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THE MARINE ALGAE OF EAST GREENLAND

II. GEOGRAPHIC DISTRIBUTION

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WITH 4 FIGURES IN THE TEXT

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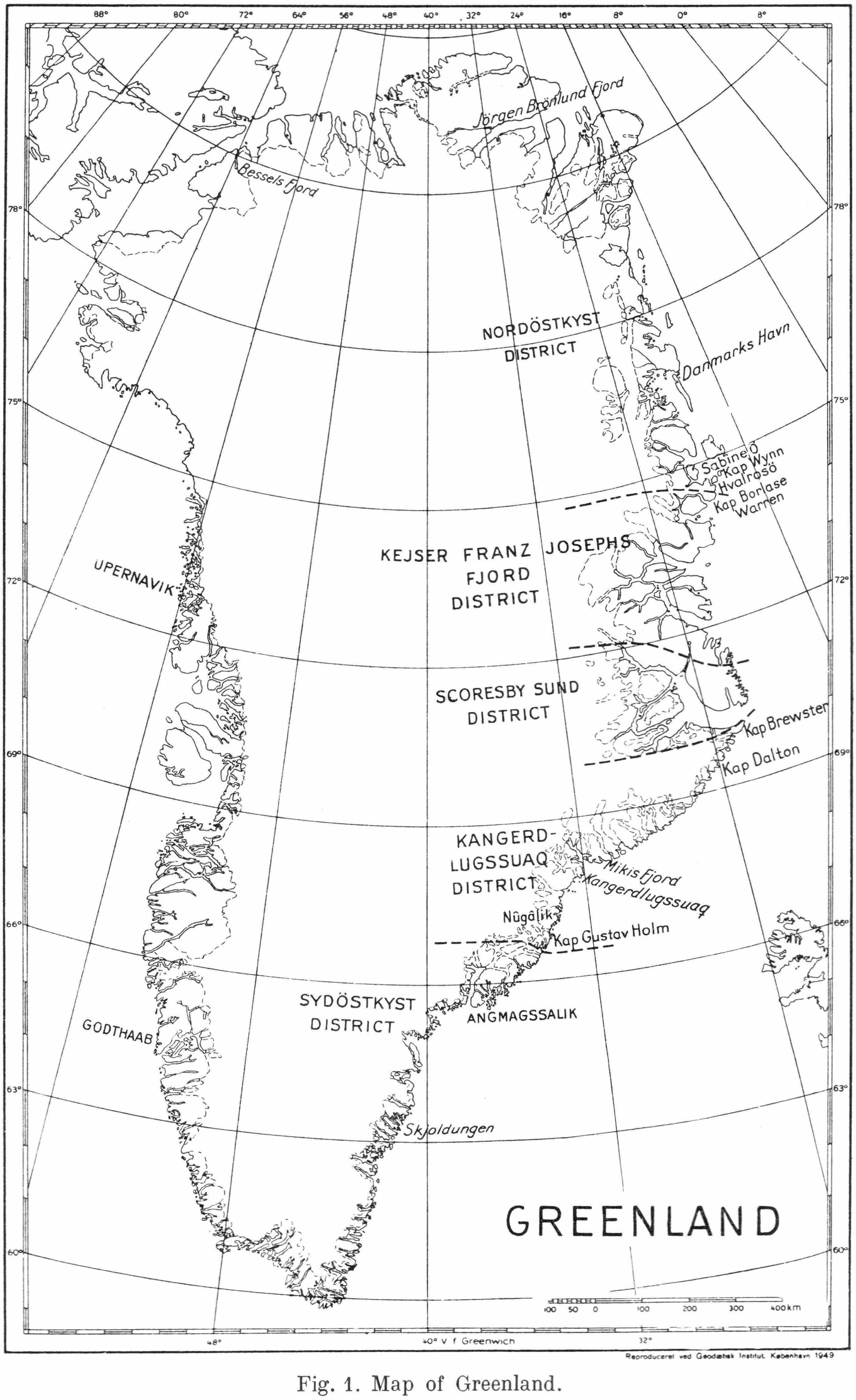


Fig. 1. Map of Greenland.

I. INTRODUCTION

Part I deals with the taxonomy of the species occurring in my area, the Scoresby Sund and Kejser Franz Josephs Fjord districts. In the present work, which should be regarded as a mere supplement to Part I, I have outlined the geographic distribution of the species and have endeavoured, on this basis, to give a contribution towards the elucidation of the phytogeographical character of the flora of that area. Furthermore, the work contains observations as regards the algal vegetation and a review of the external factors of particular importance to the algal vegetation. As was also the case in Part I, I have taken into consideration only the Green, Brown, and Red Algae, except when dealing with the algal communities of the littoral region where a couple of Blue-green Algae are mentioned.

Phytogeographical analyses of Greenland's algal flora, based exclusively on the geographic distribution, have previously been made by KUCKUCK (1897 c, p. 37: W. Gr.), ROSENVINGE (1898 a, p. 165 et seq.: W. Gr. and E. Gr.; 1910, p. 99: E. Gr.), and BØRGESEN & JÓNSSON (1905, p. XXII: W. Gr. and E. Gr.), cf. p. 32. The system established in the latter paper is used in the present work for the purpose of discussing the distribution of the species in my area. I am fully aware of the fact that to-day a system of this kind must be characterized as unsatisfactory as it does not take the ecological factors into consideration. It must, however, be admitted that the knowledge of the ecology of the marine algae of East Greenland is still too scarce to make it possible to establish a satisfactory, ecological system and there seems, therefore, to be no other choice than using BØRGESEN & JÓNSSON's system despite its shortages. It must be hoped that it will be the goal of future endeavours to establish a distributional system, classifying the species according to ecological factors.

In this connexion it is equally regrettable that, on the whole, too little is known about the biology of the arctic marine algae. Thus, it will be impossible for the time being to classify the species from the area under consideration according to their life forms similar to what was done by FELDMANN (1937 a, p. 137 et seq.) in the case of the algae of the Albères coast (the Mediterranean). A thorough field investigation of the duration of life of the individual species and the way in which they survive the adverse season will be met with keen interest.

Thus, the following survey of the distributional features should in no respect be interpreted as a modern phytogeographical review. The term "phytogeography" should be interpreted as relating merely to the geographic distribution.

BØRGESEN & JÓNSSON's system is explained in detail on p. 32 and for the purpose of this introduction it will suffice to state that five distributional groups are deliminated in that system, viz. the arctic (a), subarctic (sa), boreal-arctic (ba), cold-boreal (cb), and warm-boreal (wb) groups.

The distributional grouping may be used for the purpose of characterizing the flora of a given district. Thus, JÓNSSON (1910, p. 28; 1912, pp. 68—69) characterizes the flora as subarctic when the subarctic species constitute more than half the total number of species; as boreal when the boreal species (ba + cb + wb) constitute more than half; and as arctic-subarctic when the share of arctic species in a subarctic flora is relatively great as compared with the boreal share.

The flora encountered in my area is arctic-subarctic, and in all the phytogeographical comparisons and analyses I have followed the procedure of ascertaining how marked this character is, i. e. I have stated the joint share of arctic and subarctic species, the percentage a + sa.

The chapter dealing with the vertical distribution of the flora is fairly detailed and chiefly statistical. Such an examination has been possible first and foremost because, as already mentioned in Part I, in collecting the material I attached great importance to an exact record of the depth at which the algae were found. Moreover the material collected, of which the majority has been kept in alcohol, was examined in details by means of a binocular dissecting microscope. In this way I succeeded in getting a good deal of depth records for most of the species, which will also appear from the lists of localities given for the individual species.

My thanks are due to Professor GUNNAR THORSON for information of great value, on general as well as zoological conditions within my area, and also for handing over to me for examination the stones collected at great depth by means of the Petersen grab and appearing to be of considerable interest, as they furnished proof of benthos vegetation at surprisingly great depths.

Further, I am indebted to Professor E. STEEMANN NIELSEN for many valuable discussions, to KNUD ANDERSEN, cand. mag., who has been kind enough to prepare the graphs illustrating the length of the day (fig. 2), and to Mrs. A. M. LUND for the translation.

My especial thanks are due to the late director of Danmarks Fiskeri- og Havundersøgelser, Dr. Å. VEDEL TÅNING, for his obligingness in making a place of work available for me during recent years, thereby enabling me to finish this work.

II. EXTERNAL FACTORS INFLUENCING THE ALGAL VEGETATION

1. Temperature and Salinity of the Sea Water.

The hydrographic conditions prevailing along East Greenland's outer coasts have previously been treated in a number of papers. As far as my work is concerned hydrography is, however, only an auxiliary science; I shall, therefore, not discuss these papers, but shall confine myself to referring to one of the more recent works and its references to previous literature (Kiilerich, 1945) and to giving an outline of the main features of the hydrographic conditions. — In the East Greenland Current, flowing south along the coast, two distinct water masses of essentially different origin are distinguishable. The upper layer consists of the so-called Polar Current water of a constantly negative temperature, between 0° and —1.70°C., its salinity ranging between 32 ‰ and 34.7 ‰. Below this layer is found Atlantic water characterized by positive temperatures, between 0° and 3.5°C., and a slightly higher salinity, up to just under 35 ‰. Further, a fiord-water layer is formed in summer above the Polar Current water, its characteristics being positive temperatures and reduced salinity (less than 30 ‰). (The above figures quoted from Thorson, 1944, p. 160).

The Polar Current water originates in the Polar Sea from where it flows south as a broad current passing between Northeast Greenland and Spitsbergen. As far south as south of Scoresby Sund this current remains of considerable horizontal and vertical dimensions, its vertical extension being between well over 200 and 400 m. When passing the submarine Iceland-Greenland Ridge in Denmark Strait, stretching from Iceland to slightly north of Angmagssalik in East Greenland, the current becomes of considerably reduced width and thickness. At the southern point of Greenland it bends west and then turns north to flow along the west coast where its character gradually changes owing to mixture with the Irminger Current.

The Atlantic water or Gulf Stream layer that occurs between Northeast Greenland and the Iceland-Greenland Ridge originates in a branch of the Gulf Stream water flowing north along the Norwegian west coast. This branch extends from North Norway to the western side of Spitsbergen from where a feeble branch bends south to flow partly below the Polar Current (owing to the higher specific gravity), partly along it. South of the Iceland-Greenland Ridge the Gulf Stream layer and, consequently, the entire East Greenland Current is characterized chiefly by the Irminger Current, another branch of the Gulf Stream, extending north along the west coast of Iceland. When the Irminger Current passes the Ridge, its main volume turns toward Greenland to join the Polar Current in its further course, flowing partly below, partly along it. Together with the Polar Current it bends west and north along Greenland's west coast, while intensive mixing of the two currents takes place.

The fiord-water layer owes its existence to melt water from ice and fresh water from land, which mix with and dilute the upper layer of the Polar Current water. It is of greatest extension in August and is formed anew every year. Its thickness is, however, not too considerable, particularly on the outer coast in north-easternmost Greenland.

The hydrography of the large fiord complexes, Scoresby Sund and the Kejser Franz Josephs Fjord district, is in all essentials similar to that of the outer coast. Hydrographic investigations in Scoresby Sund have been made by RYDER (1895), USSING in THORSON (1934), and DIGBY (1953); in the Kejser Franz Josephs Fjord district by SPÄRCK (1933), THORSON (1933), JAKHELLN (1936) (see also BRAARUD (1935)), and THORSON in USSING (1938, table 1). Both districts consist mainly of a system of threshold fiords, as appears from the bathymetric charts published by THORSON (1934, pl. 6) for Scoresby Sund, and by SPÄRCK (1933, pl. 1) for the Kejser Franz Josephs Fjord district. As a rule, a glacier debouches into the head of the fiords (this does not, however, apply to Hurry Inlet and Duséns Fjord). The differences recorded in the vertical distribution of temperature and salinity as compared with the outer coast are conditioned by the location of the thresholds.

In the case of Scoresby Sund the thresholds are located at such great depths as to permit inflow of the warmer bottom water into the fiords, so that there is no great difference between the water in the fiords and that outside. In THORSON (1934, p. 65) it is indicated that the Polar Current water extends to depths of 300—400 m. Its temperature ranges between 0° and $-1.69°$ C., its salinity between 32.30 and 34.80 ‰, while the subjacent, warmer bottom water has a temperature between 0° and 1.50° C. and a salinity ranging from 34.69 to 34.95 ‰.

In the Kejser Franz Josephs Fjord district the warmer bottom water penetrates into the outer basins while the inner basins contain mixed water. SPÄRCK (op. cit., p. 34) states that the water penetrating into the outer basins is of a temperature of 1.6—1.7° C., its salinity being 34.90 ‰, while the temperature of the mixed water of the inner basins is indicated to be about 0° C., its salinity ranging between 34.60 and 34.80 ‰. The Polar Current water has a temperature of approx. —1.5° C. and a salinity of 33 to 34.50 ‰.

Hurry Inlet, in which I made collections of algae, is one of the fiords missing the warmer bottom water. This fiord is rather shallow, its maximum depth, occurring in its inner half, being of 140 m only. The depth at its mouth measures 90 m while somewhat farther up the inlet the depth is only 70 m (Thorson, 1934, pl. 6). Another similar fiord is Dusèns Fjord at the mouth of which a threshold is located, according to Spärck at a depth of 50 m, whereas Jakhelln (op. c., p. 59) states that it is located at about 90 m.

In both the Kejser Franz Josephs Fjord district and Scoresby Sund the fiord-water layer attains its maximum thickness in the inner and middle parts. This is connected with the fact that the brighter and calmer weather prevailing up the fiords causes the ice to melt more quickly than is the case in the outer parts, for which reason the period without continuous ice (free of ice or with scattered ice only) becomes longer.

This feature is most marked in the Kejser Franz Josephs Fjord district, in which the fiord-water layer in August (according to Thorson 1944, p. 161, summary of the particulars available) has a thickness of approx. 20—25 m in the innermost and middle parts as against 10—15 m in the outermost part. Furthermore, the fiord-water layer is more constant and warmer in the former parts, thus affording better chances for southern algae.

According to the same author the corresponding figures for Scoresby Sund are 10—15 m and approx. 10 m, respectively. The smaller difference recorded in Scoresby Sund is ascribable to the broader mouth of this sound, entailing a larger outflow. It is, however, beyond doubt that Rødeø and other inner localities in Scoresby Sund afford more advantageous conditions for southern algae than outer Scoresby Sund, although the conditions are not equal to those prevailing at Ella Ø.

The fiord-water layer is formed as soon as the ice breaks up, at the end of June or in July, but already before that time a layer of almost fresh water will occur below the ice cover, owing to the beginning melting of the ice and the supply of fresh water from land. In the case of Ella Ø Thorson (1933, p. 17) states that by the end of May the water is almost fresh down to a depth of 3 m, the salinity amounting to no more than some 3—4 ‰. As soon as the ice has disappeared the upper part of the Polar Current water is quickly mixed with the fresh water. Throughout summer there is a continuous formation of fiord water, due to the flow of melt water from the glaciers.

Owing to its reduced salinity the fiord-water layer will aid in stabilizing the water masses, so that the vertical convection is rather inconsiderable. On the other hand, the fiord-water layer will cause an outward surface current which is, however, partially compensated for by an inward bottom current, in Scoresby Sund flowing in at the north side of the mouth.

For the purpose of elucidating in more detail the hydrographic conditions prevailing in some of the localities visited by me I render some of the facts stated by DIGBY (1953, p. 294 et seq.) during his stay at Rosenvinges Bugt. No less than four of my localities are situated at this bay, viz. Kap Tobin, Amdrups Havn, Scoresbysund, and Kap Hope. DIGBY's records were made during the one-year period from August 1950 to 1951 and refer only to the layer between 0 and 50 m. In this locality the open season is restricted to a little more than two months.

At the end of September the uppermost 50 m had a temperature of approximately —1° C., while the salinity ranged between 29.00 ‰ at the surface and 32.00 ‰ at a depth of 50 m. By November the temperature had dropped to —1.7° C. at all depths, the salinity at the same time having increased to 32.00—32.50 ‰. From mid-November until March the temperature remained between —1.70° and —1.80° C. By April, an increase in temperature set in, accompanied by a reduction in salinity, though these changes were small until the beginning of June. The temperature reached a maximum of 3° C. at a depth of 1 m, which was recorded in July. The maximum depth of the 0° C. isotherm, 15—20 m, was reached by the end of August. In June, the salinity was 10 ‰ at a depth of 1 m, but the brackish surface layer was thin; at a depth of 10 m the salinity was but slightly reduced and only in August did it drop below 30.00 ‰.

Further, I quote some of the figures ascertained at Ella Ø by THORSON (in USSING, 1938, table 1). Every second week during the period January–May, 1932, temperature measurements were carried out and water samples were taken at every 5 m in the layer between 0 and 50 m. These investigations go to prove that hydrographic changes were but small. In January, the surface temperature amounted to —1.46° C., in May to —1.59° C., while the salinity was 27.3 and 30.77 ‰, respectively. At a depth of 50 m the temperature was at —1.50 and —1.69° C. in January and May, respectively, the salinity amounting to 32.0 ‰ and 33.1 ‰.

2. The Ice.

According to THORSON (1936, pp. 86—87, and verbal information) the ice cover at Ella Ø begins to form by the end of September. At the outset it is hard and transparent, but from the beginning of October until some time in May it is covered with a snow layer measuring some 30—40 cm in thickness and preventing the penetration of light. The ice layer eventually increases in thickness to measure at least a couple of metres. From the end of May it undergoes a change because of its beginning melting and the melting of the snow layer and becomes clear and transparent, allowing the light to penetrate. Not until the beginning of July does the ice disappear, the ice-free period thus not exceeding some three months.

At Danmarks Ø in Scoresby Sund the ice may persist longer. In some years, the period without continuous ice may even be as short as one month (cf. Rosenvinge 1898a, pp. 190, 229). There can, however, hardly be any doubt that even in such years the ice will be clear and transparent during some summer months. Likewise, the water immediately along the shore, especially in the bays and inlets, will presumably remain free of ice for a comparatively long time.

It is obvious that the snow-clad ice cover is of great consequence to the algal vegetation as a light-impeding factor. On the other hand, the possibility cannot be completely excluded that the ice cover, when it is not covered with snow, may to a certain, limited extent aid in increasing, through reflexion, the quantity of light penetrating into the water.

Through its mechanical effects, exercised partly by the ice cover which is moved up and down by the tide, partly by drift ice, the ice is of great consequence to the littoral vegetation. Also through the ice-foot, the consol-shaped ice border situated directly on the rocks in the tidal region, the ice has bearing on this vegetation as it may hinder algal colonization by occupying the substratum. On the other hand, the vegetation frozen in the ice-foot is hardly damaged in case the ice-foot melts away gradually, and it may even by the ice-foot be protected against the mechanical effects of the ice (cf. Kruuse 1912, p. 29).

No doubt the ice must be considered one of the most important factors among those restricting the littoral vegetation.

3. The Mud.

The mud is due to the melting on land and the melting of the glaciers. It is particularly of consequence in the inner fiords where, according to Spärck (1933, p. 35), the transparency may be reduced to a mere 0.5—1 m while it is recorded to be between 13 and 16 m at the mouths of the fiords and along the outer shore. The mud is most conspicuous in late summer. Thorson (1936, p. 88) states that at Ella Ø the water is clear and transparent in June while it becomes increasingly turbid towards late summer though in this locality the turbidity was by no means so pronounced as in the inner ramifications of the fiords.

When visiting Fame Øer at the head of Hurry Inlet I noticed a turbid layer of fiord water on July 8. It was obvious that only a thin surface layer was involved, the movements of the propeller of the ship revealing the presence of limpid water below the surface. As mentioned above, no glacier debouches in this fiord and the turbid surface layer is due to melting on land.

Besides being important as a light-impeding factor the mud is of consequence when settling as a layer on the algae; this feature is, of course, particularly conspicuous near the outlet of the rivers. Many algae are very sensitive to the mud and the possibility cannot be excluded that to some species the mud carried by the melt water may be of greater consequence than the reduction in the salinity caused by the melt water.

It should be strongly emphasized that the mud undoubtedly has a great influence upon the algal vegetation, so I take this opportunity to draw attention to this problem in connexion with future investigations. It will be of the greatest interest to make comparisons between the algal vegetation in muddy fiords and that of fiords in which the mud is of no importance.

4. The Altitude of the Sun.

As far as the light is concerned, the algal vegetation would seem to live under poor conditions, particularly when occurring at great depths. Owing to the high latitude, approx. 70—74° N., the sun does not appear over the horizon during part of the year and, throughout most of the time in which it does appear, its altitude is low. Hence, the reflexion of the light becomes large and only a small part of the light penetrates into the water.

In Scoresby Sund the dark period lasts for about 2 months. In a locality in lat. 70°30′ N., approximately corresponding to the latitude of Kap Tobin, Amdrups Havn, Kap Hope, the mouth of Hurry Inlet, Danmarks Ø, and Rødeø, the sun remains under the horizon from about November 19 to about January 20, after which the length of the day increases rapidly until the midnight-sun period is reached, commencing on approximately May 15 and lasting until about July 26. At the beginning of this period the altitude of the sun does not exceed 38.0° while its maximum altitude amounts to 42.9°.

In the Kejser Franz Josephs Fjord district the dark period lasts for about three months. In a locality in lat. 73°20′ N., i.e. the latitude of the head of Duséns Fjord and slightly north of Ella Ø and Vinterøer, the sun disappears under the horizon approximately on November 9 and does not reappear until about January 30, while the midnight-sun period lasts from about May 4 to about August 7. At the beginning of this period the altitude of the sun does not exceed 33.4°, the maximum altitude being 40.1°. The length of the day in the two localities mentioned is illustrated in fig. 2.

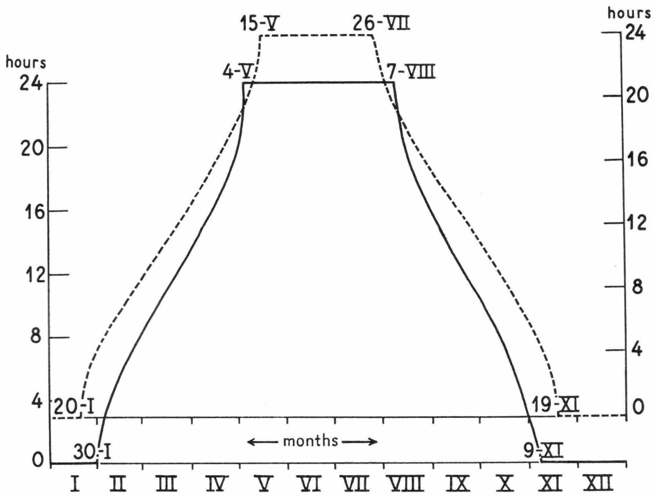


Fig. 2. Graphs illustrating the length of the day in lats. 70°30′ N. in Scoresby Sund (dotted line) and 73°20′ N. in the Kejser Franz Josephs Fjord district (solid line).

Among the factors affecting the light intensity it would be reasonable, in addition to the altitude of the sun, the snow-covered ice and the mud, to mention the fog banks occurring in particular near the outer coast, and the clouds. Finally, plankton and the occurrence of detritus may play a certain role.

5. The Bottom.

Both in Scoresby Sund and in the Kejser Franz Josephs Fjord district the bottom almost invariably consists of mud mixed with sand. At the mouth of Scoresby Sund (Kap Tobin—Kap Hope) the bottom is sandy owing to the movement of the water. On the face of it, it would seem reasonable to suppose that the districts would be little fit for algal vegetation.

A number of scattered stones occur, however, nearly always on the soft bottom, originating from the land and carried out by the ice.

To this should be added that in sheltered localities with shallow water there are often a great number of shells and minute stones.

Finally, in continuation of the rocky shore the bottom may be fairly stony. In some of the localities visited (Kap Tobin, Amdrups Havn, Bjørneøer, Vinterøer) such stony bottom continued until the depth was at least 30 m; in other localities the occurrence of stones was restricted to smaller depths.

III. THE ALGAL VEGETATION

1. Descriptions of the Vegetation.

A. Previous Investigations.

Part I (pp. 9—11) of the present work contains a review of the literature dealing with East Greenland's marine algae from a taxonomical point of view. In so far as the algal vegetation is concerned, our knowledge is very scanty and is, on the whole, restricted to rather few data in the papers mentioned below. Moreover, a couple of the taxonomical works (ROSENVINGE 1898; JÓNSSON 1904) contain information about the occurrence in nature of some of the species, based on observations made by the collectors, but no real descriptions of the vegetation are given.

On the basis of HARTZ' collections and observations ROSENVINGE (1898a) gives some particulars about the algal vegetation at Danmarks Ø. This locality is stated to be completely devoid of littoral vegetation (p. 190). From the sublittoral region records are given of a *Fucus inflatus* community ("Bælte", p. 210), a *Laminaria* community ("Formation") dominated by *Laminaria saccharina* f. *glacialis* (p. 212), a *Desmarestia aculeata* community ("Samlag", p. 218), and a community ("Formation") of loose-lying algae (pp. 219, 221). From a locality at Danmarks Ø a survey is given of the vertical distribution of the sublittoral algae (pp. 230—33) and a list is added, comprising the other algae recorded from Danmarks Ø but not found in the locality in question. Further comments on this survey are given on pp. 43 and 47 of the present work. In the same paper ROSENVINGE mentions, on the basis of BAY's collections, a supposed *Agarum* community ("Formation", p. 217) at Angmagssalik.

In ROSENVINGE 1910 (pp. 93—96) some particulars are given about the algal vegetation in the Danmarks Havn area in latitude approx. 76—$76^1/_2$° N., based on notes and collections made by LUNDAGER. Of special interest is the record of *Fucus inflatus* in the littoral region of this area (p. 96). Furthermore, the author ascertained several littoral algae in the material from one of the localities (p. 95).

KRUUSE 1912 (pp. 19—22, 24, 71, 86—87, 95—97, 99, 138, 140, 151, 154, 156, 160, 164, 167—69, 172, 177, 184, and 186) briefly describes the algal vegetation in a number of localities in which, in the years around the turn of the century, he collected most of the material later to be worked up by Jónsson (1904). In spite of their brevity several of these descriptions give a fairly good impression of the vegetation owing to the occurrence of large, easily recognized species. The localities involved are situated between approx. $65^1/_2$ and 67° N.

The short descriptions of algal vegetation available in Rosenvinge 1933 (pp. 3—4) refer to some localities between approx. 68 and $69^1/_2$° N. and are due to H. G. Wager; a photo by T. W. Böcher gives an impression of a littoral *Fucus vesiculosus* growth in a locality in latitude approx. $66^1/_3$° N.

Finally, it should be added that in a zoological work Thorson (1933, p. 53 ff.) mentions a *Desmarestia* [*aculeata*] zone, a *Fucus* [*inflatus*] zone and a "Red Algae" zone occurring at Ella Ø and in other localities in the Kejser Franz Josephs Fjord district. Both *Desmarestia* and *Fucus* occur so abundantly as to form algae meadows. While the *Fucus* and Red Algae zones are restricted to rocks and stones *Desmarestia* occurs on clay bottom. A parallel is drawn from these growths of *Desmarestia* to the boreal *Zostera* growths. In a paper published by the same author in 1934 (p. 54 ff.) mention is made of the vegetation of *Desmarestia*, *Fucus*, and "Red Algae" in Scoresby Sund.

B. Personal Observations.

The observations on the algal communities which I myself am in a position to add are not too many. Nevertheless, I feel justified in publishing them in the present work as they might be of some interest, but I want to point out that I do not aim at giving extensive sociological descriptions or at discussing the pertinent literature.

In his above-mentioned work (1898a), which deals mainly with West Greenland's algal vegetation, Rosenvinge distinguishes between a littoral and a sublittoral algal region. The upper limit of the former is fixed at the upper limit of the algal vegetation, which in West Greenland roughly coincides with high-water at neap-tide; the lower limit is fixed approximately at low-water at neap-tide. The sublittoral region extends from the latter tide-mark to the lower limit of the vegetation.

In my area, too, it is possible to distinguish between a littoral and a sublittoral region but it must be pointed out, before further comments are given, that owing to the short duration of the visits to the localities in which my material was collected I had no possibility of re-examining Rosenvinge's delimination of the littoral region in relation to the tide-marks or of making any investigations whatever of the littoral region. It has been necessary for me to adopt a less strict interpretation of the littoral region. Consequently, the upper limit of the sublittoral region cannot be exactly determined, either. It is, of course, regrettable that the lower limit of the littoral vegetation cannot be fixed exactly whereas, in the case of the upper limit of the sublittoral vegetation, a minor inexactitude is of less importance. In the following, I have designated the boundary between the littoral and the sublittoral region as "0 m".

In a single locality it was evident, however, that a littoral *Rhodochorton* vegetation extended somewhat beyond the upper limit of the littoral region as determined by Rosenvinge in relation to tide-marks. I prefer to regard this vegetation as supralittoral.

The vertical extension of the littoral region is rather small. According to Crone (1895, p. 4) the neap-tide at Danmarks Ø amounts to approx. 0.4 m, the spring-tide to approx. 1 m. Madsen (1936, p. 47) states that the tidal amplitude is about 1 metre in inner Scoresby Sund, at Fame Øer in Hurry Inlet, at Ella Ø, and in the inner part of Dusëns Fjord. Thorson (1934, p. 60), however, mentions that in the summer of 1933 he believed to note that in Hurry Inlet the tide was insignificant, owing to the strong outward surface current. Rouch (1954, p. 110) states the amplitude to be 1.10 m in Scoresby Sund.

The vegetation of the littoral region is very poor and as a rule feebly developed; it occurs as isolated growths encountered almost exclusively in sheltered localities and is a striking contrast to the abundant littoral vegetation of the North Atlantic. It differs also from the littoral vegetation recorded from localities farther south in East Greenland, where the *Fucaceae* may comprise *Fucus inflatus*, *F. vesiculosus*, and *Ascophyllum nodosum*.

The sublittoral region is of a considerable vertical extension, benthic algae being recorded down to a depth of 120 metres. In localities affording good conditions for algal growth the vegetation may be fairly abundant at depths down to 40 m while it is undoubtedly much more scattered at greater depths.

I encountered a total of 14 species in the littoral region: 10 Green Algae, 3 Brown Algae, and 1 Red Alga (besides a few Blue-green Algae). In the supralittoral region only the above *Rhodochorton* was observed. The number of species recorded in the sublittoral region amounts to 100, of which 16 are Green Algae, 53 Brown Algae, and 31 Red Algae.

Algal Communities of the Supralittoral Region.

A Rhodochorton purpureum Community was encountered in crevices and cavities at Ella Ø, passing directly over into the littoral *Rhodochorton* community.

Algal Communities of the Littoral Region.

The Calothrix scopulorum Community was the commonest of those occurring in the littoral region, which presumably is due to the small dimensions of the thallus. When inhabiting small crevices in rocks with an uneven surface *Calothrix* may avoid being scraped off by the ice. This community was as a rule unmixed and was best developed at Ella Ø, Danmarks Ø, and Bjørneøer. In the last-mentioned locality it was, however, somewhat mixed.

The Filamentous Green Algae Community was formed by *Ulothrix* or by *Ulothrix* and *Urospora.* It was observed only from July to the end of August and reached its optimum development at Kap Tobin and Scoresbysund, in which localities I encountered it on August 14 and 28, respectively. In Denmark these algae are present already early in the year, their development thus being retarded in East Greenland. The fact that *Urospora* occurs as late as the end of August, while in Denmark and South Norway it disappears already in late spring and early summer, is presumably ascribable to the low temperature of the water.

The littoral Rhodochorton purpureum Community was observed at Fame Øer and Ella Ø, in both localities represented by f. *intermedium*, forming dense, continuous growths which were encountered mainly in crevices and cavities where the humid air is retained. Hence, this community must be characterized as a shade vegetation. In both localities the *Rhodochorton* specimens were accompanied by *Calothrix scopulorum*, *Pleurocapsa amethystea*, and *Pylaiella*, at Ella Ø also by small quantities of *Rhizoclonium* and *Ulothrix*, and at Fame Øer also by *Enteromorpha clathrata.*

A feebly developed Fucus inflatus Community consisting of plants with a narrow frond, was encountered here and there. It grades directly over into the sublittoral *Fucus inflatus* community.

Algal Communities of the Sublittoral Region.

The Fucus inflatus Community is widely distributed and is encountered in nearly all sheltered or fairly sheltered localities with rocks or stones. It plays an important role, particularly at depths from approximately 0 m down to 3 m or a little below. In its uppermost part it may sometimes consist almost exclusively of the dominant species which most frequently is represented by rather low plants with a narrow frond.

When occurring a little below 0 m this community is mostly mixed with other species, the most important being *Pylaiella litoralis* and *Sphacelaria arctica*, both of which grow partly on *Fucus* plants, partly on rocks and stones. At Bjørneøer, the *Fucus* community occurring a little below 0 m contained the following species besides the two above-mentioned: *Scytosiphon lomentaria*, *Stictyosiphon tortilis*, *Punctaria plantaginea*, and *Spongomorpha vernalis*.

At slightly greater depths numerous species usually occur on or amid the *Fucus* plants. At depths greater than well over 3 m the *Fucus* plants are as a rule more scattered and the community becomes more mixed. In several localities a distinct *Fucus* community was, however, still encountered at depths of 6—9 m.

Also outside its community *Fucus inflatus* is of common occurrence. At the mouth of Hurry Inlet it was recorded at such a great depth as 35—38 m.

Besides on hard bottom, *Fucus inflatus* is encountered on soft bottom in protected localities up the fiords, where it may be abundant. In such instances the plants are, however, loose-lying or attached to very small stones; under such circumstances the plants may often be quiescent or partially decaying. This was the case i. a. at Danmarks Ø, at the head of Duséns Fjord at a depth of 15—25 m, and at Ella Ø at depths of 6—9 and 12—17 m.

The Laminaria Community, too, is widely distributed and was encountered in most of the more important localities though not at Bjørneøer, Rødeø, and Vinterøer. It was recorded at depths from less than 10 m down to below 30 m. The two predominant species are *Laminaria saccharina* and *L. solidungula*. While the former is encountered in outer as well as inner localities, the latter is chiefly restricted to outer Scoresby Sund where it plays an important role, particularly at greater depths.

Laminaria saccharina is usually represented by the high-arctic form *glacialis* which has hitherto been recorded only in Scoresby Sund and the Kejser Franz Josephs Fjord district. Its vertical distribution ranges from a few metres down to almost 40 m. In protected inner localities affording adverse conditions for growth the species may be represented by not quite well-developed individuals, possessing few haptera only. Such plants were found at Ella Ø and at the head of Duséns Fjord. In the protected locality at Fame Øer I found plants that exhibited a great number of long, branched, thin haptera which might be attached to a great number of quite small stones, gravel-particles, or shells, and might retain a clod of clay.

The other *Laminariaceae* encountered in my area, namely *L. digitata*, *L. groenlandica* (?), and *Saccorhiza dermatodea*, are of no importance in the community under consideration. *Alaria Pylaii*, which was found only in three outer localities in Scoresby Sund, is somewhat more important and was most abundant at Kap Tobin at not too great depths.

Among the other species occurring in the *Laminaria* community, *Fucus inflatus* and *Desmarestia aculeata* deserve to be mentioned; they are found chiefly in the upper part of the community which they may render fairly mixed. Another common species is *Chaetopteris plumosa* which often grows between the *Laminaria* haptera, as recorded from other waters too. This is frequently true also of *Polysiphonia arctica*. At greater depths in outer Scoresby Sund several of the Red Algae dominating the sublittoral community of Florideae may be of fairly great importance.

While *Laminaria solidungula* only seldom is inhabited by other species, *L. saccharina*—in particular its lamina—often serves as substratum to a great number of smaller Brown Algae. Among these, special mention should be made of *Litosiphon filiformis* which formed dense growths at the head of Duséns Fjord and at Fame Øer, and of *Laminariocolax tomentosoides* which was abundant in the former locality.

The Punctaria glacialis Community was encountered only at Vinterøer at a depth of 14—18 m. The dominant species by far outnumbered the accompanying species, among which the only larger was *Desmarestia viridis* (and *D. aculeata*). On the other hand, *Punctaria glacialis* served as host to a number of smaller Brown Algae. In that locality this community seems to replace the *Laminaria* community.

Punctaria glacialis is widely distributed in my area where it was recorded at depths between 4—6 m and 35—38 m. Besides at Vinterøer it was abundant also at the mouth of Hurry Inlet and at Kap Hope. It does not extend south of Scoresby Sund and is, so far, unknown outside of North East Greenland.

The Desmarestia aculeata Community is of great importance in sheltered localities on soft bottom up the fiords where it may be distributed over large areas. The *Desmarestia* plants are either attached to small stones and shells or occur loose-lying; they are as a rule less well-developed and less sturdy than normal, and they are often quiescent. This type of *Desmarestia* communities was encountered at Danmarks Ø at depths of 5 m and 15—16 m, at the head of Duséns Fjord at a depth of 15—25 m, and at Ella Ø, where it extends to a depth of 40 m.

This community was observed also on rocks and stones in outer Scoresby Sund where the *Desmarestia* plants were typical and vigorously developed. In Amdrups Havn it occurred at depths of 14—16 m and 22—25 m, and at Kap Tobin at a depth of 17—21 m. Both on hard and on soft bottom the community may be almost unmixed; in other cases it may contain *Fucus*, *Laminaria*, and other algae. The *Desmarestia* plants are, however, almost invariably inhabited by a great number of epiphytic Brown Algae.

Also outside its community *Desmarestia aculeata* is an important alga. Its vertical range is from some 4 m to at least 40 m though it seems to be most abundant between 10 and well over 20 m.

The Sublittoral Community of Florideae is encountered chiefly at greater depths in outer Scoresby Sund where it extends to some 40 m though some of its components are found also below that depth. The most important species are *Phycodrys rubens*, *Phyllophora Brodiaei* f. *interrupta*, *Turnerella Pennyi*, and *Euthora cristata*. Mention should also be made of *Polysiphonia arctica*, *Rhodomela lycopodioides*, *Dilsea integra*, and species of the genus *Lithothamnion*.

The community may often be almost unmixed. In some cases the dredge would contain almost exclusively one of the species. Thus, a dredging at a depth of 33 m at Amdrups Havn yielded almost solely *Turnerella Pennyi*, represented by large specimens.

In several instances this community contains also representatives of *Laminaria solidungula*, *L. saccharina*, *Alaria Pylaii*, *Desmarestia viridis*, *D. aculeata* and others and, as already mentioned, several of the above Red Algae may in return play an important role in the *Laminaria* community.

It is noteworthy that *Phycodrys rubens* plays a much more important role in the Florideae community in East Greenland than is the case in West Greenland. According to Rosenvinge (1898a, p. 223) the most predominant components of the community when occurring in West Greenland are *Ptilota pectinata*, *Euthora cristata*, and *Rhodophyllis dichotoma*.

The Community of Crust-Forming Algae. The most important species in this community are the two Red Algae *Lithothamnion laeve* and *L. foecundum*, and the Brown Alga *Lithoderma* s. lat. It is impossible to determine with certainty which species are represented by the latter, as practically all the crusts are sterile. The following species are, however, recognized from the area under consideration: *Lithoderma fatiscens* Aresch., *Pseudolithoderma extensum*, and *Ps. Rosenvingii*.

The community is undoubtedly widely distributed, but it is rarely unmixed. When occurring at greater depths in outer Scoresby Sund it is particularly characterized by the above two *Lithothamnion* species, but in this area it frequently constitutes only a part of the sublittoral community of Florideae. As far as could be ascertained, *Lithoderma* s.lat. is of greatest importance at not too great depths.

At a depth of 11—28 m at Bjørneøer a community of crust-forming algae was found, in which the predominant species were *Lithothamnion laeve*, *L. foecundum*, *L. glaciale*, and *Lithoderma* s. lat. It was characteristic in being almost devoid of species with erect thallus. This is presumably due to the fact that the crust-forming algae had almost completely overgrown the surface of the stones. Among the other crust-forming algae occurring in this locality was *Petrocelis polygyna*. This species occurred in greater quantities here than elsewhere but was, nevertheless, of no importance within the community.

In the lower part of the community of crust-forming algae also *Cruoria arctica* occurs; it is of most importance in Scoresby Sund. This alga is by far the commonest of the crust-forming uncalcified Red Algae. It seems always to grow on a calcareous substratum (cf. ROSENVINGE, 1910, p. 102) and was almost invariably found on *Lithothamnion*, less frequently on shells of barnacles.

Loose-lying Algae.

In the foregoing it has been mentioned that in protected localities up the fiords, where the bottom is soft, both *Fucus inflatus* and *Desmarestia aculeata* may occur abundantly as loose-lying individuals. This applies, however, not only to these species as many others may occur in the same manner—though by no means in such great quantities.

By way of example should be mentioned *Stictyosiphon tortilis*, one of the commonest algae in the districts examined, which even as a rule is encountered unattached. Another species is *Dictyosiphon foeniculaceus* which I found loose-lying in Nordbugten to a depth of at least 3 m, represented by f. *flaccidus* attaining a considerable length. Mention should also be made of *Sphacelaria arctica*.

In addition to the above species, all of which are Brown Algae, mention should be made of the Green Alga *Chaetomorpha melagonium* and the Red Algae *Phyllophora Brodiaei* f. *interrupta*, *Phycodrys rubens*, *Rhodomela lycopodioides*, *Turnerella Pennyi*, and *Halosaccion ramentaceum*.

Off Kap Hope I found some peculiar, fairly small, rounded balls consisting chiefly of fragments of *Chaetopteris*, *Sphacelaria*, and *Stictyosiphon*, though fragments of *Desmarestia aculeata*, *Pylaiella*, *Polysiphonia arctica*, and *Rhodomela* might also occur. These balls have obviously acquired their shape by being rolled along the sandy bottom by the currents.

2. Observations on the Algae in Relation to External Factors.

When the distribution of the algae is considered from a hydrographical point of view, it appears that a good deal of the species occur in both the fiord-water layer and the Polar Current water. This is true of arctic and subarctic as well as boreal-arctic species. Such species, in particular those which extend into the littoral region (e.g.

Fucus inflatus), must therefore be tolerant as regards both temperature and salinity.

On the other hand, a number of species were not found above a certain depth, and several of them must be supposed to live throughout the year in Polar Current water or to be exposed to the lower part of the fiord-water layer for a short period only. The vegetation occurring only in the Polar Current water lives under almost constant conditions as regards temperature and salinity. Such plants spend the whole of their life in water the temperature of which never becomes positive (cf. ROSENVINGE 1898a, p. 233). Conditions in the lower part of the fiord-water layer do not differ essentially, though for a short period in summer the temperature increases slightly and the salinity decreases a little.

Nearly all of these species are subarctic or arctic. Among the arctic species may be mentioned *Omphalophyllum ulvaceum*, *Laminaria solidungula*, *Lithothamnion foecundum*, *Cruoria arctica*, *Turnerella Pennyi*, *Arthrochaete penetrans*, and *Punctaria glacialis*. With the exception of the last-mentioned two, these species are known also from localities outside of East Greenland, and in most of these localities they occur in water of higher temperatures.

Among the subarctic species mention should be made of *Desmarestia viridis*, *Rhododermis elegans*, *Lithothamnion laeve*, *L. glaciale*, *L. tophiforme*, *L. compactum*. Other subarctic Red Algae, such as *Audouinella efflorescens* and *Euthora cristata*, are at small depths represented only by few specimens while their main distribution is at greater depths.

The absence at small depths of the above arctic and subarctic species is perhaps ascribable chiefly to the reduction in salinity taking place in summer.

Finally, there are some species which seem to be restricted to the fiord-water layer. This is the case with the two Brown Algae *Sorocarpus uvaeformis* and *Hecatonema maculans*, both of which have a more southern distribution and have not formerly been observed in the Arctic. Their occurrence in the fiord-water layer in East Greenland is, most probably, conditioned by the positive temperature of this layer, so that they are not, in fact, exposed to arctic conditions at all. Both species were found at Ella Ø at depths between 2—5 and 10 m, while the latter was observed also at Vinterøer at a depth of 2—3 m and at Rødeø at a depth of 1—2 m.

When the extensive vertical range of the algal vegetation is considered in relation to the light it would seem justified to suppose that, at the low temperatures prevailing, a number of species must possess a surprising adaptability to low light intensities. It is, incidentally, not only at the mouths of the fiords and at the open shore that the algae extend to surprising depths; also up the fiords they are met with at appreciable depths.

Considering the long duration of the snow-covered ice and the presence of the mud it may be regarded as rather surprising that attached algae were encountered at depths down to 40 m at Rødeø in the innermost part of Scoresby Sund. From this depth was collected a small stone inhabited by a crust-forming *Lithothamnion*. In the same locality several small stones were taken from depths between 32 and 35 m, most of them overgrown by *Lithoderma* s. lat., in addition to which I found a few, mainly small crusts of *Lithothamnion* and some few, thin shoots of *Sphacelaria arctica*. A stone collected at a depth of 34 m was inhabited by *Rhododermis elegans* and by a *Lithothamnion* crust which, in its turn, served as host to small representatives of *Omphalophyllum ulvaceum*.

At Ella Ø at depths of more than 40 m were found attached, cystocarpic specimens of *Turnerella Pennyi* inhabited by many epiphytes such as *Giffordia ovata*, *Omphalophyllum ulvaceum*, *Audouinella efflorescens*, *Pylaiella litoralis*, *Symphyocarpus strangulans*, and *Sorapion Kjellmanii*. Further, these plants served as hosts to *Arthrochaete penetrans* and *Chlorochytrium inclusum*. The same dredging also yielded stones and shells inhabited by *Lithothamnion* and *Lithoderma* s. lat. From a depth of more than 50 m in the same locality cystocarpic specimens of *Phycodrys rubens* were collected.

Incidentally, it appears from a zoological work (THORSON, 1933, p. 58) that the algal vegetation at Ella Ø extends to considerable depths, Red Algae being stated to occur at a depth of 80—85 m. No information is given about the name(s) of the species, but most likely *Turnerella* was involved.

At the open coast, off Rathbone Ø, a stone taken from a depth of 70 m was inhabited by a small *Turnerella Pennyi* plant, *Lithothamnion foecundum*(?), and *Cruoria arctica*. Off Kap Tobin at the mouth of Scoresby Sund a stone collected at a depth of 50 m was inhabited by *Lithothamnion laeve*, *L. foecundum*, and *L. glaciale*, and also by a bryozoan on which grew *Antithamnion boreale*, *Omphalophyllum ulvaceum* germlings, young shoots of *Sphacelaria arctica* (or *Chaetopteris plumosa*) as well as germlings of an undeterminable Red Alga. The same stone also bore an ascidian which served as host to *Antithamnion*.

Likewise off Kap Tobin, at a depth of 120 m, were collected stones on which the following species were found: *Lithothamnion laeve*, *L. foecundum*, *Cruoria arctica* (inhabited by *Chlorochytrium Schmitzii*), and *Lithoderma* s. lat. exhibiting peculiar, low cells. This depth is the greatest at which attached algae are known to occur in the Arctic. The locality is indicated by THORSON (1934, pl. 6) as one of the stations located in the section across Scoresby Sund near its mouth.

As all of the above-mentioned collections, with the exception of those made at Ella Ø, were made by means of the Petersen grab the exactitude of the depth records cannot be disputed. It is also beyond doubt that the algae have actually grown at the depths from which they were collected as all of them were quite normally developed (though some of them were feebly developed); hence, it is out of the question that the stones, while inhabited by the algae involved, had occurred at smaller depths from which the ice could have transferred them to greater depths. It should, moreover, be pointed out that the collections made at Kap Tobin yielded not merely one stone inhabited by algae, but several. Consequently, the collections mentioned in the foregoing substantiate that arctic marine algae actually are capable of living at considerable depths. The maximum depth at which attached algae may be found in arctic waters will have to be determined through future investigations.

Even when taking it for granted that the deep-water algae possess a considerable adaptability to low light intensities it is difficult to imagine that the penetrating light should be sufficient to enable the algae at such a considerable depth as 120 m to lead an autotrophic existence. The light intensity at this depth must be extremely low even during the short optimum period.

It is true that at Kap Tobin the water is conspicuously transparent in spring and autumn. Thus, during his one-year stay at Rosenvinges Bugt, from August 1950 to 1951, DIGBY (1953) made observations with a 30 cm Secchi disc which on March 10 was visible at a depth of 30 m, in water of a very clear, deep blue colour. From the end of September to mid-November the disc was visible to 18—20 m, at the beginning of July to 10 m and in mid-August to 20 m. The reduced transparency in summer is due to the melting. The pronounced transparency at other times of the year may be ascribable to the absence of "Gelbstoffe" (GESSNER, contribution to discussions at the Botanical Congress in Paris, 1954).

Further, light conditions in this locality—considering its high latitude—are fairly favourable throughout part of the year. As indicated by DIGBY, the sun shone brightly during the early spring months, owing to clear atmospheric conditions, whereas there were some cloudy and foggy days in June and particularly in July and August.

Finally, it seems to be a fact that the photosynthesis of marine algae in northern waters benefits from the coincidence of reduced light intensity and low temperatures. This was substantiated through experimental investigations carried out with marine algae in nature in Oslo Fjord and Trondhjems Fjord by PRINTZ (1939) who found that at a given, low altitude of the sun their capability of photosynthetic exploitation of the light on bright, sunny days is considerably larger in autumn and winter than in summer. That author is of the opinion that this must be attributed chiefly to the lower temperature, and in this connexion he refers to the fact that decreasing temperatures are first and foremost reflected in a reduction of the respiration of the algae, manifesting itself in an increase in the ratio $\frac{\text{assimilation}}{\text{respiration}}$, which makes an assimilation surplus in winter possible.

Nevertheless, the possibility suggests itself that the algae in question are, in fact, mixotrophic. The photosynthesis might even be of secondary importance as compared with the absorption of organic matter directly from the bottom of the sea.

Incidentally, the assumption that deep-water algae may be mixotrophic finds a parallel in RODHE's (1955, p. 119) statements concerning the supposed capability of minute planktonic Green Algae to proliferate on the basis of dissolved organic matter during the dark season when they occur beneath snow-covered ice in subartic lakes in Swedish Lapland, some 200 km north of the Polar Circle. In April, when the cover of ice and snow did not prevent the admission of light, two maxima were often observed, one in the upper layers and another in the deepest layers. The upper maximum is ascribed to photosynthesis, the lower is supposed to owe its existence to heterotrophy.

As the present author is not a physiologist I cannot discuss the possible occurrence of mixotrophy in deep-water algae but shall content myself with referring to the interest connected with investigations of this problem, including measurements of the submarine light.

IV. THE PHYTOGEOGRAPHIC POSITION OF THE ALGAL FLORA IN THE SCORESBY SUND AND KEJSER FRANZ JOSEPHS FJORD DISTRICTS

1. The Composition of the Flora of the Two Districts, Considered as a Whole.

For the purpose of throwing light on the phytogeographic position of the algal flora of the districts examined I have prepared Table 1. This table furnishes a review of the distribution of the species in some arctic and North-Atlantic areas, in the Mediterranean as well as in my districts; on the basis of this review the distributional type of each species is indicated. In conclusion, it will be possible to determine the share of each distributional group in the flora.

Børgesen & Jónsson (1905) published a schematic survey of the distribution in the Arctic and the northernmost part of the Atlantic of the species recorded from these waters. In a system of columns they indicate from which areas the individual species are recorded. With a view to my investigations it is of particular interest to show in which of their areas my species occur, and I have therefore in Table 1 included most of these columns which I have brought up to date and, for the sake of clearness, render in almost the same order of succession.[1])

The exact determination of the distribution of the species may, however, be hampered by the fact that in some cases the specific delimination may vary from one author to another. Likewise, literature may contain erroneous, or at least insufficient or not very reliable, identifications so as to prevent an exact determination of the distribution. Moreover, a particular species may be described under different names from different areas without it being possible to substantiate the identity (this applies e. g. to some of the members of the genus *Ulothrix*) and, finally, the absence of a species from a floral list cannot, of course, always be interpreted as a proof of its not being present in the area under consideration. Quite naturally, it is mostly small-sized species that are subject to oversight. Nevertheless, with some reservations the

[1]) While this paper was in the press Dr. A. Zinova, Leningrad, was kind enough to revise the information in Table 1 regarding Green Algae in Russian waters and to add some hitherto unpublished findings.

Table 1. The Geographic Distribution of the Species.

	Kara Sea	Barents Sea	White Sea	Spitsbergen	Jan Mayen I. and Bear Island	West Greenland	Arctic N. E. America	Atlantic N. E. America	N. and E. Iceland	S. and W. Iceland	Faroes	North Norway	West Norway	Skagerak, Kattegat and Baltic	North Sea	West Coast of England and Scotland, Ireland	Channel	W. France, N. and N. W. Spain	Mediterranean Sea	Canary Islands	Scoresby Sund		Kejser Franz Josephs Fjord District	Distributional Group
																					Outer	Inner		
Chlorophyceae	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Chlorochytrium inclusum	+	+	+	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
Ch. Schmitzii	..	+	..	..	+	+	..	+	..	+	..	..	..	..	..	..	..	..	..	..	+	+	+	sa
Ch. dermatocolax	+	+	..	..	..	+	..	..	+	+	..	..	+	+	+	+	..	..	..	..	+	+	+	sa
Gomontia polyrhiza	..	..	..	..	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	(+)	ba
Ulothrix flacca	..	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	+	ba
U. pseudoflacca	+	+	+	..	..	+	..	..	+	+	+	..	+	+	+	+	+	..	+	..	+	..	+	ba
U. consociata	..	+	..	..	..	+	..	..	+	..	+	+	+	+	+	+	+	..	..	..	..	+	(+)	sa
U. subflaccida	..	..	+	..	..	+	..	..	+	..	..	..	+	+	+	+	+	+	+	..	+	..	..	ba
Monostroma fuscum	..	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	+	..	..	sa
Enteromorpha prolifera	..	+	+	..	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	(+)		+	ba
E. clathrata	..	+	+	+	..	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	ba
Bolbocoleon piliferum	..	..	+	..	..	+	..	+	+	+	+	+	+	+	+	+	+	+	..	..	..	+	+	sa
Epicladia flustrae	..	+	..	..	..	+	..	+	..	..	..	..	+	+	+	+	+	+	+	..	+	..	(+)	ba
Pseudendoclonium submarinum	..	..	..	..	..	..	..	+	+	..	..	..	+	+	..	..	+	..	..	..	+	..	(+)	sa
Arthrochaete penetrans	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	+	+	a
Chaetobolus gibbus	..	..	..	..	..	+	..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	+	..	sa
Pringsheimiella scutata	..	+	+	..	..	+	..	+	..	+	+	..	+	+	+	+	+	..	+	..	(+)		+	ba
Pseudopringsheimia confluens	..	..	..	..	+	+	..	..	..	..	+	..	+	..	..	..	+	..	?	..	+	..	..	sa
Ps. fucicola	..	..	..	..	..	+	..	..	+	+	+	..	+	+	+	+	..	..	..	..	+	..	..	sa
Urospora penicilliformis	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	..	..	sa
Chaetomorpha melagonium	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
Rhizoclonium riparium	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	(+)		+	ba
Acrosiphonia incurva	..	..	..	..	..	+	?	?	+	+	+	+	..	..	?	+	..	..	..	..	+	..	+	sa

II

Table 1.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Spongomorpha vernalis	..	..	..	..	..	+	..	..	..	+	+	..	..	+	..	..	..	..	..	..	..	+	..	sa
Ostreobium Queketti	..	..	..	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	+	(+)	ba
Phaeophyceae																								
Pylaiella litoralis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	ba
Isthmoplea sphaerophora	+	..	+	..	..	+	..	+	+	+	+	+	+	+	+	+	+	..	..	..	+	..	..	sa
Ectocarpus confervoides	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	ba
Giffordia ovata	..	..	..	+	+	+	..	+	..	..	..	+	+	+	+	+	..	..	..	..	+	+	+	sa
G. intermedia	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	..	+	sa
Feldmannia desmarestiae	..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..	..	+	..	+	sa
Laminariocolax tomentosoides	..	+	..	..	..	+	+	+	+	+	+	..	+	+	+	+	+	..	..	..	+	..	+	sa
Sorocarpus uvaeformis	..	..	..	..	..	..	..	+	..	..	..	..	..	+	+	+	+	..	..	..	..	..	+	sa
Hecatonema maculans	..	..	+	..	..	..	..	+	..	..	..	..	+	+	+	+	+	..	..	+	..	+	+	ba
Entonema aecidioides	..	+	+	..	..	+	..	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
Phaeostroma pustulosum	..	..	..	..	..	+	..	..	+	+	..	..	+	+	+	+	+	..	..	..	+	+	+	sa
Ph. parasiticum	..	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	..	..	+	..	+	sa
Ph. endophyticum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	+	a
Ectocarpus helophorus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	+	..	..	..	..	+	+	+	sa
Symphyocarpus strangulans	..	..	..	..	..	+	..	..	..	..	..	..	+	+	+	+	..	+	..	..	+	+	+	sa
S. longisetis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	a
Sorapion Kjellmanii	..	+	+	..	..	+	+	..	..	..	+	..	..	+	?	..	..	..	..	..	+	+	+	sa
Lithoderma fatiscens	}+	}+	}+	+	..	}+	}+	}+	}+	}+	}+	}+	..	+	..	}+	..	..	..	..	+	..	+	sa
Pseudolithoderma extensum	}	}	}	..	..	}	}	}	}	}	}	}	+	+	+	}	+	..	..	..	..	+	+	sa
Ps. Rosenvingii	..	..	+	..	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..	..	+	+	+	sa
Jonssonia pulvinata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	a
Haplospora globosa	+	+	+	+	..	..	+	+	..	..	..	+	+	+	+	+	+	..	..	..	+	+	+	sa
Sphacelaria arctica	+	+	+	+	..	+	+	..	..	..	..	+	..	+	..	..	..	..	..	..	+	+	+	sa
Chaetopteris plumosa	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	+	+	+	sa
Delamarea attenuata	..	+	..	+	..	+	..	+	..	..	..	+	..	+	+	..	..	..	..	..	+	+	..	sa
Scytosiphon lomentaria	..	+	+	..	..	+	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	ba
Dermatocelis laminariae	..	..	..	..	..	+	..	..	..	+	..	..	..	..	..	..	..	..	..	..	+	..	..	sa

(continued)

Table 1 (cont.).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Ascocyclus foecundus	..	+	..	..	..	..	..	+	+	..	+	+	+	+	?	+	+	+	..	..	..	..	+	sa
Microspongium globosum	..	..	..	..	..	+	..	+	+	+	+	..	+	+	?	+	+	..	..	..	..	+	+	sa
Leptonema fasciculatum	..	+	..	..	..	+	..	+	+	+	+	+	+	+	+	+	+	..	..	..	+	+	+	sa
Elachista fucicola	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
Eudesme virescens	..	+	+	..	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	+	..	..	ba
Chordaria flagelliformis	..	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	+	+	+	sa
Desmarestia aculeata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
D. viridis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
Stictyosiphon tortilis	+	+	+	+	..	+	+	+	+	+	?	+	..	+	+	+	?	..	..	..	+	+	+	sa
Punctaria plantaginea	..	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	+	+	+	sa
P. glacialis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	+	+	a
Omphalophyllum ulvaceum	..	+	..	..	+	+	+	+	+	..	..	..	..	..	..	..	..	..	..	..	+	+	+	a
Litosiphon Mortensenii	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	..	+	sa
L. groenlandicus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	+	+	a
L. subcontinuus	..	..	..	..	..	+	..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	+	+	sa
L. filiformis	..	..	..	..	..	+	+	+	+	+	+	..	+	+	+	+	+	..	..	..	+	..	+	sa
Dictyosiphon foeniculaceus	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	+	+	+	sa
Chorda filum	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
Ch. tomentosa	..	+	+	..	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	(+)		+	sa
Saccorhiza dermatodea	+	+	+	+	+	+	+	+	+	+	..	+	..	..	..	..	..	..	..	..	+	..	..	sa
Laminaria solidungula	+	+	..	+	+	+	+	..	..	..	..	..	..	..	..	..	..	..	..	..	+	+	+	a
L. saccharina	..	+	+	..	..	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
L. groenlandica	..	..	..	..	..	+	?	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	a
L. digitata	+	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	..	(+)	sa
Alaria Pylaii	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	..	..	..	+	+	+	sa
Fucus inflatus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	+	+	+	sa
Rhodophyceae																								
Conchocelis rosea	..	..	..	..	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	+	+	(+)	sa
Acrochaetium parvulum	..	}+	}+	..	..	+	..	..	+	..	..	+	+	+	+	?	+	..	+	+	+	+	+	ba
A. hallandicum	..			..	..	..	+	..	..	..	..	..	+	+	?	?	+	+	..	..	+	..	..	sa

Table 1.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Audouinella efflorescens	+	+	+	+	..	+	+	..	..	..	+	+	..	+	+	..	+	..	..	..	+	+	+	sa
A. membranacea	..	..	..	..	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	..	+	+	+	ba
Rhodochorton purpureum	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	+	+	+	ba
Rh. penicilliforme	+	+	+	+	+	+	+	+	+	+	+	+	+	+	?	..	+	+	..	..	+	..	(+)	sa
Dilsea integra	+	+	..	+	..	+	+	..	..	..	..	..	..	..	..	..	..	..	..	..	+	+	(+)	a
Peyssonnelia Rosenvingii	..	+	..	..	..	+	..	+	+	+	..	+	..	..	+	?	+	..	..	..	+	+	+	sa
Rhododermis elegans	..	?	..	..	..	+	+	+	..	..	+	..	+	+	+	+	+	..	..	..	..	+	+	sa
Halosacciocolax Kjellmanii	..	..	..	+	..	..	..	?	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	a
Hildenbrandia prototypus	..	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	ba
Lithothamnion laeve	?	?	+	+	..	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	+	+	+	sa
L. foecundum	+	+	+	+	..	+	+	+	+	..	..	+	..	..	..	..	..	..	..	..	+	+	+	a
L. glaciale	..	+	+	+	+	+	+	+	+	+	+	+	+	..	?	+	..	..	..	..	+	+	(+)	sa
L. tophiforme	..	+	+	..	..	+	..	+	+	+	..	+	..	..	..	+	..	..	..	..	..	+	(+)	sa
L. investiens	..	+	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	..	..	+	..	sa
L. compactum	+	+	+	+	..	+	+	+	+	+	+	+	+	..	?	+	..	..	..	..	..	+	..	sa
Euthora cristata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	+	+	(+)	sa
Harveyella mirabilis	..	+	..	..	..	+	..	+	..	..	+	+	+	+	+	+	+	..	..	..	+	+	+	sa
Cruoria arctica	..	..	..	..	+	+	+	..	..	+	..	..	..	..	..	..	..	..	..	..	+	+	+	a
Petrocelis polygyna	..	..	..	..	..	..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	+	+	+	a
Turnerella Pennyi	+	+	?	+	+	+	+	..	+	..	..	+	+	..	..	..	..	..	..	..	+	+	+	a
Phyllophora Brodiaei	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	+	+	+	sa
Ahnfeltia plicata	+	+	+	+	..	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	..	..	ba
Ceratocolax Hartzii	+	+	+	..	..	+	+	..	..	+	..	..	+	+	+	?	..	..	..	..	+	+	(+)	sa
Halosaccion ramentaceum	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	..	..	..	+	+	(+)	sa
Antithamnion boreale	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	+	+	+	sa
Phycodrys rubens	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	+	sa
Polysiphonia arctica	+	+	+	+	+	+	+	..	+	+	..	+	..	..	..	..	..	..	..	..	+	+	+	a
Rhodomela lycopodioides	+	+	+	+	..	+	+	+	+	+	+	+	+	+	+	+	..	..	..	..	+	+	+	sa

review contained in Table 1 must be considered a fairly reliable survey of the distribution of the species in the areas concerned.

Among the species in my area whose distribution is difficult to determine should be mentioned *Acrosiphonia incurva*. Most probable this species is more widely distributed than stated by me, as several authors may have retained it in *Cladophora* (*Spongomorpha*) *arcta*. Mention should also be made of *Spongomorpha vernalis* which is sparsely commented on in literature and perhaps not always regarded as a distinct species. As for "*Lithoderma*" is has been possible to ascertain in few cases only whether *Lithoderma fatiscens* or/and *Pseudolithoderma extensum* was involved. In more than half the columns I have, therefore, had to insert a brace opposite these two species and indicate with a single cross the record of an unidentified "*Lithoderma*" species. Likewise, the distribution of *Stictyosiphon tortilis* may be somewhat uncertain since this species has often been confused with *Stictyosiphon subarticulatus*. The former is stated to be restricted to the Arctic and the Baltic, whereas the latter is an Atlantic species. On the other hand, it may be questionable whether it is warranted to keep the two species distinct since the difference between them is insignificant (cf. e. g. KYLIN, 1947, p. 68). Finally, *Lithothamnion glaciale* and *L. tophiforme* should be mentioned.

In their phytogeographical analyses of Greenland's algal flora KUCKUCK (1897c, p. 37) and ROSENVINGE (1898a, p. 165 et seq.; 1910, p. 99) distinguish between arctic, subarctic and North-Atlantic species. BØRGESEN & JÓNSSON (1905, p. XXII), who ascertained the number of Brown and Red Algae recorded from East and West Greenland, classified them according to a similar principle. These authors recognized five distributional groups, viz. the arctic, subarctic, boreal-arctic, cold-boreal, and warm-boreal groups, of which only the first four were represented in Greenland.

The arctic group comprises the species restricted to the Arctic. The southern limit of the arctic area is stated to extend east and north of North Norway to Iceland's southeastern point from where it extends north of Iceland, between Iceland and Greenland, toward south and west to North America where the southern limit is not indicated; it will, however, most likely be found near North Newfoundland and Labrador (cf. TAYLOR, 1937, p. 2).

The species of the subarctic group are common in the Arctic and fairly common in the North Atlantic as far south as the Faroes and Nordland (Norway) or England and Western France or, if not of common occurrence, equally frequent in the Arctic and the North Atlantic.

The boreal-arctic species are common in the Arctic and the North Atlantic and extend at least to North Africa. Some of them might be regarded as cosmopolitan.

Species designated as cold-boreal are stated to be distributed from Western France-England to South Iceland, the Faroes, and Nordland-Finmarken. Some cold-boreal species have occasionally been encountered in the Arctic, particularly in the White Sea and the Murman Sea, and a few of them extend as far south as the Mediterranean or North Africa.

Finally, the warm-boreal species extend from South Iceland, the Faroes, Norway or Scotland at least to North Africa and the Mediterranean.

While the terms arctic and subarctic as employed by KUCKUCK and ROSENVINGE correspond with the same terms as used by BØRGESEN & JÓNSSON, the term "North-Atlantic" corresponds fairly well with BØRGESEN & JÓNSSON's boreal-arctic, cold-boreal, and warm-boreal groups.

Since then, BØRGESEN & JÓNSSON's grouping has been generally adopted, also in recent literature, and it is, on the whole, employed by the present author. Though the grouping as such has proved to be valid, the delimination of one of the groups, i. e. the cold-boreal, is unsatisfactory. The species within this group ought not to occur in the Arctic and the Mediterranean alike, without any reservations being made. If this group is recognized for the Arctic it must be on the assumption that, when occurring in these waters, its species are confined to the fiord-water layer so that they are not exposed to true arctic conditions. Likewise, it will not be justified to recognize the occurrence of cold-boreal species in the Mediterranean unless they occur only during the coldest season. Thus, they cannot be considered typical for the Mediterranean.

Personally I prefer, however, to disregard the cold-boreal group in so far as the Arctic is concerned and to designate as subarctic the species that have their main distribution in West Europe but are found also in the fiord-water layer in the Arctic.

In the case of the subarctic group, too, I judge a revision of the delimination advisable. In my opinion it would be more natural to place its southern limit south of Vigo in northwestern Spain, as the algal flora on the Spanish north west coast at Vigo resemble that occurring on the coast of Britanny (HAMEL, 1929, p. 95). Not until some way down the Iberian coast does the flora change its character.

I have referred to the boreal-arctic group a few species which, although undoubtedly being boreal-arctic, have not yet been recognized on the North African Atlantic coast. The species involved have, however, been encountered in the Mediterranean.

Though as a rule the arctic species do not occur outside of the Arctic a few of them may extend beyond the southern limit. Among the species occurring in BØRGESEN & JÓNSSON's list this applies e. g.

to *Turnerella Pennyi* which extends a branch along the Norwegian west coast where it was recently recorded as far south as somewhat south of Bergen by WENNBERG (1950, p. 300) as *T. septentrionalis*. The plants involved presumably represent a physiological type having adapted itself to the conditions prevailing outside of the Arctic. At any rate it would be natural to assume that evolution of new types is still going on.

It is evident that the increased knowledge of the algal distribution, gained over the last fifty years, has proved that a number of species do actually belong to another distributional type than that indicated by BØRGESEN & JÓNSSON. Several revisions affecting the species recorded by me have already been mentioned in literature and, in addition, I have found it necessary to change the distributional type of a number of species.

To get an idea of the phytogeographical composition of the flora, based on Table 1, I have in the lists on pp. 35—36 enumerated the species in accordance with their distributional types. The lists indicate that among the total number of 109 species the arctic group constitutes 15 $^0/_0$ (16 species), the subarctic 67 $^0/_0$ (73 species), and the boreal-arctic 18 $^0/_0$ (20 species).

Thus, the subarctic group is by far the most important and among its 73 species the Brown Algae are predominant, being represented by 40 species. The Red Algae, represented by 19 species, come next while the Green Algae are represented by 14 species.

The arctic and boreal-arctic groups are almost equal in number, but while the Brown Algae are predominant within the former group, closely followed by the Red Algae, these two classes are of minor importance within the latter group. In this group the Green Algae are most numerous, comprising the same number of species as the Brown and Red Algae together. The Green Algae are quite insignificant within the arctic group, being represented by one species only.

From a phytogeographical point of view the flora must, therefore, be characterized as arctic-subarctic. The share of subarctic and arctic species in the flora is no less than 82 $^0/_0$ (89 species) while that of boreal-arctic species amounts to merely 18 $^0/_0$ (20 species). With regard to systematics, the Brown Algae are represented by 53 species, 49 $^0/_0$ or almost half the total number of species, while the 31 Red Algae constitute 28 $^0/_0$ and the 25 Green Algae 23 $^0/_0$ of the flora. The ratio between Red Algae and Brown Algae amounts to 0.6.

ARCTIC GROUP: 16 Species (= 15 %).

Chlorophyceae (1 Species):
Arthrochaete penetrans

Phaeophyceae (8 Species):
Phaeostroma endophyticum
Symphyocarpus longisetus
Jonssonia pulvinata
Punctaria glacialis
Omphalophyllum ulvaceum
Litosiphon groenlandicus
Laminaria solidungula
L. groenlandica

Rhodophyceae (7 Species):
Dilsea integra
Halosacciocolax Kjellmanii
Lithothamnion foecundum
Cruoria arctica
Petrocelis polygyna
Turnerella Pennyi
Polysiphonia arctica

SUBARCTIC GROUP: 73 Species (= 67 %).

Chlorophyceae (14 Species):
Chlorochytrium inclusum
Ch. Schmitzii
Ch. dermatocolax
Ulothrix consociata
Monostroma fuscum
Bolbocoleon piliferum
Pseudendoclonium submarinum
Chaetobolus gibbus
Pseudopringsheimia confluens
Ps. fucicola
Urospora penicilliformis
Chaetomorpha melagonium
Acrosiphonia incurva
Spongomorpha vernalis

Phaeophyceae (40 Species):
Isthmoplea sphaerophora
Giffordia ovata
G. intermedia
Feldmannia desmarestiae
Laminariocolax tomentosoides
Sorocarpus uvaeformis
Entonema aecidioides
Phaeostroma pustulosum
Ph. parasiticum
Ectocarpus helophorus
Symphyocarpus strangulans
Sorapion Kjellmanii
Lithoderma fatiscens
Pseudolithoderma extensum
Ps. Rosenvingii
Haplospora globosa
Sphacelaria arctica
Chaetopteris plumosa
Delamarea attenuata
Dermatocelis laminariae
Ascocyclus foecundus
Microspongium globosum
Leptonema fasciculatum
Elachista fucicola
Chordaria flagelliformis
Desmarestia aculeata
D. viridis
Stictyosiphon tortilis
Punctaria plantaginea
Litosiphon Mortensenii
L. subcontinuus
L. filiformis
Dictyosiphon foeniculaceus
Chorda filum
Ch. tomentosa
Saccorhiza dermatodea
Laminaria saccharina
L. digitata
Alaria Pylaii
Fucus inflatus

Rhodophyceae (19 Species):
Conchocelis rosea
Acrochaetium hallandicum
Audouinella efflorescens
Rhodochorton penicilliforme
Peyssonnelia Rosenvingii
Rhododermis elegans
Lithothamnion laeve
L. glaciale
L. tophiforme

L. investiens
L. compactum
Euthora cristata
Harveyella mirabilis
Phyllophora Brodiaei
Ceratocolax Hartzii
Halosaccion ramentaceum
Antithamnion boreale
Phycodrys rubens
Rhodomela lycopodioides

BOREAL-ARCTIC GROUP: 20 Species (= 18 %).

Chlorophyceae (10 Species):

Gomontia polyrhiza
Ulothrix flacca
U. pseudoflacca
U. subflaccida
Enteromorpha prolifera
E. clathrata
Epicladia flustrae
Pringsheimiella scutata
Rhizoclonium riparium
Ostreobium Queketti

Phaeophyceae (5 Species):

Pylaiella litoralis
Ectocarpus confervoides
Hecatonema maculans
Scytosiphon lomentaria
Eudesme virescens

Rhodophyceae (5 Species):

Acrochaetium parvulum
Audouinella membranacea
Rhodochorton purpureum
Hildenbrandia prototypus
Ahnfeltia plicata

2. The Vertical Distribution of the Flora of the Two Districts, Considered as a Whole.

After the general review of the phytogeographical character of the flora, its vertical distribution will now be made the subject of discussion. In the following, such an investigation will be made, taking into consideration both the algal classes and the distributional groups.

Table 2 gives a review of the vertical distribution of each of the species involved, as it appears from the records available. The diagram corresponds fairly well to the very instructive reviews prepared by Jónsson (1910, pp. 32—37; 1912, pp. 80—85) and Feldmann (1937a, pp. 51—66) illustrating the vertical distribution of the marine algae at Iceland and the Albères coast (the Mediterranean), respectively. In the diagram distinction is made between the supralittoral, the littoral, and the sublittoral regions, the boundary between the last-mentioned two being designated "0 m" as mentioned before. Down to 51 m, the sublittoral region is divided by a number of vertical lines at intervals corresponding to 3 m, while the part below that range is divided into two sections: 51—70 m and 70—120 m. The width of the columns of the diagram illustrating the first two regions do not represent a definite vertical extension. The occurrence of a species in either of these two regions is indicated with a cross.

Table 2. The Vertical Distribution of the Species.

	Species	Supralittoral Region	Littoral Region	Sublittoral Region, Depth in Metres (0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 70 120)
	Chlorophyceae			
sa	Chlorochytrium inclusum			6–39
sa	Ch. Schmitzii			× 9; 12–120
sa	Ch. dermatocolax		×	0–36
ba	Gomontia polyrhiza			× 24–27
ba	Ulothrix flacca		×	
ba	U. pseudoflacca		×	
sa	U. consociata		×	
ba	U. subflaccida			× 15–18
sa	Monostroma fuscum			× 3–6
ba	Enteromorpha prolifera		×	
ba	E. clathrata		×	
sa	Bolbocoleon piliferum			3–9
ba	Epicladia flustrae			× 33–36
sa	Pseudendoclonium submarinum		×	
a	Arthrochaete penetrans			9–48
sa	Chaetobolus gibbus			× 0–3
ba	Pringsheimiella scutata			× 18–21
sa	Pseudopringsheimia confluens			× 6–9
sa	Ps. fucicola		×	
sa	Urospora penicilliformis		×	
sa	Chaetomorpha melagonium			3–24
ba	Rhizoclonium riparium		×	
sa	Acrosiphonia incurva			6–15; × 18–21
sa	Spongomorpha vernalis			× 0–3
ba	Ostreobium Queketti			× 24–27
	Phaeophyceae			
ba	Pylaiella litoralis		×	0–39
sa	Isthmoplea sphaerophora			× 6–9
ba	Ectocarpus confervoides			3–36
sa	Giffordia ovata			6–39
sa	G. intermedia			× 3–6
sa	Feldmannia desmarestiae			15–21
sa	Laminariocolax tomentosoides			6–15; × 18–21
sa	Sorocarpus uvaeformis			6–9
ba	Hecatonema maculans			3–9
sa	Entonema aecidioides			6–15; × 18–21
sa	Phaeostroma pustulosum			0–21
sa	Ph. parasiticum			× 9; 12–30
a	Ph. endophyticum			6–15; × 18–21
sa	Ectocarpus helophorus			9–18

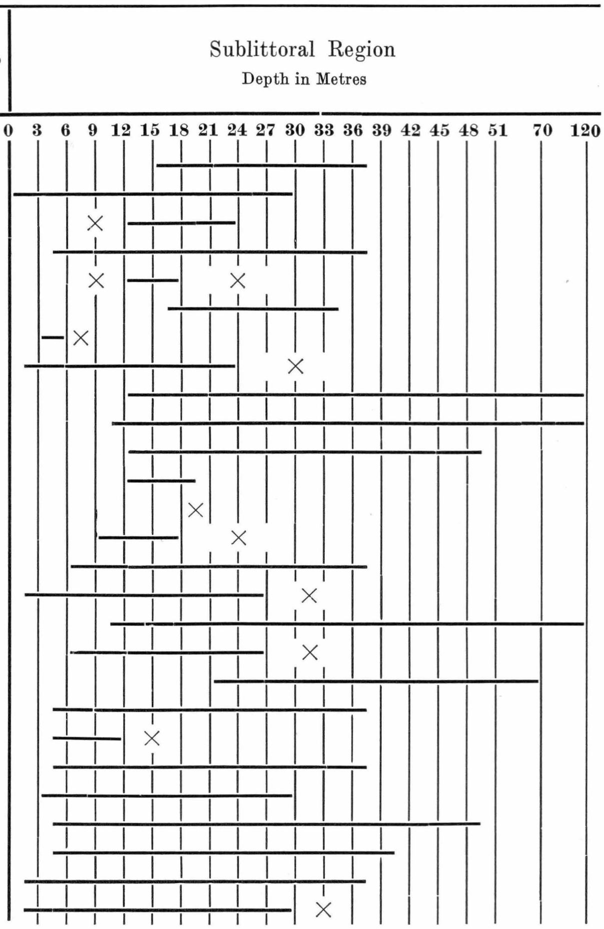
(continued)

Table 2 (cont.).

		Supralittoral Region	Littoral Region	Sublittoral Region, Depth in Metres: 0–3	3–6	6–9	9–12	12–15	15–18	18–21	21–24	24–27	27–30	30–33	33–36	36–39	39–42	42–45	45–48	48–51	51–70	70–120
sa	Symphyocarpus strangulans			—	—	—	—	—	—	—	—	—	—	—	—	—	—					
a	S. longisetus				×																	
sa	Sorapion Kjellmanii			—	—	—	—	—	—	—	—	—	—	—	—	—	—					
sa	Lithoderma fatiscens				—	—	—	—	—	—												
sa	Pseudolithoderma extensum										×											
sa	Ps. Rosenvingii						×															
a	Jonssonia pulvinata							×														
sa	Haplospora globosa				—	—	—	—	—	—	—											
sa	Sphacelaria arctica		×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
sa	Chaetopteris plumosa			—	—	—	—	—	—	—	—	—	—	—	—	—						
sa	Delamarea attenuata					×																
ba	Scytosiphon lomentaria			—	—	—	—	—	—													
sa	Dermatocelis laminariae					×																
sa	Ascocyclus foecundus				×																	
sa	Microspongium globosum				—	—																
sa	Leptonema fasciculatum			—	—	—	—	—	—	—	—	—										
sa	Elachista fucicola			—	—	—	—	—	—	—	—	—	—	—	—							
ba	Eudesme virescens					×																
sa	Chordaria flagelliformis			—	—	—	—	—	—	—	—	—	—	—	—	—						
sa	Desmarestia aculeata			—	—	—	—	—	—	—	—	—	—	—	—	—						
sa	D. viridis							—	—	—	—	—	—	—	—	—						
sa	Stictyosiphon tortilis			—	—	—	—	—	—	—	—	—	—	—	—	—						
sa	Punctaria plantaginea			—	—	—	—	—	—	—	—											
a	P. glacialis				—	—	—	—	—	—	—	—	—	—	—	—						
a	Omphalophyllum ulvaceum								—	—	—	—	—	—	—	—	—	—	—	—		
sa	Litosiphon Mortensenii					×																
a	L. groenlandicus			—	—	—	—	—	—	—												
sa	L. subcontinuus			—	—	—	—	—		×												
sa	L. filiformis					—	—	—		×												
sa	Dictyosiphon foeniculaceus			—	—	—	—	—	—	—	—											
sa	Chorda filum					—	—	—		×												
sa	Ch. tomentosa									×												
sa	Saccorhiza dermatodea						×	—	—													
a	Laminaria solidungula					—	—	—	—	—	—	—	—	—	—	—						
sa	L. saccharina			—	—	—	—	—	—	—	—	—	—	—	—	—						
a	L. groenlandica					×																
sa	L. digitata				—	—																
sa	Alaria Pylaii					—	—	—	—	—	—	—	—									
sa	Fucus inflatus		×	—	—	—	—	—	—	—	—	—	—	—	—	—						
	Rhodophyceae																					
sa	Conchocelis rosea														—	—						
ba	Acrochaetium parvulum			—	—	—	—	—	—													
sa	A. hallandicum				×																	
sa	Audouinella efflorescens					—	—	—	—	—	—	—	—	—	—	—	—					

Table 2 (cont.).

		Supralittoral Region	Littoral Region
ba	A. membranacea		
ba	Rhodochorton purpureum	×	×
sa	Rh. penicilliforme		
a	Dilsea integra		
sa	Peyssonnelia Rosenvingii		
sa	Rhododermis elegans		
a	Halosacciocolax Kjellmanii		
ba	Hildenbrandia prototypus		
sa	Lithothamnion laeve		
a	L. foecundum		
sa	L. glaciale		
sa	L. tophiforme		
sa	L. investiens		
sa	L. compactum		
sa	Euthora cristata		
sa	Harveyella mirabilis		
a	Cruoria arctica		
a	Petrocelis polygyna		
a	Turnerella Pennyi		
sa	Phyllophora Brodiaei		
ba	Ahnfeltia plicata		
sa	Ceratocolax Hartzii		
sa	Halosaccion ramentaceum		
sa	Antithamnion boreale		
sa	Phycodrys rubens		
a	Polysiphonia arctica		
sa	Rhodomela lycopodioides		



To illustrate the occurrence of the species in the sublittoral region I have used partly horizontal lines, partly crosses. A horizontal line indicates the vertical range within which it is known with certainty that the species occurs, while a cross indicates that the species occurs somewhere in the interval under consideration. As mentioned in the introduction to Part I, the depth may change considerably within one and the same dredging, thus sometimes making it impossible to state the exact depth at which the species occurred. In such cases the record is, of course, only approximate, stating e. g. 6—9 m, 6—11 m, or 15—25 m. In cases where a particular species was encountered only in a dredging at either of the first-mentioned two depths this is indicated with a cross in the column 6—9 m. If the only record originates from the last-mentioned depth it is illustrated with a cross in the middle of the interval 15—24 m and the vertical lines, which would otherwise intersect the interval, have not been drawn over this distance. However, when approximate depth records occur immediately before or after a horizontal line they are not indicated with a cross when the distance does not exceed 2—3 m; in such cases the horizontal line has been prolonged to reach the middle of the interval immediately before or after the horizontal line. Some rather rough records, originating from dredgings made at Ella Ø at depths between 40 and 60 m and between 40 and 80 m, figure in the diagram only at the depth where the dredging was started (40 m), i. e. in the interval 39—42 m. It should be mentioned that the species indicated in the interval 51—70 m were collected at a depth of 70 m and those figuring in the interval 70—120 m at a depth of 120 m.

In preparation of the diagram I have taken into consideration not only my own depth records but also those stated from Danmarks Ø by ROSENVINGE (1898), based on HARTZ' collections. On the whole, my own records were by far more extensive than the latter, which only in the case of some ten species slightly amplified my own observations.

For a few species I have, however, relied exclusively on ROSENVINGE's depth records. This applies to *Lithothamnion investiens*, *Ostreobium Queketti*, and *Gomontia polyrhiza*. It should also be mentioned that I have excluded from the diagram records of *Monostroma fuscum* and *Chaetomorpha melagonium* originating from depths greater than 4—6 m and 25 m, respectively, since it cannot be taken for granted that the fragments involved have actually lived at the depths in question.

In Table 3 I have endeavoured to interpret the diagram. In this table the area is divided into 8 vertical sections. The first section comprises the supralittoral and littoral regions and, consequently, stretches from the upper limit of the vegetation to 0 m. The range between 0 and 50 m is divided into 5 equal sections of 10 m each. The following interval comprises the depth 50—70 m, and the last interval 70—120 m. The above-mentioned records from 40—60 and 40—80 m are included only in the interval 40—50 m; the species collected at a depth of exactly 50 m figure only in the interval 40—50 m. In cases where it is difficult to ascertain whether a particular species ought to be indicated in one column or the other, the depth record being e. g. 15—25 m, it has been included in both of the columns 10—20 m and 20—30 m. Similarly, species encountered at depths of 25—35 m are included in both of the two intervals 20—30 and 30—40 m. As it is intended to give merely an outline of the distribution this procedure must be considered warranted, as long as the dredgings involved do not embrace too long distances.

In each vertical column I have indicated the number of species occurring at the depth in question and their distribution on the three algal classes, subdivided into the three distributional groups. Below.

Table 3. The Composition of the Flora at Different Depths.

The Percentages are Calculated on the Total Number of Species.

		Total		Upper limit of the vegetation / 0 m		0 m / 10 m		10 m / 20 m		20 m / 30 m		30 m / 40 m		40 m / 50 m		50 m / 70 m		70 m / 120 m	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Chlorophyceae	arctic	1	1	0		1		1		1		1		1		0		0	
	subarctic	14	13	5		10		5		5		3		2		1		1	
	boreal-arctic	10	9	5		0		4		3		3		0		0		0	
	Total...	25	23	10	9	11	10	10	9	9	8	7	6	3	3	1	1	1	1
Phaeophyceae	arctic	8	7	0		6		6		5		3		1		0		0	
	subarctic	40	37	2		36		30		28		12		4		0		0	
	boreal-arctic	5	5	1		5		3		2		2		1		0		0	
	Total...	53	49	3	3	47	43	39	36	35	32	17	16	6	6	0	0	0	0
Rhodophyceae	arctic	7	6	0		4		5		6		6		3		3		2	
	subarctic	19	17	0		13		17		15		12		5		1		1	
	boreal-arctic	5	5	1		4		5		3		2		0		0		0	
	Total...	31	28	1	1	21	19	27	25	24	22	20	18	8	7	4	4	3	3
Chlorophyceae + Phaeophyceae + Rhodophyceae	Total...	109	100	14	13	79	72	76	70	68	62	44	40	17	16	5	5	4	4
Including:	arctic	16	15	0	0	11	10	12	11	12	11	10	9	5	5	3	3	2	2
	subarctic	73	67	7	6	59	54	52	48	48	44	27	25	11	10	2	2	2	2
	boreal-arctic	20	18	7	6	9	8	12	11	8	7	7	6	1	1	0	0	0	0
	arctic + subarctic	89	82	7	6	70	64	64	59	60	55	37	34	16	15	5	5	4	4

the total number within each of the three distributional groups is indicated and, finally, the number of arctic + subarctic species. The percentages indicated are calculated on the basis of the total number of species (109).

From this table it appears that the greatest number of species is found between 0 and 30 m, in particular between 0 and 20 m. No less than 72 % of the species are recorded between 0 and 10 m. Between 10 and 20 m the percentage is 70 while in the interval 20—30 m it has decreased to 62. The interval 30—40 m contains 40 %. In my opinion it is rather remarkable that two fifths of all the species are encountered at a depth of at least 30 m. It is, however, even more striking that the lowermost two sections contain respectively 5 and 4 % of the entire flora. Contrary to the uppermost four intervals of the sublittoral region the supralittoral + littoral region contains only 13 %.

With respect to algal classes the table shows that the Brown Algae contribute most to the high percentages in the uppermost three intervals of the sublittoral region, representing respectively 43, 36, and 32 % of the total number of species. Below 30 m the percentage of this class declines steeply and the Brown Algae disappear entirely at a depth of 50 m. Above 0 m they are poorly represented as only three facultative littoral Brown Algae are encountered here, constituting 3 % of the entire flora.

The Red Algae come second after the Brown and are fairly uniformly represented in the four intervals between 0 and 40 m, their share in these intervals varying from 18 to 25 % with a maximum between 10 and 20 m. As could be expected, this class is predominant at greater depths; it takes the lead already at a depth of 30 m. Only one Red Alga, *Rhodochorton purpureum*, occurs above 0 m.

The Green Algae, which are represented by 25 species only, are of no great importance but, nevertheless, of considerable interest since they constitute no less than 6 and 3 % at such great depths as 30—40 m and 40—50 m, respectively. Even in the lowermost interval this class is represented, though only by one species, *Chlorochytrium Schmitzii*. As could be expected, this class is comparatively well represented above 0 m (10 species). Among these, 9 are restricted to the littoral region while one, *Chlorochytrium dermatocolax*, occurs also in the sublittoral region. The percentage of this class is fairly uniform in the uppermost five intervals, with a slightly pronounced maximum between 0 and 10 m.

The trend in the composition of the flora, as outlined in Table 3, is further elucidated in Table 4 which indicates the share, expressed in percentage, of each of the three algal classes in the vegetation of each interval. I have for each vertical interval stated also the ratio between Red Algae and Brown Algae $\left(\frac{\mathrm{Rh}}{\mathrm{Ph}}\right)$.

Table 4.
The Share of Each of the Algal Classes in the Vegetation of the Individual Intervals.

	Total number	Green A. %	Brown A. %	Red A. %	Rh/Ph
	109				
Upper limit of the vegetation—0 m	14	71	21	7	0.3
0— 10 m	79	14	59	27	0.4
10— 20 m	76	13	51	36	0.7
20— 30 m	68	13	52	35	0.7
30— 40 m	44	16	39	45	1.2
40— 50 m	17	18	35	47	1.3
50— 70 m	5	20	0	80	..
70—120 m	4	25	0	75	..

The table shows that the Green Algae constitute almost three fourths of the vegetation above 0 m. Already in the uppermost interval of the sublittoral region this feature is substantially changed, as the share of the Green Algae amounts to 14 % only; on the whole, it increases steadily with increasing depth. The small number of Brown Algae occurring above 0 m constitutes more than 20 % of the vegetation in that section; their great share within the uppermost three sublittoral intervals becomes even more conspicuous when calculated on the number of species occurring in each individual interval, more than half the species of each interval belonging to the Brown Algae. The single Red Alga recorded above 0 m constitutes 7 % of the vegetation in that section. In the sublittoral region the Red Algae become of increasing importance with increasing depth until the interval 50—70 m in which they constitute 80 % of the vegetation. The ratio between Red Algae and Brown Algae, which was 0.6 in the area as a whole (p. 34), is no more than 0.3 in the uppermost section while it increases with increasing depth so as to amount to 1.3 at a depth of 40—50 m.

On the basis of HARTZ' material, ROSENVINGE (1898a, p. 232) prepared a table showing a similar trend in the occurrence of the three algal classes with increasing depth. The table comprises a small collection (52 species) originating from depths down to well over 30 m at Danmarks Ø.

For the purpose of elucidating in detail the behaviour of the three algal classes with increasing depth I have prepared Table 5, which for each of the classes indicates the percentage found in each interval; this information cannot be immediately deducted from Table 3.

It appears from this table that the great share of the Brown Algae in the total number of species between 0 and 30 m is due to the fact

Table 5.

The Behaviour of the Three Algal Classes with Increasing Depth.

	Green Algae (Total 25) Percentage	Brown Algae (Total 53) Percentage	Red Algae (Total 31) Percentage
Upper limit of the vegetation—0 m	40	6	3
0— 10 m	44	89	68
10— 20 m	40	74	87
20— 30 m	36	66	77
30— 40 m	28	32	65
40— 50 m	12	11	26
50— 70 m	4	0	13
70—120 m	4	0	10

that these three intervals contain no less than 89, 74, and 66 %, respectively, of the total number of Brown Algae; in the next two intervals the Brown Algae are more poorly represented. The Red Algae maximum between 10 and 20 m is due to the occurrence of no less than 87 % of the total number of Red Algae; this class does not decrease considerably until a depth of 40 m. As regards the Green Algae, the 10 species above 0 m constitute 40 % of the total number; in contrast to the other two algal classes, the Green Alga maximum between 0 and 10 m represents no more than 44 % of their total number.

An examination of the diagram in Table 2 discloses that a great number of the species have a considerable vertical range. To get an idea of the distribution on the three algal classes of the species with a great vertical range I have in Table 6 included the species whose vertical distribution amounts to more than 20 m.

Table 6.

The Vertical Range within the Three Algal Classes, Indicated in Metres.

	Total Number	20	25	30	35	40	45	50	100	110	Number	%
Green Algae	25	1	0	0	2	1	0		1		5	20
Brown Algae	53	6	1	4	10	0	1		0		22	42
Red Algae	31	3	4	5	3	1	1		3		20	65
Total	109	10	5	9	15	2	2		4		47	43

The table indicates that no less than 47 species (5 Green, 22 Brown, and 20 Red Algae) have a vertical range of between 20 and 110 m. Fifteen species, including 10 Brown Algae, have a vertical range of between 35 and 40 m, while 8 species have a still greater vertical range. It is noteworthy that 2 of the 15 species are Green Algae. One Green Alga, *Arthrochaete penetrans*, even has a greater vertical range, amounting to 40—45 m, and another, *Chlorochytrium Schmitzii*, is distributed over more than 100 m.

In conclusion it can be stated that only 20 % of the Green Algae have a vertical range exceeding 20 m, but in this connexion it should be borne in mind that among the representatives of this class no less than 9 are restricted to the littoral region.

Among the Brown Algae 42 % have a vertical range of at least 20 m. Apart from a single species, *Sphacelaria arctica*, which is distributed over 50 m, the vertical range within this class does not exceed 40 m.

As much as 65 % of the Red Algae have a vertical range of more than 20 m, and no less than 3 species extend over more than 100 m. These three species are the subarctic *Lithothamnion laeve* and the arctic *L. foecundum* and *Cruoria arctica*.

When considering Table 3 with a view to distributional groups, it is seen that the arctic group, which does not appear until below 0 m, attains its maximum already in the intervals between 10 and 30 m, in which it represents 11 % of the total number of species. Below this depth the group begins to decrease but the steep decline in the number of arctic species does not take place until below 40 m.

The subarctic group, which is by far the most important, follows on the whole the same trend as the arctic. Being only feebly represented above 0 m it reaches its maximum in the interval between 0 and 10 m in which it constitutes 54 %; this maximum decreases only slightly in the two intervals immediately below, where this group constitutes almost half the total number of species. In the following two intervals the number of subarctic species is considerably reduced. In the interval 50—70 m, from which only 5 species have been recorded, two are subarctic, the other three arctic. In the lowermost interval two of the four species are subarctic.

The boreal-arctic group has its maximum in the interval 10—20 m. It is characteristic of this group that it is comparatively numerous above 0 m. As will be seen, no species recorded at depths greater than 50 m belongs to this group.

To examine the percentage of each distributional group occurring in the individual intervals I have prepared Table 7 on the same principles as those applied in Table 5.

Table 7.

The Behaviour of the Three Distributional Groups with Increasing Depth.

	a (Total 16) Percentage	sa (Total 73) Percentage	ba (Total 20) Percentage
Upper limit of the vegetation—0 m	0	10	35
0— 10 m	69	81	45
10— 20 m	75	71	60
20— 30 m	75	66	40
30— 40 m	63	37	35
40— 50 m	31	15	5
50— 70 m	19	3	0
70—120 m	13	3	0

The table shows that the maximum of the arctic group between 10 and 30 m is due to the occurrence of 75 % of all arctic species in these two intervals; it is noteworthy that no less than 19 % of its species extend to a depth of 70 m, 13 % of the species to a depth of 120 m. The maximum of the subarctic group between 0 and 10 m is attributable to the occurrence of no less than 81 % of all subarctic species in this interval. The maximum of the boreal-arctic species between 10 and 20 m amounts to 60 %.

For the purpose of investigating the pattern followed by the three distributional groups with increasing depth I have prepared Table 8 which indicates the share of each group in the vegetation of the individual intervals.

Table 8.

The Share of Each of the Distributional Groups in the Vegetation of the Individual Intervals.

	Total number 109	a %	sa %	ba %
Upper limit of the vegetation—0 m	14	0	50	50
0— 10 m	79	14	75	11
10— 20 m	76	16	68	16
20— 30 m	68	18	70	12
30— 40 m	44	23	61	16
40— 50 m	17	29	65	6
50— 70 m	5	60	40	0
70—120 m	4	50	50	0

The table shows that until a depth of 70 m the share of the arctic group increases steadily and in the interval 50—70 m this group is predominant. The share of the subarctic group, amounting to 50 °/₀ above 0 m, increases to 75 °/₀ between 0 and 10 m and below that interval its trend is, on the whole, decreasing though the group is predominant in all of the intervals between 0 and 50 m. The boreal-arctic group, representing no less than 50 °/₀ of the vegetation above 0 m, becomes of minor importance in the sublittoral region where its share in the vegetation varies between 11 and 16 °/₀ in the intervals above 40 m.

On the basis of the above-mentioned material collected by HARTZ at Danmarks Ø, ROSENVINGE (1898a, pp. 232—33) maintained that with increasing depth the number of arctic species decreases steeply, the number of subarctic species even more steeply, while the number of "North-Atlantic" species decreases very little. An analysis of ROSENVINGE's table, as it appears when based on the distributional types now assigned to the species involved, shows, however, that the number of arctic as well as of "North-Atlantic" species decreases only slightly, and the drop in subarctic species is less pronounced than maintained by that author. As a matter of fact, the percentages occurring in the revised table correspond fairly well to those stated for the sublittoral region until a depth of 40 m in my Table 8, where "ba" corresponds to the "North-Atlantic" species. The revision of the figures stated by ROSENVINGE is necessitated chiefly by the fact that quite a number of species which in 1898 were regarded as arctic have proved to be subarctic.

In Table 9 I have carried out an examination of the distribution on the distributional groups of the species having a vertical range of more than 20 m. Thus, this table comprises the same 47 species as Table 6.

Table 9.
The Vertical Range Within the Three Distributional Groups, Indicated in Metres.

	Total Number	20–25	25–30	30–35	35–40	40–45	45–50	100–110	Number	°/₀
a...........	16	1	1	3	1	1	1	2	10	63
sa..........	73	7	3	5	13	1	1	2	32	44
ba	20	2	1	1	1	0	0	0	5	25
Total.......	109	10	5	9	15	2	2	4	47	43

An analysis of the 47 species gives as result that the arctic species are comparatively the most numerous, being represented by 63 °/₀ of their total number. The subarctic species come second with 44 °/₀ and the boreal-arctic third, being represented by only 25 °/₀. While two arctic and two subarctic species attain a vertical range of more than 100 m, the maximum range of the boreal-arctic species is 40 m (one species).

For the purpose of ascertaining the correlation between algal classes and distributional groups within the 47 species whose vertical range exceeds 20 m I have prepared Table 10. For each distributional group both the number of species and its distribution on the three algal classes are indicated.

Table 10.

The Vertical Range Within the Three Algal Classes in Relation to the Distributional Groups.

	Number	Green Algae %	Brown Algae %	Red Algae %
a	10	10	30	60
sa	32	13	53	34
ba	5	0	40	60

It will be seen that among the arctic species the Red Algae are most numerous, followed by the Brown Algae; on the other hand, the Brown Algae come first among the subarctic species, followed by the Red Algae; within the smaller, boreal-arctic group the Red Algae are predominant while the Brown Algae come second and the Green Algae are not represented at all.

Finally, in Table 11 a survey is given of the percentage relation between the arctic and the subarctic species and between the arctic + subarctic and the boreal-arctic species in each interval. The latter condition has already been elucidated in Table 8 but, for the sake of clarity, the percentages for a+sa and ba are rendered in Table 11.

Table 11.

The Relation Between a and sa Species and Between a+sa and ba Species Within Each Interval.

	Upper limit of the vegetation	0 m	10 m	20 m	30 m	40 m	50 m	70 m	120 m
Total number of a + sa species:	7	70	64	60	37	16	5	4	
a in %	0	16	19	20	27	31	60	50	
sa in %	100	84	81	80	73	69	40	50	
Total number of species:	14	79	76	68	44	17	5	4	
a + sa in %	50	89	84	88	84	94	100	100	
ba in %	50	11	16	12	16	6	0	0	

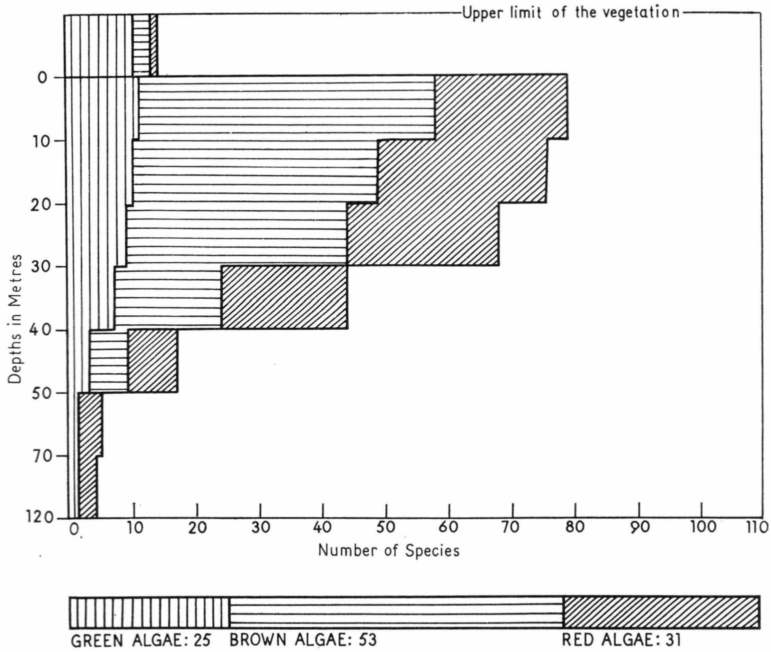


Fig. 3. The vertical distribution of the Chlorophyceae, Phaeophyceae, and Rhodophyceae. The interval above 0 m and the intervals 50—70 m and 70—120 m do not represent a definite vertical extent.

On the basis of the tables and of the review now accomplished the algal classes and the distributional groups may be characterized as follows:—

The Green Algae constitute three fourths of the total number of species occurring above 0 m. In the sublittoral region their share in the vegetation is small, though increasing below 30 m. They attain their maximum in the interval between 0 and 10 m, in which they are represented by 44 $^0/_0$ of their total number, and gradually decrease with increasing depth but are represented even at a depth of 120 m. Only one fifth of these algae have a vertical range of more than 20 m; a single species, however, extends over more than 100 m.

The Brown Algae are not represented at depths greater than 50 m. They are in particular predominant in the intervals between 0 and 30 m in each of which they constitute more than half the vegetation, and attain their maximum already between 0 and 10 m, in which interval they are represented by 89 $^0/_0$ of their total number. Two fifths of them extend over more than 20 m but only a single species has a vertical range of 50 m.

The Red Algae reach their maximum between 10 and 20 m, in which interval they are represented by 87 % of their total number. Below this interval their number diminishes, particularly below 40 m, but their share in the vegetation grows with increasing depth until 70 m; below 30 m they are predominant because of the decreasing number of Brown Algae. No less than two thirds of them extend over more than 20 m, three species even over more than 100 m.

While the ratio between Red Algae and Brown Algae in the area as a whole amounts to 0.6 it is no more than 0.3 in the section above 0 m, but increases with increasing depth to 1.3 in the interval 40—50 m (Table 4).

The vertical distribution of the three algal classes is illustrated in the graph fig. 3, in which the interval above 0 m and the intervals 50—70 and 70—120 m do not, for practical reasons, represent a definite vertical extent.

The arctic distributional group does not appear above 0 m and it attains its maximum between 10 and 30 m, where 75 % of the total number of arctic species occur. Below 30 m, particularly below 40 m, this group decreases steadily. Between 0 and 70 m its share in the vegetation increases steadily, and in the interval 50—70 m it is predominant but the number of species in this interval is insignificant. This group contains the relatively greatest number of species (10) with a vertical range exceeding 20 m, of which six are Red Algae and three Brown Algae. Two species extend over more than 100 m.

The subarctic distributional group is by far the most important and reaches its maximum already between 0 and 10 m, in which interval 81 % of all subarctic species occur. Below this interval its share is, on the whole, decreasing. Above 0 m the group constitutes half the vegetation, in the intervals 0—50 m it is predominant. Slightly less than half the subarctic species have a vertical range of more than 20 m, a little more than half of them being Brown Algae and one third Red Algae. Two species extend over more than 100 m.

The boreal-arctic distributional group increases rather steeply from the interval above 0 m until the interval 10—20 m in which it reaches its maximum, being represented by 60 % of the total number of boreal-arctic species; below this depth it decreases almost correspondingly until a depth of 40 m. Below the interval 30—40 m the group decreases steeply and is not recorded at depths greater than 50 m. Above 0 m it constitutes half the vegetation while its share in the vegetation below 0 m is insignificant though fairly uniform until a depth of 40 m. Among the boreal-arctic species only one fourth (5 species) have a vertical range of more than 20 m, three of them being Red Algae, the other two Brown Algae. Only one species extends over 40 m.

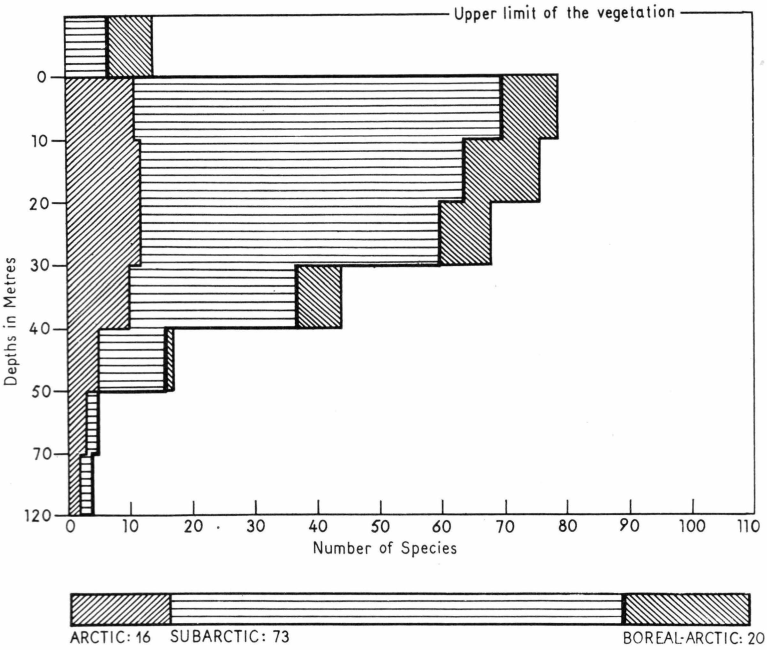


Fig. 4. The vertical distribution of the arctic, subarctic, and boreal-arctic groups. The interval above 0 m and the intervals 50—70 m and 70—120 m do not represent a definite vertical extent.

Between the upper limit of the vegetation and 0 m the flora is equally subarctic and boreal. In the intervals below 0 m, on the contrary, the character of the flora is markedly arctic-subarctic, the arctic share on the whole growing with increasing depth while the subarctic decreases (Tables 3, 8, 11).

The vertical distribution of the three distributional groups is illustrated in the graph fig. 4, prepared according to the same principles as fig. 3.

3. The Composition of the Flora of the Two Districts, Considered Separately.

It would now be natural to proceed to a comparison between the algal flora of different sections within the two districts examined by me. For the purpose of such an examination the Scoresby Sund district will first be taken into consideration. In this district, a comparison between the outer, middle, and inner parts would command interest; however, the collections made are too insufficient to make such a comparison possible, so it will be necessary to concentrate on an examination of the floristic characteristics of the outer and the inner parts. Subsequently, a comparison will be made between the algal flora of Scoresby Sund, considered as a whole, and that of the Kejser Franz Josephs Fjord district.

A perusal of the total of 109 species found in my districts yields the result that while 87 species were found in outer Scoresby Sund and 71 in inner Scoresby Sund, the number recorded from Scoresby Sund as a whole amounts to 100. Only 74 species are recorded from the Kejser Franz Josephs Fjord district.

It can, however, be taken for granted that future investigations will prove that in both districts the flora does in reality comprise a greater number of species. Thus, a review of East Greenland's marine algae shows that among 8 species, which are not yet recorded from Scoresby Sund, 7 are found both north and south of this district, while the remaining species is found in northernmost East Greenland as well as in the southernmost part of West Greenland. It would, therefore, be reasonable to add these 8 species (of which four are enumerated on p. 57 and the remaining four, also missing in the flora of the Kejser Franz Josephs Fjord district, below) to the number of species recorded from Scoresby Sund, the total number thus amounting to 108.

The flora of the Kejser Franz Josephs Fjord district lacks no less than 17 species known to occur both north and south of the district, besides the species mentioned above as being recorded farther north as well as in the southernmost part of West Greenland. Taking into account these 18 species, the floral list for this district will comprise 92 species.

As a result of the amendments, the joint number of species in the two districts examined by me is increased by 4 so as to total 113. These 4 species are: *Ulothrix scutata* (a), *Acrosiphonia hystrix* (sa), *Ptilota pectinata* (sa), and *Pantoneura Baerii* (a).

The columns to the right in Table 1 show the distribution within my East Greenlandic area of the 109 species hitherto recorded. The supposed records which still await confirmation are included, indicated with a cross in brackets.

In Table 12 I have endeavoured to interpret the distribution within my area and beside the actual records I have added the amended figures in brackets. This table, which includes the supposed records of the above four species, is prepared on the same principles as Table 3, taking into consideration both the algal classes and the distributional groups.

While the comparison between outer and inner Scoresby Sund is, quite naturally, based exclusively on the actual records, the amended figures are used in the comparison between the Scoresby Sund and the Kejser Franz Josephs Fjord districts.

Table 12.

The Composition of the Flora in Scoresby Sund and the Kejser Franz Josephs Fjord District.

		Scoresby Sund		Outer Scoresby Sund		Inner Scoresby Sund		Kejser Franz Josephs Fjord District	
		Number	%	Number	%	Number	%	Number	%
Chlorophyceae	arctic	1 (2)		1		1		1 (2)	
	subarctic	14 (15)		10		8		6 (9)	
	boreal-arctic	7 (10)		6		2		5 (8)	
	Total...	22 (27)	22 (25)	17	20	11	15	12 (19)	16 (21)
Phaeophyceae	arctic	7 (7)		7		4		6 (6)	
	subarctic	35 (36)		32		26		35 (36)	
	boreal-arctic	5 (5)		4		4		4 (4)	
	Total...	47 (48)	47 (44)	43	49	34	48	45 (46)	61 (50)
Rhodophyceae	arctic	7 (8)		7		6		5 (7)	
	subarctic	19 (20)		15		17		9 (17)	
	boreal-arctic	5 (5)		5		3		3 (3)	
	Total...	31 (33)	31 (31)	27	31	26	37	17 (27)	23 (29)
Chlorophyceae + Phaeophyceae + Rhodophyceae	Total...	100 (108)		87		71		74 (92)	
Including:	arctic	15 (17)	15 (16)	15	17	11	15	12 (15)	16 (16)
	subarctic	68 (71)	68 (66)	57	66	51	72	50 (62)	68 (67)
	boreal-arctic	17 (20)	17 (18)	15	17	9	13	12 (15)	16 (16)
	arctic + subarctic	83 (88)	83 (82)	72	83	62	87	62 (77)	84 (84)

A. Comparison Between Outer and Inner Scoresby Sund.

Before proceeding to this comparison it should be mentioned that "outer" Scoresby Sund comprises the first nine localities of those listed in Part I, pp. 13—14, while "inner" Scoresby Sund comprises the remaining six localities. Hence, the analysis made gives a comparison between the flora of the outermost part and that of the middle and innermost parts.

It appears from Table 12, that among the 87 species recorded in outer Scoresby Sund 17 are Green, 43 Brown, and 27 Red Algae, while the 71 species recorded in inner Scoresby Sund are distributed on 11

Green, 34 Brown, and 26 Red Algae. Thus, all of the three algal classes are more numerous in the outer part, though in the case of the Red Algae the difference amounts to one species only. Owing to the poorer flora in the inner part the share of the Red Algae in the flora is higher here, the percentage being 37 as against 31. The share of the Brown Algae is almost equal in the two areas, amounting to 49 $^0/_0$ in the outer part and 48 $^0/_0$ in the inner part, while the corresponding percentages of the Green Algae amount to 20 and 15. The ratio between Red and Brown Algae is 0.6 and 0.8 in the outer and the inner part, respectively.

The ratio between Red and Brown Algae in inner Scoresby Sund, as it emerges from my examinations, differs from that ascertained at Danmarks Ø by ROSENVINGE (1898a, pp. 231—32; cf. also 1910, p. 98) who found that each of these two algal classes was represented by 26 species. The number of Red Algae occurring in the material treated by that author was, however, 25 as *Lithothamnion varians* has proved to be identical with *L. glaciale* f. *subsimplex*. The species which in my calculations again increases the number of Red Algae to 26, and which was not mentioned from Danmarks Ø by ROSENVINGE, is *Audouinella membranacea*, collected by me at Bjørneøer.

As regards phytogeography, the subarctic group is slightly less prevailing in the outer than in the inner part of Scoresby Sund, the percentages being 66 and 72, respectively; within this group, the Brown Algae are predominant, constituting more than half the number of subarctic species in both the outer and the inner part. On the other hand, the share of the arctic group is slightly greater in the outer than in the inner part, the percentages being 17 and 15, respectively; in the outer part the Brown and Red Algae within this group are equal in number, in the inner part the Red Algae are the more numerous. Within the boreal-arctic group, which constitutes 17 $^0/_0$ in the outer and 13 $^0/_0$ in the inner part, the Green Algae are predominant in the outer part, the Brown Algae in the inner part. — In conclusion, the flora is arctic-subarctic in both areas, though slightly more markedly so in the inner than in the outer part, the percentage a + sa amounting to 87 and 83, respectively.

It would now be of interest to carry out a more detailed analysis of the phytogeographical conditions prevailing in the two sections. To that end I have ascertained the number of species of each of the three distributional groups common to the two areas and, likewise, the number of additional species recorded from each of the two areas. The result is shown in Table 13 which, for the sake of clarity, includes the figures from Table 12 stating the share of each of the distributional groups in the two sections and in entire Scoresby Sund.

This analysis shows that the common element constitutes 58 $^0/_0$ of the flora of entire Scoresby Sund, while the specific element of outer

Table 13.

The Share of Each of the Distributional Groups in the Flora of Outer and Inner Scoresby Sund.

	Total Number of Species			Common Element	Specific Element	
	Entire Sc.Sund	Outer Part	Inner Part		Outer Part	Inner Part
	100	87	71	58	29	13
a.................	15	15	11	11	4	0
sa.................	68	57	51	40	17	11
ba	17	15	9	7	8	2
a + sa............	83 (83 %)	72 (83 %)	62 (87 %)	51 (88 %)	21 (72 %)	11 (85 %)

Scoresby Sund amounts to 29 %, that of inner Scoresby Sund to 13 %. Of the 15 arctic species occurring in Scoresby Sund, 11 are recorded from both the outer and the inner part, while 4 occur in the outer part only. Among the subarctic species, 40 belong to the common element while 17 belong to the specific element of outer Scoresby Sund and 11 to that of the inner part. The boreal-arctic species are distributed with 7 on the common element and 8 and 2, respectively, on the specific elements of the outer and the inner parts.

The common element is markedly arctic-subarctic, the percentage a + sa amounting to 88. In the specific element of the outer part this percentage amounts to 72, whereas the specific element of the inner part is devoid of arctic species, the subarctic species alone constituting 85 %. Owing to the specific elements the arctic-subarctic character of the flora of entire Scoresby Sund is a little less marked than that of the common element.

By way of further elucidation of the flora of the two areas I have prepared the following list of the species contained in the two specific elements:

Outer Scoresby Sund

Chlorophyceae (11 Species):

- Ulothrix flacca, ba
- U. pseudoflacca, ba
- U. subflaccida, ba
- Monostroma fuscum, sa
- Enteromorpha clathrata, ba
- Epicladia flustrae, ba
- Pseudendoclonium submarinum, sa
- Pseudopringsheimia confluens, sa
- Ps. fucicola, sa
- Urospora penicilliformis, sa
- Acrosiphonia incurva, sa

Phaeophyceae (13 Species):

- Isthmoplea sphaerophora, sa
- Feldmannia desmarestiae, sa
- Laminariocolax tomentosoides, sa
- Phaeostroma parasiticum, sa
- Ph. endophyticum, a
- Lithoderma fatiscens, sa
- Jonssonia pulvinata, a
- Dermatocelis laminariae, sa
- Eudesme virescens, ba
- Litosiphon filiformis, sa
- Saccorhiza dermatodea, sa
- Laminaria groenlandica, a
- Laminaria digitata, sa

Rhodophyceae (5 Species):
- Acrochaetium hallandicum, sa
- Rhodochorton penicilliforme, sa
- Halosacciocolax Kjellmanii, a
- Hildenbrandia prototypus, ba
- Ahnfeltia plicata, ba

Inner Scoresby Sund

Chlorophyceae (5 Species):
- Ulothrix consociata, sa
- Bolbocoleon piliferum, sa
- Chaetobolus gibbus, sa
- Spongomorpha vernalis, sa
- Ostreobium Queketti, ba

Phaeophyceae (4 Species):
- Hecatonema maculans, ba
- Pseudolithoderma extensum, sa
- Microspongium globosum, sa
- Litosiphon subcontinuus, sa

Rhodophyceae (4 Species):
- Rhododermis elegans, sa
- Lithothamnion tophiforme, sa
- L. investiens, sa
- L. compactum, sa

On the basis of the species enumerated in these lists it would seem justified to conclude that the floral difference between outer and inner Scoresby Sund is more or less incidental. Thus, it would seem reasonable to presume that most of the species constituting the specific element of outer Scoresby Sund will eventually be recorded also from the inner part, with the possible exception of *Saccorhiza dermatodea*. Likewise, it must be considered probable that the species constituting the specific element of inner Scoresby Sund will in due course be encountered in the outer part.

Though it might at some later date appear that outer and inner Scoresby Sund are rather uniform as regards floral conditions it is noteworthy that many of the species constituting the common element are more or less reduced when occurring in inner Scoresby Sund. This must presumably be seen in the light of the slighter renewal of water which is reflected in less nutrients. It should also be mentioned that many of the species common to the two areas are by far less abundant when occurring in inner Scoresby Sund.

The above-mentioned characteristics are particularly true of a number of Red Algae such as *Dilsea integra*, *Euthora cristata*, *Turnerella Pennyi*, *Phyllophora Brodiaei*, *Halosaccion ramentaceum*, *Phycodrys rubens*, and *Polysiphonia arctica*, but do also apply to some Brown Algae such as *Haplospora globosa*, *Desmarestia aculeata*, *Laminaria solidungula*, *Alaria Pylaii* and others.

Other species, however, seem to thrive equally well in inner and outer Scoresby Sund, some few are even better developed when occurring in the inner part. This applies e. g. to the Red Alga *Petrocelis polygyna*, which was particularly well developed at Danmarks Ø, as well as to the two Brown Algae *Laminaria saccharina* f. *glacialis* and *Punctaria glacialis* which reached their maximum size at Danmarks Ø and

Rødeø, respectively. It might well be imagined that in the case of the last-mentioned two species the quiet conditions obtaining in the localities in question enable the thallus to attain greater dimensions. Also *Sphacelaria arctica* reached its maximum development at Rødeø in which locality it formed dense and vigorous tufts of a height of nearly 10 cm at a depth of 2 m.

Our present knowledge of the flora of Scoresby Sund should not be overestimated. It should be realized that at present it is not possible to go beyond a summing up of the results of investigations of the vegetation in a fairly limited number of localities but, on the other hand, there is no doubt that this summing up outlines the main trend in the flora. Future investigations will undoubtedly entail an increase in the number of species; as mentioned on p. 52, 8 additional species will certainly be recorded. Of these, 4 are listed on p. 52, the remaining 4 are *Enteromorpha prolifera* (ba), *Pringsheimiella scutata* (ba), *Rhizoclonium riparium* (ba), and *Chorda tomentosa* (sa).

Before concluding the analysis of the flora of Scoresby Sund I list below the species which, at any rate provisionally, reach their northern limit in East Greenland in this district. A total of 21 species are involved, viz.:

Chlorophyceae (8 Species):
- Ulothrix subflaccida, ba
- Monostroma fuscum, sa
- Enteromorpha clathrata, ba
- Chaetobolus gibbus, sa
- Pseudopringsheimia confluens, sa
- Ps. fucicola, sa
- Urospora penicilliformis, sa
- Spongomorpha vernalis, sa

Phaeophyceae (7 Species):
- Isthmoplea sphaerophora, sa
- Jonssonia pulvinata, a
- Delamarea attenuata, sa
- Dermatocelis laminariae, sa
- Eudesme virescens, ba
- Saccorhiza dermatodea, sa
- Laminaria groenlandica, a

Rhodophyceae (6 Species):
- Acrochaetium hallandicum, sa
- Halosacciocolax Kjellmanii, a
- Hildenbrandia prototypus, ba
- Lithothamnion investiens, sa
- L. compactum, sa
- Ahnfeltia plicata, ba

Seven arctic species have not yet been stated to occur in East Greenland south of Scoresby Sund; these are: *Arthrochaete penetrans*, *Punctaria glacialis*, *Dilsea integra*, and the four new species *Phaeostroma endophyticum*, *Jonssonia pulvinata*, *Litosiphon groenlandicus*, and *Halosacciocolax Kjellmanii*. Among these species *Jonssonia pulvinata* is as yet only recorded from this area.

In addition, the two forms *Laminaria saccharina* f. *glacialis* (a) and *Rhodomela lycopodioides* f. *flagellaris* (sa), have their southern limit in East Greenland in Scoresby Sund; the former is recorded also from the

Kejser Franz Josephs Fjord district while the latter, besides in Scoresby Sund, is known to occur farther north in East Greenland, and at Spitsbergen, Finmarken, and the Murman coast.

B. Comparison Between Scoresby Sund and the Kejser Franz Josephs Fjord District.

In the following, a comparison will be made between the algal flora of Scoresby Sund and that of the Kejser Franz Josephs Fjord district. It should be mentioned that the picture arising from such a comparison will not be quite satisfactory, not only because the latter district is, on the whole, far less explored than Scoresby Sund but also because no investigations have been made in typical outer localities which can be compared with Kap Tobin, Amdrups Havn, and Kap Hope in Scoresby Sund. The only locality suggesting itself in this respect is Kap Borlase Warren which previously was visited by C. KRUUSE. The material from this locality is, however, small and seems to have comprised only some 13 species. The only outer locality I visited in the Kejser Franz Josephs Fjord district, Vinterøer at the mouth of Duséns Fjord, shows most resemblance to the inner localities in Scoresby Sund.

To this should be added that, in so far as inner localities are concerned, comprehensive collections have been made in one locality only, i. e. at Ella Ø, so it would not be practicable, either, to carry out a comparison between the outer and the inner parts of the Kejser Franz Josephs Fjord district similar to that made with respect to outer an inner Scoresby Sund.

An examination of Table 12 gives as result that all the three algal classes are more poorly represented in the Kejser Franz Josephs Fjord district than in Scoresby Sund. The decrease in number is largest within the Green Algae, from 27 to 19, while it is less marked within the Red Algae, from 33 to 27, and negligible within the Brown Algae, which decrease from 48 to 46. Owing to the smaller number of species occurring in the Kejser Franz Josephs Fjord district the share of the Brown Algae in the flora is larger than in Scoresby Sund, the percentages being respectively 50 and 44. The share of the Green Algae drops from 25 to 21 $^0/_0$ and that of the Red Algae from 31 to 29 $^0/_0$. The ratio between Red and Brown Algae, which amounts to 0.7 in Scoresby Sund, decreases to 0.6 in Kejser Franz Josephs Fjord district.

As regards phytogeography each of the three distributional groups constitutes almost the same percentage of the flora in the Kejser Franz Josephs Fjord district as in Scoresby Sund. The a + sa percentage, amounting to 82 in Scoresby Sund, does not increase to more than 84 in the Kejser Franz Josephs Fjord district. As is the case in outer and inner Scoresby Sund the subarctic Brown Algae in Kejser Franz Josephs Fjord constitute more than half the total number of subarctic species. The Red Algae are predominant within the arctic group, the Green Algae within the boreal-arctic group.

A phytogeographical comparison between the two districts, carried out according to the same principles as Table 13, gives the following result:

Table 14.

The Share of Each of the Distributional Groups in the Flora of Scoresby Sund and the Kejser Franz Josephs Fjord District.

	Total Number of Species			Common Element	Specific Element	
	Sc. Sund + Kejser Fr. J. Fjord	Scoresby Sund	Kejser Fr. J. Fjord		Scoresby Sund	Kejser Fr. J. Fjord
	113	108	92	87	21	5
a	18	17	15	14	3	1
sa	75	71	62	58	13	4
ba	20	20	15	15	5	0
a + sa	93 (82 %)	88 (82 %)	77 (84 %)	72 (83 %)	16 (76 %)	5 (100 %)

The table indicates that the two districts have a common element consisting of 87 species, its a + sa percentage being 83; the specific element of Scoresby Sund consists of 21 species with an a + sa percentage amounting to 76, that of the Kejser Franz Josephs Fjord district is composed of 5 species, its a + sa percentage being 100. Like the common element of outer and inner Scoresby Sund, the common element now under consideration is markedly arctic-subarctic; the addition of the two specific elements entails only a negligible decrease in the a + sa percentage of the entire flora as compared with that of the common element.

The comparison between the districts shows that the Kejser Franz Josephs Fjord district will most probably prove to be closely related to Scoresby Sund. It contains a specific element, based on the amended figures, consisting of five species; moreover, it misses the 21 species whose northern limit is situated in Scoresby Sund (enumerated on p. 57).

The five species in question, all of them Brown Algae, are as follows: *Giffordia intermedia* (sa), *Sorocarpus uvaeformis* (sa), *Symphyocarpus longisetus* (a), *Ascocyclus foecundus* (sa), and *Litosiphon Mortensenii* (sa). All of these species were recorded at Ella Ø where they occurred in the fiord-water layer. The first-mentioned and the last-mentioned two species will, probably, eventually be found also in Scoresby Sund. The most interesting of the five species is *Sorocarpus uvaeformis* which has not previously been encountered in the Arctic and was up to now regarded as a warm-boreal species. This species is most probably a relict and its occurrence recalls Thorson's (1933, pp. 57, 59) finding of *Pecten islandicus* in the same locality and in an adjoining one, though it is not known to occur alive in other East Greenlandic localities.

The below list comprises the species which do not extend north of the Kejser Franz Josephs Fjord district.

Chlorophyceae (6 Species):
- Chlorochytrium dermatocolax, sa
- Ulothrix pseudoflacca, ba
- Bolbocoleon piliferum, sa
- Pringsheimiella scutata, ba
- Rhizoclonium riparium, ba
- Acrosiphonia incurva, sa

Phaeophyceae (20 Species):
- Ectocarpus confervoides, ba
- Giffordia intermedia, sa
- Feldmannia desmarestiae, sa
- Laminariocolax tomentosoides, sa
- Sorocarpus uvaeformis, sa
- Hecatonema maculans, ba
- Entonema aecidioides, sa
- Phaeostroma parasiticum, sa
- Ph. endophyticum, a
- Ectocarpus helophorus, sa
- Symphyocarpus longisetus, a
- Lithoderma fatiscens, sa
- Haplospora globosa, sa
- Microspongium globosum, sa
- Chordaria flagelliformis, sa
- Punctaria plantaginea, sa
- Litosiphon Mortensenii, sa
- L. subcontinuus, sa
- L. filiformis, sa
- Chorda filum, sa

Rhodophyceae (4 Species):
- Acrochaetium parvulum, ba
- Audouinella membranacea, ba
- Peyssonnelia Rosenvingii, sa
- Harveyella mirabilis, sa

Only one species of those recorded from the Kejser Franz Josephs Fjord district does not occur farther south. The species involved is *Symphyocarpus longisetus* which has been recorded only from this district.

In conclusion of the analysis of the area examined by me, the Scoresby Sund and Kejser Franz Josephs Fjord districts, it can be stated with regard to phytogeography that the main feature is the markedly uniform arctic-subarctic character of the flora in all the sections considered: outer Scoresby Sund, inner Scoresby Sund, Scoresby Sund considered as a whole, the Kejser Franz Josephs Fjord district, and the entire area considered as a whole, as the a + sa percentage varies only between 82 and 87 whether actual records or amended figures are applied.

V. SUMMING UP OF THE COMPOSITION OF THE ALGAL FLORA OF EAST GREENLAND

Following the analysis of the area in which my collections were made it would now be of interest to examine how this area fits into the picture of the algal flora of East Greenland.

At the outset, it must be regretted that our knowledge of the algal flora of East Greenland outside of Scoresby Sund and the Kejser Franz Josephs Fjord district is by far too scanty to make it possible to draw firm conclusions. None the less, it will be reasonable to review the conditions known from the districts outside of the area examined by me and, subsequently, to sum up our present knowledge of the algal flora of entire East Greenland.

Like the zoologists (in Meddelelser om Grønland, Vols. 121—123) I have divided East Greenland into five districts (fig. 1). In the southernmost of these, the Sydøstkyst district, collections of marine algae have been made almost exclusively in the area around Angmagssalik. In addition, 24 species are recorded from the southernmost part, but the long coastal stretch of some 500 km, extending between latitudes approx. 61° and $65^1/_2$° N., is completely uninvestigated. This is the more regrettable as the algal flora of this area must be expected to prove richer than that occurring farther north and to differ also in other respects, e. g. by comprising a not insignificant littoral vegetation. As assumed by ROSENVINGE (1898a, p. 178) it must be expected that the species recorded from West Greenland south of latitude 62° N. occur in S.E. Greenland too. Most of these species are included in ROSENVINGE's lists on pp. 166—72, in which they are marked with an S, while the remaining species are mentioned by JÓNSSON (1904).

Collections from the district immediately north of the Sydøstkyst district, the Kangerdlugssuaq district stretching from Kap Gustav Holm to Kap Brewster, originate from the Kangerdlugssuaq fiord complex, from a locality in latitude $67^1/_4$° N., and from 4 localities between latitudes 69° and 70° N. In my demarcation, the northern limit of this district is fixed slightly north of that applied by the zoologists.

In the Nordøstkyst district, i. e. the area north of latitude 74°25′ (approx.), collections have been made at Kap Wynn, Hvalrosø, and

Sabineø, situated in latitude $74^1/_2$—$74^3/_4$°, at Danmarks Havn in latitude 76—$76^1/_2$°, and in Jørgen Brønlund Fjord in latitude 82°10′ N.

The scarcity of collections made in the above-mentioned three districts is quite naturally reflected in a small number of species. Thus, no more than respectively 80 and 51 species are known from the Sydøstkyst and Kangerdlugssuaq districts, while 64 are recorded from the Nordøstkyst district. These figures, particularly the first two, should by no means be interpreted as giving a true picture of the conditions prevailing.

It must, however, be considered justified to add to the number of species recorded from the two southern districts such species as can with certainty be foreseen to belong to the flora, despite their not yet being found in these districts. In the case of the Sydøstkyst district it will thus be possible to add the species known to occur both in East Greenland farther north and in localities in West Greenland south of latitude 62° N., and in the case of the Kangerdlugssuaq district the species recorded from East Greenland north of this district as well as from the Sydøstkyst district and/or the above-mentioned West Greenland area. Through these amendments, the figures applying to the two southern districts are increased to 105 and 94, respectively.

It is evident that even these amended figures can by no means be expected satisfactorily to reflect the composition of the flora, but for the purpose of the review to be made it will be more warranted to rely on the amended figures than on the actual records. The 105 species thus taken into account for the Sydøstkyst district consist of 30 Green Algae, 47 Brown Algae, and 28 Red Algae. From a phytogeographical point of view 12 of them are arctic, 70 subarctic, and 23 boreal-arctic. Of the 94 species of the Kangerdlugssuaq district 24 are Green, 43 Brown, and 27 Red Algae; of these, 13 are arctic, 64 subarctic, and 17 boreal-arctic.

It is impossible to amend the number of species recorded from the Nordøstkyst district, where the actual records, 64 species, are distributed on 13 Green, 27 Brown, and 24 Red Algae; of these, 14 are arctic, 42 subarctic, and 8 boreal-arctic.

A review of the floral conditions prevailing in East Greenland based on our present, insufficient knowledge gives the result—which should be taken for no more than a provisional summing up—that the share of each of the three algal classes in the flora is, on the whole, rather uniform in all five districts. When passing from the southernmost district towards north there is a fairly steady decrease in the share of the Green Algae, while the share of the Brown and Red Algae increases. A deviation from this trend is seen in the Nordøstkyst district where there is a drop in the share of the Brown Algae (particularly the subarctic species), while the share of the Red Algae increases; this results in an almost equal share of these two algal classes in the flora. Whereas the ratio between Red and Brown Algae varies between 0.6 and 0.7 in the other districts, it amounts to 0.9 in the Nordøstkyst district.

In my opinion the deviating tendency of the flora of the Nordøstkyst district is due exclusively to insufficient investigations and should not, as intimated by ROSENVINGE (1910, p. 98), be interpreted as indicating that the relative number of Brown Algae decreases in the strictly arctic parts of the Arctic.

An examination of the changes taking place in the three distributional groups with increasing latitude shows that the share of the arctic group increases fairly steadily while that of the subarctic group remains almost uniform in all of the districts; the share of the boreal-arctic group decreases with increasing latitude. This results in an increase in the percentage of a + sa from 78 in the southernmost district to 88 in the northernmost.

A closer examination of the distribution of the species in East Greenland reveals that 47 species are recorded from all the five districts involved. This common element is markedly arctic-subarctic, its percentage of a + sa species amounting to 87. It contains 8 Green, 19 Brown, and no less than 20 Red Algae among which 5 are arctic, 14 subarctic, and 1 boreal-arctic. As the entire flora of East Greenland contains 37 Green, 68 Brown, and 38 Red Algae, the share of the Red Algae in the common element is much larger than their share in the entire flora. Consequently, the Red Algae are not only the most tolerant algal class as far as increasing depth is concerned, but also with respect to increasing latitude.

So far, nothing can be said with certainty about the possible occurrence of a phytogeographical limit as regards marine algae in East Greenland. For this purpose, it will be necessary to await the result of further investigations. For the moment, it is possible to state only that to a certain extent the flora of the Angmagssalik area and Kangerdlugssuaq is of another character than that of Scoresby Sund and the areas farther north, as it comprises a regular littoral vegetation of *Fucaceae*. This must be ascribed to the Irminger current and the ensuing tempering of the ice conditions.

The idea suggests itself that it would be natural to round off this review with a comparison between East Greenland's and West Greenland's algal flora. It would, however, be unjustified to proceed to such a comparison, not only because of our present insufficient knowledge of the algal flora of the southern two districts of East Greenland, but also because northwestern Greenland, north of Upernavik, is almost unknown as far as algology is concerned.

A rough summing up gives as result that while the number of species known from East Greenland amounts to 143, a total of 153 species are recorded from West Greenland. The total number of species known from Greenland amounts to 182. Of these, 114 (34 Green, 48 Brown, and 32 Red Algae) are common to East and West Greenland, while East Greenland's specific element contains 29 (3 Green, 20 Brown, 6 Red) and West Greenland's 39 species (14 Green, 12 Brown, 13 Red). The common element contains 13 a, 75 sa, and 26 ba species, while East Greenland's specific element is distributed on 10 a, 16 sa, and 3 ba species, and West Greenland's specific element on 6 a, 20 sa, and 13 ba species.

It should, however, again be emphasized that this summing up is carried out on the basis of our present, insufficient knowledge. Investigations of the unknown areas will be needed to gain a knowledge of the conditions actually prevailing and it must be hoped that such investigations will be made in future.

VI. SUMMARY

I. The present work gives a phytogeographical analysis of the marine algal flora in Scoresby Sund and the Kejser Franz Josephs Fjord district. The system used for this purpose is that introduced by Børgesen & Jónsson (1905), established on a purely geographical basis.

II. At the beginning of the work a review is given of the most important external factors influencing the algal vegetation: the temperature and salinity of the sea water, the ice, the mud, the altitude of the sun, and the nature of the bottom. It is proposed that the consequence of the mud to the algal vegetation be subjected to investigations. Fig. 2 illustrates the length of the day in a locality of each of the two districts.

III. 1. Subsequently, a survey is made of the algal vegetation. After a summary of the sparse literature on this subject in East Greenland a brief review is made of the communities encountered, grouped by regions. Distinction is made between a supralittoral, a littoral, and a sublittoral region, but it has been impossible to fix the boundary between them exactly by means of tide marks. The boundary between the latter two is designated as "0 m".

2. The following section contains some observations on the algae in relation to external factors. From a hydrographical point of view a good deal of the species occurred both in the fiord-water layer and in Polar Current water, others seem to be restricted to the latter water and a few to the former. Despite the adverse light conditions several species extend to considerable depths, a few of them being encountered at a depth of 120 m; hence, it cannot be excluded that such species are mixotrophic. Future investigations of this problem, including measurements of the submarine light, will be awaited with interest.

IV. 1. This chapter, which is the central part of the work, begins with an analysis of the flora of the two districts, considered as a whole. A total of 109 species are known, among them 25 Green Algae (23 $^0/_0$), 53 Brown Algae (49 $^0/_0$), and 31 Red Algae (28 $^0/_0$). Classified according to distributional groups 16 species (15 $^0/_0$) are arctic, 73 species (67 $^0/_0$) subarctic, and 20 species (18 $^0/_0$) boreal-arctic. Thus, the flora is markedly arctic-subarctic, the percentage a + sa amounting to 82. The species are listed on pp. 35—36. Within the subarctic group the Brown Algae are by far predominant. Also within the arctic group the Brown Algae are predominant, but are followed closely by the Red Algae. Within the boreal-arctic group the Green Algae are predominant. The distribution of the species in the two districts and in a number of areas outside of East Greenland is shown in Table 1.

2. Subsequently, an analysis is made of the vertical distribution of the flora of the two districts, considered as a whole. On the basis of the diagram shown in Table 2, which illustrates the vertical range of all the species involved, Table 3 states the number of species occurring in the individual depth intervals, into which the area has been divided. The greatest number of species are found in the intervals between 0 and 30 m, where the Brown Algae are predominant. Below this depth the Red Algae take the lead, and above 0 m the Green Algae. Above 0 m the flora is equally subarctic and boreal; below 0 m it is markedly arctic-subarctic, the arctic share on the whole increasing with increasing depth (Tables 3, 8, 11).

The share of the individual algal classes and distributional groups in the vegetation of each depth interval, their behaviour with increasing depth, and other aspects are elucidated in details in the Tables 4—11 and summarized on pp. 49—51. Their vertical distribution is illustrated in figs. 3—4.

3. Finally, a comparison is made between the flora of Scoresby Sund and that of the Kejser Franz Josephs Fjord district and between outer and inner Scoresby Sund. On the basis of the columns to the right in Table 1, Table 12 states the total number of species encountered in these areas. As regards the first two areas, these figures are followed by amended figures (in brackets), i. e. the number of species hitherto recorded increased by such species as must be expected to be encountered at future examinations. The comparison between these two areas is based on the amended figures. In the Tables 13 and 14 an analysis is made of the share of the individual distributional groups in the common element and specific elements of the areas examined.

While 100 species are recorded from Scoresby Sund, only 58 are met with in both the outer and the inner part. Several of the latter species are somewhat reduced when occurring in the inner part. The specific element of the outer part amounts to 29 species (pp. 55—56), that of the inner part to 13 species (p. 56). Most likely almost all of the species constituting the specific element of the outer part will eventually be found in the inner part, and all the species of the specific element of the inner part must be expected to be found in the outer part. Seven arctic species and two forms (one arctic and one subarctic) are unknown in

East Greenland south of Scoresby Sund (p. 57), while 21 species are not recorded north of this district (p. 57). One of the species is known only from Scoresby Sund.

The total, amended number of species in Scoresby Sund and the Kejser Franz Josephs Fjord district, considered as a whole, amounts to 113 (as against the 109 species actually recorded). The common element contains 87 species, while the specific element of the former district comprises 21 species (those reaching their northern limit in Scoresby Sund, p. 57), and that of the latter 5 species (p. 59). Among these 5 species, all of them occurring in the fiord-water layer at Ella Ø, is *Sorocarpus uvaeformis*. This species has not previously been encountered in the Arctic and is most probably a relict. Thirty species are not recorded north of the Kejser Franz Josephs Fjord district (p. 60); one species is known only from that district.

The percentage of the arctic + subarctic species is nearly uniform in the outer and the inner part of Scoresby Sund, entire Scoresby Sund, the Kejser Franz Josephs Fjord district, and the entire area considered as a whole, varying only between 82 and 87 whether actual records or amended figures are applied.

V. A review of the number of species recorded from the remaining East Greenlandic districts: the Sydøstkyst district, the Kangerdlugssuaq district, and the Nordøstkyst district, is followed by a summing up of the algal flora of East Greenland based on our present knowledge. These figures should, however, by no means be interpreted as giving a true picture of the conditions actually prevailing, as particularly the southernmost two districts are, so far, very insufficiently examined.

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