DET KONGELIGE DEPARTEMENT
FOR INDUSTRI OG HÅNDVERK

NORSK POLARINSTITUTT

SKRIFTER

Nr. 116

THE ALGAL VEGETATION OF SPITSBERGEN

A SURVEY OF THE MARINE ALGAL FLORA OF THE OUTER PART OF ISFJORDEN

BY
PER SVENDSEN

I KOMMISJON HOS
UNIVERSITETSFORLAGET
OSLO 1959

NORSK POLARINSTITUTT
(Formerly Norges Svalbard- og Ishavs-undersøkelser.)
Observatoriegaten 1, Oslo

SKRIFTER

Skrifter 1—50, see numbers of Skrifter previous to No. 100.

Resultater av De Norske statsunderstøttede Spitsbergenekspeditioner.

Nr. 51. BIRKELAND, B. J. et GEORG SCHOU, *Le climat de l'Eirik-Raudes-Land.* 1932. Kr. 2,00
„ 52. KIÆR, J. †, *The Downtonian and Devonian Vertebr. of Spitsb.* IV. Suborder *Cyatha spida.* 1932. Kr. 5,50.
„ 53. 1. MALAISE, R., *Eine neue Blattwespe.* 2. A. ROMAN, *Schlupfwespen.* 3. O. RINGDAHL, *Tachiniden und Musciden.* 4. M. GOETGHEBUER, *Chironomides du Groenland oriental, du Svalbard et de la Terre de François Joseph. — Zool. Res. Norw. Sc. Exp. to East-Greenland. II.* 1933. Kr. 4,00.
„ 54. VARTDAL, H., *Bibliographie des ouvrages norvégiens relatifs au Grœnland (Y compris les ouvrages islandais antérieurs à l'an 1814).* 1935. Kr. 12,00.
„ 55. OMANG, S. O. F., *Übersicht über die Hieraciumflora Ost-Grönlands.* 1933. Kr. 2,50.
„ 56. DEVOLD, J. and P. F. SCHOLANDER, *Flowering Plants and Ferns of Southeast Greenland.* 1933. Kr. 20,00.
„ 57. ORVIN, A. K., *Geology of The Kings Bay Region, Spitsbergen.* 1934. Kr. 20,00.
„ 58. JELSTRUP, H. S., *Détermination astronomique à Sabine-Øya.* 1933. Kr. 2,50.
„ 59. LYNGE, B. *On Dufourea and Dactylina. Three Arctic Lichens.* 1933. Kr. 5,00.
„ 60. VOGT, TH., *Late-Quaternary Oscillations of Level in S. E. Greenland.* 1933. Kr. 5,00.
„ 61. 1. BURTON, M., M. SC., *Report on the Sponges.* 2. ZIMMER, C., *Die Cumaceen. — Zool. Res. Norw. Sc. Exp. to East-Greenland. III.* 1934. Kr. 2,50.
„ 62. SCHOLANDER, P. F., *Vascular Plants from Northern Svalbard.* 1934. Kr. 15,00.
„ 63. RICHTER, S, *A Contr. to the Archæology of North-East Greenland* 1934. Kr. 25,00.
„ 64. SOLLE, G., *Die devonischen Ostracoden Spitzbergens.* 1935. Kr. 5,50.
„ 65. 1. FRIESE, H., *Apiden.* 2. LINDBERG, H., *Hemiptera.* 3. LINNANIEMI, W. M., *Collembolen. Zool. Res. Norw. Sc. Exp. to East-Greenland. IV.* 1935. Kr. 2,50.
„ 66. 1. NORDENSTAM, Å., *The Isopoda.* 2. SCHELLENBERG, A., *Die Amphipoden.* 3. SIVERTSEN, E., *Crustacea Decapoda, Auphausidacea, and Mysidacea. Zool. Res. Norw. Sc. Exp. to East-Greenland. V.* 1935. Kr. 5,00.
„ 67. JAKHELLN, A., *Oceanographic Investigations in East Greenland Waters in the Summers of 1930—1932.* 1936. Kr. 7,00.
„ 68. FREBOLD, H. und E. STOLL, *Das Festungsprofil auf Spitzbergen.* III. *Stratigraphie und Fauna des Jura und der Unterkreide.* 1937. Kr. 5,50.
„ 69. FREBOLD, HANS, *Das Festungsprofil auf Spitzbergen.* IV. *Die Brachiopoden- und Lamellibranchiatenfauna des Oberkarbons und Unterperms.* 1937. Kr. 10,00.
„ 70. DAHL, EILIF, B. LYNGE, and P. F. SCHOLANDER, *Lichens from Southeast Greenland.* 1937. Kr. 4,50.
„ 71. 1. KNABEN, NILS, *Makrolepidopteren aus Nordostgrönland.* 2. BARCA, EMIL, *Mikrolepidopteren aus Nordostgrönland. Zool. Res. Norw. Sc. Exp. to East-Greenland. VI.* 1937. Kr. 3,50.
„ 72. HEINTZ, A., *Die Downtonischen und Devonischen Vertebraten von Spitzbergen. VI. Lunaspis-Arten aus dem Devon Spitzbergens.* 1937. Kr. 2,00.
„ 73. *Report on the Activities of Norges Svalbard- og Ishavs-undersøkelser 1927—1936.* 1937. Kr. 10,00.
„ 74. HØYGAARD, ARNE, *Some Investigations into the Physiology and Nosology of Eskimos from Angmagssalik in Greenland.* 1937. Kr. 1,50.
„ 75. DAHL, EILIF, *On the Vascular Plants of Eastern Svalbard.* 1937. Kr. 3,50.
„ 76. LYNGE, B., *Lichens from Jan Mayen.* 1939. Kr. 4,50.
„ 77. FREBOLD, HANS, *Das Festungsprofil auf Spitzbergen. V. Stratigraphie und Invertebratenfauna der älteren Eotrias.* 1939. Kr. 5,00.

DET KONGELIGE DEPARTEMENT
FOR INDUSTRI OG HÅNDVERK

NORSK POLARINSTITUTT

SKRIFTER

Nr. 116

THE ALGAL VEGETATION OF SPITSBERGEN

A SURVEY OF THE MARINE ALGAL FLORA OF THE OUTER PART OF ISFJORDEN

BY
PER SVENDSEN

I KOMMISJON HOS
UNIVERSITETSFORLAGET
OSLO 1959

A. W. BRØGGERS BOKTRYKKERI A/S

Contents.

PREFACE

A study of the marine algal vegetation of Isfjorden at Spitsbergen was proposed by Professor Dr. Trygve Braarud as a thesis problem in marine biology. A detailed report of the investigation is deposited at the Secretariat of the University of Oslo, Blindern.

The author is deeply indebted to Professor Dr. Trygve Braarud for his continuous guidance and suggestions during all phases of the investigation.

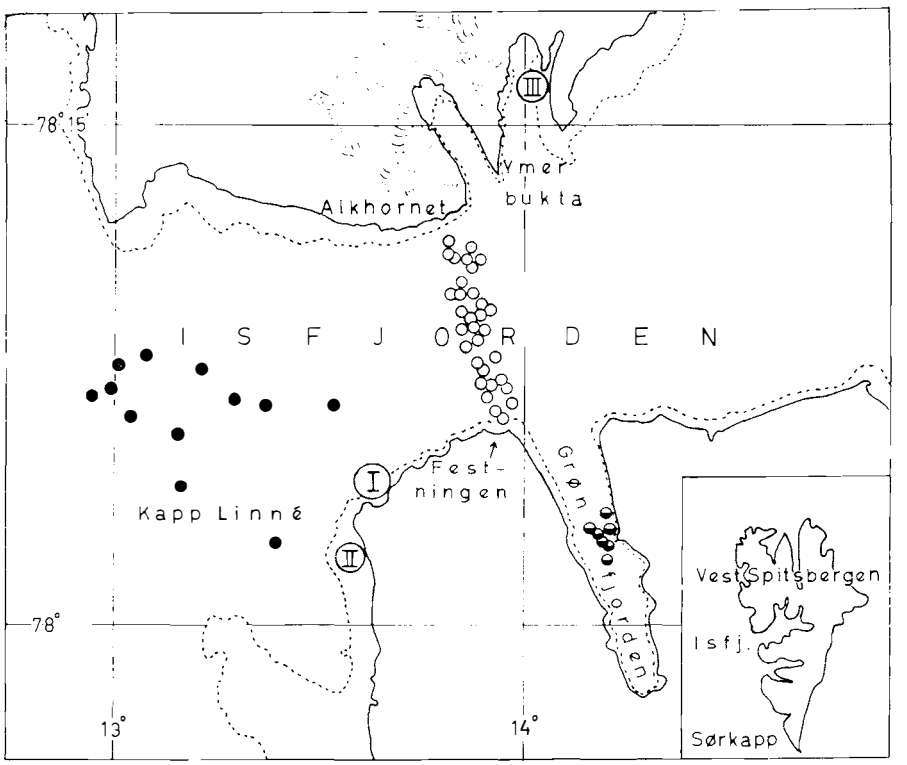


Fig. 1. The outer part of Isfjorden.
I II III — localities investigated.
◒ ○ ● — hydrographical stations of group 1, 2 and 3 respectively (see page 9).

The fieldwork, extending from the beginning of July to mid-August during 1954 and 1955, was carried out in the outermost part of Isfjorden in the vicinity of Kapp Linné (Fig. 1).

I wish to acknowledge the valuable instruction of Dr. Ove Sundene during my first week at Spitsbergen in 1954 and the assistance of Mr. Ole Jacob Wulff during 1955.

During the course of the fieldwork, food and lodging were benevolently provided at Isfjord Radio Station, Kapp Linné by the Telegrafstyret and chief operators of the radio station.

Financial assistance for the fieldwork was provided by Norges Teknisk-Naturvitenskapelige Forskningsråd and the Hielmstjerne-Rosencroneske stiftelse.

The preparation of this publication is made possible by a grant from the Norsk Polarinstitutt. I am greatly indebted to the director of the Norsk Polarinstitutt, Dr. Anders K. Orvin, whose interest in the publication of the results has been a source of encouragement.

Technical assistance was kindly provided by Mrs. Bjørg Paulsen, Mrs. Inger Berg and Miss Berit Valbø at the Institutt for marin biologi, avd. B, Blindern, Miss Bergljot Mauritz, Geologisk Museum, Tøyen, and Mr. O. Brynildsrud, Fysisk institutt, Blindern. I am especially indebted to Mrs. Norma Louise Smayda who corrected the manuscript.

I. INTRODUCTION

1. General features and topography.

The island of Vestspitsbergen[1] is situated very far north compared with most of the other arctic landmasses. The southern and northern points of the island are located at 76° 6′ N and 80° N, respectively.

The survey was confined to Isfjorden, which extends about 100 km inland to form the greatest indentation on the west coast (Fig. 1). At its entrance the shores are exposed to the open sea. Within the fjord there are a number of bays such as Ymerbukta and Grønfjorden providing unexposed conditions (Fig. 1).

Numerous glaciers and rivers discharge a rich supply of fresh water along with considerable masses of sediments. The glaciers are found chiefly along the northwestern shores of Isfjorden. In localities as Ymerbukta the transparency of the sea water is greatly reduced, even several hundred metres offshore, due to the suspensoids brought out with the fresh water. The algae become considerably covered with sediments, a condition obviously deleterious to their photosynthesis. These conditions were most conspicuous in the upper sublittoral region. Certainly, the floristic composition and the vertical extent of the algal vegetation in such localities are variously influenced.

The bottom topography within the area investigated varies somewhat. Shortly beyond the 20 m depth line (Fig. 1) in the area between Kapp Linné and Festningen, the sea floor rapidly drops to depths of 100—300 m or more, whereas south of Kapp Linné this depth line extends further offshore. At locality III shallower depths are encountered as the bottom slopes very gently. (The depth line here is only 10 m.) In the middle of the bay, the depth slightly exceeds 100 m.

Very different habitats result from the topographical and geological features of the shore. In exposed localities (I and II) algae were observed almost exclusively on rocks. The conditions most favourable to algal growth occurred at locality I. Here a rocky coastline interrupted by sandy beaches is an outstanding feature of the shore between Kapp Linné and Festningen. Geologically, sedimentary rocks such as sandstone, limestone and shale are encountered (Orvin 1940). The effects of sea, ice etc. upon

[1] Hereafter referred to as Spitsbergen.

Fig. 2. The shore at Kapp Linné. July 1955.

these materials are readily revealed. Due to erosion, furrows and cracks frequently appear throughout the surface of the rocks, especially in sandstone and shale. Gradually removal of the loose material from the brink through wave action produces the very typical coastline to be observed here (Fig. 2).

Barren beaches are prevalent at locality II where low cliffs occur infrequently. In Ymerbukta the shore consists of decomposed schist, sand and mud. The inclination was negligible.

2. Hydrography.

A. Surface temperature and salinity.

Detailed studies on the hydrography of Spitsbergen waters have been carried out by Helland-Hansen and Nansen (1912), Nansen (1915) and Mosby (1938). Investigations of the outer part of Isfjorden were conducted particularly by Nansen (l. c.).

The hydrographical observations carried out in this area since Nansen's investigations, have not been published, hence the following data will be discussed in some detail.

The data under consideration are based upon observations conducted in the outer part of Isfjorden during the period 1922—1940, chiefly during July through September. They were kindly placed at my disposal by the Geofysisk Institutt, Bergen. Unfortunately, no data were recorded for the years 1927, 1929, 1932, 1933 and 1934.

The hydrographical data reported here comprise a selection of 73 observations (0 m) from 52 stations. Geographically, the stations form three groups (Fig. 1) which will be dealt with separately.

The number of stations and observations within each group are given below:

Designation of group		Area	Number of stations	Number of observations
1.	◒	Grønfjorden	7	14
2.	○	Festningen-Alkhornet	32	45
3.	●	West of group 2	12	14

The observations of groups 1 and 3 are few in numbers and very scattered in time. Mean values of surface temperature and salinity could not be calculated on the limited data. As recorded in the tables of the original data the salinity values obtained in group 1, were in most cases below 32 ‰. As might be expected, the surface salinity varies greatly in Grønfjorden. At one station the extreme values observed were 21.87 ‰ (17/7 1935) and 32.64 ‰ (11/9 1936) respectively. The upper and lowermost values observed in that group were 34.29 ‰ (25/7 1926) and 21.87 ‰, respectively. Considering the supply of fresh water, the surface salinity must be relatively low in inshore localities like Ymerbukta.

As compared with group 1, the variations in salinity values of group 3 were far less marked. The absolute values most frequently exceeded 32 ‰. The salinity values observed in groups 1 and 3 indicate the extremes within our material.

Surface temperature and salinity of localities I and II should, according to their position, approximate those of station groups 2 and 3. To obtain mean monthly values the observations from both groups were combined (Table 1).

Table 1.

Monthly distribution of hydrographical observations, and mean monthly values of surface temperature and salinity of station groups 2 and 3 combined.

Month	Total number of observations in groups 2 and 3	Temperature, °C			Salinity, ‰		
		Min.	Max.	Average	Min.	Max.	Average
May	3						
June	1						
July	20	3.25	5.28	4.92	31.97	33.88	32.93
August	17	2.23	6.08	3.93	29.82	32.57	31.17
September ...	18	2.40	4.46	3.51	29.59	32.92	31.55

It should be emphasized that the observations are very scattered in time. May and June are not considered as observations were too few.

The highest mean temperature occurred in July, while the maximum temperature in August exceeded those of July and September. As recorded in the original data, temperatures below zero were recorded in May only.

The mean midsummer surface temperature in arctic waters is approximately 3° C, which closely agrees with the mean surface temperature during December—February along the coasts of northern Norway (Kjellman 1883). Also Kjellman (l. c.) states that the temperature seldom exceeds 0° C at those depths where the most extensive algal flora occurs.

From June through September the salinity was relatively low which might be explained by the supply of fresh water from rivers, glaciers and melting sea ice.

B. Tidal range.

Tidal observations were carried out at Kapp Linné in 1946 (26 July —12 August) by Norsk Polarinstitutt (Hornbæk 1954). The data were obtained by use of an automatic tide gauge. Approximate values for the average tidal ranges were calculated on the basis of Hornbæk's data. They were at:

Mean tide	ca. 100 cm
Spring tide	ca. 131 cm
Neap tide	ca. 70 cm

3. Light.

Due to both the periodical absence of the sun and ice formation along the coasts of arctic waters, the algae live in total darkness for several months. At Spitsbergen (Kapp Linné, 78° N) the sun is below the horizon from 26 October to 14 February, while the midnight sun appears from 21 April to 22 August. However, in these high latitudes the altitude of the sun is relatively low. Loss of incoming radiation by reflexion from the sea surface along with the moderate light intensity in arctic regions should be emphasized when light conditions are considered.

During periods of sea ice, the subsurface illumination may be greatly reduced. According to Gessner (1955) the absorption of radiation by (fresh) water and clear ice is approximately equal. With snow, however, absorption is greatly increased as revealed by the results of some experiments carried out in Germany (Table 2).

As seen the light intensity decreases rapidly with increasing depth of snow; the rate of extinction being also a function of the physical nature of the snow itself. Obviously, the subsurface illumination must be extremely low where snow-covered ice occurs.

Table 2.

Light intensity, expressed in lux and per cent, penetrating to different layers of dry and wet snow. (After Gessner 1955.)

Dry snow (21 February) Cloudy ("Trübes Wetter")			Wet snow (4 March) Clear ("Sonniges Wetter")		
Depth of snow in cm	Lux	%	Depth of snow in cm	Lux	%
0	6 400	100	0	48 000	100
5	1 300	20.3	7	800	1.66
10	330	5.16	10	140	0.292
20	24	0.39	20	30	0.063
30	2	0.03	30	3	0.0062

The unfavourable light conditions in arctic waters may effect the algal vegetation variously. In this connection, Kjellman (1883) points out the general poverty in Chlorophyceae, while Taylor (1954) notes the relatively low number of annuals encountered in arctic regions. Surely other ecological factors such as temperature and the abrasive action of ice should be considered.

4. Air temperature.

The Spitsbergen climate is surprisingly mild, considering the geographical location; this phenomenon is largely due to the Atlantic Spitsbergen Current which passes along the west coast of the island (Fig. 3). This current is a northern branch of the Gulf Stream; also, the low pressure areas passing between Norway and Spitsbergen provide a northward flow of warm air. The relationship between ice conditions on the west coast of Spitsbergen and the air and sea temperatures will be discussed later.

At Spitsbergen the mean annual air temperature is below 0° C. During the period 1911—1940, the annual mean at Isfjord Radio Station (Kapp Linné) was —5.6° C. The extreme mean monthly values during that period were —15.4° C (March) and +4.1° C (August).

Some postwar observations on the air temperature at Spitsbergen need comment. Continuous daily observations of the air temperature made at Isfjord Radio Station since the last war have been recorded.

The mean monthly temperatures during the period 1947—1953 were as follows:

Table 3.

Mean monthly air temperatures at Isfjord Radio Station during the period 1947—1953.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Temperature, °C	-10.8	-10.3	-12.5	-9.3	-3.8	+1.8	+4.4	+4.0	+1.0	-2.7	-6.2	-9.5

The annual mean during this period was —4.5° C.

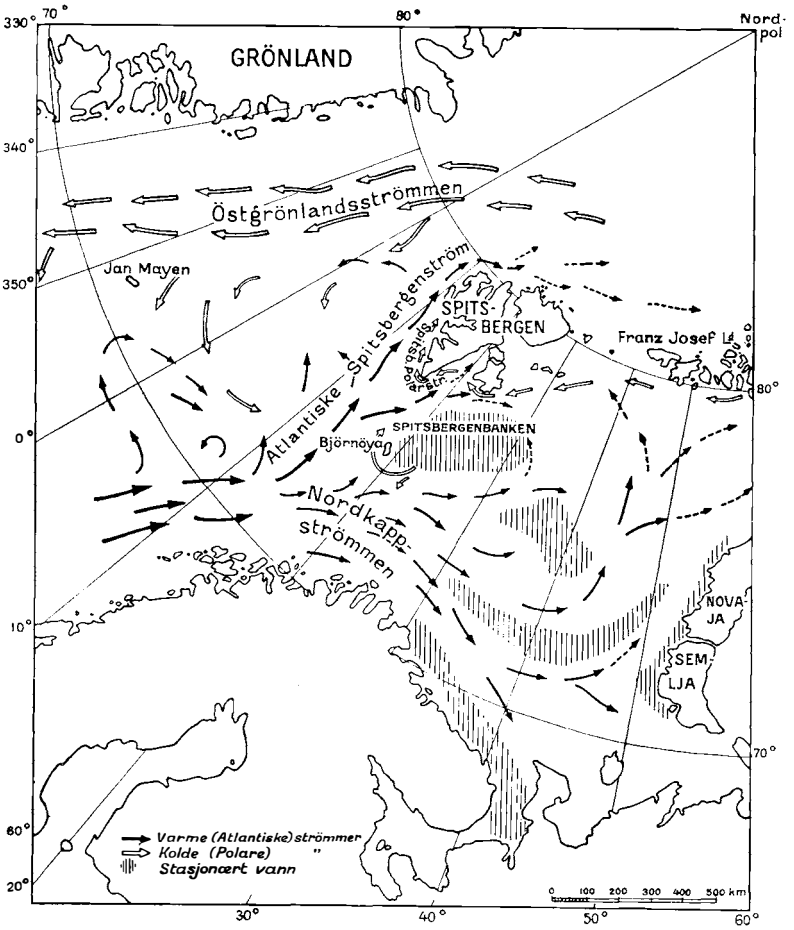


Fig. 3. Surface currents in Spitsbergen waters. (From Omdal 1953.)
Solid arrows = Warm (Atlantic) currents.
Open arrows = Cold (Polar) currents.
Shaded areas = Stationary water.

Table 4.

The differences in mean air temperatures during the periods 1929—1938 and 1899—1908, expressed as ten-year means. (From Hesselberg and Birkeland 1940.)

Station	Differences in temperature (°C). Increase from 1899-1908 to 1929-1938				
	Yearly	Winter	Spring	Summer	Autumn
Bodø	+1.60	+1.89	+1.22	+1.76	+1.33
Andenes	+1.47	+1.92	+0.97	+1.58	+1.42
Tromsø	+1.43	+1.60	+1.05	+2.14	+1.02
Alta	+1.52	+2.51	+0.57	+1.77	+1.30
Vardø	+1.23	+1.80	+0.51	+1.35	+1.35
Sørvaranger	+1.98	+3.57	+1.01	+1.53	+2.02
Karasjok	+1.91	+3.72	+0.55	+1.53	+1.93
Spitsbergen	+2.47	+5.07	+1.99	+0.21	+2.34

The means were above 0° C from June to September. The maximum mean monthly temperature occurred in July and the minimum in March.

As shown by Hesselberg and Birkeland (1940), the air temperature in northern regions has gradually increased during this century. The data presented by Hesselberg and Birkeland (l. c. Table 5) show a significant increase in the mean air temperature of 26 Norwegian stations including Spitsbergen. The observations were confined to two ten-year periods, 1899—1908 and 1929—1938. The means of the 8 northernmost stations, the most significant increases being observed here, are presented in Table 4.

The data from Spitsbergen are noteworthy since the seasonal and yearly increases, with one exception, exceed those of all other stations. During the winter season the mean temperature increased no less than 5.07° C, while during the summer the increase was rather inconspicuous. Consumption of warm air through ice melting during the summer possibly accounts for the lesser increase recorded during that season. (Hesselberg and Birkeland l. c.)

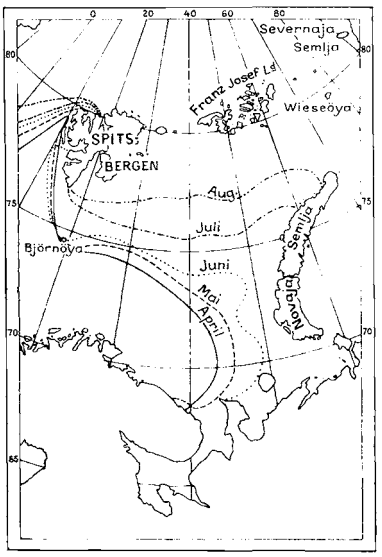
5. Ice conditions.

The importance of the ice conditions to the algal vegetation at Spitsbergen was discussed by Kjellman (1883). Considering the time interval since Kjellman's investigations, the more recent observations of the ice conditions need comment.

Along the west coast of Spitsbergen ice conditions are favourable as compared with those of other arctic regions. Undoubtedly the amount of sea ice in this area is closely related to the hydrographical conditions associated with the Atlantic Spitsbergen and Spitsbergen Polar Currents (Fig. 3) as well as the air temperature. The fjords and bays on the west coast are usually ice-covered during some months of the year. Fortunately, observations of the ice conditions in Isfjorden (Anonymous 1, 2, 3) have been recorded, though detailed records are limited to only a few years (Anonymous 1, 3). Obviously, the extent and duration of the ice cover in Isfjorden may vary considerably.

With certain reservations it is suggested that freezing usually takes place during December or later, while during May the ice breaks up and gradually disappears. Exceptionally, the greater part of Isfjorden has remained icefree during winter, save for drift ice. The winter ice may reach about 1 m in thickness.

In Svalbard waters the drift ice is confined essentially to the areas northwest to north of Spitsbergen, and secondarily to the northern Barents Sea (Omdal 1953). The great icefree region extending west of Spitsbergen (Figs. 4, 5) is peculiar to these waters. Usually the drift ice attains its maximum extent during spring, while from August to September



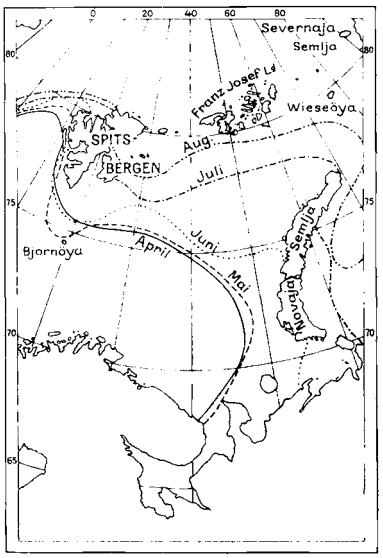


Fig. 4. Mean boundary lines of the drift ice from April to August during the period 1898—1922. (From Omdal 1953.)
Fig. 5. Mean boundary lines of the drift ice from April to August during the period 1929—1939. (From Omdal 1953.)

ice conditions are most favourable on the west coast (Figs. 4, 5). During autumn and early winter the magnitude of sea ice is usually of less importance (Frommeyer 1928, Omdal l. c.).

Due to the Spitsbergen Polar Current (Fig. 3) drift ice from the Barents Sea is frequently carried to the west coast of Spitsbergen, and during the spring a continuous ice belt may extend between Sørkapp (Fig. 1) and Isfjorden. However, the amount of drift ice on the west coast is highly influenced by the wind (Omdal l. c.). This phenomenon is of great importance in influencing ice conditions on the west coast. During unfavourable periods Isfjorden may be entirely blocked by drift ice in late June or even July.

Finally, the ice foot should be considered. This part of the sea ice which is situated above low tide level, forms a continuous rim along the shore. An sandy beaches the ice foot is rather inconspicuous, usually being covered by sand.

It is generally supposed that the formation and disappearance of the ice foot, as well as its vertical range is related to exposure (Feyling-Hanssen 1953 a). Unfortunately, there are very few records of the ice foot at Spitsbergen. According to Feyling-Hanssen it is generally assumed that the ice foot in Isfjorden forms in November and breaks down in May. As he emphasizes, the dates suggested may undoubtedly vary considerably.

Remnants of the ice foot at Kapp Linné in late June are shown in Fig. 6. In 1954 fragments of the ice foot in this locality were observed

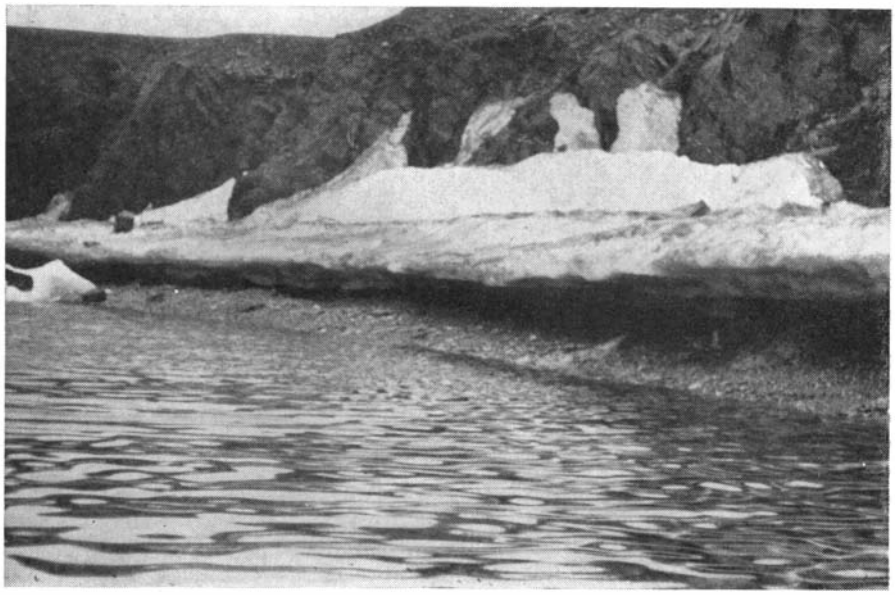


Fig. 6. The ice foot at Kapp Linné 28/6 1952. (About mean water level.)

even in late July. Probably the lower border of the ice foot in exposed localities in Isfjorden is most usually situated about high tide level (Feyling-Hanssen l. c.). In 1951 the extreme lower border of the ice foot at Kapp Linné was situated about mean water level. This occurred during March, when the mean air temperature for the year reaches its minimum (Table 3). Probably the littoral region is completely covered by the ice foot only in well sheltered localities (Feyling-Hanssen l. c.). The littoral vegetation may be variously influenced by the ice foot though the effects are insufficiently known. However, it has been suggested that the ice foot does not injure the littoral vegetation (Deichmann and Rosenvinge 1907, Steenstrup 1907, Feyling-Hanssen l. c.). Moreover, the ice foot protects the littoral algae against the abrasive action of sea ice as well as against the low air temperatures.

During this century the ice conditions along the west coast of Spitsbergen have gradually improved, the change being most significant from 1918 onward (Hesselberg and Birkeland 1940). The extent of drift ice, as expressed by mean boundary lines, has been less extensive during recent years (Figs. 4 and 5). At the same time the ice cover of the fjords has become lesser. These features are in agreement with the noted increase of the air and sea temperatures (Hesselberg and Birkeland l. c.). Some temperature records, confined to subsurface levels of 200—450 m, show a 1.3° C increase from 1913—1931 (Mosby 1938).

Valuable records of the ice conditions by Hesselberg and Birkeland (1940) have been made through observations on the duration of the

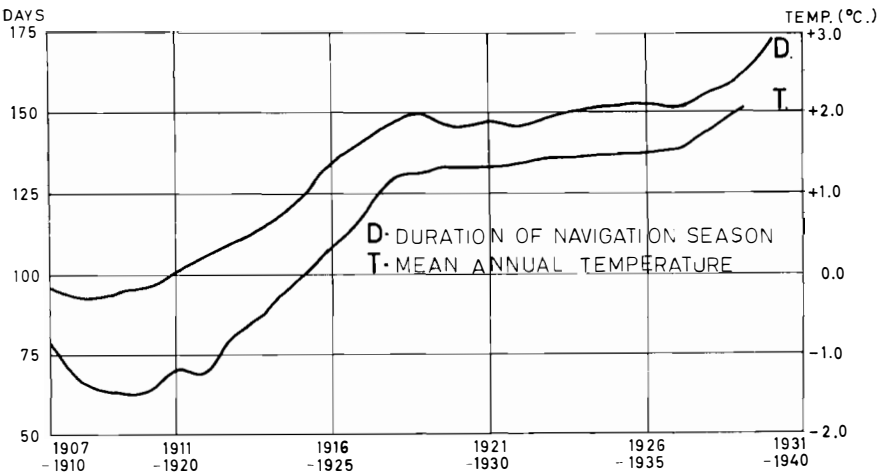


Fig. 7. Variations of the duration of the navigation season and the air temperature at Spitsbergen expressed by ten-year means. (Slightly modified after Hesselberg and Birkeland 1940.)

navigation season at Spitsbergen. Dependent upon ice conditions, the season begins during the spring and terminates 15 November.

In agreement with the improved ice conditions the duration of the navigation season, expressed by ten-year means (D Fig. 7), was gradually prolonged during the period 1907—1940. The corresponding mean air temperatures (T) show the same patterns. Unfortunately, information on the ice conditions past 1940 are insufficient.

II. THE ALGAL VEGETATION

1. Previous investigations.

Previous reports and investigations on the marine algal vegetation of Spitsbergen are largely confined to the latter half of the last century. Through the papers by Agardh (1862, 1868) scattered information is offered concerning 51 species collected on the west coast. During the year 1872—1873 comprehensive investigations on the algal vegetation were carried out by F. R. Kjellman. Observations were conducted in numerous localities on the west and north coasts of Spitsbergen, and in Isfjorden as well.

During the winter the sublittoral vegetation was studied at the northernmost station (Mosselbukta 79° 53′ N, Kjellman 1875 b). Detailed information on different species is given in two reports (Kjellman 1875 a, 1877 a) in which 87 species, including those listed by Agardh, are recorded. The general features of the algal vegetation as well as its relation to other arctic regions are discussed in another two papers (Kjellman 1877 b, 1883).

More than 80 years have lapsed since the marine algae of Spitsbergen were last studied. As previously mentioned the climate has been changing gradually during this period. The observed increase in air and sea temperature along with the improvement of ice conditions during this period has probably favoured algal growth on the west coast of Spitsbergen.

The general floristic composition and the vertical distribution of littoral algae were particularly studied by the survey in Isfjorden during the summers 1954 and 1955. Emphasis was also laid on the collection of laminariaceae and fuci. Observations of the occurrence of blue-green algae were confined to the littoral region; classification of the different species have not been made.

2. Methods and material.

The regional division of the algal vegetation as used in Isfjorden is that employed by Sundene (1953). However, the boundary between the littoral and supralittoral region was very difficult to ascertain, as a natural litus line (Sjöstedt 1928) did not occur. On Scandinavian shores the

upper limit of the *Balanus balanoides* association or the lower limit of the *Verrucaria maura* association frequently coincides with the litus line. At Spitsbergen the occurrence of *Balanus balanoides* was very scattered as stated by Feyling-Hanssen (1953 b, p. 24): "I have nowhere observed in Spitsbergen waters the continuous white lining of the littoral of rocky coasts so commonly met with in more southerly regions." Finally the author states that *Balanus balanoides* in Spitsbergen generally occurs about mid tide level. Populations of *Verrucaria* occurred not infrequently in exposed localities in the supralittoral region, but a distinct lower border did not appear.

Very few littoral species were zone-forming. In exposed localities *Fucus distichus* occurred very frequently on rocks between tide levels, usually extending to about high tide level. Occasionally *Fucus* was very poorly developed or absent, then usually replaced by *Pylaiella littoralis*. An *Ulothrix—Urospora* zone was observed as well. The upper limit of the *Fucus distichus* zone, though often indistinct, was used in most cases as the zero line in vertical measurements. Otherwise the upper border of the *Pylaiella* or *Ulothrix—Urospora* zone was used. It is stressed that the results obtained by vertical measurements should be considered with criticism.

The material was collected chiefly in the exposed area between Kapp Linné and Festningen (Fig. 1). 83 dredgings were conducted with a triangular dredge. In localities I and III (Fig. 1) dredgings were carried out from 1 m to the lower border of the vegetation, approximately 55 m and 40 m respectively. The majority of dredgings were confined to depths between 4 and 20 m. About 200 sublittoral samples were taken with a small spring grab, kindly placed at my disposal by the Norwegian Institute of Seaweed Research. When spread it covers a 35 × 40 cm are and is conveniently operated by one man.

The littoral vegetation was studied particularly at Kapp Linné. Observations were carried out in localities II and III as well, but in less detail. The vertical distribution of the most important species in locality I is illustrated by use of profiles. Measurements were carried out with a pole having 5 cm divisions. The mean water level (M. W. on the profiles) was estimated by approximation.

For the littoral species the cover, expressed according to a scale 1—5 (Sundene l. c.), was analysed in one area of locality I.

The general features of the localities were given previously. Locality II extends approximately 5 km south of Kapp Linné, while locality I covers the area between Kapp Linné and Festningen. Observations carried out in exposed localities are for the most part collectively described.

3. The vegetation in exposed localities.

A. Supralittoral vegetation.

Very few species occurred above the zero line. The following were recorded:

Enteromorpha sp.
Rhizoclonium riparium
Ulothrix pseudoflacca
Urospora penicilliformis
Fucus distichus
Hildenbrandia prototypus

Verrucaria and different Cyanophyceae occurred as well. The vegetation was extremely scattered and poor, and with the exception of *Verrucaria,* no species formed zones. For some square metres, *Verrucaria* covered the rocks, black crusts being observed to 200 cm above the zero line.

Ulothrix pseudoflacca and *Enteromorpha* sp. were the most frequently occurring species, though *Ulothrix* was commonly mixed with various Cyanophyceae or *Urospora. Enteromorpha* sp., usually solitary, formed small dense patches which occasionally occurred to 150 cm above high tide level. The remaining species were very inconspicuous. Dwarfish specimens of *Fucus* were infrequently found near high tide level.

No species were exclusively confined to the supralittoral region. Due to the patchy occurrences vertical distribution of the different species can not be estimated.

B. Littoral vegetation.

25 (26) species were recorded in the littoral region. The abundance of the different species listed in Table 5, is indicated by the following scale: c — common, cc — very common, r — rare, rr — very rare.

Table 5.
Littoral species of exposed localities.

Chaetomorpha melagonium	r
Cladophora spp.	c
Enteromorpha compressa	c
Enteromorpha sp.	r
Rhizoclonium riparium	r
Spongomorpha sp.	c
Ulothrix pseudoflacca	c
Urospora penicilliformis	c
(*Ascophyllum nodosum*)	(rr)
Asperococcus sp.	c
Chordaria flagelliformis	cc

(Table 5 cont.)

Delamarea attenuata	rr
Dictyosiphon foeniculaceus	r
Ectocarpus confervoides	r
Elachista fucicola	c
Fucus distichus	cc
Isthmoplea sphaerophora	rr
Lithoderma sp.	r
Mesogloia vermiculata	r
Pylaiella littoralis	cc
Ralfsia sp.	cc
Scytosiphon sp.	r
Halosaccion ramentaceum	r
Hildenbrandia prototypus	r
Rhodochorton rothii	r
Rhodomela lycopodioides	r

Occurrence of species by class:

Class	Number of species
Chlorophyceae	8
Phaeophyceae	13 (14)
Rhodophyceae	4

Ascophyllum has most probably drifted from southern shores as only unattached specimens were found.

Lithoderma, Halosaccion and *Rhodomela,* which were very commonly observed in the sublittoral region, usually occurred at low tide level, sometimes abundantly.

The most prominent species of the littoral vegetation were:

Enteromorpha compressa
Ulothrix pseudoflacca
Urospora penicilliformis
Chordaria flagelliformis
Fucus distichus
Pylaiella littoralis
Ralfsia sp.

E. compressa was almost exclusively confined to tidal pools, being in part luxuriously developed, while the crusts of *Ralfsia* occurred more or less commonly throughout the region. Entangled masses of *Ulothrix* and *Urospora,* not infrequently mixed with *Pylaiella,* appeared occasionally as the dominant species on smooth rocks in the upper littoral region. In general, however, the former were poorly developed. *Fucus distichus* with *Pylaiella littoralis* and *Chordaria flagelliformis* appeared as the most common and dominant littoral species. *Fucus* and *Pylaiella* extended between tide levels while *Chordaria* occurred at low tide level forming a conspicuous and continuous zone on the cliffs. This zone was confined chiefly to the sublittoral region (Figs. 8, 9). These species occurred very frequently in tidal pools as well. *Fucus* and *Pylaiella,* commonly occurring together, were less equally distributed than *Chordaria.* Occasionally *Fucus* was

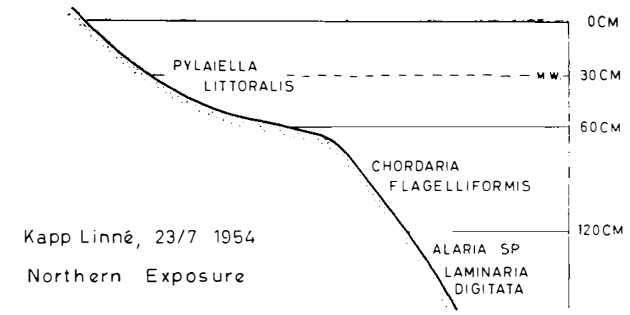


Fig. 8. Zonation of littoral species of an exposed locality.

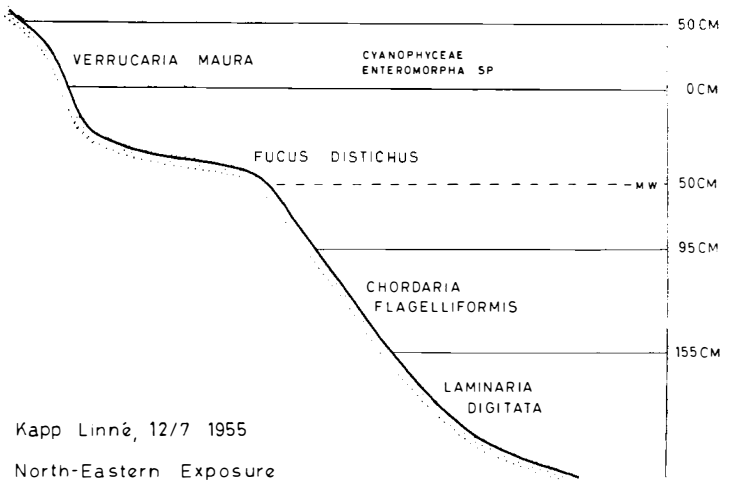


Fig. 9. Zonation of littoral species of an exposed locality.

completely replaced by *Pylaiella.* In locality II, where the vegetation was generally very poor, *Chordaria* was easily the most important species.

Typical features of zonation in exposed localities are shown by Figs. 8 and 9. The upper littoral region was dominated by *P. littoralis* (Fig. 8) and *F. distichus* (Fig. 9) respectively. *Chordaria* occupied the zone below and only occasionally extended to the mean water line. Fig. 9 reveals the occurrence of a supralittoral vegetation, *Verrucaria* being by far the most important species. *Laminaria digitata* and, less frequently, *Alaria* sp. (Fig. 8) were growing below *Chordaria.* The vertical extent of the different zones varied considerably. This was observed in the case of *Fucus* and *Chordaria,* the zones extending from 95—160 cm, and 40—110 cm respectively. Such species as *Asperococcus* sp., *E. fucicola* and *D. foeniculaceus* occurred chiefly in rock pools. The former two, usually abundant, were exclusively epiphytical. *C. melagonium* and *Spongomorpha* sp. were infrequently abundant at low tide level. *Rhodochorton* was occasionally abundant in shady places. The cover and frequency of various littoral species in exposed localities are indicated by Tables 6 and 7.

Table 6.

Locality	Kapp Linné	Kapp Linné			
Date	28 7 1954	29/7 1954			
Vertical distance	0 cm	75–120 cm			
Plots (0.2 m²)	1	1	2	3	4
(Verrucaria maura)	2	–	–	–	–
Chaetomorpha melagonium	–	–	1	–	–
Cladophora spp.	–	–	–	1	2
Spongomorpha sp.	–	1	2	1	–
Ulothrix pseudoflacca	–	1	–	4	1
Urospora penicilliformis	–	1	–	4	1
Chordaria flagelliformis	–	–	2	2	1
Fucus distichus	4	5	3	3	1
Pylaiella littoralis	2	–	2	3	5
Ralfsia sp.	–	3	2	2	1
Scytosiphon sp.	–	–	–	1	–
Halosaccion ramentaceum	–	–	1	–	–
Hildenbrandia prototypus	–	1	2	–	–
Number of species	3	6	8	9	7

Table 7.

Locality	Kapp Linné						
Date	2/8 1955						
Vertical distance	0–100 cm						
Plots (0.2 m²)	1	2	3	4	5	6	7
Chaetomorpha melagonium	–	1	–	–	–	–	–
Rhizoclonium riparium	1	1	–	–	–	–	–
Spongomorpha sp.	–	–	–	2	–	–	–
Chordaria flagelliformis	–	–	–	1	–	–	–
Fucus distichus	4	4	5	5	1	5	3
Pylaiella littoralis	1	3	–	4	4	2	4
Ralfsia sp.	3	1	3	5	3	1	5
Scytosiphon sp.	–	–	–	1	–	–	–
Halosaccion ramentaceum	–	–	–	1	–	–	–
Hildenbrandia prototypus	1	1	–	–	1	1	–
Rhodochorton rothii	1	–	–	–	–	–	–
Cyanophyceae	2	–	1	–	2	1	–
Number of species	7	6	3	7	5	5	3

Re: Table 6. The number of species within each plot was rather low. *F. distichus, P. littoralis,* and *Ralfsia* sp. were the dominant species in most plots. As it was unfeasible macroscopically to distinguish *U. pseudoflacca* and *U. penicilliformis,* they were recorded jointly.

Re: Table 7. The dominant species agreed with those of Table 6. The remaining species were very scanty. Various Cyanophyceae occurred in some plots while *Ulothrix* and *Urospora* were absent.

The littoral specimens were usually small in size.

C. Sublittoral vegetation.

Generally speaking, the main features of the sublittoral vegetation were: The littoral and sublittoral vegetation were naturally linked together through the *Chordaria* zone. Laminariaceae, such as *Alaria, Laminaria* and *Phyllaria,* were abundantly developed to a depth of approximately 15 m. At depths greater than 20 m various Rhodophyceae, in particular *Lithothamnion,* were usually the most important algae. *Lithothamnion* extended to 50—55 m, probably the approximate lower boundary of the algal vegetation in the area investigated.

The vegetation was most abundantly developed on rocky and stony bottoms. On sandy coasts algal growth was conspicuously less abundant, especially in shallow waters where frequently no algae grew.

Numerous species were encountered in the *Chordaria* zone, the most important being: *Chaetomorpha melagonium, Spongomorpha* sp., *Halosaccion ramentaceum* and *Rhodomela lycopodioides*. *Fucus* and *Pylaiella* occurred very commonly as well, although often few in numbers. On rocky bottoms, in 1—2 m depth, *Fucus* occurred occasionally in dense populations. Near Festningen (Fig. 1), *Chaetopteris, Laminaria digitata, L. saccharina, Ralfsia, Lithothamnion* and *Rhodomela* also occurred profusely at that depth. The *Chordaria* zone was absent in this locality, most probably due to the sandy substratum at that level.

Quantitatively, *Alaria grandifolia, Laminaria digitata* and *L. saccharina* were by far the most important sublittoral species, covering considerable areas where suitable substratum was provided. The amount of weeds cast ashore (Fig. 10) readily revealed that the Laminariaceae were luxuriously developed.

The Laminariaceae mentioned were most frequently mixed; occasionally *A. grandifolia* and *L. digitata* grew singly on rocks. On sandy bottoms *L. saccharina* sometimes occurred alone. The arctic *L. solidungula* was infrequently observed, never in considerable numbers, while *Phyllaria dermatodea* was a common and in part abundant species of the upper sublittoral region (Table 9).

Although mainly Laminariaceae dominated, other Phaeophyceae along with various Rhodophyceae also occurred frequently. *Halosaccion ramentaceum, Rhodomela lycopodioides* and *Rhodymenia palmata* occurred very frequently, often abundantly at depths of 0—10 m. At 4—25 m depth or more, *Euthora cristata, Phycodrys rubens, Polysiphonia arctica* and *Ptilota pectinata* were commonly observed, sometimes abundantly. At the same levels, *Desmarestia aculeata* and *D. viridis* were characteristic and common components of the flora. A few green algae were relatively common at 0—10 m (Table 9). The lower part of the region was most frequently occupied by *Lithothamnion* which extended deeper than any other species observed in Isfjorden; however, it was

Fig. 10. Seaweeds cast ashore. Locality II, July 1955.

encountered throughout the region. As with *Lithothamnion, Lithoderma* posessed a very considerable vertical range, being observed from 0 to 45 m depth.

51 species were observed in exposed localities of the sublittoral region (Table 9). As revealed through the table, the occurrences of the various species differs greatly. A considerable number of species occurred very infrequently. It should, however, be kept in mind that the number of dredgings carried out is relatively low, especially in deeper waters.

Occurrence of species by class are as follows:

Class	Chlorophyceae	Phaeophyceae	Rhodophyceae
Number of species	5	28	18

4. The vegetation in an unexposed locality.

A. Littoral vegetation.

The vegetation was extremely poor, and only 3 species were observed, viz. *Enteromorpha compressa, Fucus distichus* and *Pylaiella littoralis*. Occasionally *Enteromorpha* and *Fucus* obtained a cover of 4—5, though in very limited areas. Probably, the topographical and geological structures of this locality along with ice conditions account for the insignificant littoral vegetation.

B. Sublittoral vegetation.

The observed species are enumerated in Table 10. A distinct *Chordaria* zone was absent although this species occurred abundantly. Nor were the Laminariaceae, especially *Alaria,* as luxuriant as in exposed localities.

The vegetation was conspicuously well developed at approximately 2—5 m depth, a number of species being observed at that level. The following species were frequently found, those designated with an * being most luxurious.

Cladophora spp.
**Monostroma* spp.
Alaria grandifolia
**Chaetopteris plumosa*
Chorda filum
**Chorda tomentosa*
**Chordaria flagelliformis*
**Desmarestia aculeata*
Dictyosiphon chordaria
Ectocarpus spp.
Elachista fucicola
**Fucus distichus*
**Laminaria digitata*
**Laminaria saccharina*
Phyllaria dermatodea
**Ceramium* sp.
**Halosaccion ramentaceum*
**Rhodomela lycopodioides*
**Rhodymenia palmata*

The occurrence of certain species such as *Monostroma* spp., *Chorda filum, C. tomentosa, Chaetopteris plumosa, Dictyosiphon chordaria* and *Ceramium* sp. were conspicuous when compared with their occurrences in exposed areas.

Below 5 m depth, these five species were prominent:

Chaetopteris plumosa
Desmarestia aculeata
Desmarestia viridis
Laminaria saccharina
Phyllophora brodiaei

P. brodiaei (f. *interrupta*) was occasionally well developed in the lower part of the region. Kjellman (1883) recorded that notable amounts of this species occurred near glaciers on a clay bottom. These specimens were invariably unattached.

A comparison of Tables 9 and 10, shows that the number of species were significantly greater in exposed localities. Several species, such as *Antithamnion boreale, Euthora cristata, Phycodrys rubens, Polysiphonia arctica, Porphyra miniata* and *Ptilota pectinata* were infrequently observed if not absent in Ymerbukta, while being commonly found in exposed localities. The scattered and relatively sparse occurrence of *Lithoderma, Ralfsia* and *Lithothamnion* is probably due to bottom conditions.

The dredgings (Table 10) indicate 35—40 m as the lower limit of

the vegetation of locality III, this level being significantly less than that observed at Kapp Linné. This difference is easily understood when the conditions of the subsurface illumination in Ymerbukta are considered.

Some records by Kjellman (1883), Jónsson (1910) and Lund (1954) of the occurrence of various sublittoral algae should finally be mentioned briefly. The former author notes the presence of algae at 80, 100 and 150 fathoms depth. It is highly probable that the specimens have drifted from shallower waters.

As previously stated, the maximum depth at which algae were observed in Isfjorden was approximately 55 m. Since the number of dredging conducted in deeper waters were relatively few (cf. Tables 9, 10) and various algae in other arctic regions have been observed at greater depths, the lower boundary of the algal vegetation in Isfjorden cannot now be safely stated. According to Jónsson l. c. *Lithothamnion* may be abundant even at 88 m depth. At East-Greenland (Scoresby-sound) Lund (l. c.) records the presence of *Lithoderma, Cruoria* and *Lithothamnion* at a depth of 120 m. As, in this occasion, samples were carried out by a Petersen grab, the depth values should be correct.

5. Discussion.

A. Comparison with previous investigations at Spitsbergen.

a. *Species not previously recorded.*

According to the data of Kjellman (1875 a, 1877 a) there are no previous records of the following species in Spitsbergen waters:

Ulothrix pseudoflacca	(*Laminaria saccharina*)
Asperococcus sp.	*Mesogloia vermiculata*
Chorda tomentosa	*Ralfsia* sp.
Dictyosiphon corymbosus	*Scytosiphon* sp.
Isthmoplea sphaerophora	*Rhodochorton membranaceum*

In fact *Isthmoplea, Mesogloia,* and *Ralfsia* as well as *Asperococcus* and *Scytosiphon* are unrecorded genera. Indeed, Kjellman (1883) listed *Scytosiphon attenuatus,* a species now referred to the genus *Delamarea* (Børgesen and Jónsson 1905, Taylor 1937).

The afore mentioned species and genera, except *Asperococcus,* are more or less generally distributed in other arctic waters (Børgesen and Jónsson l. c.). Also, most of them are observed in Finnmark.

The occurrence of *Isthmoplea* is questionable (p. 38) while *Laminaria saccharina* is probably related to previously recorded forms (p. 38).

b. *Remarks on past and present occurrences of some species.*

The absence of an algal vegetation within the greater part of the littoral region along the coasts of Spitsbergen was stated by Kjellman (1883). Kjellman used a definition of the littoral region different from that used in the present report.

The following littoral species were recorded by Kjellman:

1. *Chaetophora (Pilinia) maritima*
2. *Codiolum nordenskiöldianum*
3. *Enteromorpha compressa*
4. *Ulothrix discifera*
5. *Urospora penicilliformis*
6. *Rhizoclonium riparium*
7. *Spongomorpha arcta*
8. *Chaetopteris plumosa*
9. *Fucus distichus*
10. *Pylaiella littoralis*
11. *Rhodochorton intermedium*
12. *Rhodochorton rothii*
13. (*Calothrix scopulorum*)

According to Kjellman's data (1875 a, 1877 a), the majority of these species and particularly Nos. 2, 4, 7, 8, 10, 11 and 12, were infrequently observed in the littoral region. It is noteworthy that most species were scanty also in the sublittoral region. *Fucus distichus,* along with *Chaetopteris plumosa,* occurred very commonly in the sublittoral region, but seldom in the intertidal zone. The most common littoral algae were species of *Enteromorpha, Rhizoclonium, Urospora* and *Calothrix.*

According to the finds in Isfjorden, numerous species have extended their range into the littoral region. Such species are:

Chaetomorpha melagonium
Cladophora spp.
Enteromorpha sp.
Ulothrix pseudoflacca
Asperococcus sp.
Chordaria flagelliformis
Delamarea attenuata
Dictyosiphon foeniculaceus
Ectocarpus confervoides
Elachista fucicola
Isthmoplea sphaerophora
Mesogloia vermiculata
Ralfsia sp.
Scytosiphon sp.
Halosaccion ramentaceum
Hildenbrandia prototypus
Rhodomela lycopodioides

The recent appearance of typical littoral algae such as *Chordaria, Ralfsia* and *Hildenbrandia* is noteworthy. It may be stated that certain littoral species such as *Fucus distichus, Pylaiella littoralis, Rhodochorton rothii,* and probably *Spongomorpha arcta* (p. 33) as well, have become more common in the littoral region since Kjellman's investigation. Observations on the blue-green algae in Isfjorden indicate a more frequent occurrence of this group too. Members of the families Chrococcaceae, Oscillatoriaceae, Rivulariaceae, and Stigonemataceae were found.

The present abundance of *Chordaria flagelliformis* is conspicuous since its occurrence was characterized by Kjellman (1883, p. 311) as local, scarce and invariably sublittoral. Finally, it should be mentioned that such species as *Cladophora* spp., *Chorda filum, Ectocarpus confervoides, Pylaiella littoralis, Euthora cristata* and *Porphyra miniata* have probably increased in numbers, though far less conspicuously than *Chordaria.*

The increased number of littoral species along with their more frequent occurrences, and finally the presence of species not previously recorded, is undoubtedly closely related to the change to a warmer climate discussed previously, ice conditions being possibly the most important factor. The importance of the increased sea temperature is difficult to estimate.

B. Comparison of the algal vegetation of Spitsbergen with that of other northern regions, especially that of Finnmark.

Firstly some general features of the arctic algal vegetation will be considered. The geographical extent of the arctic algal flora is comprehensively discussed by several authors (Kjellman 1883, Børgesen and Jónsson 1905, Simmons 1905). According to Børgesen and Jónsson l. c., North Norway does not belong to the area of the arctic algal flora, while Iceland in part does.

A general feature of the arctic algal vegetation pointed out by Kjellman (1883) is the superiority of the families Fucaceae, Laminariaceae and Corallinaceae. However, Fucaceae are of less importance in strictly arctic regions where the littoral vegetation is poorly developed or even absent. Laminariaceae is the most prominent family within the arctic regions (Kjellman l. c.). More infrequently, the sublittoral vegetation is dominated by various other algae, such as *Dictyosiphon, Lithoderma, Lithothamnion* and *Rhodymenia* (Kjellman 1877 b, 1883).

Within the Spitsbergen floristic province (Kjellman 1883, Simmons 1905) the algal vegetation is characterized chiefly by the following species:

Alaria grandifolia
— *membranacea*
Laminaria agardhii
Laminaria digitata
— *nigripes*
— *solidungula*

According to Simmons (l. c. p. 161), relatively few species are common to all arctic regions, while the majority of arctic algae are found in the Atlantic Ocean as well. On the other hand very few algae are common to both the Pacific and Arctic Oceans (Simmons l. c. p. 167).

Of 80 genera (43 Phaeophyceae and 37 Rhodophyceae) recorded within the arctic regions, no less than 79 occurred in the Atlantic Ocean too (Simmons l. c.).

Considering the phytogeographical distribution of species within arctic and North Atlantic regions, Børgesen and Jónsson (l. c.) arrived at the following conclusion: "The Boreal flora of the Atlantic extends far into the northern Polar Sea on the coast of Europe, whereas, on the coast of America the arctic flora extends far southwards into the Atlantic, which also corresponds with the hydrographical conditions."

The algal flora of Spitsbergen is relatively rich in species compared with that of other arctic regions. While the number of species encountered on the coasts of Siberia and arctic America is less than that of Spitsbergen, the areas of East-Greenland, West-Greenland and northeast Iceland are superior to Spitsbergen in this respect. Within North Atlantic regions such as southwest Iceland and Finnmark the number of species is even more superior to that of Spitsbergen (Børgesen and Jónsson 1905, p. XXII).

Contrary to Kjellman, the opinion was advanced by Taylor (1954) that the algal flora of Spitsbergen is most closely related to that of western arctic regions, such as West-Greenland and arctic America. A significant feature of the Greenland flora is the considerable occurrence of littoral species having a relatively southern extent. In contrast, southernly extending species constitute a conspicuous part of the sublittoral flora in Spitsbergen waters (Rosenvinge 1899 b).

The algal flora of Spitsbergen, East- and West-Greenland are termed subarctic, while that of southwest Iceland and Finnmark have a true boreal character (Jónsson 1910).

Certain phytogeographical features of the algal flora of Spitsbergen and Finnmark are given below, according to the account by Børgesen and Jónsson l. c. The Chlorophyceae were omitted by the authors.

Table 8.

Occurrence of species by phytogeographical groups (highly modified after Børgesen and Jónsson 1905).

Group	Number of species	
	Spitsbergen	Common to Spitsbergen and Finnmark
A. Arctic species	10 (11)	6 (8)
B. Subarctic species ...	38 (39)	38 (39)
C. Boreal species	10 (21)	9 (18)

The numbers in parenthesis indicate the uncertain occurrence of some species. The number of subarctic species at Spitsbergen is significant, while the numbers of arctic and boreal species are relatively low. However, numerous uncertain species are confined to the latter group. The majority of species are common to both areas. It is necessary to

emphasize that a great number of boreal species are exclusively confined to Finnmark. The numbers of brown and red algae in the two areas are as follows:

Area	Phaeophyceae	Rhodophyceae	Total number
Spitsbergen	30	37	67
Finnmark.....	60	65	125

The difference in the total number of species is very significant. However, the numerical proportion of brown and red algae within the two areas is about equal. It is suggested that the difference in the total number of species would be still greater if the Chlorophyceae were included. Approximately 40 species of Chlorophyceae are recorded in Finnmark (Foslie 1890), a number greatly exceeding that of Spitsbergen which is about 12.

The littoral vegetation of the two areas is significantly different. In Finnmark various Fucaceae, the majority of which do not occur in Spitsbergen waters, are abundantly developed (Foslie 1890, Baardseth 1955). Also, numerous Rhodophyceae and Chlorophyceae are luxuriously developed in the littoral region of Finnmark. At Spitsbergen the bulk of Fucaceae and Rhodophyceae occur in the sublittoral region. Some Chlorophyceae are occasionally abundant in the littoral region, f. i. in Isfjorden.

Generally speaking, several species typical of the littoral vegetation of Finnmark are confined chiefly or exclusively to the sublittoral region in Spitsbergen waters. Such species are: *Monostroma blyttii, Spongomorpha arcta, Halosaccion ramentaceum, Rhodomela lycopodioides, Rhodymenia palmata.* Probably, the ice conditions account for the negligible occurrence of these species in the littoral region at Spitsbergen. Approximately 60 % of the brown and red algae observed in Finnmark occur in the littoral region, the corresponding number at Spitsbergen (Isfjorden) being about 25 %.

Several species common to Spitsbergen and Finnmark are abundantly developed in both areas. Such species are: *Chordaria flagelliformis, Desmarestia aculeata, D. viridis, Pylaiella littoralis, Euthora cristata, Halosaccion ramentaceum, Lithothamnion glaciale, Phycodrys rubens, Ptilota pectinata, Rhodomela lycopodioides* and *Rhodymenia palmata.*

Considering the sublittoral vegetation, and particularly the occurrence of Laminariaceae within the two areas, the dominating species differ. The dominant species of Finnmark are *Laminaria hyperborea* and *Alaria esculenta* (Grenager 1953), while *Alaria grandifolia, Laminaria digitata* and *L. saccharina* are the most important species at Spitsbergen. *L. hyperborea* does not occur at Spitsbergen, whereas *L. solidungula* is not observed in Finnmark. Common to both areas are *L. digitata* and

L. saccharina. The occurrences of *A. esculenta* at Spitsbergen (Kjellman 1883) and *A. grandifolia* in Finnmark (Foslie 1890) are uncertain.

The common features of the algal flora of Finnmark and Spitsbergen must in part result from the hydrographic conditions. Probably several species are carried to Spitsbergen by the Atlantic Spitsbergen Current, and possibly also by ships.

III. TAXONOMICAL AND BIOGEOGRAPHICAL REMARKS

The nomenclature and taxa as used by Kylin (1944, 1947, 1949) and, in part, Taylor (1937) and Kjellman (1883) were used.

The taxonomical classification is confined to genera and species, listed alphabetically.

Unfortunately, the taxonomical status of several species is for the present unsolved, and hence they are identified only to genus. A couple of unidentifiable red and brown algae are omitted in this paper.

Chlorophyceae.

CHAETOMORPHA Kützing

Chaetomorpha melagonium (Web. et Mohr) Kütz.

Found in the littoral and sublittoral region on exposed shores to a depth of 14 m. In general rather sparse, but occasionally small, dense patches occurred at low water level. 6—18 cm long.

CLADOPHORA Kützing

Cladophora spp.

Various forms were observed. The specimens revealed variations in habitus and cell structure, but were not referred to species.

Cladophora was frequently observed in tidal pools and near low tide level in the littoral region. Below, specimens were encountered to 15 m depth. Usually sparse. Fertile specimens were often recorded. Height 3—9 cm.

ENTEROMORPHA Link

Enteromorpha compressa (L.) Grev.

This species was mainly observed in tidal pools, usually growing in dense populations. Scattered specimens occurred below low tide line. The specimens closely agreed with forms recorded by Grenager (1947, p. 162—163) in Oslofjord.

Enteromorpha sp.

A tiny species, 10—20 mm long. Observed in the littoral and supralittoral region of exposed localities. Small patches occurred on rocks.

The habitus and growth closely agree with that of *E. minima* Nägeli (Kjellman 1877 b).

Monostroma Thuret

Monostroma spp.

The following species were previously recorded by Kjellman (1877 a): *M. blyttii, M. fuscum* and *M. lubricum,* the first one being most common. *M. blyttii* and *M. fuscum* are identical species (Rosenvinge 1893, Taylor 1937). Some specimens observed in Isfjorden were probably related to the former species. The finds being confined to relatively few specimens and the genus posing considerable taxonomical problems, a further identification has not been established.

Scattered individuals of *Monostroma* occurred in exposed and sheltered localities at depths of 2 to 17 m. Fertile.

Rhizoclonium Kützing

Rhizoclonium riparium (Roth) Harv.

Tiny patches were infrequently encountered in the littoral and supralittoral region in exposed localities. To 3 mm long. Fertile.

Spongomorpha Kützing

Spongomorpha sp.

Spongomorpha occurred most frequently in the lower littoral region and just below low tide level. Sometimes abundant in exposed localities. The specimens were 2.5—4 cm tall. This species may probably be referred to *Spongomorpha arcta* (Dillw.) Kütz. which was previously reported by Kjellman (1877 a). Kjellman, however, includes several species under *S. arcta.*

Ulothrix Kützing

Ulothrix cf. *pseudoflacca* Wille.

Observed in exposed places in the littoral and supralittoral region. Sometimes luxuriously developed on smooth rocks, usually mixed with *Urospora.*

The cell structure did not agree with that of *U. discifera* Kjellm. reported by Kjellman (1877 a). With reservations it may be referred to *U. pseudoflacca.*

Urospora Areschoug

Urospora penicilliformis (Roth) Aresch.

Occurrence similar to that of *Ulothrix.* Observed by Kjellman (1877 a) on the northwestern and northern coasts.

Phaeophyceae.

ALARIA Greville

Alaria grandifolia J. Ag.

Very abundant and common in exposed localities, while less frequently observed at locality III. Occurred from 1 to 15 m depth or more, usually on a rocky substrate. Grows alone or mixed with other Laminariaceae. *A. grandifolia* is a very large species, its size probably exceeding that of all other species in Spitsbergen waters. The largest specimen encountered in Isfjorden was 405 cm long, the stipe alone being 140 cm. Specimens to 8 m in length have been recorded (Taylor 1937).

The taxonomical status of *A. grandifolia* is disputed. It was classified as *A. pylaii* var. *grandifolia* by Jónsson (1904) and Rosenvinge (1910), while Kjellman (1883) and Taylor (1937) consider this form as an independent species. Three forms of *A. pylaii* are recorded by Jónsson and Rosenvinge viz. var. *typica,* var. *grandifolia* and var. *membranacea.* The latter two are very closely related (Jónsson l. c.), and may be distinguished by their size only.

Alaria sp.

The specimens classified here as *Alaria* sp. possibly represent early stages of the preceding species, the size being the essential difference between *A. grandifolia* and *Alaria* sp. It may support this opinion that Kjellman (1877 a) recorded abundant occurrences of a relatively small *Alaria* form, similar to *A. membranacea* J. Ag., a species referable to *A. grandifolia.*

Alaria sp. occurred frequently in the upper sublittoral region.

ASPEROCOCCUS Lamouroux

Asperococcus sp.

A very common epiphyte on *Chordaria flagelliformis* which was sometimes densely covered by this species. 10—(15) cm tall. The taxonomical status of this species is uncertain.

A study of transverse sections revealed sessile, unilocular oblong-shaped sporongia, superficially scattered on the thallus. Several-celled clubshaped paraphyses were observed as well. However, according to Kylin (1947) and Taylor (1937) the sporangia of *Asperococcus* occur in sori.

Relation to other genera was not obvious, hence this species is referred to *Asperococcus.*

There are no previous records of *Asperococcus* at Spitsbergen.

Chorda Stackhouse

Chorda filum (L.) Stackh.

Observed in exposed and sheltered localities at 2—15 m depth on gravel and mud. Scattered occurrences. Fertile.

Chorda tomentosa Lyngb.

Previously not recorded from Spitsbergen. Occurrence chiefly like *C. filum*. At locality III this species was somewhat abundant in shallower depths. Height to 200 cm. Fertile.

According to Jaasund (1957), *C. tomentosa* ought to be classified as *Halosiphon tomentosa* (Lyngb.) Jaasund.

Chordaria Agardh

Chordaria flagelliformis (Müll.) Ag.

Very common and abundant in exposed and sheltered localities. A conspicuous zone at low tide level is seen on rocks in exposed localities. An important species in tidal pools as well. It extended to 14 m depth, growing on rocks, stones and frequently epiphytically on *Fucus distichus, Laminaria digitata* (upon the lamina), *Halosaccion ramentaceum* and *Rhodymenia palmata*. 20—30—(43) cm tall. Different forms occurred, the type of branching being an outstanding feature. As to the inner structure, the assimilatory filaments varied somewhat in shape and number of cells. Most specimens were richly covered with hairs.

Chaetopteris Kützing

Chaetopteris plumosa (Lyngb.) Kütz.

A common sublittoral species, recorded at 2—20 m depth. Very abundant at locality III. Attached to stones or growing on algae such as *Alaria, Fucus* and *Halosaccion*. To 11 cm tall.

Delamarea Hariot

Delamarea attenuata (Kjellm.) K. Rosenv.

A few, fertile specimens occurred in the littoral region and at a depth of 3 m. Height about 5 cm. The shape and size of the paraphyses are features typical of this species (Kjellman 1883, Pl. 26, Figs. 1—5).

Desmarestia Lamouroux

Desmarestia aculeata (L.) Lamour.

Very common, most frequently found in exposed areas. Growing on stones or frequently unattached. 15—40—(90) cm tall.

Desmarestia viridis (Müll.) Lamour.

Usually recorded in the same habitats as *D. aculeata,* though less frequently observed. To 30 cm tall.

Dictyosiphon Greville

Dictyosiphon chordaria Aresch.

Infrequently observed below low water line to 15 m depth. Never numerous. Unilocular sporangia were observed. According to Foslie (1881) plurilocular sporangia are to be found as well. Some specimens might be referred to f. *dumontioides* (Rosenvinge 1893).

Dictyosiphon cf. *corymbosus* Kjellm.

The few specimens encountered in Isfjorden were less densely branched than those observed by Kjellman (1883, Pl. 26, Fig. 12).

D. corymbosus has been recorded in various arctic regions though previously not at Spitsbergen.

Dictyosiphon foeniculaceus (Huds.) Grev.

Scattered individuals were observed infrequently in tidal pools and at depths of 2—15 m. The specimens were 15—40 cm tall. Most of them belonged to f. *typicus* Levr., while a few should probably be referred to f. *hippuroides* (Lyngb.) Levr.

Ectocarpus Lyngbye

Ectocarpus confervoides (Roth) Le Jol.

Epiphytical on various sublittoral algae. Occurred frequently at 4—10 m depth. Sometimes recorded in tidal pools. The specimens were 2—20 mm tall, usually fertile.

Ectocarpus spp.

This group includes various unidentified forms recorded to 20 m depth. They were relatively common. One form was very similar to *E. praparnaldioides* (Crn.) Kjellm. Sporangia were commonly observed by all forms.

E. ovatus Kjellm. was recorded by Kjellman (1877 a) but was not observed during the present investigation. This species and *E. confervoides* (Roth) Le Jol. are commonly distributed in arctic waters (Børgesen and Jónsson 1905).

Elachista Duby

Elachista fucicola (Vell.) Aresch.

A very common epiphyte on different algae such as *Chaetomorpha, Monostroma, Desmarestia aculeata, Fucus, Halosaccion* and *Rhodymenia.*

Kjellman (1883) stated the presence of *E. lubrica* Rupr. as well, this species being most common. However, the specimens from Isfjorden did not differ significantly from *E. fucicola,* which is distinguished from *E. lubrica* chiefly by the shape of the paraphyses (Taylor 1937). The latter species is considered as a form of *E. fucicola* by Rosenvinge (1899 a) among others.

Fucus Linné

Fucus distichus L. emend. Powell.

Numerous forms were observed (Pl. I), the characters typical of *F. distichus,* viz. hermaphrodite conceptacles (one form was sterile) and caecostomata (Powell 1957) being invariably present. This species was previously recorded at Spitsbergen as *Fucus evanescens* Ag. (Kjellman 1883).

The littoral forms (Pl. I, a, c, e) were for the most part small, 2—12 cm. Certain littoral forms (Pl. I, a, c) may be related to *F. evanescens* f. *nana* and *F. evanescens* f. *bursigera* (Kjellman l. c.). Larger forms were encountered in tidal pools near low tide level and the sublittoral region (Pl. I, b, d, f, g). A very peculiar form, identical to *F. inflatus* Vahl, f. *latifrons* Kjellm. (Zinova 1914, p. 301), is shown in Pl. I, f. This was the only sterile form observed. Another conspicuous sublittoral form shown in Pl. I, g, might probably by referred to *F. evanescens* f. *pergrandis* (Kjellman l. c.). The size of the different forms as well as the size and shape of the receptacles are very variable features.

The species was in general the most important littoral alga although being sometimes scattered or absent. Common and in part very abundant in the upper sublittoral region and tidal pools as well, the specimens here measuring to 30—45 cm.

Haplospora Kjellman

Haplospora globosa Kjellm.

Observed twice only at low tide level and at 12 m depth. Height 1.5 cm. Reproductive organs appeared.

Isthmoplea Kjellman

Isthmoplea sphaerophora (Carm.) Kjellm.

A few unattached specimens occurred in a tidal pool. Therefore, the occurrence of this species at Spitsbergen may not be safely stated at the present. It was not recorded by Kjellman.

Laminaria Lamouroux

Laminaria digitata (Huds.) Lamour.

Very different forms occurred (Pl. II, a-f), the shape of the lamina and sie of the plants being most variable features. The benzidin test (Jensen and Haug 1952), carried out on all forms, gave the reaction typical of *L. digitata.* A very characteristic form is shown in Pl. II, c. The lamina was extremely split, and the upper half of the long stipe conspicuously flattened Pl. II, a shows another remarkable form, the very short stipe being an essential feature as well as the moderate size of the plant.

Possibly some forms (cf. Pl. II, d-f) might be referred to *L. intermedia* Foslie (1884). The last-named forms were growing in relatively deep water or in sheltered localities (locality III). There were previously recorded at Spitsbergen two other species within the Digitatae-group, namely *L. nigripes* and *L. fissilis* (Kjellman 1883). According to Rosenvinge (1893), the latter is a form of *L. nigripes.*

L. digitata was very common and abundant at depths from 0.5—20—(30) m growing on rocks, stones and in the lower sublittoral also on a sandy bottom. Some forms were fertile. The largest specimen observed was 220 cm tall.

Laminaria saccharina (L.) Lamour.

Three different forms were found (Pl. II, g, h, i), that of Pl. II, g being most frequently observed. The very divergent form seen in Pl. II, i, occurred but once.

The arctic *saccharina*-form, *L. agardhii,* which was reported to be very common at Spitsbergen (Kjellman 1883), is essentially similar to that in Pl. II, g. Since mucilage canals, typical of *L. saccharina,* and absent in *L. agardhii* (Kjellman l. c., Taylor 1937), were not looked for, all forms were referred to *L. saccharina.*

It is noteworthy that *L. agardhii* is very closely related to *L. saccharina* (Kjellman l. c.) and mucilage canals are not always present in the latter species (Foslie 1884).

L. saccharina occurred in abundance, being common in all localities to a depth of 15 m though observed to 30 m depth. Quantitatively, this species is perhaps the most important one, together with *Alaria grandifolia.* The specimens were to 370 cm tall. Usually fertile, *L. saccharina* occurred on rough and sandy bottoms.

Laminaria solidungula J. Ag.

This species, (Pl. II, j) being confined to arctic regions, was far less common and abundant than the afore mentioned Laminariaceae. Occurred on stony and rocky bottoms at 4—17 m depth. 50—110 cm tall. Usually fertile.

Lithoderma Areschoug

Lithoderma sp.

Occurred chiefly in exposed localities from low tide level to 45 m depth, growing on pebbles.

Kjellman (1883) recorded the presence of a *Lithoderma fatiscens* formation (association) at 10—28 m depth on the northwest and north coast of Spitsbergen. The amount of *Lithoderma* observed in Isfjorden was not conspicuous.

As sporangia were not observed, the taxonomical status of this species is uncertain for the present.

Mesogloia Agardh

Mesogloia cf. *vermiculata* (Smith) Le Jol.

The habitus and anatomical structure of this species did not correspond in all details with the description of *M. vermiculata* given by Kylin (1947). The specimens observed by Kylin were more extensively branched. Kylin (l. c., p. 54) reports the following dimensions for sporangia: 35—45 μ long, 25—35 μ diam., while the sporangia of some Isfjorden specimens were 42—103 μ long and 20—70 μ diam. A single axial thread, a structure typical of *M. vermiculata,* was not observed. Possibly we are concerned with a northern form of *M. vermiculata* although this species was not recorded previously in this area.

Mesogloia was very infrequently found. Scattered individuals occurred in some tidal pools and at 1—3 m depth. 15—62 cm tall.

Phyllaria Le Jolis

Phyllaria dermatodea (De la Pyl.) Le Jol.

Common on rocks in the upper sublittoral region, sometimes in dense populations. To 100 cm tall.

Phyllaria lorea, recorded by Kjellman (1883) has proved to be young plants of *P. dermatodea* (Rosenvinge 1893 and others).

Pylaiella Bory

Pylaiella littoralis (Lyngb.) Kjellm.

A prominent littoral species in all localities, extending between low and high tide levels. It also occurred in the upper sublittoral region. *Pylaiella* grew on rocks and very commonly on *Fucus. Chaetomorpha* and

Rhodymenia were common hosts as well. Uni- and plurilocular sporangia occurred. 4—11 cm tall.

Pylaiella varia Kjellm.

This sublittoral species, which occurred to 14 m depth, was relatively common but sparse. Typical specimens (Kjellman 1883, Pl. 27, Figs. 1—12), were observed. Rosenvinge (1893) and Jónsson (1904) consider this species to be a form of *P. littoralis*.

Ralfsia Berkeley

Ralfsia sp.

This genus is new to the algal flora of Spitsbergen.

The various internal anatomical structures as revealed by vertical sections, did not correspond in all details with those of other species distributed in arctic and North Atlantic waters. The assimilatory filaments, arising at right angles from the basal layer, were 8—11 μ diam. The paraphyses were 100—150 μ long, consisting of (6)—8—10 cells; the lower cells were 2.5—3 μ in diam. and the upper 6—9 μ. Elongated, pyriform, unilocular sporangia occurred. They were 85—125 μ long, 14—22 μ in diam. The thallus, usually dark brown in colour, was closely adherent to the substratum.

This species might be referable to *R. clavata* (Carm.) Crouan according to the cell dimensions. *R. clavata* occurs in several arctic regions.

Ralfsia was observed chiefly in the littoral and upper sublittoral region. Common and in part abundant.

Scytosiphon Agardh

Scytosiphon sp.

Certain features, typical of *S. lomentaria,* (Taylor 1937, Pl. 15, Fig. 2) were not observed on the specimens from Isfjorden. The thallus was hollow, flattened, not locally constricted but spirally twisted, a feature most conspicuous on older specimens. Paraphyses did not occur. Plurilocular sporangia, typically arranged in superficial sori, occurred. As to habitus, this species is closely related to *S. lomentaria* f. *tortilis* Yamada (Yamada 1935, Pl. 1). The author notes, however, that the structure of f. *tortilis* is similar to that of *S. lomentaria,* except for the spiral thallus. Possibly, *Scytosiphon* sp. might be referred to *S. lomentaria* (Lyngb.) Ag. v. *complanatus* K. Rosenv. (Taylor 1937). According to Taylor l. c. v. *complanatus* is "hollow but flattened, not constricted, without paraphyses".

Scattered specimens occurred infrequently below low tide level to 10 m depth, and sometimes in the littoral region. Height 4—17 cm.

Sphacelaria Lyngbye

Sphacelaria sp.

Small specimens occurred infrequently by dredging at 7—17 m. The infrequent occurrence of this species (Tables 9, 10), is strange since Kjellman (1883) recorded *Sphacelaria* (*arctica*) as common and abundant at Spitsbergen. The specimens were sterile.

Rhodophyceae.

Antithamnion Nägeli

Antithamnion boreale (Gobi) Kjellm.

Most frequently observed in the lower sublittoral region at 20—40 m depth. Common but sparse. Growing on barnacles, tunicates and algae such as *Ptilota* and *Phycodrys*. 0.5—1.5 cm tall, usually fertile (tetrasperangia). Two different forms occurred, namely f. *typica Kjellm.* and f. *corallina* (Rupr.) Kjellm. (Kjellmann 1883, Pl. 16, Fig. 2—3, and Figs. 4—5).

Ceramium Roth

Ceramium sp.

Abundant in locality III, but elsewhere scarce. Ceramium was confined to the sublittoral region, extending to 30 m depth. 9—12 cm tall. Tetrasporangia occurred. This species is closely related to *C. rubrum* (Huds.) Ag. f. *squarrosa* Harv. (Kjellman 1883, Pl. 15, Fig. 7).

Dilsea Stackhouse

Dilsea edulis Stackh.

Two individuals were observed in locality III.

Dilsea integra (Kjellm.) K. Rosenv.

Very scarce. A few specimens, 4—5 cm tall, occurred at 2—3 m depth. Loose specimens were very infrequently found on the shore. This species, previously classified as *Sarcophyllis arctica* Kjellm. (Kjellman 1883, Pl. 14, Figs. 1—3), is exclusively confined to arctic regions (Børgesen and Jónsson 1905).

Euthora J. Agardh

Euthora cristata (L.) J. Ag.

A very common, though usually sparsely occurring, sublittoral species. It was frequently epiphytic on *Ptilota pectinata* and *Halosaccion* and grew on barnacles, tunicates and bryozoa as well, at depths between 4 and 28 m. The specimens were small, 2—4 cm tall. Tetrasporangia were observed.

Halosaccion Kützing

Halosaccion ramentaceum (L.) J. Ag.

Very common and usually abundant at 0—10 m on rocky bottoms. Small, dense populations occurred infrequently at low tide level. Numerous, closely related forms occurred (cf. Kjellman 1883). 5—25 cm long. Fertile, with tetrasporangia.

Hildenbrandia Nardo

Hildenbrandia prototypus Nardo.

Small, scattered patches were encountered at locality I in the littoral region and less frequently below low water line. The littoral specimens were usually covered by *Fucus*. Fertile.

Lithothamnion Philippi

Lithothamnion sp.

A dominant species of the lower sublittoral region, although it extended commonly throughout this region. Grew on rocks, stones, shells, and less frequently on the hapteres of *Laminaria*. It occurred most frequently in exposed localities.

Several species of this genus have been recorded in arctic regions, though at Spitsbergen only *L. glaciale* (Kjellman 1883). This species is widely distributed in arctic waters. According to Kjellman (l. c., Pl. 2, 3) older specimens of *L. glaciale* are characteristically shaped, being more or less spherical. Such specimens were not observed in Isfjorden even though *Lithothamnion* was very abundant.

Lithothamnion sp. is strongly adherent to the substratum, sometimes surrounding the supporting object. Short conically-shaped upgrowths appeared on older specimens.

Its external features are similar to those of *L. foecundum* Kjellm. (Foslie 1929, Pl. II, Figs. 12—14).

Odonthalia Lyngbye

Odonthalia dentata (L.) Lyngb.

A few specimens were obtained by dredging at depths of 4—10 m. 10—12 cm tall.

Pantoneura Kylin

Pantoneura baerii (Post. and Rupr.) Kylin.

Very infrequently observed by dredging (Table 9). On two occasions numerous individuals were found on the stipe of a washed ashore *Alaria grandifolia* specimen. The specimens had tetra- and carposporangia. Thallus 8—10 cm. *P. baerii* is an arctic species according to its geographical distribution (Børgesen and Jónsson 1905).

Phycodrys Kützing

Phycodrys rubens (Good. and Woodw.) Kütz.

Very common and partly abundant in exposed localities at 5—42 m depth. Frequently attached to barnacles. Height to 20 cm. Tetra- and carposporangia were frequently found.

Phyllophora Greville

Phyllophora brodiaei (Turn.) J. Ag.

It was almost exclusively the northern form, f. *interrupta* (Grev.) K. Rosenv. that occurred. The typical form described by Taylor (1937, Pl. 39, Fig. 2) was sporadically observed.

F. *interrupta* was occasionally luxuriously developed at locality III, being to 15 cm tall. It did not occur in exposed localities.

Polysiphonia Greville

Polysiphonia arctica J. Ag.

Occurred frequently at locality I, sometimes in abundance. Found between 5 and 30 m, 8—25 cm tall.

Porphyra Agardh

Porphyra miniata (Lyngb.) Ag.

Two forms were observed. One tiny, 1—5 cm tall form, was very frequently epiphytical on different algae such as, *Chaetomorpha, Alaria, Desmarestia aculeata, Laminaria digitata, Phycodrys* and *Pantoneura.* The thallus was monostromatic.

The other form, seldom found, was conspicuously larger. One specimen was 50 cm long and 30 cm broad. This form, the thallus being two cell layers thick, might be referred to *Diploderma amplissimum* (Kjellman 1883, Pl. 17, 18) which according to Rosenvinge (1893) and Taylor (1937), belongs to *P. miniata.* The latter two authors claim that the thallus of *P. miniata* may have one or two cells layers.

The two forms were similarly shaped.

Ptilota Agardh

Ptilota pectinata (Gunn.) Kjellm.

Several forms were noted by Kjellman (1893). The specimens from Isfjorden were closely related to *P. plumosa* f. *serrata* (Kützing *12,* Pl. 55).

A very common sublittoral species in exposed localities, at 2—25 m depth. Usually attached to stones. 5—17 cm tall. Tetrasporangia and cystocarpia occurred frequently.

Ptilota plumosa (L.) Ag.

This species occurred a few times only in the sublittoral region.

Rhodochorton Nägeli

Rhodochorton membranaceum Magnus.

Though this species occurs in different arctic regions, it was previously not recorded from Spitsbergen. In Isfjorden it was very infrequently observed in hydroids.

Rhodomela Agardh

Rhodomela lycopodioides (L.) Ag.

Abundant and common in all localities, most frequently observed at 0—10 m depth. Sometimes growing in dense populations at low tide level. The specimens belong to f. *tenuissima* (Ruprecht 1848, Pl. 10).

A common epiphyte on *Fucus* and *Chaetopteris,* it otherwise grew on various substrates. 5—12 cm tall. Fertile individuals had tetrasporangia and cystocarpia.

Rhodophyllis Kützing

Rhodophyllis dichotoma (Lepech.) Gobi.

A very rare species, being occasionally washed ashore, and observed once by dredging. 2—6 cm tall.

Rhodymenia Greville

Rhodymenia palmata (L.) Grev.

Common everywhere in the area investigated. The large number of individuals frequently washed ashore indicate a greater population than that obtained by dredging (Tables 9, 10).

Various forms occurred, the most common being f. *typica* (Kiellman 1883). A remarkable form, probably identical to var. *latifolia* K. Rosenv. (Rosenvinge 1893), has a rather leathery texture, and the thallus is conspicuously perforated. The specimens of this form were to 40 cm tall. According to Rosenvinge (l. c.) the specimens recorded by Kjellman as *R. pertusa,* belong to var. *latifolia.*

IV. SUMMARY

A survey of the marine algal vegetation of the outer part of Isfjorden, Spitsbergen, was carried out during the summers 1954 and 1955. The material, especially that from the littoral region, was essentially collected in exposed localities. The floristic composition of the littoral and sublittoral vegetation along with the vertical distribution of the littoral algae were subject to examination. A few analyses of the cover of littoral species were carried out in an exposed locality.

It is discussed whether the recent climatical changes have influenced the algal vegetation of Isfjorden. The algal vegetation of Spitsbergen is compared with that of other northern regions, especially Finnmark. The phytogeographical distribution of the brown and red algae is discussed as well.

Approximately 60 species were encountered. They belong mainly to the classes Phaeophyceae and Rhodophyceae, essentially being species of the sublittoral region.

A general feature was the poverty of the littoral vegetation. The number of species was relatively low, and the cover of most species insignificant. On account of this poverty and the moderate tidal range, the littoral vegetation showed a relatively inconspicuous zonation.

Compared with previous records, several genera and species have extended their range to Spitsbergen. Some sublittoral and littoral species which have been recorded previously, now have become more abundant. This is especially evident in the case of *Chordaria flagelliformis*. The total number of littoral species has increased.

The algal vegetation of Spitsbergen is most closely related to that of the western arctic regions such as West-Greenland, arctic America and the North Atlantic regions. The majority of species observed at Spitsbergen also occur in Finnmark.

The algal flora of Spitsbergen is subarctic, and the number of true arctic species is relatively low.

The observed species were listed, and taxonomical and biogeographical remarks given.

References.

Agardh, J. G. 1862. Om Spetsbergens alger. Akademiskt program. Lund.

— 1868. Bidrag till kännedomen af Spetsbergens alger. K. svenska Vetensk. Akad. Handl. *7*, 8.

Baardseth, E. 1955. A statistical study of the structure of the Ascophyllum zone. Rep. Norweg. Inst. Seaw. Res. 11.

Børgesen, F. and Jónsson, H. 1905. The distribution of the marine algæ of the Arctic and of the northernmost of the Atlantic. Botany of the Færøes. Part III. Copenhagen 1908.

Deichmann, H. and Rosenvinge, L. Kolderup. 1907. Bemerkninger om isfod og tangrand ved Grønlands kyster. Bot. Tidsskr., *28*, 1—2.

Feyling-Hanssen, R. W. 1953 a. Brief account of the ice-foot. Norsk geogr. Tidsskr. *XIV*, 1—4.

— 1953 b. The Barnacle Balanus balanoides in Spitsbergen. Skr. Norsk Polarinst., 98.

Foslie, M. 1881. Om nogle nye arctiske havalger. Forh. Vidensk. Selsk., Krist. *14*.

— 1884. Ueber die Laminarien Norwegens. Ibid., *14*.

— 1890. Contribution to knowledge of the marine algæ of Norway. I. East-Finmarken. Tromsø Mus. Aarsh. *13*.

— 1929. Contributions to a monograph of the Lithothamnia. Collected and edited by H. Printz. K. norske vidensk.Selsk. Skr.

Frommeyer, M. 1928. Die Eisverhältnisse um Spitzbergen und ihre Beziehungen zu klimatischen Faktoren. Ann. Hydrogr., Berl.

Gessner, F. 1955. Hydrobotanik. Bd. I. Energiehaushalt. Berlin.

Grenager, B. 1947. Orienterende undersøkelser over algevegetasjonen i indre Oslofjord og dens avhengighet av forurensning. MS.

— 1953. Kvantitative undersøkelser av tareforekomster i Øst-Finnmark. Rep. Norweg. Inst. Seaw. Res., 13.

Helland-Hansen, Bj. and Nansen, Fr. 1912. The sea west of Spitsbergen. Vidensk.-Selsk. Skr., I. Mat.-naturv. Kl., 1912, no. 12, Kristiania.

Hesselberg, Th. and Birkeland, B. J. 1940. Säkuläre Schwankungen des Klimas von Norwegen. Die Lufttemperatur. Geofys. Publ., *XIV*. 4.

Hornbæk, H. 1954. Tidal observations in the Arctic. 1946—52. Skr. Norsk Polarinst., 104.

Jensen, A. and Haug, A. 1952. Fargereaksjon til adskillelse av Stortare (Laminaria Cloustonii) og Fingertare (Laminaria digitata). Tidsskr. Kjemi, Bergv. Nr. 8.

Jónsson, H. 1904. The marine algae of East-Greenland. Medd. Grønland, XXX.

— 1910. Om algevegetationen ved Islands kyster. København.

Jaasund, E. 1957. Marine algae from Northern Norway. II. Bot. not. Vol. 110. Fasc. 2. Lund.

Kjellman, F. R. 1875 a. Om Spetsbergens marina, klorofyllförande thallophyter. I. Bihang till K. svenska Vetensk. Akad. Handl., *3*, 7.

— 1875 b. Vegetation hivernale des algues de Mosselbay, d'après les observations faites pendant les dragaues d'hiver de l'expédition polaire Suédoise en 1872—73. Bull. Soc. bot. Fr., *22*.

— 1877 a. Om Spetsbergens marina, klorofyllförande thallophyter. II. Bihang till K. svenska Vetensk. Akad. Handl., *4*, 6.

— 1877 b. Über die Algenvegetation des Murmanschen Meeres an der Westküste von Nowaja Semlja und Wajgatsch. Nova Acta Soc. upsal. *II*. extra ordin. edis.

— 1883. Norra Ishafvets Algflora. Vega-expeditionens vetenskapliga iakttagelser. 3, Stockholm.

Kylin, H. 1944. Die Rhodophyceen der Schwedischen Westküste. Acta Univ. Lund N. F. Avd. 2, *40,* 2.

— 1947. Die Phaeophyceen der Schwedischen Westküste. Ibid., *43,* 4.

— 1949. Die Chlorophyceen der Schwedischen Westküste. Ibid., *45,* 4.

Kützing, F. T. 1845—1869. Tabulæ Phycologicæ oder Abbildungen der Tange. Bd. 1—19. Nordhausen.

Lund, S. 1954. The algal zones in East Greenland and their ecological factors. VIIIe Congrès international de Botanique Paris. Section 17, pp. 132—133.

Mosby, H. 1938. Svalbard waters. Geofys. Publ., *XII.* 4.

Nansen, Fr. 1915. Spitsbergen waters. Vidensk.-selsk. Skr., I. Mat.-naturv. Kl. 1915, No. 2. Kristiania.

Omdal, K. 1953. Drivisen ved Svalbard 1924—1939. Medd. Norsk Polarinst. 72.

Orvin, A. K. 1940. Outline of the geological history of Spitsbergen. Skr. Svalb. og Ishavet, 78.

Powell, H. T. 1957. Studies in the genus Fucus L. I. Fucus distichus L. emend. Powell. J. mar. biol. Ass. U. K. 36.

Rosenvinge, L. Kolderup, 1893. Grønlands havalger. Kjøbenhavn.

— 1899 a. Deuxième Mémoire sur les algues marines du Grœnland. Medd. Grønland, 20.

— 1899 b. Om algevegetationen ved Grønlands kyster. Ibid., 20.

— 1910. On the marine algae from north-east Greenland. Ibid., XLIII.

Ruprecht, F. J. 1848. Tange der Ochotskischen Meeres. A. Th. v. Middendorff: Reise in den äussersten Norden und Osten Sibiriens während der Jahre 1843 und 1844. *I.* St. Petersburg.

Simmons, H. G. 1905. Remarks about the relations of the floras of the Northern Atlantic, the Polar Sea and the Northern Pacific. Bot. Zbl., *19,* Beih Abt. II, 1.

Sjöstedt, L. G. 1928. Litoral and supralitoral Studies on the Scanian Shores. Lunds Univ. Ärsskrift, N. F. Avd. 2, Bd. 24, No. 7, Lund.

Steenstrup, K. V. J. 1907. Kan tangranden benyttes til bestemmelse af forandringer i vandstanden? Medd. Grønland, XXXIII.

Sundene, O. 1953. The algal vegetation of Oslofjord. Skr. norske Vidensk. Akad., 2.

Taylor, W. R. 1937. Marine algae of the Northeastern Coast of North-America. Univ. Mich. Stud. *XIII.*

— 1954. Algae: Non-planktonic. The cryptogamic flora of the Arctic. Bot. Rev., *20,* 6—7.

Yamada, Y. 1935. The marine algae of Urup, middle Kuriles, especially from the vicinity of Jema Bay. Sci. Pap. Inst. algol. Res. Hokkaido. Univ., *I,* 1.

Zinova, E. S. 1914. Algae Murmanicae. II. Phaeophyceae. Trav. Soc. Nat. St. Petersb. (Leningr.) *XLIV,* ser. 3.

Anonymous.

(1) Ismeldinger fra Isfjord Radio. (Observations of the ice conditions during periods of the years 1941, 1954, 1955 and 1956.) Vervarslinga i Nord-Norge. Tromsø. MS.

(2) Isforholdene i de arktiske have. Publ. danske met. Inst. 1946—53.

(3) Detaljopplysninger om isforholdene i havet ved Spitsbergen og Bjørnøya 1899—1923. Norsk Polarinst. MS.

Table 9.

Dredgings at exposed localities (I and II).

Depth intervals in metres and number of dredgings for each interval	0—10 m 37	Frequency of occurrence	10—20 m 12	Frequency of occurrence	20—30 m 6	Frequency of occurrence	30—40 m 3	Frequency of occurrence	40—60 m 5	Frequency of occurrence
Chlorophyceae										
Chaetomorpha melagonium	+	11	+	1	–	–	–	–	–	–
Cladophora spp.	+	9	+	3	–	–	–	–	–	–
Enteromorpha compressa	+	2	(+)*	(1)	–	–	–	–	–	–
Monostroma sp.	+	6	+	2	–	–	–	–	–	–
Spongomorpha sp.	+	9	–	–	–	–	–	–	–	–
Phaeophyceae										
Alaria grandifolia	+	29	+	7	–	–	–	–	–	–
Asperococcus sp.	+	2	–	–	–	–	–	–	–	–
Chorda filum	+	9	+	2	–	–	–	–	–	–
— tomentosa	+	4	–	–	–	–	–	–	–	–
Chordaria flagelliformis	+	8	+	1	–	–	–	–	–	–
Chaetopteris plumosa	+	4	+	1	–	–	–	–	–	–
Delamarea attenuata	+	1	–	–	–	–	–	–	–	–
Desmarestia aculeata	+	20	+	6	+	3	–	–	–	–
— viridis	+	7	+	5	+	2	–	–	(+)	(1)
Dictyosiphon chordaria	+	4	–	–	–	–	–	–	–	–
— corymbosus	+	1	+	1	–	–	–	–	–	–
— foeniculaceus	+	3	+	1	–	–	–	–	–	–
Ectocarpus confervoides	+	6	–	–	–	–	–	–	–	–
— spp.	+	5	+	2	–	–	–	–	–	–
Elachista fucicola	+	3	+	1	–	–	–	–	–	–
Fucus distichus	+	3	–	–	–	–	–	–	–	–
Haplospora globosa	+	1	+	1	–	–	–	–	–	–
Laminaria digitata	+	28	+	3	+	1	–	–	–	–
— saccharina	+	28	+	9	–	–	–	–	–	–
— solidungula	+	7	–	–	+	1	–	–	–	–
Lithoderma sp.	+	5	+	3	+	2	+	1	+	1
Mesogloia vermiculata	+	2	–	–	–	–	–	–	–	–
Phyllaria dermatodea	+	14	+	3	–	–	–	–	–	–
Pylaiella littoralis	+	5	+	1	–	–	–	–	–	–
— varia	+	3	+	1	–	–	–	–	–	–
Ralfsia sp.	+	1	–	–	–	–	–	–	–	–
Scytosiphon sp.	+	6	–	–	–	–	–	–	–	–
Sphacelaria sp.	+	2	+	3	–	–	–	–	–	–
Rhodophyceae										
Antithamnion boreale	–	–	+	3	+	3	+	2	+	1
Ceramium sp.	+	2	–	–	–	–	–	–	–	–
Euthora cristata	+	10	+	2	+	3	+	1	–	–
Halosaccion ramentaceum	+	25	+	4	+	3	–	–	–	–
Hildenbrandia prototypus	+	2	–	–	–	–	–	–	–	–
Lithothamnion sp.	+	7	+	6	+	5	+	3	+	4
Odonthalia dentata	+	2	–	–	–	–	–	–	–	–
Pantoneura baerii	+	2	–	–	–	–	–	–	–	–
Phycodrys rubens	+	16	+	4	+	4	+	1	+	1
Polysiphonia arctica	+	9	+	8	+	4	–	–	–	–
Porphyra miniata	+	9	+	4	+	1	–	–	–	–
Ptilota pectinata	+	19	+	4	+	3	–	–	–	–
— plumosa	+	2	–	–	–	–	–	–	–	–
Rhodochorton membranaceum	+	2	–	–	–	–	–	–	–	–
— rothii	+	3	+	2	–	–	(+)	(1)	–	–
Rhodomela lycopodioides	+	10	+	1	–	–	–	–	–	–
Rhodophyllis dichotoma	+	1	–	–	–	–	–	–	–	–
Rhodymenia palmata	+	8	+	3	–	–	–	–	–	–
Number of species	50		32		13		6		5[1]	

* (+) indicates species probably drifted from shallower waters.

[1] 5 at 40—50 m, 1 at 50—60 m.

Table 10.
Dredgings at locality III.

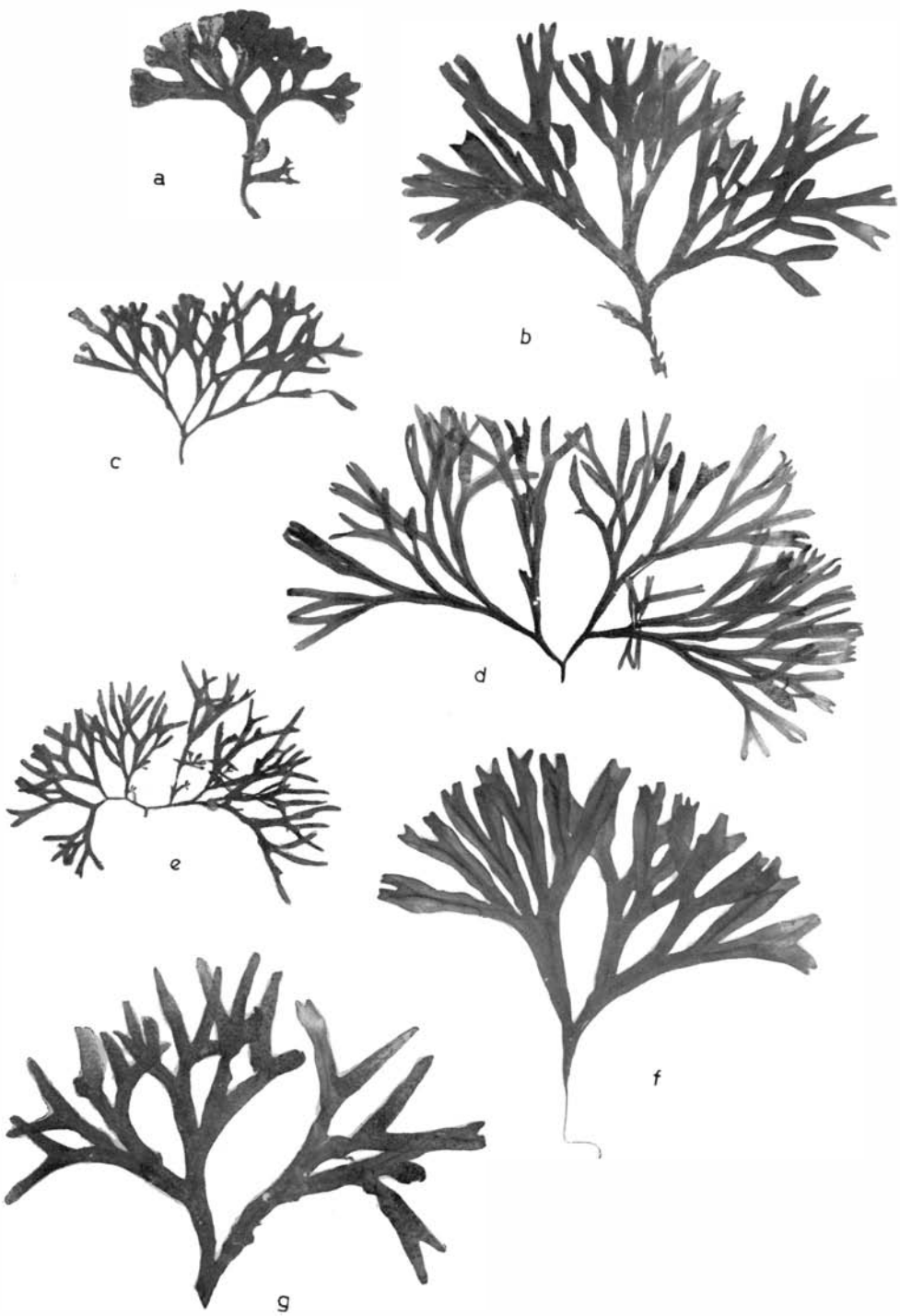
Depth intervals in metres and number of dredgings for each interval	0—10 m 10	Frequency of occurrence	10—20 m 6	Frequency of occurrence	20—40 m 4	Frequency of occurence
Chlorophyceae						
Chaetomorpha melagonium	+	7	+	2	+	1
Cladophora spp.	+	4	+	1	–	–
Enteromorpha compressa	+	2	–	–	–	–
Monostroma sp.	+	5	–	–	–	–
Phaeophyceae						
Alaria grandifolia	+	5	+	4	+	1
Asperococcus sp.	+	3	–	–	–	–
Chorda filum	+	4	–	–	–	–
— tomentosa	+	5	–	–	–	–
Chordaria flagelliformis	+	5	–	–	–	–
Chaetopteris plumosa	+	10	+	4	+	2
Desmarestia aculeata	+	6	+	5	+	2
— viridis	+	2	+	3	–	–
Dictyosiphon chordaria	+	3	+	1	–	–
— corymbosus	+	1	–	–	–	–
— foeniculaceus	+	2	–	–	–	–
Ectocarpus confervoides	+	3	–	–	–	–
— spp.	+	4	–	–	–	–
Elachista fucicola	+	5	+	1	–	–
Fucus distichus	+	4	–	–	–	–
Laminaria digitata	+	6	+	1	+	1
— saccharina	+	8	+	5	+	2
— solidungula	+	1	+	2	+	1
Lithoderma sp.	+	1	+	1	–	–
Phyllaria dermatodea	+	3	+	1	–	–
Pylaiella littoralis	+	3	–	–	–	–
— varia	+	2	–	–	–	–
Ralfsia sp.	+	1	–	–	–	–
Scytosiphon sp.	+	1	–	–	–	–
Sphacelaria sp.	+	1	–	–	–	–
Rhodophyceae						
Ceramium sp.	+	6	+	1	+	1
Dilsea edulis	+	1	–	–	–	–
— integra	+	1	–	–	–	–
Halosaccion ramentaceum	+	8	+	1	–	–
Lithothamnion sp.	+	2	+	5	–	–
Phyllophora brodiaei	+	3	+	6	–	–
Phycodrys rubens	+	1	–	–	–	–
Polysiphonia arctica	–	–	+	1	+	1
Rhodomela lycopodioides	+	9	+	2	+	1
Rhodymenia palmata	+	8	–	–	–	–
Number of species	38		19		10 [1]	

[1] 5 at 20—30 m, 8 at 30—40m

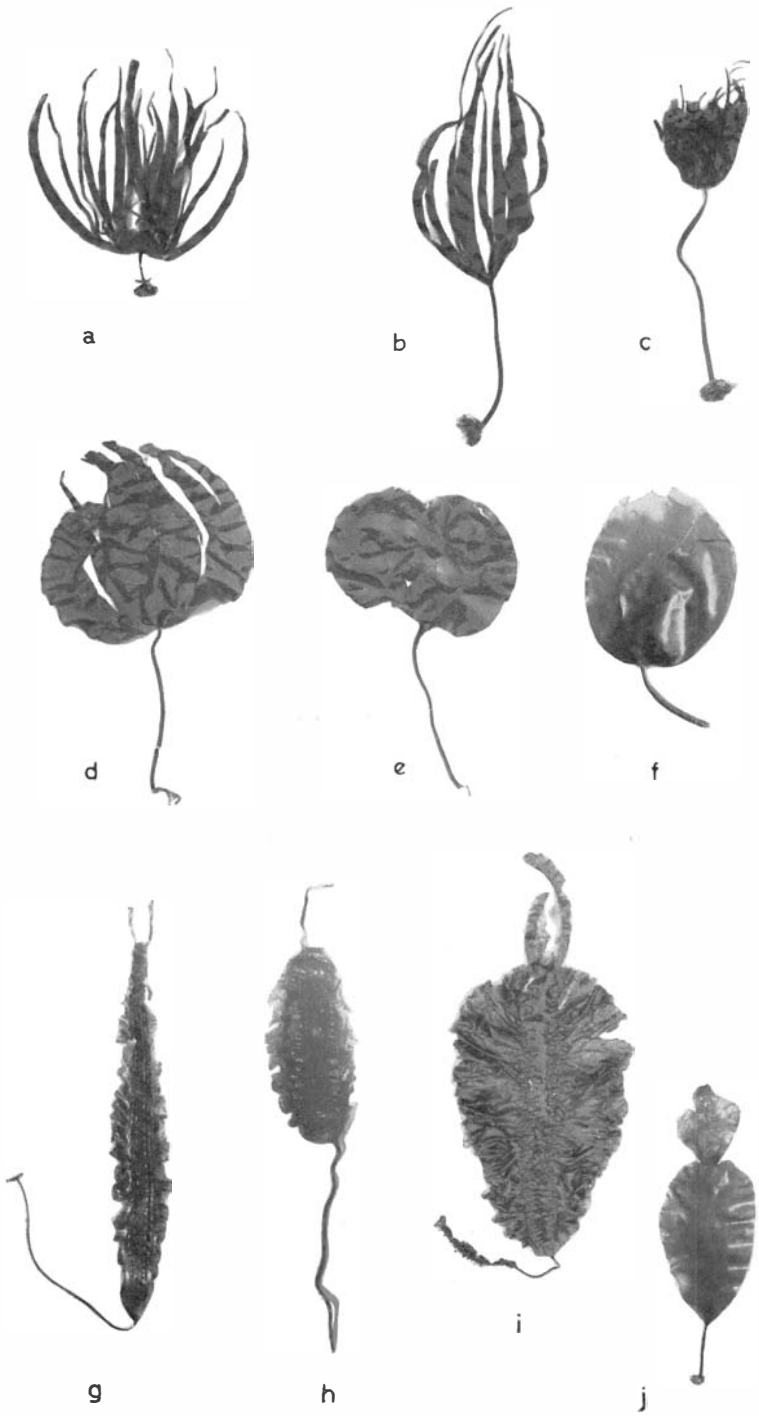
PLATES

Plate I. *Fucus distichus* L. emend. Powell. a (1 ×), c (0.7 ×) and e (0.35 ×) littoral forms, c and e tidal pool specimens. b (0.3 ×), d (0.4 ×), f (0.3 ×) and g (0.3 ×) sublittoral forms.

Plate II. Three species of *Laminaria* Lamouroux, a—f *Laminaria digitata* (Huds.) Lamour. g—i *Laminaria saccharina* (L.) Lamour. j *Laminaria solidungula* J. Ag. a, b, d, g, h, i (1/20 ×), c (1/25 ×), e (7/100 ×), f (3/50 ×), j (1/10 ×).


a
b
c
d
e
f
g

Pl. II.



Nr. 78. ORVIN, ANDERS K., *Outline of the Geological History of Spitsbergen.* 1940. Kr. 7,00.
„ 79. LYNGE, B., *Et bidrag til Spitsbergens lavflora.* 1940. Kr. 1.50.
„ 80. *The Place-Names of Svalbard.* 1942. Kr. 50,00.
„ 81. LYNGE, B., *Lichens from North East Greenland.* 1940. Kr. 14,00.

Norges Svalbard- og Ishavs-undersøkelser. Skrifter.

„ 82. NILSSON, TAGE, *The Downtonian and Devonian Vertebrates of Spitsbergen. VII. Order Antiarchi.* 1941. Kr. 11,50.
„ 83. HØEG, OVE ARBO, *The Downt. and Devonian Flora of Spitsbergen.* 1942. Kr. 33,00.
„ 84. FREBOLD, HANS, *Über die Productiden des Brachiopodenkalkes.* 1942. Kr. 6,00.
„ 85. FØYN, SVEN and ANATOL HEINTZ, *The Downtonian and Devonian Vertebrates of Spitsbergen. VIII.* 1943. Kr. 5,00.
„ 86. *The Survey of Bjørnøya (Bear Island) 1922—1931.* 1944. Kr. 9,00.
„ 87. HADAČ, EMIL, *Die Gefäßpflanzen des „Sassengebietes" Vestspitsbergen.* 1944. Kr. 6,00.
„ 88. *Report on the Activities of Norges Svalbard- og Ishavs-undersøkelser 1936—1944.* 1945. Kr. 6,50.
„ 89. ORVIN, ANDERS K., *Bibliography of Literature about the Geology, Physical Geography, Useful Minerals, and Mining of Svalbard.* 1947. Kr. 12,00.

Norsk Polarinstitutt. Skrifter.

„ 90. HENIE, HANS, *Astronomical Observations on Hopen.* 1948. Kr. 3,00.
„ 91. RODAHL, KÅRE, *Vitamin Sources in Arctic Regions.* 1949. Kr. 6,00.
„ 92. RODAHL, KÅRE, *The Toxic Effect of Polar Bear Liver.* 1949. Kr. 12,50.
„ 93. HAGEN, ASBJØRN, *Notes on Arctic Fungi. I. Fungi from Jan Mayen. II. Fungi collected by Dr. P. F. Scholander on the Swedish-Norwegian Arctic Expedition 1931.* 1950. Kr. 2,00.
„ 94. FEYLING-HANSSEN, ROLF W. and FINN A. JØRSTAD, *Quaternary Fossils.* 1950. Kr. 8,25.
„ 95. RODAHL, KÅRE, *Hypervitaminosis A.* 1950. Kr. 22,50.
„ 96. BUTLER J. R., *Geochemical Affinities of some Coals from Svalbard.* 1953. Kr. 3,00.
„ 97. WÄNGSJÖ, GUSTAV, *The Downtonian and Devonian Vertebrates of Spitsbergen.* Part IX. *Morphologic and Systematic Studies of the Spitsbergen Cephalaspids.* A. Text, and B. Plates. 1952. Kr. 75.00.
„ 98. FEYLING-HANSSEN, ROLF W., *The Barnacle Balanus Balanoides (Linné, 1766) in Spitsbergen.* 1953. Kr. 8,00.
„ 99. RODAHL, KÅRE, *Eskimo Metabolism.* 1954. Kr. 10,00.
„ 100. PADGET, PETER, *Notes on some Corals from Late Paleozoic Rocks of Inner Isfjorden, Spitsbergen.* 1954. Kr. 1,00.
„ 101. MATHISEN, TRYGVE, *Svalbard in International Politics 1871—1925.* 1954. Kr. 18,00.
„ 102. RODAHL, KÅRE, *Studies on the Blood and Blood Pressure in the Eskimo and the Significance of Ketosis under Arctic Conditions.* 1954. Kr. 10,00.
„ 103. LØVENSKIOLD, H. L., *Studies on the Avifauna of Spitsbergen.* 1954. Kr. 16,00.
„ 104. HORNBÆK, HELGE, *Tidal Observations in the Arctic* 1946—52. Kr. 2,50.
„ 105. ABS, OTTO und HANS WALTER SCHMIDT, *Die arktische Trichinose und ihr Verbreitungsweg.* 1954. Kr. 4,00.
„ 106. MAJOR, HARALD and THORE S. WINSNES, *Cambrian and Ordovician Fossils from Sørkapp Land, Spitsbergen.* 1955. Kr. 4,00.
„ 107. FEYLING-HANSSEN, ROLF W., *Stratigraphy of the Marine Late-Pleistocene of Billefjorden, Vestspitsbergen.* 1955. Kr. 22,00.
„ 108. FEYLING-HANSSEN, ROLF W., *Late-Pleistocene Deposits at Kapp Wijk, Vestspitsbergen* 1955. Kr. 3,00.
„ 109. J. J. DONNER and R. G. WEST, *The Quaternary Geology of Brageneset, Nordaustlandet, Spitsbergen.* 1957. Kr. 5,00.
„ 110. KAARE Z. LUNDQUIST, *Magnetic Observations in Svalbard 1596—1953.* 1957. Kr. 6,00.
„ 111. H. U. SVERDRUP, *The Stress of the Wind on the Ice of the Polar Sea.* 1957. Kr. 2,00.
„ 112. ORVIN, ANDERS K., *Supplement I to The Place-Names of Svalbard. Dealing with new Names 1935—55.* 1958. Kr. 13,00.
„ 113. SOOT-RYEN, TRON, *Pelecypods from East-Greenland.* 1958. Kr. 4,00.
„ 115. GROOM, G. E. and SWEETING, M. M., *Valleys and Raised Beaches in Bünsow Land Central Vestspitsbergen.* 1958. Kr. 3,00.
„ 116. SVENDSEN, PER, *The Algal Vegetation of Spitsbergen.* 1959. Kr. 7,00.

MAPS AND CHARTS

The following topographical maps and charts have been published separately:

Maps:

Bjørnøya. 1:25 000. 1925. New edition 1944. Kr. 5,00.
Bjørnøya. 1:10 000. [In six sheets.] 1925. Kr. 36,00.
Adventfjorden—Braganzavågen. 1:100 000. 1941. Kr. 2,00.
Svalbard. 1:2 000 000. 1958. Kr. 2,00.
Topografisk kart over Svalbard. Blad C 13. Sørkapp. 1:100 000. 1947. Kr. 5,00.
Topografisk kart over Svalbard. Blad B 10. Van Mijenfjorden. 1:100 000. 1948. Kr. 5,00.
Topografisk kart over Svalbard. Blad C 9. Adventdalen. 1:100 000. 1950. Kr. 5,00.
Topografisk kart over Svalbard. Blad B 11. Van Keulenfjorden. 1:100 000. 1952. Kr. 5,00.
Topografisk kart over Svalbard. Blad B 12. Torellbreen. 1:100 000. 1953. Kr. 5,00.
Topografisk kart over Svalbard. Blad B 9. Isfjorden. 1:100 000. 1955. Kr. 500.
Topografisk kart over Svalbard. Blad C 12. Markhambreen. 1:100 000. 1957. Kr. 5,00.
Topografisk kart over Svalbard. Blad A 8. Prins Karls Forland. Kr. 5,00.
Austgrønland. Eirik Raudes Land frå Sofiasund til Youngsund. 1:200 000. 1932. Kr. 2,00.
Jan Mayen. 1:100 000. 1955. Førebels utgåve. Kr. 2,00.
Dronning Maud Land. Sør-Rondane. 1:250 000. 1957. Kr. 4,00.

Preliminary topographical maps [1:50 000] covering claims to land in Svalbard and a preliminary map of Hopen 1:100 000 may be obtained separately.

In addition, Norsk Polarinstitutt has prepared a wall map: Norden og Norskehavet in 4 sheets. This map is to be obtained through H. Aschehoug & Co. (W. Nygaard), Oslo, at a price of kr. 27,80.

Charts

No. 501. Bjørnøya. 1:40 000. 1932. Kr. 10,00.
„ 502. Bjørnøyfarvatnet. 1:350 000. 1937. Kr. 10,00.
„ 503. Frå Bellsund til Forlandsrevet med Isfjorden. 1:200 000. 1932. Kr. 10,00.
„ 504. Frå Sørkapp til Bellsund. 1:200 000. 1938. Kr. 10,00.
„ 505. Norge—Svalbard, nordre blad. 1:750 000. 1933. Kr. 10,00.
„ 506. Norge—Svalbard, søre blad. 1:750 000. 1933. Kr. 10,00.
„ 507. Nordsvalbard. 1:600 000. 1934. Kr. 10,00.
„ 508. Kongsfjorden og Krossfjorden. 1:100 000. 1934. Kr. 10,00.
„ 509. Frå Storfjordrenna til Forlandsrevet med Isfjorden. 1:350 000. 1936. Kr. 10,00.
„ 510. Frå Kapp Linné med Isfjorden til Sorgfjorden. 1:350 000. 1936. Kr. 10,00.
„ 511. Austgrønland, frå Liverpoolkysten til Store Koldeweyøya. 1:600 000. 1937. Kr. 10,00.
„ 512. Jan Mayen. 1:100 000. 1955. Kr. 10,00.

Prices above do not include purchase tax.

A. W. BRØGGERS BOKTRYKKERI A/S