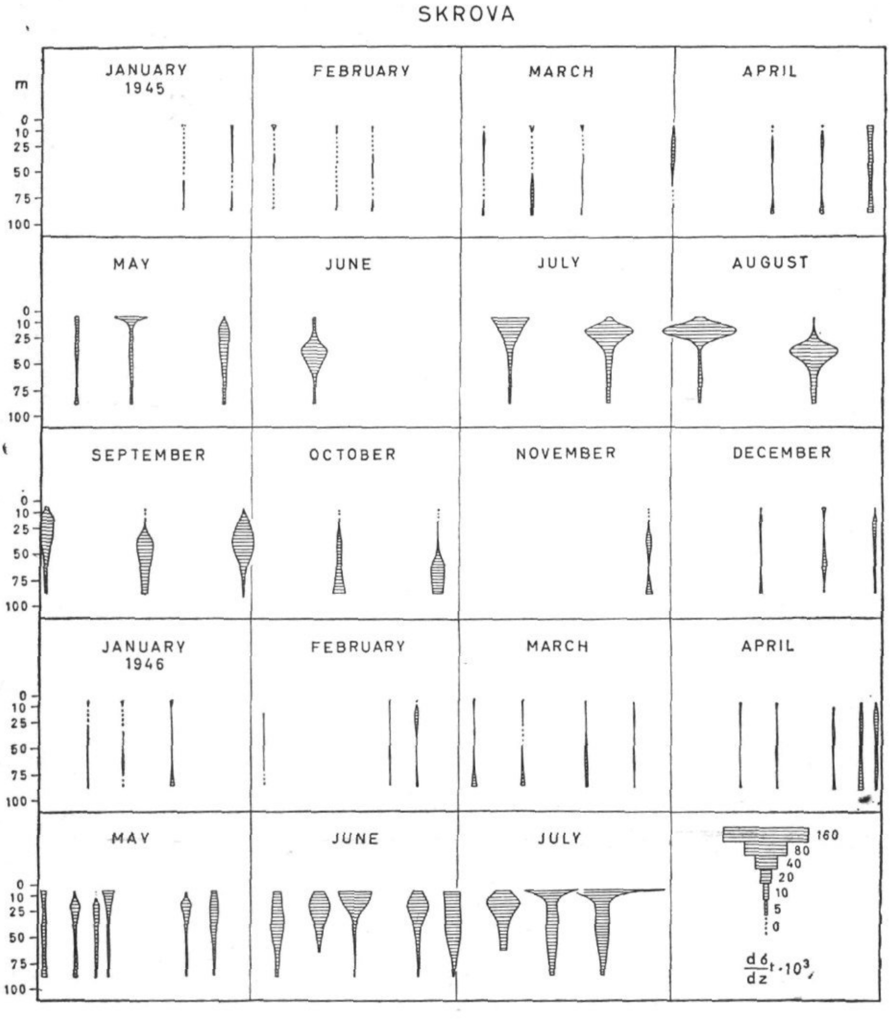

Fig. 7. Stability diagrams for station Skrova during the period of investigation.

relatively very numerous, while diatoms were very scarce. *Coccolithus huxleyi* occurred in numbers up to 324.000/L in late July 1945 and the population gradually fell off during August and early September.

Below are given some details from the observations, which cover the period 31 March 1945 to 20 July 1946.

31 March 1945.

When observations started at this date, a diatom population was recorded which consisted of rather few species. *Chaetoceros debilis*

(12.500/L) and *Fragilaria oceanica* (18.000/L) were most numerous. The other groups, apart from *Gymnodiniaceae* (8.500/L), were poorly represented.

14 April 1945. — Table XI.

A rich diatom vegetation occurred at this time with many species, some of them abundant: *Ch.debilis* (10.000/L), *Ch.socialis* (103.000/L), *Fragilaria oceanica* (212.000/L), *Sceletonema costatum* (24.000/L), *Thalassiosira gravida* (48.500/L) and *Th. nordenskioeldi* (44.000/L). The dinoflagellate component was very modest.

21 April 1945.

A similar society was recorded at this time, although most of the diatoms now occurred in smaller numbers. *Phaeocystis poucheti* occurred at all levels, but was not counted.

28 April 1945.

The spring maximum had now definitely passed. Only very few *Chaetoceros* were recorded and all diatoms occurred in small numbers. The dinoflagellate component was much the same as before, but *Gymnodiniaceae* reached 48.500/L.

5 May 1945.

The population resembled that of the week before, but it is noteworthy that *Euglenaceae*, a group which in 1946 was attaining prominence at this time, were recorded in numbers up to 42.500/L.

There is a gap in the observations from 5 May to 7 July, so this year we are unable to follow the development after the spring maximum any further.

7 July 1945.

The vegetation was now dominated by dinoflagellates. Ceratia were very scarce, while the more prominent members of the society were: *Exuviaella baltica* (6.000/L), *Goniaulax spinifera* (2.500/L), *G. ostenfeldi* (12.500/L), *Peridinium triquetrum* (12.500/L) and *P.trochoideum* (22.500/L). The heterotrophic species were also present in great variety. Diatoms were very few.

21 July 1945. — Table XII.

Ceratia were now more abundant. A new feature is the occurrence of *Coccolithus huxleyi* in considerable numbers (324.000/L).

4 August, 20 August and 1 September 1945.

The same type of vegetation was also recorded on 4 August and continued during the remainder of August. The coccolithophorids became scarcer and there were changes in the relative abundance of the dinoflagellates. *Gymnodiniaceae*, which on 4 August occurred in numbers up to 34.500/L, were recorded in similar numbers on the following dates of sampling, when the plankton was still dominated by dinoflagellates.

After a gap in the observations from 1 September to the end of the year a number of observations in January, February and early March showed an extremely poor winter plankton. Not until 18 March came the first signs of an increase in the diatom population, but even at this date the plankton was still poor.

No observations are available from 18 March to 5 May 1946. A number of observations during May, June and early July 1946 showed that at this time of the year the plankton was poor, apart from large populations of *Euglenaceae* (see Table XIII). On 5 May numbers up to 390.000/L were recorded and on 10 May the maximum of 974.000/L was attained. From this date the population fell off and in late June only amounted to 15.000/L. In early July the dinoflagellate component increased noticeably, ceratia becoming more numerous and other forms, *Peridinium triquetrum* (16.500/L) and *P.trochoideum* (2.500/L), occurring in fair numbers.

e) *Eggum.*

Tables IV,XIV—XVI, Figs. 8,9 and 11.

The spring diatom development seemed to start in the later part of March and early April. It may have reached its peak in the middle of April (the exact date for 1945—46 can not be given).

A succession in the diatom population and a gradual impoverishment took place during April—May and in June (1946) the phytoplankton was very poor.

The most conspicuous feature would seem to be the extremely rich diatom vegetation in early July, which also continued, although less abundant, during August and rose again in early September when a new peak, an autumn maximum, was recorded. Afterwards the vegetation gradually fell off until the poor winter vegetation prevailed in late October, November, December and the first months of the year.

The vegetation seemed to have two periods of poverty: the winter period and the period after the spring increase. At this latter time, however, a very numerous *Euglenaceae* population was recorded in both years. The dinoflagellate population was varied and abundant in summer —early autumn, while the coccolithophorids attained populations which may be characterized as moderate (158.000/L) for such small forms.

Below are given some details from the observations which cover the period from 3 April 1945 to 6 June 1946.

3 April 1945.

The phytoplankton was poor, apart from that of the 50 m sample, where 71.000/L of *Sceletonema costatum* and 19.000/L of *Thalassiosira*

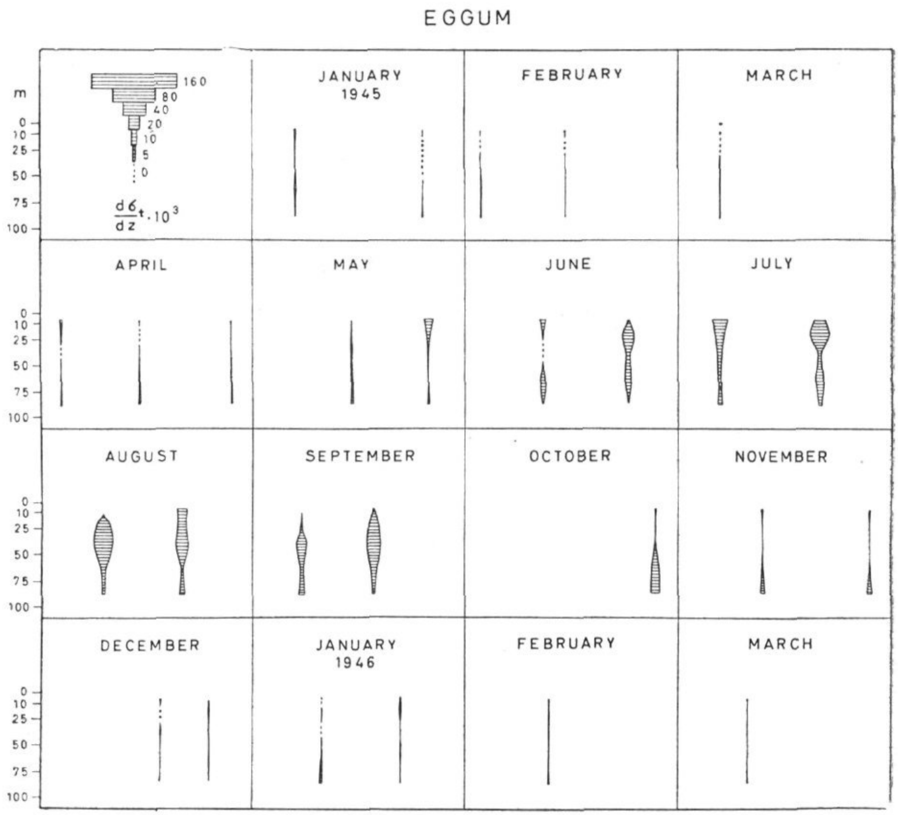

Fig. 8. Stability diagrams for station Eggum during the period of investigation.

gravida in company with a number of other diatoms gave a total of 144.500/L. It is rather difficult to interpret conditions at this time, since no observations are available from the preceding period.

27 April 1945. — Table XIV.

Now a more luxurious diatom vegetation predominated with *Chaetoceros* and *Thalassiosira* species fairly evenly distributed within the upper 50 m, as might be expected as this layer had practically the same density. *Thalassionema nitzschioides, Sceletonema costatum* and *Fragilaria oceanica* were other characteristic members of the society, which would seem to represent the peak of the spring flowering, although the exact course of the development cannot be traced as the 14 April samples were not available for examination.

14 May and 25 May 1945.

On 14 May the diatom population had fallen off to small numbers. At this time the most outstanding feature was the occurrence of a numerous population of *Euglenaceae* (176.000/L) and this component was also prominent on 25 May when otherwise the phytoplankton was rather poor, especially in diatoms. At this time stratification was pronounced.

6 July 1945. — Table XV.

From 25 May to 6 July no samples are available, but at this last date a very large population, mainly of diatoms, was recorded. *Chaetoceros debilis* in numbers up to 1 million/L, *Leptocylindrus danicus* (19.500/L), *Sceletonema costatum* (13.000/L), *Thalassiosira decipiens* (106.000/L) and *Th.nordenskioeldi* (11.000/L) were the most numerous species in the profuse diatom society. Among the dinoflagellates *Exuviaella baltica* (8.000/L) and *Goniaulax ostenfeldi* (19.500/L) were characteristic species. The waters were well stabilized (see Fig. 8).

20 July 1945.

Although the population as a whole had fallen off, a rather rich diatom population still occurred at this time. *Chaetoceros debilis* remained the most numerous species (216.000/L). The society had a composition similar to that of the previous July observation.

9 August 1945.

The diatom population had continued to drop and dinoflagellates and other flagellates (*Chilomonas marina* and *Euglenaceae*) formed the most conspicuous parts of the society.

20 August and 7 September 1945. — Table XVI.

On 20 August the diatom fraction had risen again. *Chaetoceros affinis, debilis, decipiens, laciniosus* and *socialis* occurred in fair numbers, the *Nitzschia* and *Rhizosolenia* species also being important members. At the same time *Coccolithus huxleyi* reached higher figures than before (41.500/L). This varied and rich society of diatoms, dinoflagellates, coccolithophorids and other flagellates, but in still higher numbers, was recorded also on 7 September. At this time *Coccolithus huxleyi* reached its highest numbers (154.000/L) and the whole society yields the impression of excellent conditions of growth for members of all groups.

17 September 1945.

Diatoms had now become scarcer while the *Ceratium* population was even more abundant than on 7 September, a number of species occurring in considerable numbers, the size of these organisms taken into account.

27 October 1945.

The *Ceratium* population was still varied and rich, while diatoms and coccolithophorids were now very scarce.

12 November, 27 November and 17 December 1945.

On 12 November a decidedly poorer phytoplankton was recorded, in its qualitative composition similar to that recorded a fortnight before, and on 27 November the population had decreased still further and on 17 December was extremely poor.

10 January, 21 January, 12 February and 10 March 1946.

The winter poverty continued during January, February and March.

23 March 1946.

Now the first signs of an increase were noticeable, fair populations of several diatoms occurring: *Chaetoceros socialis, Fragilaria oceanica* and *Sceletonema costatum.*

11 April and 23 April 1946.

On 11 April the diatom population was still larger, but it was not extremely numerous, and on 23 April a society of diatoms was recorded which was fairly rich, although it may represent a somewhat late stage in the spring development. The actual peak of the spring maximum may have been missed.

9 May, 22 May and 6 June.

A conspicuous decline had taken place from 23 April to 9 May, when diatoms were extremely scarce and the other groups also very poorly represented apart from *Euglenaceae,* as in 1945. This state prevailed during May and early June.

f) *A comparison between the phytoplankton populations of the two northern localities, Skrova and Eggum.*

These two localities show different trends in their annual phytoplankton cycles during the period of investigation. At Skrova the picture of the seasonal changes is rather simple: After a poor winter period the spring diatom outburst took place and the diatom vegetation disappeared within a couple of weeks to be replaced by a qualitatively much poorer plankton dominated by *Euglenaceae.* In the course of June and July this society was replaced by a more varied one with dinoflagellates as its main component. There was no sign of an autumn maximum of diatoms and the summer vegetation gradually fell off until the poor winter vegetation was established.

The development at Eggum was much the same during the spring, although our observations would indicate that the spring maximum of diatoms was less pronounced. The succeeding *Euglenaceae* society was similar in the two localities, but the further development during the

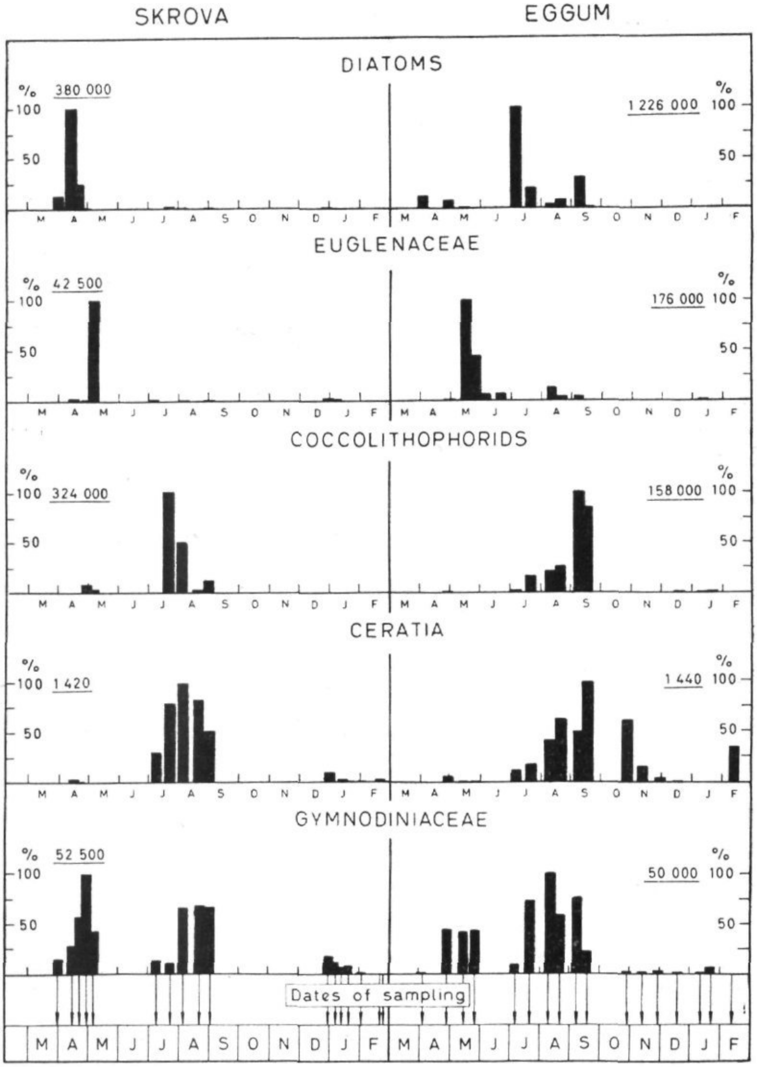

Fig. 9. Seasonal changes in the main components of the phytoplankton at stations Skrova and Eggum in 1945. — For each date the maximum number recorded at the station is represented as percentage of the maximum population of the group during the year.

summer was at Eggum characterized by a very profuse diatom vegetation in July, falling off to smaller quantities in August and rising again to a pronounced autumn maximum in September. Parallelling the diatom abundance in the summer, ceratia and other dinoflagellates showed a gradual increase from early July until a maximum was reached in the middle of September, when a very rich vegetation was recorded. In August and especially in early September, *Coccolithus huxleyi* also attained considerable abundance. This development came later here than at Skrova. The dinoflagellates kept up their numbers for a longer period during autumn than at Skrova. The annual phytoplankton cycle recorded at Eggum resembles in many ways that observed in the outer part of Malangen fjord, a little to the north (GAARDER 1938).

On the whole it would seem as if the vegetation at Eggum must have enjoyed far better conditions for growth than at Skrova, although a quantitative estimate of the actual production in the two areas obviously can not be given on the basis of our population records. This seems to pertain mainly to the summer and autumn periods. In this connection it may be mentioned that WIBORG (1954) recorded larger net plankton volumes at Eggum than at Skrova (see Fig. 10).

III. Hydrographical and ecological factors of importance for the annual phytoplankton cycle of the coastal waters of western Norway.

In the preceding chapter we have presented data on the annual cycle of the phytoplankton at four points off the Norwegian west coast. They illustrate how, in the coastal waters outside the islands and skerries, the annual cycle is by no means uniform along the coast and, in addition, how the conditions in one locality may change from one year to another. Although a detailed analysis of the actual causes of these differences is out of question here, it may be useful to consider which ecological factors are mainly involved and how variations in some of these factors are tied up with the hydrographical forces which seemingly are at play in producing local variations.

Winter minimum — spring development.

The poverty of the late autumn and winter populations seems readily explained by the low light supply and low stability of the upper layers (see Figs. 2, 3, 7 and 8). The onset of the spring development is effected by the seasonal increase in submarine light and the establishment of a certain degree of stabilization so the phytoplankton may stay long enough within the euphotic layer to obtain a net production which suffices for an increase of the population (BRAARUD and KLEM 1931, GRAN and BRAARUD 1935). For our discussion of the conditions in coastal waters the assumptions necessary for estimating the critical depth (SVERDRUP

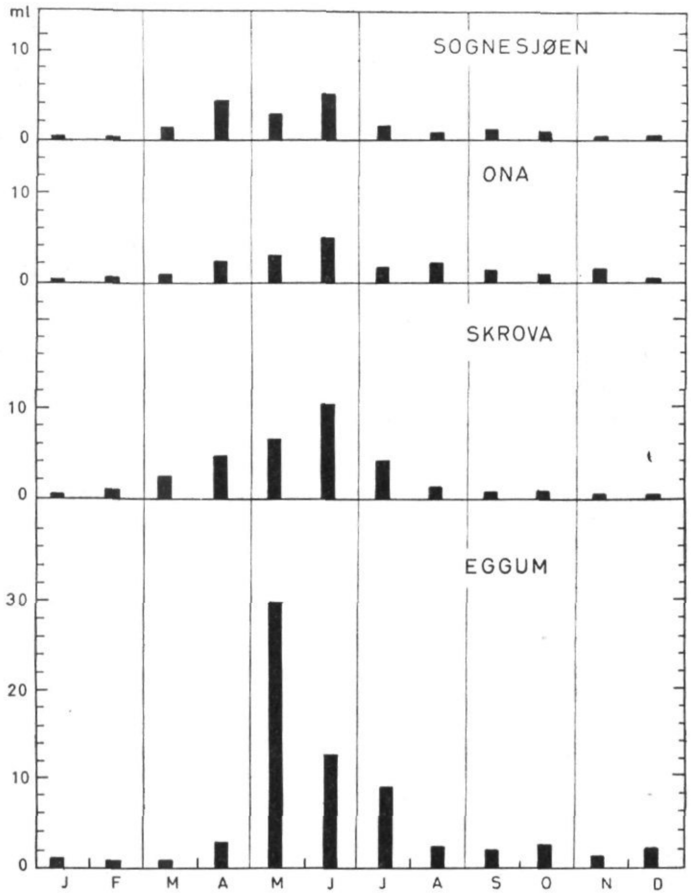

Fig. 10. Seasonal variations in the volumes of net plankton, 0—50 m, at the stations Sognesjøen, Ona, Skrova and Eggum. (Redrawn after WIBORG 1954, Fig. 24.)

1953) at various localities during the period preceding the vernal outburst would, however, rest upon a too scanty observational basis to be of any value.

The time difference of about three weeks between the spring maxima at the two southern and the two northern stations would find its general explanation in the favourable light conditions at this time of the year in the south as compared with the stations in the north. In addition, the earlier thermal stabilization at the southern stations would favour an earlier growth there, but it is not possible to distinguish this effect from that of stabilization caused by the less saline waters of the Baltic Current which definitely influence the southern localities (see Fig. 12).

Another feature which should not be overlooked is the fact that the waters arriving at the southern stations in early spring may hold initial populations originating from the Kattegat and Skagerrak, where conditions for growth even in winter are not so poor as in the localities discussed. In this way initial populations for a spring increase may be larger at the southern localities than at the northern ones. The waters occurring in the north at this time of the year have been subjected to winter mixing during their drift northwards, a mixing which is more extensive there than at the southern localities. This may be expected to have lead to a heavy reduction of the standing stock of the upper layers and, consequently, the initial populations for the spring increase are apt to be very small in the northern localities.

Late spring decline.

The factors which would seem to be most important in this period are nutrient supply and grazing.

Available observations on the changes in the concentrations of nitrates and phosphates (BRAARUD and KLEM 1931, SOOT-RYEN 1934, BRAARUD and BURSA 1939, GRAN 1930) indicate that the spring diatom outburst is accompanied by a consumption of these nutrients which results in an exhaustion of these compounds in the euphotic layer. At the low concentrations which are then reached, the rate of reproduction is apt to be low as compared with that during the period of ample supplies of these inorganic nutrients earlier in the season.

Parallel to this an increase in the grazing intensity may be assumed to take place. WIBORG (1954) has demonstrated how in the coastal waters of western Norway there is a general increase in the volumes of net plankton during the period March to May (see Fig. 10). The large populations of zoo-plankton occurring at the time when the winter supply of inorganic nutrients has been consumed quickly graze down the now slowly propagating diatom populations. Only in localities where the supply of inorganic N- and P-compounds allows the rate of reproduction in diatoms to be kept up, may fairly large diatom populations be maintained, as at Sognesjøen in 1945.

At this time of the year the other components of the vegetation, which may not be so demanding in their nutrient requirements, especially as to inorganic compounds, are subordinate.

Variations in the populations of ceratia and other brown dinoflagellates.

The seasonal variations in the maximum numbers of ceratia are illustrated in Figs. 4 and 9, expressed as percentages of the maximum numbers for the whole year at each locality.

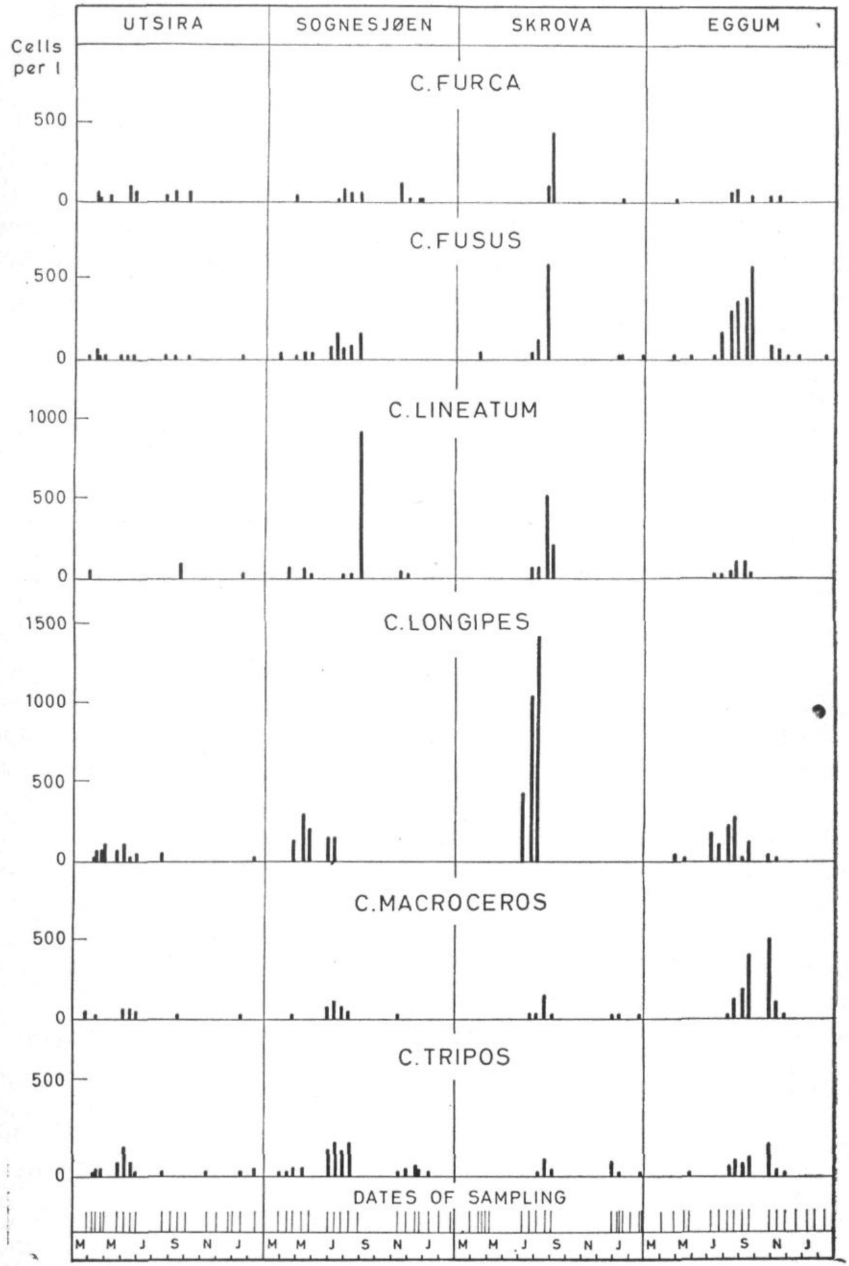

Fig. 11. Seasonal changes in the populations of the *Ceratium* species at Utsira, Sognesjøen, Skrova and Eggum, March 1945 to February 1946.

Utsira stands out as the locality with the poorest populations, while the maximum at the other three localities are much the same. The two southern stations are characterized by having relatively higher values for the spring period than the northern ones.

At all localities the following species were regular members of the plankton: *Ceratium furca, fusus, lineatum, longipes, macroceros* and *tripos,* while the relative importance of these species changes from one locality to the other. This is demonstrated in Fig. 11, where the records for the four localities during the period March 1945 to February 1946 are presented. Apart from one single record of *C. lineatum* (920/L) in late August, the Sognesjøen station exhibits a poverty similar to that of the Utsira station. The populations at the two northern stations are notably larger for most of the species.

On the whole the composition of the *Ceratium* populations seems to be very irregular, indicating that in the coastal waters there may be a definite patchiness so the sequence-effect leads to quick changes in the qualitative composition which is being recorded in a certain locality. Examples of such sudden changes in the relative importance of the various species are found in all the three localities where populations at times are fairly abundant.

At the Sognesjøen station the observations also demonstrate great variations from one year to another, exemplified by records from the same time in August of 1945 and 1946 (the last observations are not included in Fig. 11). The maximum numbers of *C. furca* and *C. lineatum* were then:

27 August	1945:	60/L	*C. furca*	and	920/L	*C. lineatum*
26 —	1946:	1 200/L	—		140/L	—

Previously similar differences in the composition of the *Ceratium* populations from year to year have been recorded from the Oslofjord (Braarud and Bursa 1939, Braarud 1945, Birkenes and Braarud 1952, Hasle 1950).

The greater abundance of ceratia during summer and autumn is in accordance with the experimental observations by Nordli (1957) who found the temperature optimum of the *Ceratium* species of these waters to lie between 15 and 20°C. A more difficult problem is how to explain the occurrence of large populations of ceratia and other brown dinoflagellates at times when diatoms obviously are unable to maintain large populations. This problem will not be discussed here as no observations are available on the actual concentrations of inorganic nutrients in these localities.

The coccolithophorid component of the plankton.

Coccolithophorids never attained such large populations in our samples as those previously recorded in certain years in Norwegian coastal waters (Braarud 1945, Birkenes and Braarud 1952, Berge unpubl.). In Figs. 4 and 9 are shown the maximum populations recorded at the four localities and the seasonal changes in the population. It is noteworthy that in the two southern localities the group attained fairly large populations as early as in May—June, while in the two northern ones it occurred mainly as a component of the late summer plankton. The predominant species was *Coccolithus huxleyi*.

The June vegetation of Euglenaceae.

At the two northern localities large populations of *Euglenaceae* were recorded from May and June. This group of flagellates comprises a diversity of physiological types. The representatives observed at our localities were not identified to species. There is a possibility of dependence upon organic compounds in these populations, which might give an explanation of their abundance at a time when the diatom vegetation had declined to small numbers only. Further studies are necessary before a well-founded view on this detail of the succession at the northern localities can be presented.

The variable populations of diatoms.

One of the outstanding features of the annual cycles observed at the four localities is the variation in the summer time with regard to the size of the diatom populations.

It is reasonable to assume that this feature is mainly due to local differences in the supply of nutrients to the euphotic layer through turbulence, although variations in the grazing may also account for some of the variations between the four localities.

Unfortunately the hydrographic situation is too complex for a comparison as to the relative turbulent activity at the border between the deep layers and the euphotic zone at the four localities. In Fig. 12 the t-S-diagrams for each locality all through the observational period are presented. It is readily seen that the two northern localities are characterized by having smaller amplitudes of salinity and temperature for the year than the two southern ones. The greater salinity amplitude at the southern localities finds its explanation by the fact that the waters

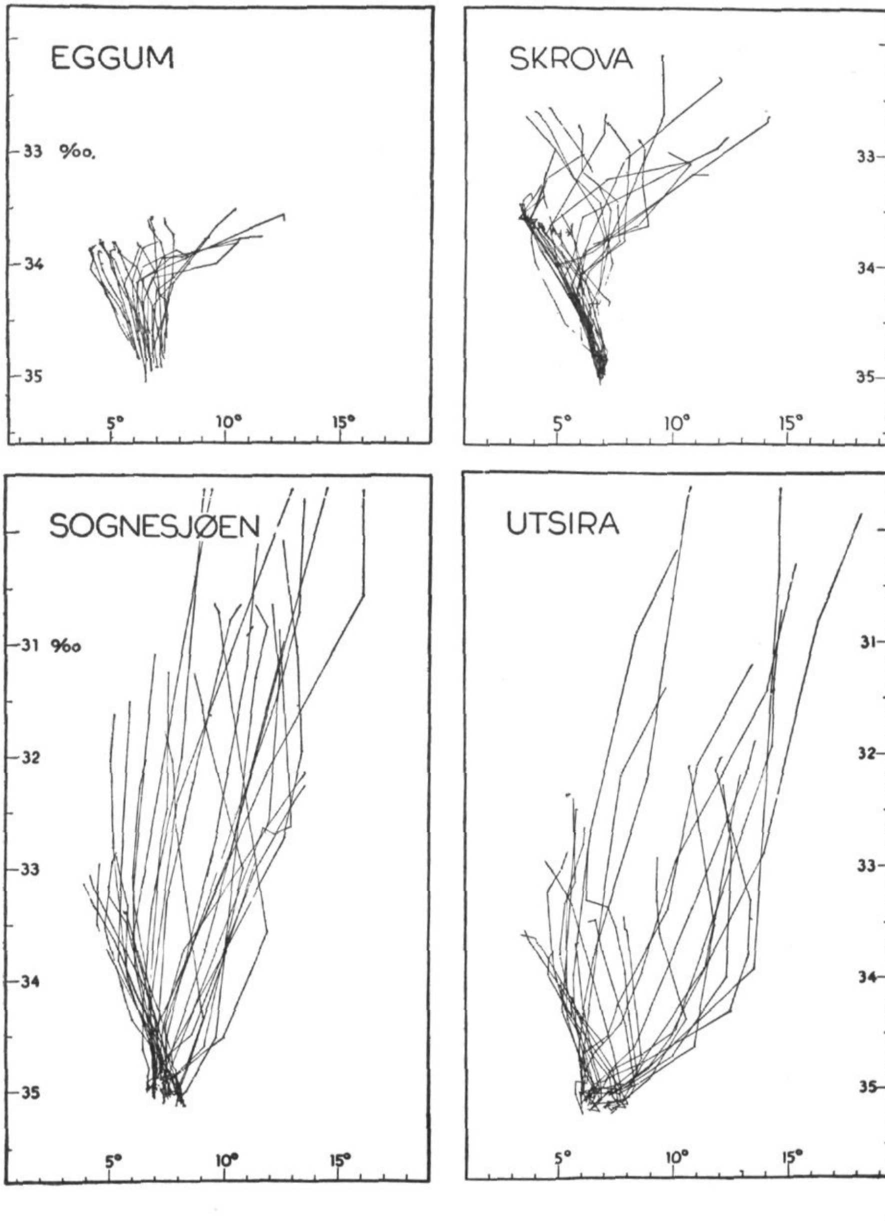

Fig. 12. t-S-diagrams for the stations Utsira, Sognesjøen, Skrova and Eggum during the period of investigation. (According to hydrographical data supplied by Dr. JENS EGGVIN.)

occurring here are receiving fresh-water both from the Baltic, where drainage from the Eastern European continent is discharged in large quantities, and from the Norwegian fjords where, during summer, the snow and glaciers of the alpine region thaw and thus are responsible for a pronounced seasonal increase in the fresh-water discharge into the fjords. At the northern localities, on the other hand, the waters arriving from the south have been subjected to winter mixing with the saltier deep layers and have acquired a high salinity on their passage northwards. The local supply of fresh-water is here much smaller than further south since the rivers in this area only drain a narrow strip of land near the coast.

The differences in temperature amplitude find their explanation in the obvious differences in air temperature of the two areas.

On account of the basically different hydrographic situations in the south and north the stability diagrams do not suffice for a characterization of the conditions for turbulent activity in the two areas, but some general comments may be made. Stratification is never as extreme in the northern area as in the south and one may, therefore, expect that the turbulent action set up by currents — both wind currents and currents of a more permanent nature — is more extensive at the northern localities. This may explain the noteworthy abundance of phytoplankton at the Eggum locality, where exposure to wind and the local current situation would seem to offer especially favourable conditions for a turbulent activity even in summer, so nutrients may be supplied to the euphotic layer also during this season.

IV. Phytoplankton and fisheries research.

Along the Norwegian coast spawning of cod, herring, sprat and other important commercial fishes takes place. The basis for a plentiful renewal of the stock of these fishes is a successful survival and growth of the fry; this again is dependent upon an adequate food supply for the organisms on which the young stages of these fishes feed. Insight into the variations in the availibility of phytoplankton, which represents the ultimate food source for the animal population, is therefore, a necessary prerequisite for obtaining a sound view as to the causes of variations in year classes of the fish stock. So far, it must be admitted, our ignorance as to the actual fluctuations, from one locality to another and from year to year, in available plant food is a paramount obstacle to an all-round consideration of this question.

The inadequacy of our knowledge is brought out clearly by the studies which have been carried out, in as much as they demonstrate how unrepresentative each of them is for the whole area. This refers especially to late spring, summer and autumn conditions. The few all-year surveys from Norwegian coastal waters consider mainly the inner coastal areas. RINGDAL GAARDER (1938) studied the Balsfjord and Malangen in Troms, BRAARUD and BURSA (1939) the Oslofjord, BRAARUD and HOPE (1952) the Nordåsvatn, BRAARUD and FØYN (1958) the semi-closed bay Hunnebunnen and BRAARUD, FØYN and HASLE (1958) the Dramsfjord; an all-year survey is also being undertaken in the Hardangerfjord and adjacent parts of the Sunnhordland fjords. Through these investigations information has been obtained on the highly varied conditions for phytoplankton growth in the inner coastal waters. For the outer part, just outside the islands and the important bank region, observations are far more scanty, the present survey being the only one covering all seasons.

The irregularity in the phytoplankton occurrence along our coast has been illustrated in a popular way through the mass occurrence in certain years of the coccolithophorid *Coccolithus huxleyi*. In the Oslofjord (BRAARUD 1945, BIRKENES and BRAARUD 1952), in the outer part of the Sunnhordland archipelago (BERGE unpubl.) as well as in the Lofoten area huge populations of this species produced in certain years a striking discoloration of the water, turning it green or even milky white. The special hydrographic situation of the years in question seems to be responsible for the trend which the development of the phytoplankton follows in "*Coccolithus huxleyi* years" For the Oslofjord the conclusion was drawn that the irregular occurrence of this special type of vegetation was due to annual fluctuations in the hydrographic situation prevailing in the Skagerrak and the North Sea (BIRKENES and BRAARUD 1952). The observations in the Sunnhordland area by BERGE clearly brought out that the mass occurrence of *C.huxleyi* was a result of a delayed thermal stratification in spring combined with an admixture of offshore waters containing an initial population of *C.huxleyi*.

The examples given in this paper of hydrographical forces locally inducing special features in the annual phytoplankton cycle do not in any way suffice for giving a clear picture of the effect of hydrographical fluctuations in our coastal areas upon the phytoplankton conditions. For the purpose of surveying the food chain underlying the fish production with a view of tracing causes of annual variations in the fish population a regular supervison of the phytoplankton would be desirable. The general information needed for planning such a supervision in a satisfactory way is, however, still lacking. Therefore, it seems expedient to undertake combined hydrographic-planktological surveys on a fairly large scale to bring out the broad features of the relationship between the regularly occurring types of hydrographic situations and the corresponding phytoplankton development.

Hydrographic surveys have demonstrated that essential fluctuations in the hydrographic situation in our coastal area take place from year to year (see f. i. EGGVIN 1941, 1944) and a very extensive observational material has been compiled by the Research Branch of the Fisheries Directorate of Norway on the occurrence of commercial fishes in a certain year as related to the prevailing hydrographic situation. Observations on the occurrence of eggs and larvae have also been made over a number of years (for literature see WIBORG 1957). An extension of these continuous hydrographic-biological studies of our coastal waters, which have brought so many valuable results, to include the phytoplankton would doubtless yield information which would give a broader basis for the discussion of important problems in fisheries biology.

V. Summary.

1. Quantitative phytoplankton samples from four of the Permanent Oceanographic Stations of the Institute of Marine Research of the Fisheries Directorate, Bergen: Utsira and Sognesjøen in the southern part of the Norwegian west coast and Skrova and Eggum in the northern part, covering all seasons of the year, were examined by the sedimentation method. The results were correlated with hydrographic data, supplied by Dr. JENS EGGVIN.

2. The main features of the annual phytoplankton cycle at these points of the outer coastal region are described. Common are the winter poverty and the spring increase, which occurred about three weeks earlier at the southern stations than at the northern ones. During the remainder of the year: late spring, summer and autumn, the seasonal changes were notably different at all four localities. Essential annual changes at the same locality were also observed.

3. Factors of general nature: the different light supply due to geographical position and the delayed vernal stabilization at the northern stations, conditioned by a smaller fresh-water supply, were pointed out as main factors causing the delay in spring phytoplankton growth in the north. Extensive winter mixing, inducing a more pronounced dilution of the winter population in the north, may also result in smaller phytoplankton stocks in early spring.

4. The difference in the changes taking place after the spring increase were tentatively traced back to hydrographical factors. The impression was gained that, at this time of the year, the outer coastal waters constitute a mosaic of vegetation areas, conditioned by the variation in the degree of stabilization and by the local admixture of adjoining water masses, the fjord waters to the east and offshore waters to the west. At the Eggum station the effect of local hydrographical conditions seemed to be very pronounced.

5. The composition of the populations was described in some detail. The occurrence of large populations of *Euglenaceae* in May—June at the northern stations is a noteworthy feature.

6. No detailed analysis of the ecological factors which are at play has been feasible, but the ecological situation at the various seasons was discussed.

7. A brief review of the present situation in phytoplankton research of Norwegian coastal waters was presented, especially in view of its application to fisheries problems.

REFERENCES

ATKINS, W. R. G. 1923: The phosphate content of fresh and salt waters in its relationship to the growth of the algal plankton. — J. Mar. biol .Ass. N.S. *XIII*, 1923—1925.

BIRKENES, E. and BRAARUD, T. 1952: Phytoplankton in the Oslo fjord during a "Coccolithus Huxleyi-summer". — Avh. norske Vidensk. Akad. No. 2.

BRAARUD, T. 1935: The "Øst"-expedition to the Denmark Strait 1929. II. The phytoplankton and its conditions of growth. (Including some qualitative data from the Arctic in 1930.) — Norske Vidensk.Akad. Hvalråd. Skr. Nr. 4.

— 1944: Planteplanktonets høstmaksimum ved Norskekysten. — Blyttia *2*.

— 1945: A phytoplankton survey of the polluted waters of inner Oslo Fjord. — Norske Vidensk.Akad. Hvalråd. Skr. Nr. 28.

BRAARUD, T. and BURSA, A. 1939: The phytoplankton of the Oslofjord 1933—34. — Norske Vidensk.Akad. Hvalråd. Skr. Nr. 19.

BRAARUD, T. and FØYN, B. 1958: Phytoplankton observations in a brackish water locality of south-east Norway. — Nytt Mag. Bot. *6*.

BRAARUD, T., FØYN, B. and HASLE, G. RYTTER 1958: The fresh-water and marine phytoplankton of the Dramsfjord and the adjacent part of the Oslo Fjord, March—December 1951. — Norske Vidensk. Akad. Hvalråd. Skr. Nr. 43.

BRAARUD, T. and HOPE, B. 1952: The annual phytoplankton cycle of a landlocked fjord near Bergen (Nordåsvatn). — Fiskeridir. Skr. Havundersøk. *IX*, 16.

BRAARUD, T. and KLEM, A. 1931: Hydrographical and chemical investigations in the coastal waters off Møre and in the Romsdalsfjord. — Norske Vidensk. Akad. Hvalråd. Skr. Nr. 1.

BRAARUD, T., GAARDER, K. RINGDAL and GRØNTVED, J. 1953: The phytoplankton of the North Sea and adjacent waters in May 1948. — Rapp. Cons. Explor. Mer, *CXXXIII*.

EGGVIN, J. 1940: The movements of a cold water front. — Fiskeridir. Skr. Havundersøk. *VI*, 4.

— 1941: Den store utskiftning av vannmassene langs norskekysten i 1940. — Årsberetn. Norg. Fisk. 1940, *2*.

— 1944: Den oceanografiske situasjon i det norske kysthav 1941 og fem- års middeltemperaturer i overflatelaget og ved bunnen. — Fiskeridir. Skr. Havundersøk. *VII*, 6.

FØYN, B. RUUD 1929: Investigation of the phytoplankton at Lofoten, March—April, 1922—1927. — Skr. norske Vidensk. Akad. 1928 No. 10.

GAARDER, K. RINGDAL 1938: Phytoplankton studies from the Tromsø district 1930—31. — Tromsø Mus. Årsh. Nat. hist. avd. 11, *55* (1932) 1.

GRAN, H. H. 1897a: Bemerkungen über das Plankton des Arktischen Meeres. — Ber. dtsch. bot. Ges. *XV*, 2.

— 1897b: Protophyta: Diatomaceæ, silicoflagellata and cilioflagellata. — Norske Nordhavs-Expedition 1876—78. — Chra. 1897.

— 1900a: Bemerkungen über einige Planktondiatomeen. — Nytt Mag. Naturv. *38*, 2.

— 1900b: Hydrographic-biological studies of the North Atlantic Ocean and the coast of Nordland. — Rep. Norweg. Fish. Invest. *I*, 5.

— 1901: Über die Verbreitung einiger wichtiger Planktonformen im Nordmeere. — Petermanns Mitt. *47*.

— 1902: Das Plankton des norwegischen Nordmeeres von biologischen und hydrographischen Gesichtspunkten behandelt. — Rep. Norweg. Fish. Invest. *II*, 5.

— 1904: Die Diatomeen der arktischen Meere. I. Teil: Die Diatomeen des Planktons. — Fauna Arctica. Jena. *III*, 3.

— 1905: Diatomeen. — Nordisches Plankton, Bot. Teil. *XIX*.

— 1910: Det Pelagiske planteliv. — John Murray og Johan Hjort: Atlanterhavet. Kap. V. Kristiania 1912.

— 1927: The production of plankton in the coastal waters off Bergen, March —April 1922. — Rep. Norweg. Fish. *III*, 8.

— 1929: Investigation of the production of plankton outside the Romsdalsfjord 1926—27. — Rapp. Cons. Explor. Mer, *LVI*.

— 1930: The spring growth of the plankton at Møre in 1928—29 and at Lofoten in 1929 in relation to its limiting factors. — Skr. norske Vidensk. Akad. No. 5.

GRAN, H. H. and BRAARUD, T. 1935: A quantitative study of the phytoplankton in the bay of Fundy and the gulf of Maine (including observations on hydrography, chemistry and turbidity). — J. biol. Bd. Can. *1*, 5.

HALLDAL, P. 1953: Phytoplankton investigations from Weathership M in the Norwegian Sea 1948—1949, including observations during the "Armauer Hansen" cruise, July 1949. — Norske Vidensk.Akad. Hvalråd. Skr. Nr. 38.

HARVEY, H. W. 1926: Nitrate in the Sea. — J. Mar. biol. Ass. U. K. *XIX*, 1.

HASLE, G. RYTTER, 1950: Phototactic vertical migration in marine dinoflagellates. — Oikos, *2*,*2*.

HELLAND-HANSEN, B. and NANSEN, FR. 1909: The Norwegian Sea. — Rep. Norweg. Fish. Invest. *II*, 2.

JØRGENSEN, E. 1905: Protistplankton. — Hydrographical and biological investigations in Norwegian Fjords by O. Nordgaard. — Bergens Mus. Aarb.

LILLICK, L. C. 1937: Seasonal studies of the phytoplankton off Woods Hole, Massachusetts. — Biol. Bull. Woods Hole, *LXXIII*, 3.

MARTENS, E. 1929: Hydrographical investigations in the Norwegian Sea off Møre 1925—1928. — Rapp. Cons. Explor. Mer, *LXI*.

MOHN, H. 1887: Nordhavets Dybder, Temperatur og Strømninger. — Den Norske Nordhavs-Expedition 1876—78. *XVIII*.

NORDLI, E. 1957: Experimental studies on the ecology of ceratia. — Oikos, *8*,2.

RUUD, B. 1926: Quantitative investigations of plankton at Lofoten, March— April 1922—24. Preliminary Report. — Report Norweg. Fish. Invest. *III*, 7.

SOOT-RYEN, T. 1934: Hydrographical investigations in the Tromsø district 1930. — Tromsø Mus. Årsh. Nat. hist. avd. No. 3. *52* (1929) 1.

SVERDRUP, H. U. 1953: On conditions for the vernal blooming of phytoplankton. — J. Cons. int. Explor. Mer, *XVIII*, 3.

WATTENBERG, H. 1927: Die Deutsche Atlantische Expedition auf Meteor. 4. — Z. Ges. Erdk. Berl. 5—6.

WIBORG, KR. FR. 1954: Investigations on zooplankton in coastal and offshore waters of western and northwestern Norway. With special reference to the copepods. — Fiskeridir. Skr. Havundersøk. *XI*, 1.

— 1957: Factors influencing the size of the year classes in the Arcto-Norwegian tribe of cod. — Fiskeridir. Skr. Havundersøk. *XI*, 8.

LIST OF SPECIES

DIATOMS:

Centric forms:

Actinoptychus senarius (Ehrbg.) Ehrbg.
— undulatus, see A.senarius
Bacteriosira fragilis Gran
Biddulphia aurita (Lyngb.) Bréb. et God.
Cerataulina bergoni Perag.
Chaetoceros affinis Laud.
— — var. willei (Gran) Hust.
— atlanticus Cl.
— borealis Bail.
— — f.concavicornis (Mang.) Braarud
— brevis Schütt
— cinctus Gran
— compressus Laud.
— constrictus Gran
— convolutus Castr.
— curvisetus Cl.
— danicus Cl.
— debilis Cl.
— decipiens Cl.
— diadema, see subsecundus
— didymus Ehrbg.
— furcellatus Bail.
— laciniosus Schütt
— mitra (Bail.) Cl.
— pseudocrinitus Ostf.
— radicans Schütt
— similis Cl.
— simplex Ostf.
— socialis Laud.
— subsecundus (Grun.) Hust.
— teres Cl.
— tortissimus Gran
— wighami Brightw.
Corethron hystrix Hens.
Coscinodiscus asteromphalus Ehrbg.
— centralis Ehrbg.
— concinnus W.Sm.
— curvatulus Grun.
— nodulifer A.S.
— radiatus Ehrbg.
Coscinosira polychorda Gran
Dactyliosolen mediterraneus Perag.
Detonula confervacea (Cl.) Gran
Ditylum brightwelli (West) Grun.
Eucampia zoodiacus Ehrbg.
Guinardia flaccida (Castr.) Perag.
Lauderia borealis Gran
Leptocylindrus danicus Cl.
Melosira nummuloides (Dillw.) Ag.
— sulcata (Ehrbg.) Kütz.
Porosira glacialis (Grun.) Jørg.
Rhizosolenia alata Brightw.
— — f.gracillima (Cl.) Grun.
— fragilissima Berg.
— hebetata f.semispina (Hens.) Gran
— imbricata var. shrubsolei (Cl.) Schröd.
— setigera Brightw.
— stolterfothi Perag.
Sceletonema costatum (Grev.) Cl.
Thalassiosira bioculata (Grun.) Ostf.
— constricta Gaarder
— decipiens (Grun.) Jørg.
— gravida Cl.
— hyalina (Grun.) Gran
— nordenskioeldi Cl.

Pennate forms:

Achnanthes sp.
Asterionella japonica Cl.
Fragilaria oceanica Cl.

Grammatophora sp.
Licmophora sp.
Navicula sp.
Nitzschia closterium (Ehrbg.) W.Sm.
— delicatissima Cl.
— seriata Cl.
Pleurosigma sp.
Synedra sp.
Tabellaria flocculosa (Roth) Kütz.
Thalassionema nitzschioides Grun.
Thalassiothrix longissima Cl. et Grun.

DINOFLAGELLATES:

Amphidinium sp.
Amphidoma sp.
Blepharocysta sp.
Ceratium bucephalum (Cl.) Cl.
— buceros f. molle (Kof.) Jørg.
— furca (Ehrbg.) Clap. et Lach.
— fusus (Ehrbg.) Dujardin
— horridum Gran
— lineatum (Ehrbg.) Cl.
— longipes (Bail.) Gran
— — f. balticum Ostf.
— macroceros (Ehrbg.) Cl.
— tripos (O.F.Müller) Nitzsch
— — f.balticum Schütt
— — f.subsalsum Ostf.
Dinophysis acuminata Clap. et Lach.
— acuta Ehrbg.
— norvegica Clap. et Lach.
Exuviaella apora Schill.
— baltica Lohm.
Glenodinium danicum Pauls.
— lenticula (Bergh) Schill.
Goniaulax borealis O.Nordli
— digitale (Pouch.) Kof.
— ostenfeldi (Pauls.) Pauls.
— polychorda Stein
— spinifera (Clap. et Lach.) Diesing
— tamarensis, see G.ostenfeldi
— triacantha Jørg.
Gymnodinium elongatum Hope
— lohmanni Pauls.
— maximum O.Nordli
Murrayella sp.
Oxytoxum sp.
Paulsenella chaetoceratis (Pauls.) Chatt.
Peridinium breve Pauls.
— brevipes Pauls.
— conicoides Pauls.
— conicum (Gran) Ostf. et Schm.
— crassipes Kof.
— depressum Bail.
— divergens Ehrbg.
— globulus Stein
— — var.ovatum (Pouch.) Schill.
— — — f.simulum (Pauls.)
— — var.quarnerense Br.Schröd.
— grani Ostf.
— leonis Pav.
— minusculum Pav.
— oceanicum Vanh.
— pallidum Ostf.
— pellucidum (Bergh) Schütt
— roseum Pauls.
— steini Jørg.
— thorianum Pauls.
— triquetrum (Ehrbg.) Lebour
— trochoideum (Stein) Lemm.
Phalacroma braarudi O.Nordli
— mucronatum Kof. et Skogsb.
— rotundatum (Clap. et Lach.) Kof. et Mich.
— ruudi Braarud
Porella perforata (Gran) Schill.[1])
Prorocentrum micans Ehrbg.
Protoceratium reticulatum (Clap. et Lach.) Bütschli
Pyrocystis lunula Schütt
Pyrophacus horologicum Stein

COCCOLITHOPHORIDS:

Acanthoica sp.
Anthosphaera robusta (Lohm.) Kpt.
Coccolithus huxleyi (Lohm.) Kpt.
— pelagicus (Wall.) Schill.
Lohmannosphaera sp.
Michaelsarsia sp.
Ophiaster hydroideus (Lohm.) Schill.
Pontosphaera sp.

[1]) Lillick 1937, p. 497 has proposed a new generic name, *Mesoporos*, to avoid confusion with the liverwort genus *Porella* (Dill.) L.

Rhabdosphaera nigra Schill.
Syracosphaera mediterranea Lohm.
— nodosa Kpt.
Zygosphaera sp.

OTHER FLAGELLATES, etc.

Carteria sp.
Chilomonas marina (Braarud) Halldal
Dictyocha fibula Ehrbg.
Dinobryon sp.
Distephanus speculum (Ehrbg.) Haeckel
— — var. pentagonus Lemm.
— — var. septenarius (Ehrbg.) Jørg.
Ebria tripartita (Schumann) Lemm.
Euglena sp.
Eutreptia lanowi Steuer
Halosphaera viridis Schmitz
Phaeocystis poucheti (Hariot) Lagerh.
Pterosperma cristatum Schill.
— dictyon (Jørg.) Ostf.
— moebiusi (Jørg.) Ostf.
— parallelum Gaarder
— vanhoeffeni (Jørg.) Ostf.
Pyramidomonas sp.
Solenicola setigera Pav.
Trochiscia sp.

CILIATES:

Acanthostomella elongata Kof. et Camp.
— norvegica (Daday) Jørg.
Codonellopsis lagenula (Clap. et Lach.) Jørg.
— tuberculata (Daday) Jørg.
Didinium parvulum Gaarder
Favella sp.
Helicostomella subulata (Ehrbg.) Jørg.
Laboea conica Lohm.
— crassula Leeg.
— emergens Leeg.
— strobila Lohm.
Lohmanniella oviformis Leeg.
Mesodinium rubrum Lohm.
Parafavella denticulata (Ehrbg.) Kof. et Camp.
— edentata (Bdt.) Kof. et Camp.
Parundella sp.
Ptychocylis obtusa Bdt.
— urnula (Clap. et Lach.) Bdt.
Rhabdonella sp.
Salpingacantha ampla Kof. et Camp.
Salpingella acuminata (Clap. et Lach.) Jørg.
Stenosemella acuminata (Clap. et Lach.) Jørg.
— oliva (Meunier) Kof. et Camp.
Strombidium sp.
Tintinnopsis campanula (Ehrbg.) Daday
— parvula Jørg.
— ventricosoides Meunier
Tintinnus fraknói Daday
— tubulosus Ostf.
Woodania conicoides Leeg.

Table I. *UTSIRA*. *Summary of plankton records and*
Populations are recorded as

Date		26/3	5/4	12/4	23/4	28/4	22/5	6/6	18/6	29/6
Tempera-	1m	5,95	5,48	5,71	5,88	6,21	10,19	10,75	9,77	
ture, °C	10m	5,87	5,18	5,79	5,83		9,45	10,68		11,10
	25m	5,80	4,56	5,34		5,45	6,40	8,92		
Salinity, $^0/_{00}$	1m	33,69	32,88	32,40	32,50	32,66	30,19	28,84	31,40	
	10m	33,70	33,03	33,15	32,50		30,94	29,07		32,10
	25m	33,70	33,24	33,34		33,28	32,78	32,22		
Diatoms,	1m	5 871 000	243 000	7 010	3 000	147 000	3 500	180	2 740	
all	10m	6 800 000	831 000	7 900	—		1 500	40		860
	25m	6 862 000	1 812 000	16 550		3 000	—	3 000		
Sceletonema	1m	5 825 000	202 000	160	—	145 000	—	—	—	
costatum	10m	6 750 000	700 000	1 500	—		—	—		—
	25m	6 750 000	1 325 000	1 500		3 000	—	—		
Chaetoceros	1m	25 000	33 000	1 300	2 000	—	—	140	740	
spp.	10m	20 000	52 000	4 300	—		—	—		—
	25m	68 000	160 000	5 720		—	—	2 000		
Thalassio-	1m	13 000	5 000	—	—	—	—	—	—	
sira spp.	10m	19 000	51 000	—	—		—	—		—
	25m	21 000	260 000	140		—	—	—		
Coccolitho-	*1m*	*100*	*2 500*	—	*7 000*	—	*36 500*	*632 500*	*575 000*	
phorids,	10m	—	—	—	—		144 500	1 082 500		55 000
all	25m	—	2 000	—		1 500	14 500	200 000		
Dinoflagellates,										
except	1m	4 460	2 340	3 240	200	700	1 260	900	3 320	
Gymno-	10m	8 440	1 480	1 280	120		660	1 360		100
diniaceae	25m	7 020	740	180		60	500	15 380		
Ceratium	1m	40	120	80	160	140	240	400	240	
spp.	10m	100	200	260	60		160	360		100
	25m	20	20	—		20	—	360		
Peridinium	1m	2 800	660	820	40	20	—	—	1 500	
spp.	10m	3 700	660	460	40		—	—		—
	25m	2 860	460	80		40	—	14 020		
Gymnodini-	1m	13 940	7 020	4 220	5 500	7 500	4 500	2 000	6 500	
aceae	10m	16 980	9 760	8 640	—		18 000	9 500		18 000
	25m	14 500	11 500	17 680		5 000	288 000	11 500		
Ciliates, all	1m	9 700	2 660	140	1 000	3 580	8 620	1 540	3 120	
	10m	7 060	10 260	5 700	20		1 520	2 000		15 640
	25m	6 440	3 760	7 240		2 040	80	1 540		

hydrographical data for the depths of 1 m, 10 m and 25 m.
number of cells per litre.

18/8	3/9	17/9	1/10	12/11	30/11	21/12	31/12	14/1	13/2	2/3	11/3	22/3	29/3
	12,95	14,73	14,26	10,80	9,36	7,88	6,35	6,35	4,45	3,41			4,80
	11,87	14,44		10,78	9,34		6,23			4,07	3,72	5,20	4,63
13,98			14,67		9,45			6,66					4,60
	32,19	30,71	27,78	32,10	32,91	33,45	32,85	33,50	32,95	33,61			33,77
	33,47	31,33		32,11	33,32		33,31			33,65	33,66	34,17	33,82
32,89			30,40		33,61			33,48					33,97
	126 940	1 000	—	+	—	220	120	160	110	435			2 855 380
	314 980	—		80	—		180			1 520	720	2 140	784 640
14 680			—		—			820					271 240
	40 000	—	—	—	—	—	—	—	—	—			1 040 000
	107 000	—		—	—		—			200	—	2 000	65 000
120			—		—			—					17 500
	6 220	1 000	—	—	—	80	—	—	—	—			1 372 400
	74 280	—		—	—		—			—	—	40	558 560
12 300			—		—			—					67 140
	220	—	—	—	—	—	—	—	100	60			51 000
	40	—		—	—		20			820	100	60	51 000
520			—		—			—					174 500
	273 500	960	20	500	—	3 600	13 600	7 340	7 500	500			6 500
	333 000	3 000		—	12 000		12 020			1 020	500	15 000	10 000
62 500			20		5 180			11 040					10 000
	3 640	7 920	700	+	—	180	160	120	140	1 200			2 680
	1 180	80		560	—		80			—	1 700	720	2 520
6 220			160		—			100					1 600
	80	100	60	—	—	40	—	20	60	125			—
	—	—		20	—					40	—	20	120
120			40		—			60					20
	380	5 500	520	—	—	20	—	—	—	25			520
	540	40		—	—		—			60	200	620	340
1 220			80		—			—					40
	2 660	4 500	21 500	—	—	3 500	—	1 500	60	—			33 580
	20 500	22 500		500	—		—			80	3 500	4 000	1 040
15 000			2 000		—			6 500					7 120
	22 580	1 620	7 100	500	—	40	100	500	20	25			2 780
	15 660	1 060		20	4 040		60			100	3 300	660	800
260			540		3 500			—					1 040

Table II. *SOGNESJØEN. Summary of plankton records and hydrographical data for*

Date		27/3	12/4	24/4	12/5	26/5	30/6	12/7	26/7	9/8	27/8
Tempera-	1m	5,26	5,93	6,60	7,63	9,13	14,77	—	16,00	—	13,61
ture, °C	10m	5,10	5,61	6,34	7,55	8,19	10,29	12,64	16,09	13,61	13,08
	25m	5,20	5,51	6,05	7,23	6,85	7,93	10,33	11,82	8,20	11,34
Salinity, ‰	1m	31,63	31,51	32,04	31,25	29,54	24,35	18,41	28,97	20,19	32,26
	10m	32,05	32,76	32,29	32,47	32,01	31,14	30,97	30,55	32,14	32,41
	25m	32,82	33,23	33,07	32,78	33,36	32,43	32,86	32,18	33,76	33,04
Diatoms,	1m	247 300	81 870	103 480	247 250	264 790	235 880	260 260	9 820	4 500	154 500
all	10m	2 513 140	185 590	141 740	84 380		2 700	61 720	12 590	6 060	
	25m	4 119 780	93 220	13 400	19 500	27 920	140	1 510 690	39 240	43 440	564 490
Sceletonema	1m	57 500	32 500	21 500	44 500	45 500	34 000	83 500	—	—	117 000
costatum	10m	1 822 000	119 500	15 500	34 000		2 500	20 000	—	2 020	
	25m	3 810 000	65 500	11 500	8 000	23 500	—	1 135 000	3 000	4 000	205 000
Chaetoceros	1m	84 600	39 220	59 500	161 820	179 500	198 860	160 000	—	—	22 000
spp.	10m	391 000	47 440	103 340	39 500		60	10 600	—	1 000	
	25m	147 000	29 500	1 420	2 000	380	—	74 000	8 000	32 000	449 500
Thalassio-	1m	61 960	2 660	2 620	280	1 060	—	—	—	—	—
sira spp.	10m	99 000	3 400	2 200	1 260		—	—	—	—	
	25m	80 500	3 460	140	6 500	100	—	—	—	200	1 080
Coccolitho-	1m	—	—	8 000	—	56 500	55 000	22 000	32 500	—	98 000
phorids,	10m	—	320	1 500	19 200		56 000	48 500	16 500	33 000	
all	25m	—	700	2 540	36 500	35 000	1 000	19 500	46 000	19 500	76 000
Dinoflagellates, except	1m	3 200	4 960	6 500	10 980	8 860	7 180	27 340	7 530	940	3 5000
Gymno-	10m	6 660	6 300	1 920	6 820		460	9 820	7 900	1 920	
diniaceae	25m	1 700	640	480	6 020	540	520	6 670	1 700	360	3 900
Ceratium	1m	20	80	140	20	260	320	200	140	320	—
spp.	10m	40	—	200	420		300	360	280	180	
	25m	—	40	60	20	20	260	380	360	—	1 140
Peridinium	1m	180	280	2 240	5 140	8 000	220	6 480	3 480	500	3 500
spp.	10m	120	600	420	3 380		40	7 800	6 940	820	
	25m	180	440	300	1 500	340	40	1 760	960	300	1 640
Gymnodini-	1m	300	540	8 500	280	13 000	1 000	22 500	13 500	23 000	20 500
aceae	10m	520	1 460	11 000	40 500		1 500	8 500	32 500	14 500	
	25m	480	1 240	8 000	23 500	5 500	10 000	7 000	28 500	7 000	67 000
Ciliates, all	1m	140	760	1 220	280	720	880	6 060	1 540	420	1 500
	10m	1 160	2 940	1 640	920		220	4 020	660	280	
	25m	80	800	560	500	140	80	1 480	500	420	320

the depths of 1 m, 10 m and 25 m. Populations are recorded as number of cells per litre.

12/11	27/11	14/12	20/12	31/1	22/2	4/3	11/3	25/3	30/7	13/8	26/8	11/9	30/9
9,62	8,75	7,46		5,67	4,99	4,20	3,90	4,60	15,43				
9,66	9,11	7,80		5,67	5,04	4,23	3,94	4,53	15,54				
9,82	9,15	7,94		5,70	5,71	4,33	4,28	4,50	14,95				
30,62	31,26	31,78			33,17	33,06	33,12	32,95	27,05				
30,64	31,54	32,05		33,38	33,26		33,15	33,17	28,37				
30,71	31,68	32,65		33,40	33,50	33,17	33,31	33,38	28,72				
	540	1 080	340	3 540		124 760	1 378 250	2 194 160	1 500	—	100	120	1 380
	740	5 500		60	18 760	136 500	290 000		50	—	20	20	
1 300			40	120		129 000	555 580	3 296 450	—	—	—	20	100
	—	—	—	3 000		102 500	726 000	1 688 000	—	—	—	—	—
	400	—		—	3 500	98 000	76 000		—	—	—	—	
100			—	—		92 500	382 000	2 801 000	—	—	—	—	—
	—	—	—	—		4 000	525 500	227 800	—	—	—	—	—
	—	—		—	4 000	16 500	169 500		—	—	—	—	—
—			—	—		4 000	98 540	234 060	—	—	—	—	—
	—	—	—	40		1 680	46 500	8 160	—	—	—	—	—
	—	—		20	120	9 000	19 720		—	—	—	—	
—			—	—		5 500	11 220	19 000	—	—	—	—	—
	960	3 840	960	4 000		12 500	—	2 500	76 840	4 560	5 020	6 020	33 000
	10 260	1 000		6 500	8 780	9 500	7 000		7 400	5 560	29 580	3 040	
4 500			4 460	3 580		3 500	8 000	3 000	4 120	5 060	9 700	10 400	1 540
	300	80	80	100		260	4 500	4 220	8 480	1 420	2 660	4 300	3 480
	220	260		80	60	1 500	2 840		13 660	1 540	5 700	1 840	
400			100	590		1 000	1 040	1 680	11 750	680	1 220	600	60
	60	—	40	—		—	—	80	760	560	800	320	360
	60	80		—	—	—	40		640	800	1 640	840	
200			60	—		—	—	—	600	460	560	140	40
	120	40	40	20		200	1 500	2 280	6 250	420	1 220	1 140	2 560
	120	180		20	20	1 500	1 080		10 360	180	2 860	280	
80			20	500		—	540	480	160	80	580	60	20
	4 500	11 000	1 500	2 500		25 000	22 500	30 000	5 100	8 500	18 660	25 000	16 060
	16 500	2 500		8 500	7 000	14 500	30 000		6 500	61 040	46 220	23 000	
5 500			1 000	3 000		9 000	11 000	20 000	6 500	14 520	19 580	4 540	3 040
	1 520	140	—	140		100	—	1 760	600	860	340	5 080	12 760
	120	60		20	1 000	3 000	2 060		960	4 260	1 440	1 040	
2 060			20	—		2 500	140	440	720	440	2 160	120	20

Table III. *SKROVA. Summary of plankton records and hydrographical data for the*
(Observations for 24/2, 9/3, 8/5, 25/5,

Date		31/3	14/4	21/4	28/4	5/5	7/7	21/7	4/8	20/8	1/9	29/12
Tempera-	0m	3,41	3,50	3,90	4,50	4,31	10,80	12,37	11,59	14,27	11,96	3,53
ture, °C	10m	3,39	3,43	3,82	4,35	4,16	7,11	11,90	10,86	14,17	12,02	3,70
	25m	3,61	3,51	3,49	4,37	3,90	4,69	6,12	6,52	14,12	7,95	4,91
Salinity, ‰	0m	33,45	33,50	33,39	33,17	33,27	33,06	32,84	33,18	32,67	32,30	32,65
	10m	33,44	33,45	33,35	33,29	33,33	33,23	32,94	33,18	32,65	32,33	32,68
	25m	33,57	33,45	33,42	33,39	33,40	33,64	33,56	33,87	32,70	33,04	32,98
Diatoms,	0m	51 780	379 070	32 100	80	1 500	—	—	420	—	—	—
all	10m	4 600	270 740	52 100	320		—	—	240	70		2 000
	25m	15 140	271 780	98 630	1 320	—	1 000	7 490	2 460	—	3 480	—
Sceletonema	0m	—	24 000	—	—	—	—	—	—	—	—	—
costatum	10m	—	11 500	420	—		—	—	—	—		—
	25m	—	5 000	—	—	—	—	280	—	—	—	—
Chaetoceros	0m	20 500	124 400	4 500	—	1 000	—	—	—	—	—	—
spp.	10m	3 000	16 040	20 700	—		—	—	—	—		—
	25m	2 000	12 500	31 660	60	—	—	7 120	80	—	2 580	—
Thalassio-	0m	1 700	79 500	6 000	—	—	—	—	—	—	—	—
sira spp.	10m	1 000	106 360	19 020	—		—	—	—	—		—
	25m	1 100	67 260	44 560	—	—	—	—	—	—	—	—
Coccolitho-	0m	—	—	1 000	1 500	11 000	500	324000	142 000	—	38 500	500
phorids,	10m	500	500	500	500		—	131500	161 000	—		1 000
all	25m	—	—	20	1000	500	—	500	—	6 000	21 500	1 000
Dinoflagellates,												
except	0m	2 580	180	620	580	720	56 370	14 080	6 880	9 200	4 640	1 660
Gymno-	10m	5 020	640	860	600		43 900	19 070	7 380	9 480		40
diniaceae	25m	40	1 160	360	1 800	1 140	14 720	1 660	1 980	7 680	1 660	20
Ceratium	0m	—	—	20	—	—	60	200	560	1 040	720	140
spp.	10m	—	20	20	—		180	600	1 000	860		40
	25m	—	40	—	—	—	420	1 120	1 420	400	180	—
Peridinium	0m	60	160	100	520	720	40 600	7 580	380	3 200	320	—
spp.	10m	20	600	850	440		28 000	12 500	1 540	3 580		—
	25m	20	1 120	460	940	900	11 700	460	500	980	260	—
Gymnodini-	0m	7 500	5 500	10 040	29 220	14 000	7 160	6 000	25 000	30 000	35 120	9 000
aceae	10m	4 500	11 060	13 800	10 180		5 220	5 540	34 540	24 500		—
	25m	8 500	12 500	30 500	15 000	23 000	2 120	—	3 000	36 040	11 040	2 500
Ciliates, all	0m	120	580	40	7 020	540	1 260	940	620	1 280	1 080	20
	10m	500	80	1 600	5 900		1 160	1 140	360	860		20
	25m	20	120	180	1 200	3 620	860	180	140	2 820	140	—

depths of 0 m, 10 m and 25 m. Populations are recorded as number of cells per litre. 10/6 and 24/6 1946 are not included.)

7/1	12/1	19/1	2/2	20/2	5/3	18/3	5/5	10/5	21/5	4/6	15/6	29/6	6/7	13/7	20/7
4,59	4,60	4,65	4,29	3,26	2,28	2,45	3,77	4,24	4,69	6,11	8,62	10,80	12,17	13,09	14,48
4,63	4,59	4,65	4,29	3,29	2,47	2,64	3,76	4,00	4,63	5,48	7,03	9,46	11,53	10,79	11,37
4,76	4,65	4,71	4,46	3,25	3,22	3,06	3,39	3,50	4,08	5,51	5,18	7,46	9,18	9,59	10,59
33,06	33,17	33,17		33,25	33,05	33,33	33,29	33,21	33,35	32,95	32,70	32,77	32,99	32,62	30,84
33,09	33,20	33,19	33,19	33,26	33,04	33,36	33,29	33,48	33,35	33,04	33,17	32,96	33,12	33,42	33,19
33,08	33,16	33,19	33,24	33,26	33,29	33,44	33,57	33,62	33,70	33,06	33,70	33,75	33,81	33,53	33,61
—	—	770	1 000	500	40	4 580	—	2.000	3 500	—	—	1 000	20	3 500	3 600
—	1 000	—	—	20	80		500	—	—	4 000	20	500	620	1 100	
—	20	20	—	—	1 500	10 520	500	500		—	500	—	2 160	1 560	11 260
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—		—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	500	—	—	—	—	3 000	3 000	—	—	—	—	3 500
—	—	—	—	—	—		—	—	—	—	—	—	—	1 000	
—	—	—	—	—	—	—	—	500		—	—	—	—	—	11 060
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—		—	—	—	—	—	—	1 000	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	500	—	500	—	—	—	—	—	—	—	—	4 500	—	—
—	—	—	20	—	—		2 000	—	—	—	—	60	540	—	
—	500	—	—	—	—	—	—	—		—	—	—	1 000	—	2 000
40	1 000	1 040	20	500	—	500	520	2 000	3 040	—	—	5 100	13 320	21 060	11 640
20	—	—	40	60	20		4 000	—	500	1 000	—	620	21 680	22 240	
	100	40	—	20	20	—	4 150	500		—	560	560	22 120	31 630	30 540
20	—	—	—	—	—	—	—	—	—	—	—	—	120	360	560
20	—	—	—	60	20		—	—	—	—	—	40	100	200	
	60	20	—	—	—	—	—	—		—	60	20	40	440	580
—	—	40	20	—	—	500	20	—	20	—	—	80	1 060	6 180	1 080
—	—	—	—	—	—		500	—	—	—	—	40	1 740	12 580	
	—	—	—	—	20	—	620	—		—	—	—	280	19 180	3 760
2 500	1 500	3 500	500	—	—	—	9 000	2 500	3 000	26 000	11 000	35 100	65 500	30 720	63 740
6 000	3 000	500	—	—	—		8 000	3 000	—	136 500	14 500	31 000	53 500	15 160	
	1 500	500	—	—	—	—	15 500	5 500		360 000	4 500	40 500	45 000	24 640	31 540
—	40	—	—	—	—	—	20	140	—	80	1 000	2 540	300	400	240
—	—	—	500	—	—		20	—	—	560	520	2 020	780	340	
—	40	40	—	—	—	500	—	—		80	1 000	1 000	20	760	320

Table IV. *EGGUM. Summary of plankton records and hydrographical data for the*

Date		3/4	27/4	14/5	25/5	6/7	20/7	9/8	20/8	7/9	17/9
Tempera-	0m	4,41	4,62	5,20	6,23	10,54	11,59	12,56	11,32	9,31	10,47
ture, °C	10m	4,12	4,48	5,17	5,99	9,14	10,65	12,55	10,48	9,29	10,38
	25m	4,13	4,49	4,96	5,69	7,66	8,11	11,13	9,57	9,12	9,60
Salinity, ‰	0m	33,83	33,90	33,87	33,85	33,80	33,75	33,61	33,75	33,75	33,50
	10m	33,88	33,88	33,86	34,02	33,86	33,76	33,55	33,77	33,76	33,51
	25m	33,90	33,88	33,88	34,12	33,93	33,93	33,67	33,89	33,77	33,66
Diatoms,	0m	13 500	66 600	15 380	5 380	147 420	2 080	22 000	75 540	248 050	—
all	10m	16 360	85 690	6 330	4 000	578 360	61 560	180	99 680	359 940	2 150
	25m		104 200	5 540	1 500	1 225 920	253 230	6 100	68 660	210 580	3 440
Sceletonema	0m	2 040	8 000	6 000	2 000	4 000	—	—	—	1 000	—
costatum	10m	10 000	11 500	3 000	—	13 000	—	—	—	3 000	—
	25m		17 000	—	—	12 500	460	—	—	1 500	—
Chaetoceros	0m	3 980	14 060	40	40	115 500	1 560	22 000	55 500	174 230	—
spp.	10m	960	14 160	120	2 000	514 400	59 000	—	64 100	291 280	880
	25m		25 080	40	—	1 072 600	237 820	4 050	26 480	165 120	2 660
Thalassio-	0m	3 260	28 700	5 000	2 500	3 780	—	—	—	—	—
sira spp.	10m	3 380	32 280	—	—	35 000	60	—	—	—	—
	25m		17 700	—	—	117 500	360	—	—	—	—
Coccolitho-	0m	40	1 660	—	500	4 000	9 500	32 500	42 000	11 220	97 000
phorids,	10m	—	20	160	500	1 020	27 500	—	33 000	157 500	131000
all	25m		20	120	—	2 020	—	28 500	43 000	125 020	—
Dinoflagellates, except	0m	20	180	5 000	680	19 500	10 420	10 660	7 340	7 320	3 100
Gymno-	10m	20	780	380	20	28 720	10 180	10 820	17 080	15 360	2 560
diniaceae	25m		3 120	4 140	80	9 120	6 620	4 440	1 580	7 460	520
Ceratium	0m	—	—	—	—	20	180	280	260	500	1 100
spp.	10m	—	80	20	20	120	260	600	920	720	14 440
	25m		40	—	20	180	60	420	260	260	20
Peridinium	0m	20	140	—	100	1 480	1 140	460	1 240	7 460	20
spp.	10m	—	620	20	—	520	860	620	3 880	1 860	80
	25m		340	140	20	100	420	200	620	680	—
Gymnodini-	0m	500	2 000	10 000	8 360	2 000	5 500	25 000	27 000	38 000	4 000
aceae	10m	—	20 720	19 500	21 500	4 260	36 000	50 060	26 560	36 000	11 000
	25m		22 180	2 060	6 500	1 660	13 500	42 500	10 000	12 500	—
Ciliates, all	0m	1 500	1 140	520	1 040	1 240	460	3 300	2 660	940	1 000
	10m	80	120	260	1 500	1 060	200	520	2 660	900	560
	25m		580	1 400	20	300	450	400	240	1 760	20

depths of 0 m, 10 m and 25 m. Populations are recorded as number of cells per litre.

27/10	12/11	27/11	17/12	10/1	21/1	12/2	10/3	23/3	11/4	23/4	9/5	22/5	6/6
7,36	6,71	6,60	6,16	5,89	5,57	4,94	4,04	3,94	4,05	4,52	5,20	6,32	6,76
7,37	6,74	6,69	6,20	5,89	5,62	4,96	4,04	3.95	4,19	4,41	4,96	5,45	6,72
7,75	6,73	6,73	6,26	5,94	5,76	4,96	4,03	4,10	4,52	4,46	4,97	5,25	6,61
33,58	33,57	33,59	33,80	33,84	33,74	33,89	33,88	33,93	34,06	33,99	34,07	33,88	33,95
33,62	33,57	33,65	33,83	33,84	33,75	33,91	33,88	33,99	34,12	34,05	34,09	33,98	33,96
33,63	33,59	33,66	33,84	33,89	33,84	33,91	33,89	34,00	34,24	34,11	34,14	34,03	33,97
840	420	—	1 020	1 000		—	20	26 000		18 520	3 000	—	500
20	1 080	—	—	—	500	—	20	51 700	43 160		—	2 000	20
730	520	60	1 000	500	—	500	—	23 780	69 380	61 970	20		
—	—	—	320	—		—	—	3 500		—	—	—	—
—	—	—	—	—	—	—	—	6 500	3 500		—	—	—
—	—	—	1 000	—	—	—	—	8 000	15 500	—	—		
60	—	—	1 000	—		—	—	2 000		11 000	500	—	—
—	300	—	—	—	—	—	—	23 500	19 240		—	2 000	20
—	—	—	—	—	—	—	—	7 500	15 540	34 500	—		
—	—	—	—	—		—	—	1 500		1 000	—	—	—
—	—	—	—	—	—	—	—	320	3 320		—	—	—
—	—	—	—	—	—	—	—	440	3 500	4 660	—		
1 000	1 000	—	—	500		—	—	2 000		2 000	4 000	1 000	1 000
—	—	—	—	—	1 500	—	—	2 500	2 500		500	500	—
—	—	—	—	1 000	500	—	—	3 500	6 000	3 000	500		
1 060	1 200	40	—	500		1 500	40	—		2 060	20	—	2 000
1 060	160	40	—	—	1 520	380	80	60	1 560		20	—	—
960	120	60	—	500	1 000	80	20	60	4 000	2 120	20		
880	180	40	—	—		—	20	—		—	20	—	—
900	120	40	—	—	—	—	—	—	—		—	—	—
880	120	60	—	—	—	20	—	20	—	—	20		
80	20	—	—	—		—	20	—		1 020	—	—	2 000
40	—	—	—	—	20	80	—	—	80		20	—	—
40	—	—	—	—	—	20	—	40	500	540	—		
20	2 000	1 500	—	500		—	—	1 500		7 500	4 000	—	—
1 000	4 260	500	—	—	3 000	—	—	1 500	—		1 500	—	—
—	1 660	—	—	500	1 000	—	—	3 500	4 500	6 000	1 000		
560	—	—	—	40		—	520	—		—	—	—	40
40	—	—	—	—	1 000	—	—	—	160		—	—	120
—	—	40	—	—	500	—	—	20	20	—	—		

Table V. *Utsira. 26 March 1945.*

Populations recorded as cells/L. For hydrographical data see Table I.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Achnanthes sp.				20
Cerataulina bergoni				80
Chaetoceros affinis			32 000	9 500
— compressus		3 500	10 500	10 000
— curvisetus			2 000	10 500
— debilis	4 000		5 000	
— decipiens			2 000	
— furcellatus		7 500	3 500	
— laciniosus				2 000
— sp.	21 000	9 000	13 500	
Coscinodiscus spp.	20	40		
Coscinosira polychorda	60			
Lauderia borealis		640	240	
Nitzschia closterium		20		
— delicatissima		>40		1 500
Porosira glacialis		720	220	20
Rhizosolenia fragilissima	+		2 500	
Sceletonema costatum	5 825 000	6 750 000	6 750 000	3 500 000
Thalassionema nitzschioides	3 000	2 500	2 000	2 000
Thalassiosira decipiens	4 000	7 500		
— gravida	9 000	4 040	18 500	+
— sp.		8 000	19 000	3 000
Centric diatoms, not classified	2 500	6 500	2 000	
Pennate diatoms, not classified	2 000	500		500
Coccolithophorids:				
Anthosphaera robusta	100			
Coccolithus huxleyi	+			
Dinoflagellates:				
Ceratium fusus	20	20	20	
— lineatum	20	40		
— macroceros		40		
Dinophysis acuminata	60		20	
— acuta			20	
Exuviaella baltica	1 500	3 500	2 000	
— sp.		500	80	500
Glenodinium danicum		500		
Goniodoma ostenfeldi	60	40	20	
Gymnodinium elongatum		500	1 000	
— lohmanni	440	480	500	>100

Table V (continued).

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Gymnodiniaceae	13 500	16 000	13 000	1 500
Peridinium brevipes		80		
— globulus var. ovatum	20	240	1 840	
— — quarnerense	2 600	2 400		
— grani		200		
— pallidum			20	
— pellucidum	20			
— steini		20		
— trochoideum	>160	800	1 000	
— sp.		40		
Phalacroma rotundatum		20		
Porella perforata			2 000	
Protoceratium reticulatum				20
Other flagellates:				
Carteria sp.		1 500		
Chilomonas marina	1 000	1 000	1 000	
Euglenaceae	4 000	5 500	500	
Distephanus speculum		250		
Flagellate, not classified		500		
Ciliates:				
Acanthostomella norvegica	>40	120	220	
Codonellopsis lagenula		20		20
Didinium parvulum	20	40	1 000	
Laboea conica	460			
— strobila	40			
— sp.	20	40	20	
Lohmanniella oviformis	9 000	6 500	5 000	1 500
Parafavella denticulata	20	40		
Salpingella acuminata				20
Stenosemella oliva		80	40	
Tintinnopsis parvula				
Ciliates not classified	100	240	140	
Forms not identified	1 000	6 500	1 500	

Table VI. *Utsira. 6 June 1945.*

Populations recorded as cells/L. For hydrographical data see Table I.

Depth, m	1	10	25	75
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Chaetoceros borealis	140			
— sp.			2 000	860
Melosira nummuloides	40	40		
Centric diatoms, not classified			1 000	
Coccolithophorids :				
Coccolithus huxleyi	632 500	1 082 500	200 000	
Dinoflagellates:				
Ceratium bucephalum	40			
— furca	20	100	100	
— fusus	20		20	
— longipes	80	100	60	
— macroceros	60		40	
— tripos			40	
— — f.subsalsum	180	160	100	
Exuviaella baltica	500	1 000	500	
Glenodinium sp.			500	
Gymnodiniaceae	2 000	9 500	11 500	2 000
Peridinium depressum			20	
— trochoideum			14 000	20
Other flagellates:				
Chilomonas marina	5 500	11 500	17 000	
Flagellates not classified				500
Ciliates:				
Acanthostomella norvegica			20	
Laboea conica	20		20	
Lohmanniella oviformis	1 500	2 000	1 500	
Woodania conicoides	20			
Forms not identified	3 000		40	

Table VII. *Utsira. 3 September 1945.*

Populations recorded as cells/L. For hydrographical data see Table I.

Depth, m	1	10	50
Number of ml examined	2 & 50	2 & 50	2 & 50
Diatoms:			
Chaetoceros affinis	100	100	
— compressus		460	
— curvisetus		220	
— laciniosus	120		
— cf.furcellatus	6 000	73 500	
Leptocylindrus danicus		160	
Nitzschia closterium	2 000	5 500	
— delicatissima	75 000	120 000	
Sceletonema costatum	40 000	107 000	
Thalassionema nitzschioides	440	2 500	20
Thalassiosira decipiens	220	40	
Centric diatoms not classified	3 000	2 000	
Pennate diatoms not classified	60	3 500	
Coccolithophorids:			
Acanthoica sp.	500		
Anthosphaera robusta	4 500	6 500	
Ophiaster hydroideus		1 000	
Coccolithus huxleyi	267 500	325 000	900
Coccolithophorid not classified	1 000	500	
Dinoflagellates:			
Ceratium furca	60		
— fusus	20		
Dinophysis norvegica	20		
Exuviaella baltica	1 500	500	500
— sp.	500		
Goniodoma ostenfeldi?	20		
Goniaulax spinifera	40		
Gymnodinium lohmanni	160		
Gymnodiniaceae	2 500	20 500	
Peridinium globulus		20	
— minusculum	>120	>20	
— steini	20		
— trochoideum	>220	500	
— sp.	20		
Porella perforata	20	>60	
Prorocentrum micans	420	20	
Dinoflagellates not classified	500	60	

Table VII (continued).

Depth, m	1	10	50
Number of ml examined	2 & 50	2 & 50	2 & 50
Other flagellates etc.:			
Chilomonas marina	5 000	2 500	
Dictyocha fibula	90		
Distephanus speculum	10	10	10
Pterosperma sp.	20		
Ciliates:			
Acanthostomella norvegica	60		20
— sp.		60	
Laboea conica	20	80	
Lohmanniella oviformis	22 500	14 500	
Parafavella edentata		20	
Woodania conicoides		500	
Ciliates not classified		500	
Forms not classified	1 500	40	

Table VIII. *Sognesjøen. 27 March 1945.*

Populations recorded as cells/L. For hydrographical data see Table II.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Achnanthes sp.			40	
Chaetoceros affinis	4 000		8 000	
— borealis f.concavicornis			3 000	60
— compressus			17 000	
— constrictus	2 500			
— convolutus				60
— curvisetus				4 500
— debilis			75 000	200
— didymus	4 000			
— laciniosus			11 500	
— subsecundus	7 000		17 500	
— sp.	66 500	391 500	15 000	140
Coscinodiscus centralis			20	
— sp.	140	280	260	120
Coscinosira polychorda	19 000	20 000	7 500	40
Ditylum brightwelli	40			
Lauderia borealis	80	560	1 040	
Licmophora lyngbyei		40		
Navicula sp.		240	620	80
Nitzschia closterium		40	1 000	1 000
— delicatissima + seriata		123 500	42 000	8 000
Pleurosigma sp.			60	
Porosira glacialis	2 300	3 640	4 060	40
Rhizosolenia alata	660	840	880	
Sceletonema costatum	57 500	1 822 000	3810 000	2 950 000
Thalassionema nitzschioides	21 000	51 500	24 500	1 200
Thalassiosira decipiens	2 960	31 000	27 000	1 340
— gravida	59 000	68 000	49 500	1 200
— sp.			4 000	
Centric diatoms not classified	500			
Pennate diatoms not classified	120		300	20
Dinoflagellates:				
Ceratium fusus		40		
— tripos	20			
Exuviaella baltica	3 000	6 500	1 500	
Gymnodinium lohmanni	300	520	480	140
Peridinium brevipes			40	
— globulus			140	
— pellucidum	20			
— sp.	160	120		
Dinoflagellates not classified			20	

Table VIII (continued).

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Other flagellates etc.:				
Chilomonas marina		3 500	4 000	1 500
Distephanus speculum		20	10	
Halosphaera viridis			20	
Ciliates:				
Acanthostomella elongata	20			
Mesodinium rubrum	120	80	20	
Strombidium sp.		40		
Ciliates not classified		1 040	60	60

Table IX. *Sognesjøen. 12 July 1945.*

Populations recorded as cells/L. For hydrographical data see Table II.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Chaetoceros affinis		2 000	16 000	
— borealis		100		
— brevis			8 000	
— compressus		6 000	40 500	
— curvisetus	138 000	2 000	2 000	
— danicus	10 000			
— debilis			5 000	
— wighami	11 500			
— sp.	500	500	2 500	40
Guinardia flaccida		120	3 500	
Leptocylindrus danicus	160		5 500	
Licmophora lyngbyei	40	2 500		
Nitzschia closterium	1 000	3 000	4 000	
— delicatissima + seriata	1 000	22 500	284 000	3 000
Rhizosolenia hebetata f.semispina			190	
Sceletonema costatum	83 500	20 000	1 135 000	2 000
Tabellaria flocculosa	60			
Thalassionema nitzschioides	14 500	3 000	3 500	
Centric diatoms not classified			1 000	
Pennate diatoms not classified		500		
Coccolithophorids:				
Coccolithus huxleyi	19 500	43 500	18 000	13 000
Michaelsarsia sp.		1 000		
Coccolithophorids not classified	2 500	4 000	1 500	500
Dinoflagellates:				
Ceratium furca			20	
— fusus		160	40	
— horridum			100	
— longipes			140	
— macroceros		120		
— tripos	200	80	80	20
Dinophysis acuta		20	20	
— norvegica		20		
Exuviaella baltica	19 500	1 500	4 000	
— sp.	1 000		500	
Goniaulax sp.	20			
Gymnodiniaceae	22 500	8 500	7 000	2 000
Peridinium brevipes		20	60	
— depressum	40		80	

Table IX (continued).

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Peridinium globulus	20	40	100	
— grani		20	60	
— minusculum			1 000	
— pallidum		40		
— pellucidum	100	20		
— steini			20	
— triquetrum	6 000	7 000	400	
— trochoideum	320	660		40
— sp.			40	40
Phalacroma rotundatum	100	40	20	
Protoceratium reticulatum	40			
Pyrocystis lunula		40		
Dinoflagellates not classified		40	20	20
Other flagellates etc.:				
Chilomonas marina	2 500	4 000	4 500	
Distephanus speculum			10	
Euglenaceae	1 000			
Halosphaera viridis		40		
Trochiscia sp.	40		20	
Monads not classified	2 000	120	2 500	
Cysts	240	160	60	120
Ciliates:				
Acanthostomella sp.		40	660	60
Codonellopsis sp.		80	40	
Helicostomella subulata	120			
Laboea conica		1 760	320	
Lohmanniella oviformis	40		220	
— sp.	20	280		20
Parafavella sp.		80	40	
Ptychocylis urnula			20	
Salpingella sp.	5 000	60		
Strombidium sp.	760	1 500		
Ciliates not classified	120	220	180	60

Table X. *Sognesjøen. 30 July 1946.*

Populations recorded as cells/L. For hydrographical data see Table II.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Rhizosolenia alata f.gracillima		10		
Thalassionema nitzschioides	1 500			
Pennate diatoms not classified		40		
Coccolithophorids :				
Coccolithus huxleyi	48 500	3 500		500
Rhabdosphaera cf.nigra	340	400	120	40
Coccolithophorids not classified	28 000	3 500	4 000	1 500
Dinoflagellates:				
Ceratium furca	640	500	260	
— fusus	60	60	200	
— horridum	20			
— lineatum			20	
— longipes			60	20
— macroceros		20		
— tripos	40	60	60	
Dinophysis acuminata		20	40	20
— acuta	20	40	40	
— norvegica		20		20
— sp.	20			
Erythropsis sp.	40			
Exuviaella baltica	1 000	1 000	5 000	1 000
Glenodinium danicum				40
— sp.				20
Goniaulax spinifera	20	500		
Gymnodinium elongatum	80	1 000		
— lohmanni	20			
Gymnodiniaceae	5 000	5 500	6 500	> 60
Peridinium brevipes	20	80	40	
— divergens	20			
— globulus var. ovatum	20	40		
— — quarnerense	120			
— grani			20	
— steini		280	100	
— trochoideum	6 000	10 000		20
— sp.	80			20
Phalacroma ruudi				20
Porella perforata	20	1 000	6 000	
Prorocentrum micans	40	20		
Protoceratium reticulatum	80	20		

Table X (continued).

Depth, m	1	10	25	50
Number of ml examined	*2 & 50*	*2 & 50*	*2 & 50*	*2 & 50*
Pyrophacus horologicum	20		40	
Dinoflagellates not classified	140			20
Other flagellates etc.:				
Dinobryon sp.			+	
Euglenaceae	20			
Pterosperma cristatum	20			120
Cysts				
Ciliates:				
Acanthostomella norvegica				60
Codonellopsis lagenula	80	560	540	360
— sp.	20			
Helicostomella subulata	220	300	80	
Laboea conica	120			
— sp.	20			
Parafavella spp.			40	
Salpingella acuminata				20
Tintinnopsis campanula			20	
Tintinnids not classified	60		20	
Ciliates not classified	100	100	20	80
Forms not classified	*9 500*	*2 000*	*2 000*	

Table XI. *Skrova. 14 April 1945.*

Populations recorded as cells/L. For hydrographical data see Table III.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Bacteriosira fragilis	2 000		6 500	1 000
Biddulphia aurita	1 100	160		200
Chaetoceros borealis f.concavicornis	260		4 500	
— compressus	1 180	6 500		
— constrictus	7 000			
— curvisetus	180			4 500
— debilis	10 000	3 500		
— decipiens		40		
— didymus	2 000	1 000	1 500	1 000
— laciniosus	120			
— socialis	103 500	4 000	6 500	13 500
— subsecundus	160	40		
Coscinodiscus concinnus		180	180	40
— radiatus				20
Coscinosira polychorda	9 500	8 000	5 000	8 000
Fragilaria oceanica	130 000	120 500	143 000	212 000
Melosira sulcata	40	480		
Navicula sp.	5 500	5 000	4 000	5 000
Nitzschia closterium	1 500	1 000	260	
— seriata	80	7 000	3 500	3 000
Pleurosigma sp.		20	80	
Rhizosolenia alata	40			
Sceletonema costatum	24 000	11 500	5 000	1 000
Thalassionema nitzschioides	6 000	1 220	3 500	6 000
Thalassiosira gravida	48 500	46 500	12 500	80
— hyalina	3 000	3 140	2 260	11 000
— nordenskioeldi	28 000	44 000	44 000	16 500
Pennate diatoms not classified	3 000	6 000	29 500	4 000
Coccolithophorids:				
Coccolithus huxleyi		500		
Dinoflagellates:				
Ceratium fusus		20	40	
Dinophysis acuminata	20			
Exuviaella baltica	1 000			
Gymnodinium cornutum	20			
— lohmanni		60		40
— sp.	5 000	11 000	12 500	14 000
Peridinium brevipes		20	20	
— depressum	20		20	
— globulus		60		20

Table XI (continued).

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Peridinium minusculum			500	
— pellucidum			20	
— triquetrum		20	40	
— trochoideum	140		40	
— sp.		20		
Dinoflagellates not classified		20		
Other flagellates etc.:				
Chilomonas marina		500		500
Distephanus speculum	20	20		
Eutreptia lanowi	40		20	
Phaeocystis poucheti	+	+	+	+
Ciliates:				
Laboea conica	20			
Lohmanniella oviformis	40	40	40	20
Mesodinium rubrum		40	80	
Tintinnopsis sp.	20			
Ciliates not classified	20			

Table XII. *Skrova. 21 July 1945.*

Populations recorded as cells/L. For hydrographical data see Table III.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Chaetoceros danicus			7 000	
— sp.			120	
Nitzschia seriata			40	
Rhizosolenia alata			30	
— fragilissima			20	
Sceletonema costatum			280	500
Coccolithophorids:				
Coccolithus huxleyi	324 000	131 500	500	
Coccolithophorids not classified			1 000	
Dinoflagellates:				
Amphidinium sp.		500		
Ceratium fusus		40		
— lineatum			60	
— longipes	180	560	1 040	
— macroceros	20		20	
Dinophysis acuminata	20			
— acuta	200	180		
Exuviaella baltica	4 000	4 000		
Glenodinium danicum	2 000	1 000		
Goniaulax polyedra			20	
— ostenfeldi	80	60	120	
Gymnodinium lohmanni		40		
— sp.	6 000	5 500		
Peridinium brevipes	660	920	60	20
— crassipes	40	60		
— conicum		60		
— depressum		20	60	
— globulus var. ovatum		60	20	20
— — quarnerense	140	320	60	
— minusculum	1 500	500		
— pellucidum		60	20	
— triquetrum	4 000	2 500		
— trochoideum	520	3 500	160	
— — rest.sp.	700	4 500	80	
— sp.	20			
Phalacroma rotundatum	80	140		
Pyrophacus horologicum		100		
Other flagellates:				
Chilomonas marina	7 000	16 000		

Table XII (continued).

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Ciliates:				
Laboea conica	20			
— crassula	20	20		
— strobila	60	140		
Lohmanniella oviformis	260	320	120	
Parafavella sp.	80	140	60	
Ptychocylis obtusa		20		
Strombidium sp.		20		
Ciliates not classified	20			

Table XIII. *Skrova. 10 May 1946.*

Populations recorded as cells/L. For hydrographical data see Table III.

Depth, m	*1*	*10*	*25*	*50*
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Chaetoceros simplex			500	
Melosira sulcata	80			
Thalassionema nitzschioides				120
Dinoflagellates:				
Dinophysis acuminata				20
Exuviaella baltica	2 000			
Glenodinium danicum			500	
Gymnodinium sp.	2 500	3 000	5 500	2 500
Peridinium grani				20
Other flagellates etc.:				
Chilomonas marina	4 000	3 500		
Euglenaceae	974 500	387 000	14 000	
Phaeocystis poucheti	+	+		
Pterosperma parallelum	500			
Ciliates:				
Laboea conica	40			
Mesodinium rubrum	100			

Table XIV. *Eggum. 27 April 1945.*

Populations recorded as cells/L. For hydrographical data see Table IV.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Cerataulina bergoni		60	140	
Chaetoceros affinis		860	300	
— compressus		1 500	500	5 000
— curvisetus	4 000	450	5 500	1 100
— debilis	4 000	6 500	11 500	7 000
— decipiens		480	60	180
— furcellatus		480	140	1 000
— laciniosus	3 000	1 500	3 000	4 500
— subsecundus		460		4 500
— teres	60	80	80	100
— sp.	3 000	1 840	4 000	7 500
Coscinodiscus sp.	140	520	380	220
Coscinosira polychorda	460	1 280	1 360	2 160
Ditylum brightwelli		20		
Fragilaria oceanica	4 000	180	860	3 680
Lauderia borealis		140		
Melosira sp.			60	6 000
Nitzschia closterium		180	120	
— delicatissima		280	2 000	300
— seriata		620	7 500	4 000
Pleurosigma sp.		60		
Rhizosolenia alata	500	30		
Sceletonema costatum	8 000	11 500	17 000	1 000
Thalassionema nitzschioides	8 500	17 000	12 000	12 500
Thalassiosira bioculata	40			
— decipiens	2 000	1 280	200	220
— gravida	26 500	12 500	11 500	20 000
— nordenskioeldi	160	19 500	6 000	5 000
Centric diatoms not classified	240	380	16 000	
Pennate diatoms not classified	2 000	6 000	4 000	3 500
Coccolithophorids:				
Coccolithus huxleyi		1 500		
Coccolithophorids not classified		160	20	60
Dinoflagellates:				
Amphidinium sp.			2 500	20
Ceratium furca		20	20	
— fusus		20	20	
— longipes		40		20
Dinophysis acuminata	20			
— norvegica	20	40	60	

Table XIV (continued).

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Exuviaella baltica			160	180
Gymnodinium lohmanni		720	1 180	440
— sp.	2 000	20 000	21 000	12 500
Peridinium conicum		20		
— depressum	20		40	
— globulus var. ovatum		120	180	100
— — quarnerense		20		
— minusculum		220	100	80
— thorianum		160		
— trochoideum		80		
— sp.	120	40	20	20
Protoceratium reticulatum, rest. sp.		40	20	20
Other flagellates etc.:				
Distephanus speculum		20		
Eutreptia lanowi		480	60	120
Halosphaera viridis		300	80	100
Phaeocystis poucheti	+	+	+	+
Trochiscia sp.				40
Ciliates:				
Laboea conica		620		20
Lohmanniella oviformis			60	60
Ptychocylis urnula		120	60	20
Strombidium sp.		40		
Ciliates not classified		360		

Table XV. *Eggum. 6 July 1945.*

Populations recorded as cells/L. For hydrographical data see Table IV.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Cerataulina bergoni			100	
Chaetoceros compressus		1 000	3 500	
— debilis	112 000	499 000	1 052 000	95 000
— furcellatus, r.sp.				7 500
— laciniosus	2 000	4 500	1 000	2 000
— subsecundus		3 500	10 500	
— teres		6 000	2 000	
— wighami		400		
— sp.	1 500		4 500	3 000
Corethron hystrix	20	200	1 000	120
Coscinodiscus sp.		20		
Eucampia zoodiacus		1 840	1 500	680
Leptocylindrus danicus	19 500	10 000	8 500	60
Nitzschia seriata	100	2 360	3 500	140
Rhizosolenia alata		40		
— fragilissima		740	4 500	
— hebetata f.semispina		30		
— setigera		10		
Sceletonema costatum	4 000	13 000	12 500	6 500
Thalassionema nitzschioides				60
Thalassiosira bioculata			920	
— gravida	280	2 500		
— decipiens	1 500	24 000	106 500	18 000
— nordenskioeldi	2 000	8 500	11 000	
Cysts of diatoms, not classified	1 500			
Centric diatoms not classified	2 500			
Pennate diatoms not classified	40			
Coccolithophorids:				
Coccolithus huxleyi	2 500	1 000	2 000	3 000
Coccolithophorids not classified	1 500		20	60
Dinoflagellates:				
Ceratium fusus		20		
— lineatum		20		
— longipes	20	80	180	
Dinophysis norvegica		20	20	
Exuviaella baltica	8 000	6 000	4 500	320
Glenodinium danicum	3 000	80	1 500	1 500
Goniaulax ostenfeldi	6 000	19 500	820	120
Gymnodinium lohmanni		260	160	180

Table XV (continued).

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Gymnodinium sp.	2 000	4 000	1 500	3 000
Peridinium globulus var.quarnerense	400	220	40	
— trochoideum	1 000	220	40	
— sp.	80	80	20	
Dinoflagellates not classified	1 000	2 000	2 000	6 500
Other flagellates etc.:				
Chilomonas marina	7 500	1 000	500	
Euglenaceae	10 620	8 620	3 000	5 000
Trochiscia sp.	20			
Flagellates not classified	1 500			
Ciliates:				
Acanthostomella sp.	20	40	20	
Didinium sp.			20	
Favella sp.		40		
Laboea conica	40	100	80	
— sp.			40	
Lohmanniella oviformis	140	260	80	60
Parafavella sp.			40	
Salpingella acuminata	40	20	20	
Strombidium sp.	20	120		
Ciliates not classified	20			

Table XVI. *Eggum. 7 September 1945.*

Populations recorded as cells/L. For hydrographical data see Table IV.

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Diatoms:				
Chaetoceros affinis	3 500	11 000	940	20
— borealis		60	160	
— compressus	120 000	187 000	87 000	
— constrictus	120			
— curvisetus	200	640	240	
— debilis	53 000	66 500	58 000	
— — rest.sp.	140	3 000	6 500	20
— decipiens	520	16 000	1 200	20
— laciniosus	2 500	80	80	
— socialis	3 000		11 000	500
— sp.	12 500	7 000		20
Corethron hystrix	140	80		
Coscinodiscus sp.	40	20	40	20
Dactyliosolen mediterraneus	480	420	740	180
Eucampia zoodiacus		340		
Fragilaria oceanica	3 500			
Leptocylindrus danicus	2 800	35 000	19 000	
Licmophora sp.	20			
Nitzschia closterium	360	900	100	
— delicatissima	4 000	8 000	4 000	
— seriata	11 000	8 500	2 200	80
Rhizosolenia alata	4 000	2 500	2 000	
— fragilissima	3 000	2 300	3 500	
— hebetata f.semispina	50	530		
— stolterfothi	12 500	4 840	3 500	100
— imbricata var.shrubsolei		800	320	
Sceletonema costatum	1 000	3 000	1 500	2 000
Thalassionema nitzschioides	680	1 210	6 000	40
Centric diatoms not classified	6 000		2 500	
Pennate diatoms not classified	3 000	220	80	
Coccolithophorids:				
Coccolithus huxleyi	10 000	154 000	125 000	12 000
Syracosphaera mediterranea	1 000	500		
Coccolithophorids not classified	220	3 000	20	
Dinoflagellates:				
Amphidinium sp.	220	2 500	2 500	
Ceratium bucephalum	40	60	20	
— fusus	180	380	40	
— lineatum	40	100	20	

Table XVI (continued).

Depth, m	1	10	25	50
Number of ml examined	2 & 50	2 & 50	2 & 50	2 & 50
Ceratium longipes				20
— macroceros	160	160	180	
— tripos	80	20		
Exuviaella baltica	3 500	8 000	3 000	
Dinophysis acuminata	20	40		
Glenodinium danicum	60	80	20	
Goniaulax ostenfeldi		40		
— spinifera		60	20	
Gymnodinium sp.	38 000	36 000	12 500	1 000
Peridinium brevipes	40		20	
— crassipes	40	80	20	
— globulus var. quarnerense	200	200		
— grani			60	
Peridinium minusculum	1 000	1 000	500	
— triquetrum	60	80		
— trochoideum	440	540	60	
— — rest.sp.	20		20	
— sp.	60			
Phalacroma rotundatum		40		
— ruudi		20	20	
Porella perforata	40	60		
Prorocentrum micans	40			
Dinoflagellates not classified	120			
Other flagellates etc.:				
Chilomonas marina	1 000	1 000	2 500	
Distephanus speculum	3 000	1 080	440	
Euglenaceae	6 500	2 000	3 500	
Pterosperma cristatum		500	500	
Trochiscia sp.		20		
Ciliates:				
Acanthostomella norvegica			20	
Codonellopsis lagenula			40	
Didinium parvulum	20	20	20	
Laboea conica	40	20	60	20
Lohmanniella oviformis	180	60	40	
Parafavella sp.		·		20
Ptychocylis sp.	40	160	40	20
Salpingella acuminata	140	160	100	
Tintinnus sp.	40			