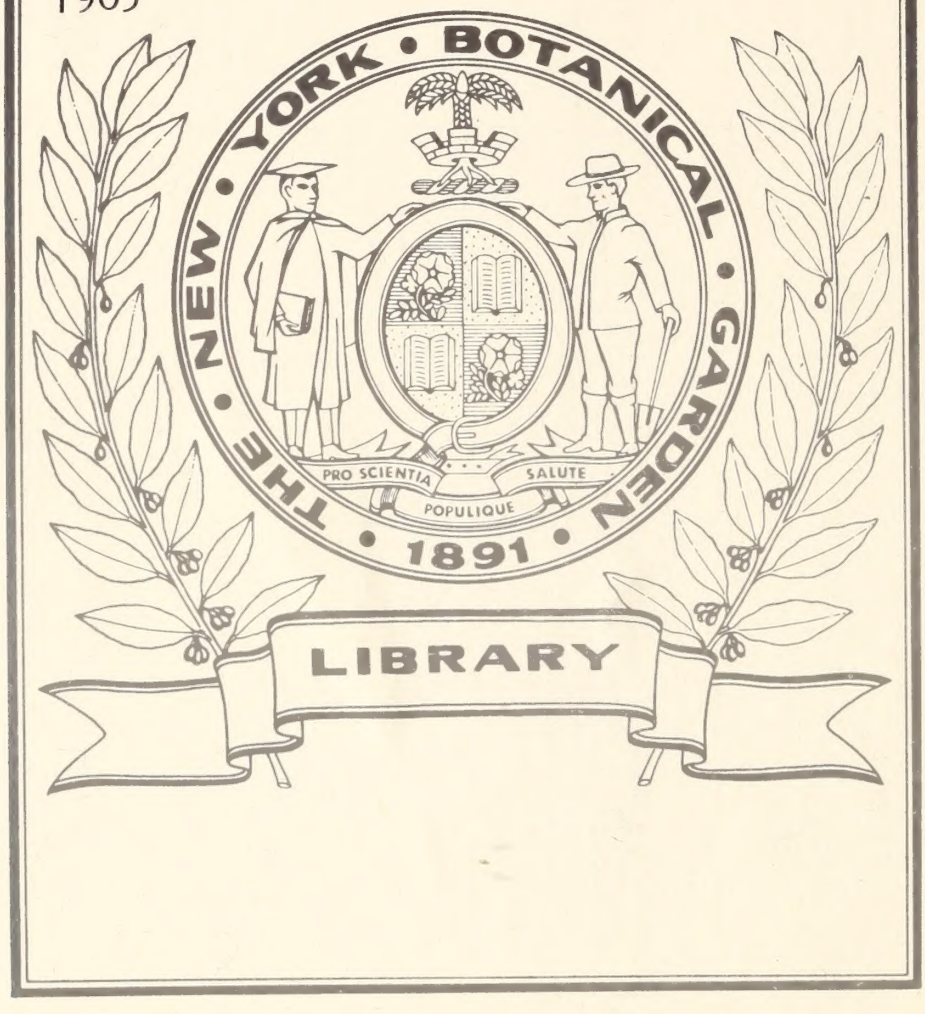

F. BØRGESEN

THE ALGÆ-VEGETATION OF THE FÆRÖESE COASTS

WITH REMARKS ON THE PHYTO-GEOGRAPHY

REPRINTED FROM THE »BOTANY OF THE FÆRÖES«, PART III
PUBLISHED BY THE AID OF THE CARLSBERG FUND

ISSUED NOVEMBER 1 1905

COPENHAGEN
PRINTED BY H. H. THIELE
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CONTENTS.

THE ALGÆ-VEGETATION OF THE FÆRÖESE COASTS

WITH REMARKS ON THE PHYTO-GEOGRAPHY

BY

F. BØRGESEN.

PREFACE.

This paper contains the final report on my six journeys to the Færöes in the period 1895—1902. During my first three visits (1895, 1896 and 1898) I travelled about, partly by boat, partly by the local steamer »Smiril«, but the last three times I visited the islands, (1899, 1900 and 1902), I stayed on board the vessels stationed at the Færöes for the protection of the fisheries and for surveying purposes, the first two years on the gunboat »Guldborgsund«, in 1902 on the torpedoboat »Beskytteren«.

In this way I have been able to obtain a far more thorough knowledge of the algæ-vegetation than would otherwise have been possible. I have for instance visited all the islands, except Fuglø, and have been on a great many islets and cliffs, and on many remote coasts, where access might otherwise have been difficult. Further, the vessels of the Navy have not only helped me to make wide excursions, but their assistance has also been of advantage to my work as I then had the opportunity of working with larger apparatus than I could have used from a small boat. Thus in 1899 I had the use of a small trawl which helped me to obtain a rich material, and in 1902 a very large iron scraper was used, also with good results.

INTRODUCTION.

As is well known, J. G. Agardh was the first to try to give a description of the different regions of the algal vegetation on the Scandinavian coasts in his well-known work, »Novitiæ Floræ Sveciæ« (2)[1]. In this work he distinguishes between three regions: 1. *Regnum Algarum Zoospermarum.* 2. *Regnum Algarum Olivacearum* and 3. *Regnum Algarum Floridearum,* which are further divided into subregions.

[1] This and the following figures refer to the Index to literature.

At the same period (1836) Lyngbye was dealing with the algæ-vegetation in a paper entitled »Rariora Codana«, which was only published much later (1879) by Professor Warming. Lyngbye makes a division into three Zones: firstly that of the *Ulvaceæ*, reaching from the surface of the sea to a depth of 30 feet, secondly that of the *Florideæ*, as far down as from 30 to 60 feet, and finally that of the *Laminariaceæ*, from 50 to 90 feet. For each zone he mentions a number of specifically characteristic species, partly from Denmark, partly from the Færöes and from Norway. Lyngbye's division does not however seem quite satisfactory to me. It would have been most natural to determine the zone of the *Florideæ* as the lowest one, as in J. Agardh's division. Besides, several species (I refer only to the Færöese specimens mentioned by Lyngbye) do not occur in the depths mentioned. Thus *Fucus loreus, Scytosiphon filum lomentarius* and *Callithamnion arbuscula* are mentioned as belonging to the zone of the *Florideæ*; they are, however, all littoral. *Laminaria agarum* is given as in the zone of the *Laminariaceæ*, but it has never been found in the Færöes; to this zone he also refers *Callithamnion arbuscula.* It seems as if his memory had been failing him, and most likely his strength had already grown less as it was but a short time before his death (compare Warming's introduction [60, page 3]). It must be remembered also, that he wrote his paper many years after his visit to the Færöes.

In 1844 Ørsted published his well-known work, »De Regionibus Marinis«, in which, relying on the above-mentioned work of J. Agardh, he gives a detailed description of the algal vegetation of the Sound. He subdivides this into firstly, »*Regio Algarum viridium s. Chlorospermearum*«, reaching from the surface of the sea to a depth of 2 to 5 fathoms and embracing: »*Subregio Oscillatorinearum*« above, »*Subregio Ulvacearum*« below; secondly, »*Regio Algarum olivacearum s. Melanospermearum*«, consisting of »*Subregio Fucoidearum et Zosteræ marinæ*« and »*Subregio Laminariearum*« below it, and whose upper limit lies in depths of 3 to 5 fathoms and lower in 7 to 8 fathoms; finally, *Regio Algarum purpurearum s. Rhodospermearum,* in depths of 8 to 20 fathoms. Ørsted seeks the chief explanation for this distribution of the Algæ in the varying degrees of penetration of the light through the water, and, in connection with this, in the different colour of the light at different depths.

In addition to these authors, Areschoug, Kleen, Ekman and others have also contributed to our knowledge of the algæ of

the Scandinavian coasts, but it is only in different works by Kjellman, especially in his fundamental work: »Ueber Algenregionen und Algenformationen im östlichen Skager Rack« (45) that a more precise limitation and terminology of the particular algal regions and communities are first introduced. Several papers on the algæ-vegetation have been published later; amongst the more important of these, which are at the same time interesting as a means of comparison with the Færöese algæ-vegetation, I need only mention those dealing with the Norwegian algæ by Boye (6), Gran (36, 37) and Hansteen (38), and the detailed description of the Greenland algal vegetation by Rosenvinge (71).

With regard especially to the Færöes, Landt (57) is, so far as I know, the first to give some particulars of the occurrence and growth of some few algæ, in his list of Færöese algæ. Some short notes are also given by P. A. Holm (40, p. 203, 204). Rostrup, who states (72, p. 16—17) that many algæ are so abundant as to form regular forests of seaweeds, gives some information as to the habits of the algæ; thus he states, that *Porphyra laciniata* occurs abundantly on rocks washed at high tide. The paper by Simmons: Zur Kenntniss der Meeresalgen-Flora der Færöer«, published in 1897, is the first important contribution to our knowledge of the Færöese algæ-vegetation.

In accordance with Kjellman, Simmons makes a division between the littoral, the sublittoral and the elittoral regions, and gives a description of different formations belonging to these regions. Moreover he tries to compare the algal vegetation of the Færöes with that of the coasts of the adjacent countries, and his main results are briefly as follows: the Færöese algal vegetation is characterized by its strong concentration in the littoral and sublittoral regions and by its disappearance at no very great depth; secondly, an algal vegetation closely connected with that of the Færöese seems to occur in Nordland on the western coast of Norway, which lies far more towards the north than the Færöes. As to the first statement, however, I do not consider it quite correct; as a vigorous growth of *Laminaria hyperborea* is found even at a depth of about 15 fathoms (as to this I shall give further information later), and on the whole the algal vegetation is found down to a depth of 25 fathoms, wherever circumstances are favourable to its occurrence. This agrees with the observations made in adjacent countries.

Further investigations of the algal vegetation of Nordland

will probably prove, that there is no little resemblance between the algal vegetation of Nordland and that of the Færöes. Kleen has expressed the same view (51, p. 6—7, Note); but on the other hand, Kleen's descriptions are too brief and too few to allow any final conclusion to be drawn from them. Moreover his statement (page 9) that »on steep, overhanging cliffs, in immediate vicinity of the sea, no sort of luxuriant vegetation is found above the lowest water mark, where mostly nothing but small tufts of *Ceramium acanthonotum* and *Callithamnion arbuscula* occur«[1], is quite incompatible with the luxuriant littoral vegetation of the Færöes.

My investigations on the algal vegetation of the Færöes were published in Danish in the spring of 1904, and the present issue in English is based essentially on the Danish edition. My work has been sharply attacked by Porsild and Simmons, to whose criticisms I have already replied in the »Botaniska Notiser«. Referring to these notices for particulars, I may briefly mention here, that the main criticisms of these authors are directed against my view, that it is quite possible, that the Færöese algal flora may be transported over the sea to these islands. Thus, Porsild maintains that it is a »physical impossibility« for algæ, for example, to be carried from Ireland or the west coast of Scotland across the Gulf Stream to the Færöes. In his opinion algæ from the west coast of Norway, from the Shetlands, Orkneys and Scotland, must be carried far into the Arctic Ocean before they could reach the Færöes; a journey taking at least 3 years, probably more! Porsild further maintains, that but few of the Færöese algæ can float; also, that 26,7 % of all the Færöese species of algæ is what he calls »strictly sublittoral«, meaning thereby those algæ which are never found, in his opinion, so high up as low water mark, and which therefore can never have the chance to fix themselves on floating timber or the like and thus be carried about in the sea. Finally, 12,4 % according to Porsild are calcareous algæ, either living in calcareous shells, or incrusting stones, etc. »These algæ can certainly not float, and by far the majority of them are sublittoral forms, which can also not fix themselves to stones or shells borne by algæ which can float«. As to the biological conditions for the algæ during their drift to the Færöes, Porsild maintains in opposition to my

[1] »På branta, ytterst mot hafvet belägna klippor saknas all rikare vegetation ofvenför lägsta vattenmärket; och man träffar derstädes vanligen blott små tufvor af *Ceramium acanthonotum* och *Callithamnion arbuscula*«.

view: 1) that the biological conditions in the currents, which lead to the Færöes, are very variable and different from those at the Færöese coasts, 2) that marine algæ are very sensitive to changes of temperature and salinity, and also, 3) that the white light of the surface may have a destructive influence especially on the sublittoral algæ, 4) that the algæ could neither fix themselves again after the drift across the sea, nor develop new reproductive organs, these being lost presumably on the way. Consequently, even though cases are known of marine algæ having drifted a long way, yet the probability of any effective distribution occurring in this way is extremely small, and so far as known it has never been observed. Further Porsild opposes the possibility that algoid spores may be distributed widely by the oceanic currents, and considers navigation of no importance as a means of distribution. In fact, according to Porsild, the algal flora of the Færöes can only have arisenthrough some postglacial communication with land.

Simmons entirely agrees with Porsild's view. He also endeavours moreover, to criticise my description of the algal communities and my comparison of the Færöese flora with that of the neighbouring lands, and, for this purpose gives a list of the algal forms of the North Atlantic as well as of the Arctic Ocean. I shall not enter upon further details here, however, but merely mention that his list is not drawn up with sufficient accuracy to enable it o form the basis of a thorough comparison.

I.

ON THE EXTERNAL CONDITIONS AFFECTING THE ALGAL VEGETATION ON THE FÆRÖESE COASTS.

1. Climatic and hydrographic conditions.

a. Temperature and Salinity of the Sea.

The Færöes, lie in the Atlantic Ocean in 61° 23′—62° 24′ N. Lat. and 6° 14′—7° 41′ W. Long. The climate is markedly insular, the temperature very uniform, in summer low, but in winter relatively high. Rain and fogs are frequent, and the climate on the whole stormy and rough. Consequently the sea is most often in motion, and on exposed coasts there is much surf.

This very rough climate is mostly due to the fact that the boundary line between the warm Gulf Stream and the cold East Icelandic Polar Current is found at, or at any rate near by, the

Færöes. The boundary line between these two currents is influenced by the predominant direction of the wind, and thus goes sometimes nort hand east, sometimes west and south, of the Færöes (see Martin Knudsen 52). In a morere cent paper (»Havets Naturlære« 53, p. 29) Knudsen says: »It seems as if the Polar Current hardly ever reaches so far down as to surround the Færöes, but it may happen. On the other hand the Polar Current rarely recedes far northward from the Færöes«.

Whilst the Gulf Stream, as mentioned by Knudsen (52, p. 158), has a rather high temperature and a salinity above 35,25 ‰, the Arctic current is of a much lower temperature, which may even reach the freezing point of the sea in winter and spring, and its salinity is below 35,25 ‰. In summer and autumn a thin layer on the surface of the Polar Current will, however, attain a temperature almost equal to that of the adjacent water of the Atlantic Ocean. The Ingolf expedition passed the dividing line between the two currents several times, and it was then observed: »that in passing from the Atlantic Ocean to the East Icelandic Polar Current the salinity of the surface was reduced from more than 35,25 ‰, to less than this. A slight, but still perceptible, fall of temperature was likewise observed«.

In spite of the proximity of the colder Polar Current, the influence of the Gulf Stream predominates, causing the temperature of the sea to be very uniform all the year round, and in winter especially very high. When Simmons writes (78, p. 263), that it is rather low, his statement must only be applied to the temperature of summer, which is indeed much below that of the west coast of Norway in the same latitude, where an almost corresponding temperature is only met with much farther north, in Nordland. If we look at a map of the Northern Ocean, showing the temperature of the surface in summer (see for instance Hjort, Nordgaard and Gran: Report on Norwegian Marine Investigations 1895 to 1897, Bergen 1899), we observe that the isotherm of 12° C. is drawn midway across the Færöes. The isotherm first bends a little south east towards the Shetland Isles, and then north west to the centre of Nordland. The isotherm of 11° C., which passes close by the west and south coasts of Iceland, extends northward round the Færöes at no great distance from the Nordreöerne, and ends on the west coast of Norway as far up as the centre of Lofoten. The isotherm of 13° C. passes at a somewhat great

distance southward round the Færöes, goes between the Shetland Isles and the Orkneys, and ends on the west coast of Norway, a little north of Trondhjem Fjord. In winter and spring on the other hand the water is warmer round the Færöes than on the west coast of Norway. According to Mohn: »Den Norske Nordhavs Expedition«, 2 vol. Christiania 1883, the isotherm of 6°C. runs in March midway across the Færöes, then it bends northward, then southward, and stops almost in the centre of the east coast of Scotland.

According to observations made near Thorshavn (see Willaume-Jantzen 84, p. 29), the annual mean temperature of the surface of the sea is 7,8°C.; from January to March its temperature is 5,5°C., and from July to September 10—10,5°C., in exact accordance with the average observations of 20 years. The lowest mean temperature of the surface of the sea was in one month (March) 4,25°C., and the highest in an equally long period (August) 11,75°C. These figures clearly show the very small difference of temperature in the sea round the Færöes, where the greatest difference observed between the mean temperature of the warmest and the coldest months thus only amounts to 7,50°C. Ice is also unknown, and it is only in the inmost part of the larger fjords such as Skaalefjord, little affected by the tides, and where much fresh water streams into the sea, that the water may sometimes be covered by a thin crust of ice.

The above-mentioned figures only refer to the surface of the sea, but as the marine algæ are found down to a depth of about 25 fathoms, (for the Færöes I believe that this may be stated as the lowest limit), it would of course be of interest to our subject to know the temperature as far down as this depth. Such observations, however, do not exist, so far as I know, but on my application the officers of the »Guldborgsund« in 1899—1900 were kind enough to obtain some hydrographical data by aid of a reversing thermometer lent me by the Metereological Institute. The accompanying table shows the results of these observations and indicates that the difference of temperature between the surface of the sea and the lower layers of water is exceedingly small. During the warmer period of the year the temperature of the surface rises slightly, yet seldom more than $^1/_2{}^0$, whereas in winter the water is somewhat warmer deep down than on the surface. In the fjords only, there may be a greater difference (see e. g. the observation $^{10}/_2$ Klaksvig): it is due

Deep-water temperatures in the sea around the Færöes 1899—1900.

(The temperature is given in degrees Celsius and is everywhere +).

Locality	Date	Time	Surface	5 fathoms	10 fathoms	15 fathoms	20 fathoms	25 fathoms
Fuglefjord	1900 16/1	p. m. 1½	6.5°	6.8°	6.8°	Bottom 7.0°		
Klaksvig[1]	1900 10/2	noon 12	1.8°	Bottom 5.5°				
Sjov (Strömö)	1900 12/2	p. m. 6	4.0°	4.3°	4.5°	4.9°	Bottom 5.1°	
Sörvaag	1900 28/2	a. m. 10	4.8°	4.3°	5.3°	Bottom 5.4°		
Kvannesund	1900 10/2	p. m. 3	5.5°	5.5°	Bottom 5.5°			
Lopra	1899 17/6		9.0°	8.8°	Bottom 8.7°			
Viderejde	1899 14/7		9.2°	8.8°	8.7°	8.8°	8.9°	Bottom 8.8°
Thorshavn	1899 21/7		9.4°	9.8°	Bottom 9.2°			
Trangisvaag	1899 26/7		9.4°	9.1°	9.0°	Bottom 9.0°		
Tværaa	1900 8/8	p. m. 4½	10.3	10.0	10.0	Bottom 9.8		
Porkere	1900 9/8	p. m. 3	10.3	10.0	Bottom 9.9			
Tværaa	1900 28/8	p. m. 3	10.8	10.2	10.0	Bottom 9.9		
Tværaa	1900 29/8	p. m. 7	10.4	10.0	10.0	Bottom 10.0		
Thorshavn	1900 1/9	a. m. 7½	10.2	10.0	Bottom 9.9			
Vestmanhavn	1899 18/9	p. m. 2½	10.1°	Bottom 10.0°				
Thorshavn	1899 21/9	a. m.	9.9°	9.9°	Bottom 9.8°			
Kongshavn	1899 22/9	p. m. 3	9.8°	9.8°	9.8°	9.8°	Bottom 9.8°	
Trangisvaag	1899 2/10	a. m. 7	9.0°	8.5°	9.1°	Bottom 9.1°		
Fundingsbotten	1899 8/10	a. m. 1½	9.5°	9.3°	9.2°			
N. f. Ennebjærg (Viderejde)[2]	1899 1/11	a. m. 10½	9.6°	9.7°	9.8°			

[1] The surface of the sea covered with snow. Calm.

[2] Change of current; depth, 45 fathoms, the thermometer was broken at 15 fathoms.

here to the more stagnant water, the surface of which may be somewhat cooled at a low temperature of the air, whereas the water of the open sea and of the sounds is constantly renewed by the strong current and mixed with the lower water-layers, so that it does not have time to be cooled to any degree worth mentioning. The algæ growing in deep water live consequently at more uniform temperatures than those growing in shallow water.

Near the shore among the seaweeds and in tide pools, the sun of course may warm the water to a considerable extent, so as to make it almost lukewarm; thus in a somewhat large water-basin at Skuö, 25° C. was observed on June 11th, 1900, and in smaller pools the temperature may certainly rise still higher.

As to the salinity, it varies, as already remarked, according to whether the salter water of the Atlantic Ocean (above 35,25 ‰) or the less salt water of the Polar Current reaches the coasts; the difference however is never very great.

Fresh water streams into the sea from almost all parts of the Færöese coasts, but on account of the strong oceanic currents it has hardly any effect in comparison with the large volume of circulating seawater, and as a rule it is only of local importance to the growth of algæ at the outlets of brooks and waterfalls. But at the bottom of larger fjords, where the water is more seldom renewed, the fresh water from the land is perceptible to a greater extent, and here the water often becomes more or less brackish. This has no small influence on the algal vegetation, which in these places is extremely poor in species.

b. Tides. Oceanic Currents.

Tides occur almost everywhere on the coasts of the Færöes. The difference between high and low tide is not great, as the tide does not rise to anything like the heights reached on the coasts of Norway and Scotland.

On the western side of the islands, where the tidal wave is strongest, the difference between ebb and flood will at most amount to 8—10 feet during the spring-tides, on the eastern side to hardly more than 4—5 feet.

The accompanying observations on the tides, made in the summer of 1900 and kindly placed at my disposal by the officers of the »Guldborgsund« further illustrate this. The observations extend

over quite a month, during which period the weather was calm, so that storms had no disturbing effects.

Vaagfjord (open to the east). Almost at the end of the fjord, the difference between high and low water is a little more than 3 feet when the current is strongest (spring-tide); with »fair« current (neap-tide) only $^3/_4$ feet. High and low water occur very regularly in this fjord.

Trangisvaagfjord (open to the east). High and low water do not occur so regularly in this fjord as in Vaagfjord. When the current is strongest the difference is generally about 3 feet, but one day during the period of observation it reached 6 feet; with »fair« current the difference is only 1 foot.

Sörvaagfjord (open to the west). Regular tides occur. At spring-tide there is a difference of ca. 6 feet, at neap-tide of ca. 3 feet.

Midvaagfjord. The fjord is open to the south-east, but on account of the western situation of the island the difference is considerable. Regular tides occur. At spring-tide there is a difference of ca. $5^1/_2$ feet, at neap-tide of $2^1/_3$—3 feet.

Vestmanhavn. The fjord is open to the west, and at Vestmanhavnsund to the north-west and south-west. Regular tides occur. At spring-tide there is a difference of ca. 6 feet, at neap-tide of ca. 2 feet

Sandsbugt (open to the south-west). Regular tides occur. At spring-tide there is a difference of about $5^1/_2$, but it may reach to about 7 feet; when the current is »fair« the difference is hardly 2 feet.

As appears from these observations, the greatest difference noted with certainty is about 7 feet; but there is no reason to doubt that there are places where a somewhat greater difference may occur. This is probably the case on the western side of Syderö and on the north-western side of Strömö. At Famien on Syderö, the inhabitants have told me that the difference may amount to from 8—10 feet. These figures are however small in themselves and would only mean a littoral algal vegetation of relatively limited extent compared with that of the western coasts of Norway and of the British Isles, were it not that other circumstances aid the algæ of exposed coasts to grow even far above the highest water mark.

The tidal wave, or, as they say in the Færöes, the »Westfall« and the »Eastfall«, produces a very rapid current, changing regularly every 6th hour[1] in open fjords and especially in the sounds.

At spring-tide, when the current is most rapid, it may in certain places, such as Vestmanhavnsund, flow as fast as 8—10 miles an hour, and in such places the larger algæ are of course exposed to a very great strain.

Whilst on all exposed coasts and in most fjords and sounds

[1] Nolsöfjord however excepted; on account of peculiar circumstances the current there runs 8 hours one way and 4 hours the other.

there are tides and consequently currents, there is a large tract of water without either tides or currents, or with at any rate almost imperceptible ones. This is found between Strömö and Österö, bounded on the south by a line drawn from Höjvig to Næs on Österö, reaching on the north as far as Kvalvig in Sundelaget, thus including the three large fjords Skaalefjord in Österö, Kalbak- and Kollefjord in Strömö, besides »the Sounds« between both islands. This almost stagnant area of water naturally shelters an algal vegetation of a peculiar kind. It is e. g. the true habitat of *Laminaria færoensis*, and this characteristic alga reaches here its highest development.

c. Action of the Waves. Exposed Coasts; sheltered Coasts.

As already mentioned, the surf breaks more or less vigorously on all the coasts of the Færöes during the greater part of the year. The heavy, unbroken waves of the Atlantic roll in on the mostly steep and rocky coasts, and during the storms of winter the waves may be strong enough to move rocks, as was the case at Bosdalafos on the western coast of Vaagö, about 80 feet above the level of the sea. It may even happen, that the sea rushes into Sörvaags Lake itself, to which Bosdalafos is the outlet. It is not unusual for the surf to reach 100 feet up the cliffs, and it has even been said to reach several hundred feet up. Even in summer, when the weather is fine, there is almost always some surf produced by the swell, when it meets the land. Still periods may occur, especially in summer, when the weather is so fine and the sea so calm that the surf almost disappears.

When the algal vegetation of a country is investigated, it will soon be observed, that the more or less exposed condition of the localities is of great importance. The open coasts, constantly exposed to the surf, are covered by an algal vegetation differing greatly from that on sheltered coasts. The difference is so great, that with some few exceptions the species growing on exposed coasts are of quite another kind than those growing on sheltered coasts. This is quite easy to explain, as the mechanical influence of the waves is not the only influence affecting the algæ of open coasts in contrast to those on sheltered coasts; it is also probable, that the water is more rich in oxygen, more nutritive and often salter than in sheltered places, and further the water coming in contact with the algæ is more frequently renewed by the dashing of the

waves on exposed coasts than is the case on sheltered coasts, where the change of substance is likely to occur more slowly.

From the composition of the algæ-vegetation one may tell at once whether the coast on which they grow is exposed or sheltered, and if we come from the open sea towards a sheltered place we may notice how the algal vegetation changes in character. The change often comes on gradually, but sometimes a sudden bend in the coast may as suddenly change the character of the vegetation.

This fact may often be observed, and by way of illustration I may mention an investigation I made from the mouth to the head of Kalbakfjord. I landed at short distances along the southern side of this fjord, starting from Hvidenæs and noting the most important species of algæ. Tides and current are here scarcely perceptible.

At Hvidenæs there is a perfect »open sea« algal vegetation. Some small creeks with calcareous gravel excepted, the coast is here mostly steep, almost vertical, and as is usual in such places is covered from low water mark downwards by a dense *Alaria*-vegetation, and above it by the *Balanus*-belt, which supports several of the smaller red and brown algæ, e. g. *Ceramium acanthonotum*, *Polysiphonia urceolata*, *Callithamnion arbuscula*, *Ectocarpus litoralis*, etc. The littoral vegetation is however rather scanty on these vertical cliffs, which is probably due to the fact, that the sea is often relatively calm at this place, especially in summer, Nolsö as well as Österö yielding it some shelter. A little west of Hvidenæs (the place is marked 1 on the accompanying sketch, Fig. 151) the following species were the most prominent, passing upwards from the sea level: *Alaria esculenta*, *Himanthalia lorea*, *Gigartina mamillosa*, *Ceramium acanthonotum*, *Callithamnion arbuscula*, *Scytosiphon lomentarius* in small numbers in shallow pools, *Fucus spiralis f. nana* and *Porphyra umbilicalis;* as may be seen, exactly the vegetation of exposed coasts. A little farther on, at 2, where the shore is likewise steep, but with scattered rocks fallen from the overhanging cliffs, almost the same algæ were found: *Alaria esculenta*, *Himanthalia lorea*, *Gigartina mamillosa*, *Fucus spiralis f. nana*, *Porphyra*, *Enteromorpha intestinalis* var. *genuina* and var. *micrococca*. We thus have still the algal vegetation of exposed coasts, which was also found at 3, although the somewhat larger forms of *Fucus* indicate a somewhat more sheltered spot, viz.: *Alaria esculenta* and *Laminaria digitata*, *Himanthalia*, *Polysiphonia urceolata*, *Gigartina mamillosa*, *Ceramium acanthonotum* and *C. rubrum*, *Callithamnion arbuscula*, rather large

specimens of *Fucus inflatus, Fucus spiralis f. nana, Porphyra umbilicalis* and *Enteromorpha.*

At 4, the algal vegetation has also the character of algæ belonging to somewhat exposed coasts. The shore was here rather steep with almost flat rocks in front close to the water's edge; here were found *Laminaria digitata, Alaria esculenta* with a subgrowth of *Corallina, Gigartina mamillosa, Chordaria flagelliformis, Scytosiphon lomentarius, Ceramium rubrum*, large specimens of *Fucus inflatus* with *Elachista fucicola, Porphyra umbilicalis, Enteromorpha intestinalis* var. *micrococca* and *Ectocarpus litoralis.* At 5, the flora has still almost the same character; here were found *Laminaria*

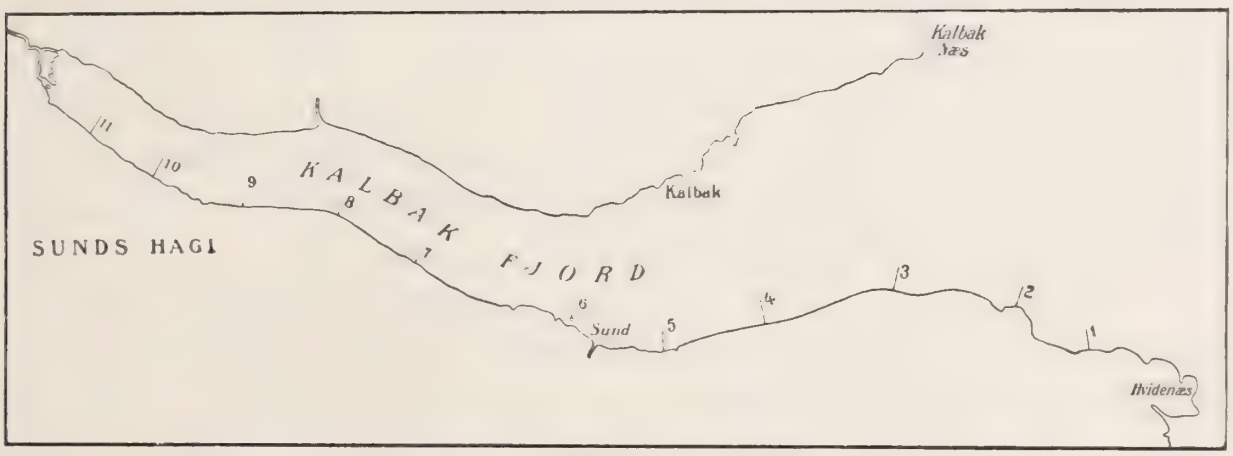


Fig. 151. Sketch of Kalbakfjord after the map of the generalstaff.

digitata, L. saccharina, Alaria esculenta, Himanthalia lorea, Rhodymenia palmata, Gigartina mamillosa, Ceramium rubrum, Dumontia filiformis, Acrosiphonia spec. *(albescens?), Fucus inflatus* (large) with *Elachista fucicola, Fucus spiralis* (large) and *Porphyra.* Close by the village of Sund there is a small and low mass of rocks (6). On its eastern side, towards the mouth of the fjord, the following species were found: *Laminaria digitata, Alaria esculenta, Himanthalia, Rhodymenia palmata, Gigartina mamillosa* and *Ceramium acanthonotum, Acrosiphonia, Fucus inflatus* (large), *Porphyra* and *Enteromorpha intestinalis*, the principal vegetation thus resembling that of exposed coasts; on the other hand, the western side of the rock, facing landwards, was covered by the typical flora of sheltered coasts, with *Fucus vesiculosus* at the top and next to that large luxuriant masses of *Ascophyllum nodosum* covering the almost horizontal surfaces from high water mark downwards. On the rock were found several pools of different sizes filled with water, the bottoms covered by *Corallina officinalis*, and *Leathesia difformis* was growing epiphytically on the latter in great profusion. *Monostroma fuscum, M. Gre-*

villei, *Chordaria flagelliformis*, *Ceramium rubrum* and *Acrosiphonia* spec. were also found.

From Sund a little farther up, the fjord inclines slightly towards the north, with the result that the algal vegetation remains similar to that of somewhat exposed coasts; at 7, where the coast is fringed by steep rocks, were found: *Alaria esculenta*, *Laminaria digitata*, *Rhodymenia palmata*, *Fucus inflatus* (large), *Ceramium rubrum*, *Porphyra* together with *Bangia* and *Urospora penicilliformis*, and still farther, at 8, *Laminaria digitata*, *Alaria esculenta*, *Corallina officinalis*, *Gigartina*, *Cladophora rupestris*, *Fucus inflatus* (large), *Fucus spiralis* (large), *Porphyra umbilicalis*, *Enteromorpha*, and so on, that is, a vegetation typical on the whole of somewhat exposed coasts, but large and vigorous specimens of *Fucus spiralis* and *Fucus inflatus*, up to 2 feet long, now occur. That the waves may wash heavily at times even so far up the fjord as this, is clear from the fact that there was some surf even on the day of my visit, in spite of the great calmness of the sea.

The fjord now bends again more towards the west, and the vegetation is henceforward typically that of sheltered coasts. At 9, the beach slopes gently and is covered with stones of different sizes on which are found sublittorally *Laminaria saccharina* and *Chorda filum*, (*Alaria* is now no longer found), *Himanthalia lorea* and *Fucus inflatus* (on open shores, the two last are always littoral), the lastmentioned still continuing far enough upwards to become littoral, and to form large clumps on the stones; then come *Fucus spiralis* and some few *Porphyra umbilicalis*. A little farther, at 10, in water one foot deep, were found: *Chorda filum*, *Laminaria saccharina*, *Ceramium rubrum*, *Monostroma fuscum*, *Enteromorpha Linza*, *Ectocarpus litoralis* (in large, thick masses), *Dictyosiphon foeniculaceus*, *Stictyosiphon tortilis*, *Scytosiphon lomentarius*; in shallower water: large clumps of *Fucus inflatus;* and at the surface: *Fucus vesiculosus* and *Fucus spiralis*, the latter partly dried. Still farther, at 11, were noted: *Laminaria saccharina*, *Ceramium rubrum*, *Acrosiphonia*, *Enteromorpha Linza*, *Monostroma fuscum*, *Dumontia filiformis*, *Fucus inflatus*, all sublittoral; and at the water's edge and a little above: *Ascophyllum nodosum*, *Fucus vesiculosus* and *Fucus spiralis*.

At the head of the fjord, *Enteromorpha clathrata*, *E. intestinalis*, *Ectocarpus litoralis*, *Ceramium rubrum* and *Fucus inflatus* were found at low water: farther also, *Fucus vesiculosus* and *Fucus spiralis* littorally, and highest of all *Pelvetia canaliculata*. Much fresh water

flows into the sea here, which is therefore often very brackish, and at certain places almost fresh. Even at the mouths of the large effluents only *Enteromorpha intestinalis* and a few *Ectocarpus litoralis* are found, but at a short distance from the exit specimens of *Fucus*, *Enteromorpha clathrata*, *Ceramium rubrum* and others.

Thus it is evident, and examples can be met with everywhere in the Færoës, that in passing from exposed to sheltered coasts the flora of these two localities will be found to vary greatly. Further illustration of this will be given in the section concerning communities of algæ.

Flowing or stagnant water are likewise of great importance to the algal vegetation and give it a widely varying character. The current constantly carries fresh sea-water, and thus new nutritive substances, to the algæ, whereas the vital functions must naturally proceed more slowly in stagnant water, where the supply of fresh sea-water is much smaller. If we examine the same forms of algal vegetation, e. g. the *Laminaria hyperborea*-association, we likewise find it much more vigorously developed than in places where the water is stagnant. Most likely this is also due to the mechanical influence of the current; at any rate we find a very well developed algal vegetation in places where there are rapid currents.

Just as a current causes fresh-water plants to become elongated, many algæ growing in places much exposed to currents have long and rather narrow fronds. I have seen very fine examples of this at Götebue near Mjovenæs on Österö, on dredging in ca. 10 fathoms of water. Here a *Laminaria hyperborea*-association was found, in which the main plant was strong and robust, but the lamina had narrow laps; and growing epiphytically on this, were some *Delesseria alata* a foot in length, and some still longer *Delesseria sinuosa* and *Odonthalia dentata*, all with very narrow fronds. On the other hand, the thallus of other species e. g. *Euthora cristata* and *Rhodophyllis dichotoma* was broad and robust in this place as elsewhere in rapid currents and on exposed coasts.

The same species of algæ is often very different in its appearance according to its habitat. Thus it seems, that many algæ in sheltered places are inclined to form proliferations, that is, long, thin appendages from the otherwise broad thallus; fine examples of this are shown by *Delesseria sinuosa*, which in sheltered places has a peculiar form, f. *lingulata*, remarkable for its numerous narrow proliferations, and *Enteromorpha intestinalis*, a variety of

which, var. *prolifera*, has by many authors been designated a separate species, but which is most likely nothing but strongly proliferating individuals, often loose and floating, growing in sheltered places.

In other species, such as *Rhodophyllis dichotoma*, the thallus becomes almost filiform when it grows at the bottom of fjords, but may become a centimeter broad in the open sea, as mentioned above. Kjellman has given a description and sketch of this peculiar narrow form (48, table XII, fig. 3). Exactly the same may be said with reference to *Euthora cristata*, which, as mentioned above, is robust with rather broad fronds in the open sea, whilst these are almost filiform in fjords. According to Rosenvinge (71, p. 227), similar conditions have been observed in Greenland.

Other species are also more or less transformed in stagnant water, e. g. *Himanthalia lorea*, the receptacles of which may become irregularly swollen; *Laminaria digitata*, where the lamina, as is well known, is split into a great many lobes, and which on exposed coasts with rapid currents has a form known as f. *stenophylla*, considered a separate species by many algologists, is often found in places of stagnant water with its lamina undivided and more or less sinuous and often urceolate in shape (f. *cucullata*). The fronds of *Alaria esculenta* and *Laminaria saccharina* likewise change according to the habitat. A special form of the latter, f. *linearis*, is found on exposed coasts and is remarkable for a narrow, but thick and robust thallus (see fig. 85 of my flora), whereas its broad forms, f. *bullata* and f. *grandis*, are found in sheltered places or in deep water; *Alaria* too becomes broad in sheltered places without currents (the narrow form from exposed coasts is drawn in my flora p. 449, fig. 84). It is most peculiar, that similiar conditions may act quite differently on different species of algæ, as may be seen from the preceding. I am unable to explain this satisfactorily.

d. Temperature and Humidity of the Air.

So far as the littoral algæ are concerned, and especially in the Færöes where the littoral algal vegetation often reaches far above the highest water mark, the warmth and humidity of the air are naturally of great importance and may therefore be briefly mentioned here.

With regard firstly to the amount of heat, the average temperature is 6,5° C. according to Willaume-Jantzen. January, the coldest month, has a temperature of 3,2°, July, the hottest, 10,8° C.,

and according to observations during 25 years the lowest temperature is — 11,6 °, the highest 21,2 °, but these extremes are very rare and on the whole of very short duration when they occur. Thus it is evident, that the temperature of the Færöes is relatively high in winter, low in summer, and very uniform all the year round. It is of course the direct influence of the sun that is of special importance to the algæ, and on hot, sunshiny days the amount of heat and consequently the evaporation and drying increase considerably. But days of really hot sunshine are as a rule few, (the Færöes have no so-called summer days, according to Willaume-Jantzen); moreover, the sun's warmth acts directly, as a rule, for but a short period and is soon replaced by rain, fogs or clouds, so that the danger of the algæ on the Færöese coasts being exposed to high temperature and consequently to evaporation is greatly diminished.

The amount of humidity in the air is rather high in the Færöes; for the whole year it is 82, in summer a little more, about 85, in spring a little less, about 80. Deviations naturally may occur, but are generally of short duration.

The very uniform and low mean temperature of the air together with the high degree of humidity, both varying but a little from the normal, are certainly of great importance to the littoral algal vegetation, the very luxuriant growth of which is certainly due for the most part to these conditions. This view has partly also been put forward by Simmons (75). On page 263, he writes: »Das Auftreten vieler Arten in weit höherem Niveau als sonst, kann deshalb, was die färöische (und wohl auch Nordlands) Algenvegetation betrifft, nur oder wenigstens am besten durch die Temperaturverhältnisse erklärt werden.« In addition to the temperature, the little direct sunshine, the weaker light on the whole, the humid air with much rain and fog, and especially the rough sea are naturally likewise important factors.

e. Light.

The climate of the Færöes is, as already mentioned, rich in fogs, rain, and cloudy weather, and on the other hand rather wanting in sunshine. According to Willaume-Jantzen, the amount of clouds at Thorshavn is 7,4 (0 = clear sky; 10 = overcast); and the Færöes have in all 178 »cloudy days«, that is,

days when the amount of clouds stands at 8. We must add that the amount of clouds is the greatest and fogs the most frequent at the brightest time of the year. The direct influence of the sun on the algæ-vegetation is thereby still more diminished just at the time of the year, when it might be most effective; at the darker time of the year the sun is so low in the sky, that its influence is but very slight.

Thus the fact, that the algæ-vegetation on the coasts of the Færöes does not grow at any greater depth, may most likely be accounted for by the small amount of sun and light. By dredging in a depth of 25 fathoms, I have sometimes found some tolerably well developed specimens of some *Florideæ*, but no vegetation whatever will by any means be found below 25—30 fathoms.

This is in agreement with Rosenvinge (71, p. 233), when he says: »As to the Arctic and the northern part of the Atlantic Ocean, all investigators seem to agree in this, that below 20 fathoms nothing but a scanty algæ-vegetation is in any case to be found, whereas it is very usual for the vegetation to reach as far down as this.« In more southern countries the algæ-vegetation will, however, be found at much greater depths. At Capri in the Bay of Naples, in clear water, Berthold (5, p. 414) found a luxuriant algæ-vegetation of deep-water forms at a depth of 120—130 metres, that is, almost three times as far down as at the Færöes[1]. It is true that algæ have been said to be found in very deep water, even in arctic districts, but these statements are surely in so far incorrect, as the algæ fished up in deep water were certainly floating and not fixed to any substratum, which has been pointed out by Kjellman and Rosenvinge.

On the whole, the fact, that the intensity of light diminishes and its colour changes as depth increases, is one of the most important factors as to the distribution of the algæ. As to the Bay of Naples, Berthold points out (5, p. 415), that among algæ growing in greater depths the *Florideæ* are certainly predominant, whereas only a small number of *Florideæ* and *Chlorophyceæ* but especially the bulk of brown algæ seek direct sunshine in shallow water. This is, however, almost in agreement with what has been observed at the Færöes. I have found that the *Laminariæ* and other larger,

[1] According to Sauvageau (77, p. 234—5, note), Rodriguez observed that the extreme limit to which the algæ-flora reached was 160 metres in the middle of the Mediterranean Sea, near Minorca.

brown algæ generally disappear at a depth of about 15—20 fathoms, leaving an almost pure vegetation of *Florideæ*, with the exception of some green, and bluish-green algæ, living in testa, and, however, often turning reddish here. On the beach, especially in its lower part, as well as in the upper part of the sublittoral region, where light is still intense, a vigorous vegetation of brown algæ is found. To these must be added several algæ, especially some green and bluish-green at the upper part of the beach, and at the lower part several red algæ.

That this distribution is principally, perhaps solely due to light, its quantity as well as its quality, may easily be proved by an investigation of the algæ-vegetation of one of the numerous caves on the coasts of the Færöes. When rowing into such a cave, it will be observed, that the species of algæ, common at the entrance, gradually disappear and are replaced by a great many different sublittoral *Florideæ*, directly under the surface of the water[1]. This will be more thoroughly explained later on, when the cave vegetation is dealt with. This fact has also been mentioned by several investigators, e. g. Berthold and Falkenberg (18, p. 220). But whilst Berthold only seeks the cause of the distribution of algæ in the intensity of light, Gaidukow maintains that it is entirely due to its quality. Founding his opinion on Engelmann's well known investigations as well as on his own, Gaidukow has recently in an interesting and instructive paper (35) clearly shown, that the distribution of the algæ is not so much due to the intensity as to the colour of the light. The fact is, that the green and bluish-green algæ grow uppermost, as the red

[1] In this connection it should however not be forgotten, that it seems as if some sublittoral species on the shores of the Færöes are only to be found at a certain depth, never directly under the surface of the sea, not even in dark places, e. g. several species of *Lithothamnion, Callophyllis laciniata, Rhodophyllis dichotoma, Antithamnion Plumula, Desmarestia aculeata* and *D. viridis*, etc. As to Greenland, some species are likewise mentioned by Rosenvinge (71, p. 228) as never occurring near the surface of the sea. He thinks that this is due to the fact, that temperature and salinity both become less variable as the depth increases. Several of these algæ may however be found littorally in other districts. Kjellman for instance states, that *Desmarestia aculeata* and *D. viridis* can occur in the littoral region, on the west coast of Norway, and *Antithamnion boreale* is sometimes met with littorally in the Norwegian Polar sea. Le Jolis (58) writes that *Callophyllis lacinata* is to be found at the lowest part of the beach. As these algæ do not appear on the shores of the Færöes at such a high level, even in the caves, it is most probably due to the fact that they cannot bear the strong surf here.

rays which they especially need, already become fainter at a small depth. The red algæ grow deepest, as they need the green rays, occurring at greater depths, the most; finally the brown algæ are specifically fitted for growing at a depth between that of the green and the bluish-green algæ on one side, and that of the red algæ on the other side. He calls our attention to the fact, that the algæ are very well able to accommodate themselves to the colour of the light of their habitats. He refers to the interesting observation made by Nadson, that certain *Cyanophyceæ* and *Chlorophyceæ* are represented by green specimens, near the surface of the sea, and by red, in deep water. This may also happen on the coasts of the Færöes, as I have already mentioned. Nadson thinks for instance, that *Conchocelis rosea* is a deep water form of *Ostreobium Quekettii.*

Berthold and Oltmanns determine the *Florideæ* as shade plants, but this is criticised by Gaidukow, who asserts that Oltmann's experiment only confirms Engelmann's theory, that the *Florideæ* of deep water have the typical colour of the *Florideæ*, because they grow in green and blue light, whereas they turn brown and yellow near the surface in the white light[1].

The Engelmann-Gaidukow theory on the whole coincides with my observations; still it seems to me that the quantity of the white light must practically be of no small importance not only to the colour of the algæ, but also to their distribution. On the coasts of the Færöes, on the beach, and even above it, a great many *Florideæ* of a deep red colour are found, perhaps sometimes of a more reddish-brown, but I have hardly ever seen them turning almost light yellow as the same species do, for instance, on the west coasts of Norway or on our own coasts[2]. No doubt this is due to the weaker light at the Færöes, where fogs are frequent, and the sky much overcast; and as a vegetation of *Florideæ*, typically red and including some of the forms usually belonging to great depths, is often found in small inlets between Thorshavn and Arge, in water not even 2 fathoms deep and overshadowed by *Laminariæ*, this is certainly also due to the

[1] In the West Indies *Florideæ* growing in shallow water, exposed to direct sunlight, are often perfectly green, or bluish-green, e. g. *Grateloupa filicina.* Svedelius has observed the same fact on the shore of Ceylon (compare: Bot. Notiser. 1905, p. 181).

[2] On one occasion I found *Porphyra umbilicalis* turning yellow, in the sounds north of Kvalvig.

weaker, but yet rather white light, which reaches it. The *Florideæ* growing near the surface of the sea, in the often very lofty caves on the Færöes, must likewise be supposed to get a some perhaps rather weak, but still white light, besides the still weaker, reflected, blue or green light, that comes up from the sea.

As the epiphytes on stipes of *Laminaria hyperborea* have always been found to be growing in a precise order, from the top downward (more will be said of this in connection with the *Laminaria hyperborea*-association), it is certainly solely due to a regard for light. The fact is, that those at the top are algæ wanting much light, and those further down, overshadowed by the latter, are algæ generally found in greater depths. Similar observations have been made by Berthold in the Mediterranean (5, p. 421—422), showing that the epiphytic algæ on a stem of *Cystosira* are likewise arranged according to their requirements of light.

Light is likewise, as before mentioned, of no small importance to the colour of the algæ, especially to the *Florideæ*. *Florideæ* growing in deep water or in the shade are of pure, bright red colour; most *Florideæ* growing littorally are of a dark reddish-brown often of an almost blackish shade, e. g. *Callithamnion arbuscula, Ceramium acanthonotum, Gigartina mamillosa, Polysiphonia urceolata, Porphyra umbilicalis, Chondrus crispus* and others, whereas the same species, when they find themselves in the shade, will recover their bright *Florideæ*-colour. According to Berthold (5, p. 416—417) the same thing has been observed in the Bay of Naples. This author likewise points out, that many more *Florideæ* are found on exposed than on sheltered coasts. This is in perfect agreement with my observations made on the coasts of the Færöes. That the *Florideæ* are thus found growing littorally in great numbers on exposed coasts, must naturally in the first instance be attributed to the fact that, in conformity with the Gaidukow-Engelmann's theory, they are of a reddish-brown colour. There may surely, however, also be some truth in the explanation given by Berthold, who supposes that, as the algæ are constantly stirred by the surge, and thus incessantly turning other sides to the light which reaches them, the influence of the light can only be of short duration on each part of their thallus; moreover the foam of the surf also lends some shade. Possibly many of these algæ are in different degrees adapted to stand the intense light; several species, e. g. *Chondrus crispus, Rhodymenia palmata, Odonthalia dentata* become

beautifully iridescent, as they are able to reflect certain rays of the light that reaches them, and it has been proved by an experiment made by Berthold (l. c. p. 419), that a vigorously iridizing specimen of *Chylocladia kaliformis* lost its iridizing power by being placed in the shade, and recovered it by being once more exposed to the light. A rich profusion of hairs is likewise probably of some importance to the algæ, as a means of protection from the intensity of the light. Several of the algæ growing in shallow water, especially in sheltered places, e. g. most of the species belonging to the *Stictyosiphon*-association, are rich in hairs. It is however most probable, that the hairs are in the first instance meant to serve as organs of absorption and respiration, as pointed out by Rosenvinge[1]. Whether they are likewise capable of defending the algæ against the dashing of the waves, as suggested by Henckel (Scripta botanica XX, p. 105), I cannot tell.

From what precedes it will be seen that I do not fully agree with Simmons when he writes (p. 262): »Was den Einfluss der Lichtintensität betrifft, so bin ich geneigt anzunehmen, dass man besonders, vas die Florideen angeht, derselben zu grosse Bedeutung hat zutheilen wollen. Wie will man nämlich erklären, dass im nordwestlichen Norwegen, wo doch im Sommer nicht von geringer Lichtintensität die Rede sein kann, die noch dazu während der Ebbe trocken liegende Litoralregion so viele Florideen beherbergt?«

There are always some *Florideæ* which require a great deal of light, and in the Færöes, where the light is far from strong, and the direct insolation particularly slight, a great many *Florideæ* may therefore easily thrive on the beach, even above the highest water mark, without fading, whilst they fade in districts with more light, are less numerous, and do not grow so far above the level of the sea, except where local circumstances are especially favourable.

During a journey in Norway in 1904, I stayed a few days at Christianssund, thus getting an opportunity of observing the algæ-flora there. It was interesting to observe, how much less developed the littoral algæ-vegetation was here than on the Færöes, the floral composition of the two vegetations, however, being much the same. The *Florideæ* were faded, light yellow to yellowish-

[1] Rosenvinge, L. Kolderup: Sur les organes piliformes des Rhodomelacées (Oversigt over det kgl. danske Videnskabernes Selskabs Forhandlinger, 1903, Nr. 4, p. 447—449).

brown, the vegetation was scattered, and with the exception of some faded fragments of the *Bangia*, it did not reach beyond high water mark. It was moreover most instructive to notice the difference between the littoral algæ-vegetation of coasts facing the North or facing the South. On exposed shores of the former places a rather luxuriant algæ-vegetation grew, not only littorally, but even above the highest water mark, whereas the latter places were almost destitute of algæ. I have not met with a similar difference on the coasts of the Færöes.

2. Nature of the Coast.

The Færöese coast is particularly favourable to algal vegetation. We meet with more or less broken cliffs everywhere on the open shore, especially on the northern and western sides of the islands. The rocks are of basalt and similar readily crumbling materials, which the wearing of the sea and weather make very uneven, thereby offering a very good hold for the algæ.

Sometimes the walls of the cliff descend almost vertically to considerable depths, sometimes they slope down gently and evenly, allowing the surf to wash up the slope constantly. Or long stretches of the coast, as at Myggenæs, on the western side of Syderö and the northern sides of Strömö and Vaagö, are wild and rugged, with numerous large and small rocks shelving into the sea and with masses of fallen rocks piled on one another; in this way the most varying habitats are produced, from the much exposed to those relatively sheltered behind the sea cliffs; the beach too offers many different degrees of light to the algæ, daylight sometimes coming straight down on the algæ, at other times obscured by overhanging or fallen rocks. Finally there are many ravines and caves along the coasts, where even sublittoral algæ, occurring elsewhere only in deep water, find suitable light at the very surface of the water.

At the foot of these almost vertical rocks there is often an almost horizontal or but slightly sloping foreshore, which is sometimes very broad, and more or less covered at high tide, but perfectly dry at ebb-tide. In such places a very luxuriant algal vegetation is often found, and on account of the sometimes very slight slope, the different algæ can spread widely in a horizontal direction, whilst those on vertical rocks are often reduced to a minimum, as many species only occur within a very limited regi-

onal level out of which they never thrive or only exceptionally. We therefore find the same belt-like mode of growth in the water-pools on the beach and practically all round the coast, one algal community gradually replacing another, exactly as an inland flora grows in belts round lakes and pools.

Lastly, numbers of large and small pools and basins filled with water are found on the beach at every possible level above the sea, sometimes so high up, that they are only filled with salt water by the storms of winter and consequently get more or less brackish and polluted in the course of summer, sometimes so low that they are cut off from the sea only for a short time at low ebb; the great variety of the algal vegetation in these shore-pools is naturally due to these varying habitats. In fjords and sounds the bottom frequently consists of stones or gravel forming a developing ground for many algæ, but most often the bottom is soft, covered with sand or mud which, apart from various free-floating algæ, is perfectly barren, as *Characeæ* are wanting, and *Zostera*, which at other places generally covers such regions of somewhat shallow water and often shelters a rich epiphytical algal vegetation, is but rarely found in the Færöes; it has only been met with in the innermost parts of Vaagfjord on Syderö, covering the bottom of a small locality where the water was from 1 to 2 fathoms deep.

On the whole, however, the rocky coasts of the Færöes must be considered especially favourable to algal vegetation; wherever one approaches the coast, it is found covered by a luxuriant vegetation, and such barren rocks as on the coasts of Greenland, mentioned by Rosenvinge (71, p. 152), are nowhere found on the coasts of the Færöes.

As to the conditions at the bottom, these are not everywhere favourable to the algæ. In the fjords, the bottom in shallow water often consists of sand, and in deep water, as in the sounds, of mud. Yet, large regions are covered with stones or rocks offering a favourable habitat for the growth of the algæ. On account of the great depth sometimes met with in the immediate vicinity of the land, the algal vegetation naturally disappears at such places close to land, the depth-limit of the sublittoral region being soon reached here. According to the most recent survey, the curve of 25 fathoms is found at a mean distance of about 6000 feet from the coast in southern islands, but only 2000 feet in the northern, especially in the Sounds. Occasionally it lies several miles from the coast.

II.

ALGÆ-REGIONS AND ALGÆ-FORMATIONS ON THE COASTS OF THE FÆRÖES.

In his well-known paper on the algæ-flora of the Murmann Sea (44, p. 57) Kjellman divides the flora: »in drei Gebiete und zwar in das litorale, sublitorale und elitorale«. By littoral »Gebiet« he means the part of the bottom of the sea which is left dry by the ebb of the spring tide, that is, from the highest tide mark to the lowest ebb mark. The sublittoral »Gebiet« extends from directly below the littoral »Gebiet« down to a depth of 20 fathoms, and finally the elittoral »Gebiet« consists of the bottom lying below yet overgrown by algæ. In a later paper (45) on the algæ-flora of the Skagerak, Kjellman introduces the name »region« instead of »Gebiet«. He asserts that the limit between the two first named regions is distinct and natural. The vegetation of the littoral region is essentially different from that of the sublittoral region, evidently a natural consequence of the very different local circumstances prevailing in each of these two regions. The limit between the sublittoral and the elittoral regions is, however, less distinct.

With more or less variation of the limits of these regions, later authors have used this division by Kjellman as a basis for their division of the algæ-vegetation of other tracts of the sea. I shall do the same, with some alterations.

Smaller types of vegetation belonging to the algæ-regions are named »Algenformationen« by Kjellman (45, p. 10); his definition is as follows: »Unter einer Algenformation sollte folglich ein Abschitt der ganzen Algenvegetation verstanden werden, der durch ein eigenthümliches Vegetations-Gepräge ausgezeichnet ist. Im Allgemeinen erhalten diese Abschnitte dadurch dieses Gepräge, dass eine oder einige Algenarten die Hauptmasse ihrer Bestandtheile ausmachen.«

I propose the name of association for these types of vegetation. These associations are often united in a natural way in larger communities, where they live together under the same or very similar biological and ecological conditions. I propose the name of formation for these more comprehensive groups. If any further subdivision is particularly wanted, we may use the word facies,

applied by Lorenz in his interesting and instructive paper[1]. Accepted in the sense applied by him to this word, it, however, mainly coincides with the term »formation«.

The species which form these formations and associations, often differ widely from each other in outer habit, their growth-form may vary much; but ecologically they must of course as a rule demand the same physical conditions (light, the temperature of the air, the temperature and salinity of the sea, the dashing of the waves, etc.). The large characteristic algæ of the formations do not grow under the same conditions as the smaller epiphytes which find their home on them. Epiphytes growing under the thallus of larger algæ are exposed to a weaker light, and on the beach larger algæ not only shade smaller epiphytes by their thallus, but also protect them from being dried or heated by the sun, from the dashing of the waves etc. Protected by the larger algæ, the smaller, often more delicate species thus obtain suitable surroundings; they are of course only found in localities answering to their requirements.

I. The Littoral Region.

It has been pointed out by Rosenvinge in his report on the algæ-flora of the coast of Greenland (71, p. 189), that Kjellman's determination of the limits of the littoral region as being respectively the highest tide mark and the lowest ebb mark, is not quite satisfactory, and in so far as the Færöes are concerned, Kjellman's determination is certainly not quite suitable. As to the uppermost limit, the algæ-vegetation on the exposed coasts of the Færöe Isles really extends far beyond, in more exposed places most likely even more than 100 feet beyond, the highest water mark. In sheltered places, subject to the influence of the tide, the uppermost tide-mark will be almost identical with the uppermost limit of the algæ-vegetation. According to Rosenvinge, the sea at springtide rises beyond the uppermost limit of the algæ-vegetation in Greenland; this will hardly ever happen even in the most sheltered places in the Færöes. It is true, that sheltered places with ebb and flood are but small in numbers here, so that my

[1] Lorenz, I. R., Physicalische Verhältnisse und Vertheilung der Organismen im Quarnerischen Golfe. Wien 1863. Page 188 he defines the facies as follows: »Die Facies sind also Vegetations- (oder Thier-) Formationen, oder Unterabtheilungen (Typen) derselben, betrachtet vom Standpunkte der Location und der bedingenden physicalischen Agentien.«

observations are relatively few; but according to my observations in Vestmanhavn, Klaksvig, and Trangisvaagfjord, *Pelvetia* is found a little below as well as a little above the highest water-mark, and the *Enteromorpha*-association, growing above that and indeed preferring places where fresh water oozes from the rocks, is met with far above the highest water-mark.

I therefore fully agree with Rosenvinge in thinking that the upper limit of the littoral region should be stated at the level where the algal vegetation begins[1]; but when Rosenvinge declares this limit to be identical with neap-tide mark at high water in Greenland, it is evident from what has already been said, that this greatly differs from the observations made on the Færöes, at any rate on their exposed coasts.

On account of the very luxuriant algal vegetation which extends, as before mentioned, far beyond the highest water-mark, it might perhaps be justifiable to introduce a special supralittoral region, as Lorenz has done (l. c. p. 193) and Warming suggested; (compare Simmons, 66, p. 173). I shall briefly state the reasons why I do not side with this view.

I take for granted that the highest water-mark is the lowest limit of such a region; but on investigating an exposed rocky coast, the algal vegetation will be found to offer not the slightest traces whatever of any limit. The specifically littoral region, which might thus be stated to be below the highest water-mark, merges imperceptibly into that of the algal vegetation above it; a line drawn at the highest water-mark on the rocks would certainly cut through several formations, causing the same formation to belong to both regions. As to the littoral and the sublittoral regions circumstances are quite different, the limit being often for miles sharp and distinct, though irregularities may indeed occur in the algal vegetation. Moreover, the more or less exposed situation of the coast might cause the same formation to belong, now to the supralittoral, now to the littoral region. It therefore seems most natural to me to say, that the littoral region includes also the algal vegetation growing beyond the highest water-mark, just as in what follows I say that the sublittoral includes the elittoral region, no dividing line being found between them.

As to the determination of the lowest limit of the littoral region,

[1] »at den övre Grænse for denne Region bör sættes der, hvor Algevegetationen begynder«.

I likewise agree with Rosenvinge in stating, that it ought to be drawn somewhat above the lowest ebb-mark. On the coasts of the Færöes, the *Himanthalia*-association of this region distinctly marks the limit. At very low tide a rather large portion, up to one or two feet of the *Alaria*-vegetation growing under *Himanthalia*, may sometimes be dried, but this undoubtedly belongs to the sublittoral region; Rosenvinge moreover reports, that portions of the *Laminaria*-vegetation, which naturally belong to the *Laminaria*-formation growing below that, are likewise uncovered at low tide in Greenland. The lower limit of the littoral region must therefore be fixed at about the ebb mark at neap-tide.

On tidal coasts it is therefore not very difficult to make a natural division of the algæ-vegetation into a littoral and a sublittoral region, but on non-tidal coasts the determination of these regions is much more difficult. Attempts have been made to define the limits in other ways; for Tönsbergfjord Gran, for the western part of the Baltic Sea Reinke, for Bohuslän Kjellman have made use of certain characteristic species growing within well-defined limits in the localities in question. In his valuable work on »Östersjön's Hafsalger«, Svedelius (79) is however certainly right in objecting that this division is anything but satisfactory, as one and the same species may grow at very different depths in different parts of the sea.

It is for instance a well-known fact, pointed out by Kjellman, that many algæ which are littoral on the west coast of Norway are sublittoral on those of Bohuslän, where the fresher surface current does not reach them. Svedelius therefore is certainly right, when he warns us against drawing a parallel between the regions belonging to heterogeneous flora domains, as the factors which in one place justify a very distinct division into regions and make a limit for the occurrence of a species, may be totally wanting in another.

As I have already explained in the introduction, there is in the Færöes a small tract of the sea between Österö and Strömö where the tides are almost imperceptible. Here the question is where to fix the limit between the two regions.

If the limit be fixed at the beginning of the *Laminariæ* as Kjellman has done on the coasts of Bohuslän, it would be very easy to point out a very distinct line between the two regions within the area mentioned, as the *Laminaria færoensis*-association

begins at a depth of about 3 to 4 feet; the *Stictyosiphon*-association growing above that would then be reckoned littoral.

I have not, however, done this. A comparison between this algal vegetation and that of a sheltered tidal locality e. g. Vestmanhavn, proves that under the *Fucaceæ*-formation just below the lowest water mark, a perfectly similar vegetation, the *Stictyosiphon*-association, is found, which is here sublittoral.

In this area of the sea the littoral region is therefore but slightly developed, only consisting of some scattered *Pelvetia, Porphyra umbilicalis, Fucus vesiculosus* and a few others, besides some crusts of bluish-green algæ, *Hildenbrandia* and *Rhodochorton.*

The algæ-vegetation found on exposed coasts differs as a rule considerably from that found on sheltered coasts; as in the former a great many species occur that are not always found in the latter places, and as the species common to both places are often represented by varying forms in each place I have divided the algæ-vegetation into that of exposed and that of sheltered coasts. The Norwegian investigators Hansteen and Boye have dealt in the same way with the algal vegetation of the west coast of Norway. We will first consider the vegetation of exposed coasts.

a. Exposed Coasts.

The Hildenbrandia-Formation,

or the formation of the crustlike algæ as well as of lichens is widely spread along the exposed coasts of the Færöes. It covers the rocks with a dense mat of various colours to a considerably height, i. e. up to more than two feet above the level of the sea and down to the *Corallina*-formation. The uppermost part of it mostly consists of lichens, which, according to the Rev. Deichmann Branth, belong to different species of *Verrucaria*, but crusts of bluish-green algæ soon appear, especially *Calothrix scopulorum, Rivularia atra* etc. and the crimson *Hildenbrandia rosea;* the last mentioned algæ I have found on the west coast of Vaagö, about eight feet above the level of the sea. At a shorter distance from the sea, *Hildenbrandia* becomes more and more predominant, still crusts of lichens and bluish-green algæ are intermingled with it, and another crust-alga, *Ralfsia verrucosa,* can now be found; this however prefers littoral pools where the water is constantly renewed by the surf. The walls of such basins

are almost always covered by brown, red, and black crusts, respectively consisting of *Ralfsia*, *Hildenbrandia* and *Lichens*.

These algæ, with the exception of *Ralfsia*, must necessarily be able not only to live for a long time without sea water and consequently to be dried up, but also to be washed by fresh water. They are moreover excellently fitted for resisting the surf, as they are very firmly attached to the rocks, of which they may almost be said to form a part. Lastly, they must be well fitted to stand intense light and great changes of temperature, as the southern side of rocks is often much heated by the sun.

On the west coast of Syderö at Vaag's Ejde I have seen extensive growths of *Ralfsia*, which are here found in large flat littoral pools with only a few inches of water. Whilst *Ralfsia* thrives best in littoral pools with shallow water, *Hildenbrandia* will thrive excellently in the latter, as well as on steep rocks which are dry in calm weather.

Among other algæ contributing to form this formation, *Pilinia maritima*, *Pleurococcus* spec., *Codiolum gregarium*, etc., which I have found intermingled with crusts of bluish-green algæ, ought likewise to be mentioned.

This formation is exposed to clear daylight and to the varying influence of the weather in its elevated habitats; in more low-lying regions it will often be found as a subvegetation covered by different larger algæ of the place.

Almost in the middle of the beach or somewhat farther down, this formation is replaced partly by *Corallina officinalis*, partly by *Phymatolithon polymorphum*, both spreading widely downwards into the sublittoral region.

Simmons briefly describes a »*Hildenbrandtia*-formation«, but he says that it is only to be found »An ruhigeren Oertlichkeiten«, and that »die Steine und Felsen in der Wasserfläche von dieser Formation bedeckt sind.« Later on he gives (66, p. 173) a further explanation of this formation, defining it as purely littoral.

The Chlorophyceæ-Formation.

The characteristic algæ of this formation are: *Prasiola crispa* subspec. *marina*, different forms of *Enteromorpha intestinalis*, *Rhizoclonium riparium*, *Prasiola stipitata*, *Prasiola furfuracea* and a few other species.

This formation stretches like a green belt along the exposed

coasts of the Færöes. Certain bluish-green algæ and perhaps *Hildenbrandia* excepted, this is the algæ-vegetation which extends the farthest upwards on bare rocks, on which, with the exception of lichens, an inland vegetation may only be found at a considerable height, in very exposed places, never less than several feet above the level of the sea. On exposed coast this formation therefore may be found many feet above the level of the sea; on the west coast of Vaagö, at Bosdalafos, the outlet of Sörvaagsvandet, at the time of year when the sea is calmest, that is, in June and July, above the cataract, consequently about 80 feet above the level of the sea, in moist cracks in the rocks shaded from the sun, I have gathered forms of *Enteromorpha intestinalis* and *Rhizoclonium riparium*, which are characteristic of the formation under discussion.

As a matter of course the algæ belonging to this formation must be able to do without water, and to be washed by fresh water. Some, but not quite all these species, may also be found under certain forms growing in more or less brackish water. They generally grow so far above the level of the sea, that they are only reached by the surf and the spray, and if the sea be calm for some length of time, which may sometimes happen, especially in summer in the very changeable climate even of the Færöes, they are totally prevented from being moistened by salt water. On the contrary they are at times soaked by fogs and rain to such a degree, that they are most probably completely deprived of salt. Some few of the algæ belonging to this formation moreover grow in localities where fresh water oozes from the rocks. On the other hand several of these algæ may in dry weather and sunshine appear to dry up, some of them, e. g. *Prasiola crispa* subsp. *marina*, *Prasiola stipitata* and *Enteromorpha intestinalis* even so as to be easily pulverised. As to *Rhizoclonium riparium*, I have not found it dry; it generally occurs on wet rocks and thus always keeps rather moist.

The algæ belonging to this formation must moreover be able to stand the full day and sunlight, as they grow on rocks facing south as well as north. On the other hand they are less in danger of being injured by the surf, as they most often grow so far up that only the spray can reach them. When they grow farther down, it may be supposed that the low, dense, often very gregarious growth of, for instance, *Prasiola stipitata* and *P. furfuracea* and *Enteromorpha*, serves as a means of protection from the dashing

of the waves. *Prasiola crispa* **marina* and *Rhizoclonium* may likewise be protected by the great flexibility and elasticity of their thallus. The upper limit of this algæ-vegetation changes as the locality becomes more or less exposed, the lower limit likewise gradually moving downward as the locality becomes more sheltered. Several of these algæ, for instance, *Prasiola stipitata* and *Enteromorpha*, may be found rather far down in the littoral region, in more sheltered places.

This green algæ-formation may be divided into several associations according to the predominant characteristic algæ. Naming them from the top downward: a *Prasiola crispa*-association, a *Rhizoclonium*-association, an *Enteromorpha intestinalis*-association and a *Prasiola stipitata*-association.

The *Prasiola crispa*-association is found at least 40 feet above the level of the sea[1]. It prefers steep, precipitous rocks, on which it is found as a dense cover, turning light yellowish-green when it dries up. This light colour makes it stand out against the dark rocks to which the thallus is fixed. When moist it turns dark green, each thread becomes free and sways with the waves. As subvegetation we find blackish lichen crusts, which have been defined by the Rev. Deichmann Branth as *Verrucaria mergacea, V. maura, V. mucosa* and *V. striatula.*

The *Rhizoclonium*-association may be found at the same level above the sea, but it prefers moist localities, for instance, such where fresh water is constantly dripping down, or pools and caves, where the air is very damp. I never found this alga perfectly dry; it is evident that it cannot stand to be dried up. It often forms large, unmixed growths and is easily discernible on account of its light-green colour and its often crisp, almost curly, appearance. In some places, at Glivernæs for instance, I have found *Vaucheria coronata* at about the same level in moist, but more sheltered little depressions in the rock.

The *Enteromorpha*-association is generally found farther down, but on an exposed coast it may reach to about the same height, that is ca. 40 feet. It consists for the most part of *Enteromorpha intestinalis* var. *micrococca*, and smaller forms of var. *genuina*, especially f. *cornucopiæ*. *Enteromorpha* prefers places where fresh water oozes from the rocks, but also grows in dry places and

[1] As before mentioned, several of these algæ, however, may be found growing scattered at least twice as high up on the rocks.

is sometimes found perfectly dry. This association may be found covering large stretches of rocks as a dense, moss-like mat, sometimes only consisting of *Enteromorphæ*, sometimes of *Enteromorphæ* mingled with *Prasiola stipitata* etc.

In some places the latter algæ, however, grow quite unmixed with any other species, and often carpet the rock with a short, dark

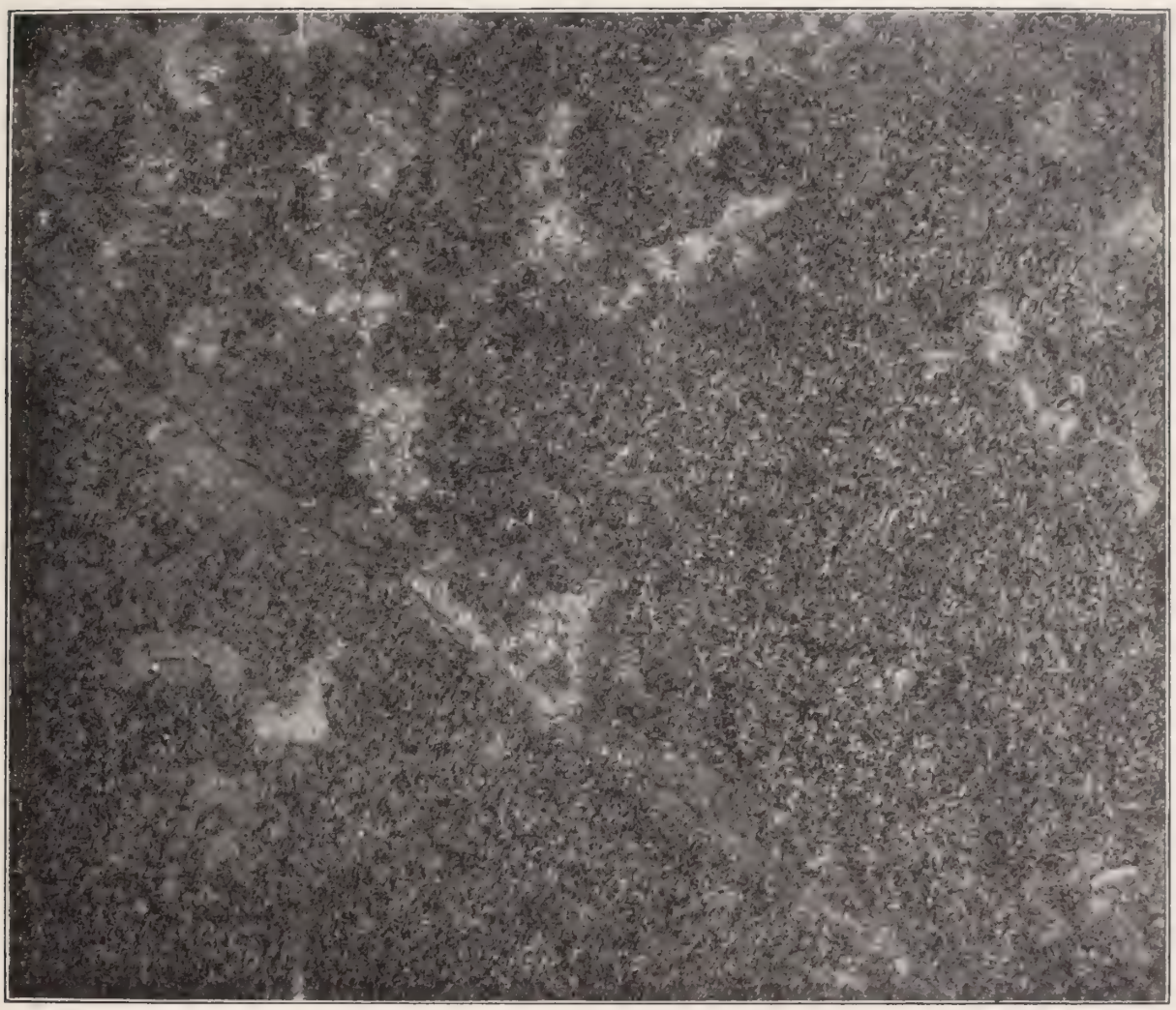


Fig. 152. *Prasiola stipitata*--association. From rocky coast near Höjvig. (F. B. phot.).

green covering, as shown in fig. 152. *Prasiola stipitata* grows as a rule on horizontal or slightly sloping sides of rocks, and prefers places where birds live, especially the summits of rocks under fowling cliffs. This alga may also be found quite dry.

Simmons mentions (78, p. 251) an *Enteromorpha*-formation which, judging from the species mentioned by him, must at any rate partly belong to the *Enteromorpha*-association. But on the other hand he also mentions some *Cladophora*-species as belonging to this association; these species, according to my observations, belong to algæ-associations which grow farther down.

The Porphyra-Association.

This association is found under the *Chlorophyceæ*-formation, but still on exposed coasts far above the level of the sea, 40—50 feet, perhaps even more. It is widely spread along the coasts of the Færöes, on which it extends as a belt often many feet broad.

In much exposed places it extends to far above the level of the sea; at Bosdalafos on the west coast of Vaagö to at least 40 feet. On the north western side of Viderö, I visited a rock (see plate XIII) about 30 feet high which was quite covered by *Porphyra umbilicalis*. On the islet of Myggenæs, where the southern side of the rocky coast slopes gently upwards, *Porphyra* certainly extends up to at least 50 feet above the level of the sea. These observations were moreover all made in summer time; in winter, when the surf reaches much farther up the coast, it is most probable, that *Porphyra* also grows at a greater height.

With the exception of the *Hildenbrandia*-formation, which here often forms a subvegetation, and of some species belonging to the *Chlorophyceæ*-formation, *Porphyra umbilicalis* is almost predominant in this association. *Porphyra umbilicalis* covers the rocks, sometimes densely, sometimes more sparsely. It grows in small tufts, 2 to 3 inches high, whose convolutions gives them the appearance of crumpled paper (see Wille 85, p. 38). The colour of this vegetation is a dark reddish-brown; sometimes, however, more purple, sometimes more tawny. On account of its crumpled nature *Porphyra umbilicalis* can retain sea-water for some length of time among the many folds of its thallus. If the exterior of the plant looks dry, there is, however, often some moisture left between the interior parts of the thallus and those parts which turn downwards. Nevertheless it can stand to become so dry, that it will creak when trodden upon. It is not only liable to be dried up, but also to being soaked in fresh water, i. e. by rain, for a long time. It is probably protected from the surf by the elasticity and toughness of its thallus, and by the lubricity of its surface. In more sheltered places *Porphyra umbilicalis* becomes higher, often to one foot or more, and its large, curling membranes then cover the rocks or hang down vertical rock-sides like long tufts swaying in the wind (see plate XVII). In sheltered places of this kind it likewise grows far down into the littoral region.

As before mentioned, this association generally only consists of

this alga together with *Hildenbrandia* and some species of *Verrucaria* as subvegetation, but different forms of *Enteromorpha intestinalis, Ectocarpus littoralis* and others are, however, often intermingled; the *Fucaceæ*-formation mentioned below (page 720) likewise sometimes extends into the *Porphyra*-association.

The *Porphyra*-vegetation was well developed in the months, April to August, when I visited the Færöes; Mag. H. Jónsson likewise tells me, that he has found it vigorously developed when he visited the islands from October to December, 1897. Thus it seems to be well developed all the year round, and is not, as Simmons says (l. c. p. 250), mostly a »Winterformation« on exposed coasts, even if it may be supposed to be still more vigorously developed in the winter, judging by its growth in other places. On coasts especially exposed to the surf it may also be supposed to extend still further up above the level of the sea. In more southern districts the *Porphyra*-association is really a characteristic winter vegetation. Thus when Kjellman (45) visited the »Skærgaard« of Bohuslän from Dec. 1874 to Jan. 1875, he found a luxuriant *Porphyra*-vegetation on the outer rocks facing the sea, whilst this vegetation is totally wanting in summer, which I have also observed during a visit to Lysekil in 1899. Neither was this alga found on the rocks in the Firth of Forth at North Berwick, where I had an opportunity of observing the local algal vegetation one day in July 1900. In winter it is most likely vigorously developed here also. On the west coast of Norway, Boye points out (6, p. 20—21), that Sognefjorden seems to be the southern limit of its occurrence; he founds this opinion on his own as well as on Hansteen's observations. This is, however, scarcely correct. Mr. E. Norum, teacher at Haugesund, has for a long time investigated the marine algæ growing on this part of the west coast of Norway, and kindly reports, that *Porphyra umbilicalis* is met with as an unmixed vegetation in much exposed places at Haugesund and Utsire, an island about 3 miles west of Haugesund. At Utsire, where Mr. Norum made his observations in July, the *Porphyra*-vegetation reaches to a height of 2 to 3 metres above the »*Balanus*-belt« on the southern and eastern sides of the island, and it may be supposed that it reaches still further on its northern side. At Christianssund, I have myself seen *Porphyra* at the beginning of August, growing some few feet above the highest water mark on an exposed coast; but the association was indeed only slightly developed here, compared with that of the coasts of the Færöes.

A summer vegetation of *Porphyra* as luxuriant as that of the Færöes will most likely only be found in more northern parts of Norway. As to Nordland, Kleen for instance writes, that *Porphyra umbilicalis* is found at the highest level, often far above the highest water mark. That it may be found luxuriant even in summer, in the Færöes, is certainly due to the fact that the sea is almost always stormy. Even in calm weather there is most often a swell and therefore surf along the coast. And even when it happens that the sea is quite calm for some time, the littoral algæ-vegetation is not in great danger of being dried up, because the air is very moist, the weather often cloudy, and fogs and rain frequent. That it, however, may happen, that the littoral algæ-vegetation, to which the *Porphyra*-association belongs, may be found dried on sunshiny days has already been mentioned.

The lowest limit of the *Porphyra*-association is determined by Boye to lie at the highest usual water mark, which is almost identical with the sharply-marked, white line formed by the *Balanus*, as he likewise points out. As may be seen in my illustration from Midvaag (see plate XVII), his view agrees with observations from the Færöes, although only in somewhat more sheltered places. In more exposed places, the *Porphyra*-association is replaced here by other algæ, and is not found until far above the highest water mark. In these exposed places it may extend far in a vertical direction, sometimes even to many metres, thus Simmons' remark, that the *Porphyra*-association has »nur eine recht geringe vertikale Verbreitung«, holds good only in the case of somewhat sheltered places.

The Rhodochorton-Association.

The *Rhodochorton*-association commonly forms a kind of close felt, reddish-brown to crimson, on stones and rocks, but in places where it is apparently more exposed to be dried up and to the surf, it may be found on the rocks in small firm lumps resembling peas (f. *globosa*). It often grows on the underside of rocks and stones, in clefts in the rocks, and in the caves (about which more will be said presently); but it may also be found growing in full daylight.

It is found partly in the littoral region, especially in its higher part, and partly far above the highest water mark, especially in the caves.

The association almost exclusively consists of *Rhodochorton Rothii*, yet *Sphacelaria britannica*, *Ectocarpus littoralis*, *Callithamnion*, etc. may be found intermingled with it, and, epiphytically on *Rhodochorton*, *Pleurocapsa amethystea* var. is often found in great numbers.

Rhodochorton Rothii can stand to be dried up to a considerable degree, and may even be found apparently quite dry. It also very well stands fresh water, not only rain, but also that of small cataracts, growing sometimes at the very spot where the water falls on the rock.

The *Rhodochorton*-association has been briefly described by Simmons (p. 250), and Hansteen (p. 348) and Boye (p. 30) have mentioned its occurrence on the west coast of Norway.

The Bangia-Urospora-Association.

On exposed coasts, prominent points and steep rocks are often covered by a dense and matted reddish-brown vegetation, which in dry condition shines almost like silk, unless it is curled up like wool, as is often the case. It is *Bangia fuscopurpurea*, an alga very common on the coasts of the Færöes. It is found like a dense covering on the rocks, often at a very great height, 5—6 metres or more, above the highest water mark. Consequently it can stand being dried up for a long time, as well as being soaked with fresh-water.

Intermingled with *Bangia*, a luxuriant vegetation of *Urospora mirabilis* is likewise often found; its growth is quite similar to that of *Bangia*; it also bears to be dried up, though perhaps to a lesser extent. It forms a similar covering, on the rocks, only dark green. They are both algæ growing typically where the waves dash on the coast (cf. Gran, 37, p. 9). Of these two algæ, *Bangia* certainly grows highest above the sea level, often forming here a pure *Bangia*-facies; in much exposed places it extends far into the *Porphyra*-association; *Urospora* however may also be found far above the highest water mark. On Myggenæs Holm, for instance, this alga was found at a height of at least 20 feet above the sea level, partly as a subvegetation under and among larger algæ, such as *Fucus inflatus* f. *disticha*, *Rhodymenia palmata*, etc.

Hansteen, who, strange to say, has not observed the *Bangia*-association on the west coast of Norway, writes that it has been found by Wille at Mandal. According to Wille, it formed an

almost continuous, light yellow belt of dried up threads of *Bangia*, on rocks and stones above the average high water mark.

According to what Mr. E. Norum kindly informs me, *Bangia* is found in the neighbourhood of Haugesund on exposed coasts, to a height of 6 feet above the *Balanus*-region, often covering sloping rocks abundantly. Mr. Norum supposes, that its total absence in some years from long stretches of coast, may be the reason why Hansteen, as mentioned above, has not observed this species on the west coast of Norway. At Christianssund I saw *Bangia* myself; it grew on an exposed coast up to a few feet above the highest water mark, and was easily distinguishable because of its light yellow colour.

Similar light yellow growths of *Bangia* may fairly often be found in Denmark and on »Kullen« at the entrance to the Sound. In the Færöes *Bangia* however always keeps its dark, reddish-brown colour.

According to Gran, *Bangia* is the alga growing at the greatest height above the sea-level in Christiania Fjord; it is not so in the Færöes, where several algæ are found at a much greater height.

However much the two algæ treated in this section may differ, they agree very well biologically and form a very characteristic association, whether growing in the same locality, or, what is also frequent, each in its place forming a *Bangia*-, and an *Urospora*-facies. Intermingled with *Urospora* a great many *Ulothrix flacca* and other species of *Ulothrix* are found.

According to H. Jónsson, *Urospora* is in autumn and winter partly replaced by species of *Ulothrix* and *Codiolum*, which may each of them form extensive associations.

On the coasts of Greenland, Rosenvinge (71, p. 201) has observed a very similar association, composed of *Monostroma groenlundicum, Ulothrix flacca, Urospora mirabilis* and *Bangia fusco-purpurea.* Thus it is also here formed by thread-like, branchless algæ, as pointed out by Rosenvinge. He calls it the *Monostroma groenlandicum*-formation.

The Fucaceæ-Formation on exposed coasts.

This formation is found spread, but very commonly on all the exposed coasts of the Færöes, even in the most exposed places, as for instance Store and Lille Dimon, Myggenæsholm, the west coast of Suderö, Viderejde, Sumbö Holm, etc. It prefers

sloping rocks and especially recesses in these rocks that may be reached by the sea. In much exposed places this formation may extend far above the highest water mark, and the algæ growing here are consequently in danger of being dried up for rather a long time; this they, however, greatly avoid by means of their low, tuftlike growth, and especially by their great amount of mucus, in which *Fucus inflatus* f. *disticha* is particularly rich.

Fig. 153. *Fucus spiralis* f. *nana* and, below, *Fucus inflatus* f. *disticha* on steep rocky coast near Viderejde. (F. B. phot.).

The formation is typically formed by two species of *Fucus*, that is, *Fucus spiralis* f. *nana* and *Fucus inflatus* f. *disticha*. *Fucus spiralis* grows uppermost, often a couple of feet higher up than *Fucus inflatus*. They almost always grow together, but as *Fucus spiralis* seems to be able to stand being dried up better than *Fucus inflatus*, the former is found in somewhat more sheltered places, where the sea may happen to be calm for some length of time. On the other hand, it is most often only *Fucus inflatus* f. *disticha* which is found in particularly exposed places, and which seems thus to be the best fitted for resisting the surf. I have found vigorous specimens of it, 2—4 inches long, on Myggenæs Holm and Muletangen at

Vaag's Ejde, whilst *Fucus spiralis* only was found less exposed in the latter place. I must nevertheless point out, that I have found both species growing together on the west coast of Lille Dimon, which must also be considered a particularly exposed place.

The *Fucus*-plants hang in small, dense tufts, a few inches long, down the sloping rocks, often covering them so closely, that it is only by removing them that we discover the red subvegetation of *Hildenbrandia* which is common here, together with the intermingled lichens.

Forms of *Ectocarpus littoralis*, species of *Ulothrix*, besides *Elachista fucicola*, and a few others frequently grow epiphytically on the *Fucus*-plants. Among the latter, *Porphyra umbilicalis*, *Enteromorpha intestinalis* and other littoral algæ are often met with.

Whilst these small specimens, only a few inches high, are characteristic of the most exposed places (see fig. 153), the *Fucus*-plants gradually become larger as the locality becomes more sheltered (see plate XIV), and the most regular gradations may then be found, from the typical large form, f. *edentata* (fig. 158), to the dwarf form, f. *disticha*. Sometimes they may even be found growing in the same locality, the smaller form still growing uppermost, at or above the highest water mark, whilst large, well-developed specimens belonging to the main form grow at the lowest part of the beach.

This may easily be observed along the coast, between Arge and Gliversnæs, on the east of Strömö (see plate XIV), a locality where Nolsö really affords some shelter, but which must be considered rather exposed. A very easy transition may be found here from the *Fucus*-vegetation of exposed coasts to that characteristic of a sheltered coast, as not only the two species of *Fucus* growing on exposed coasts gradually become larger, but they are joined by *Pelvetia canaliculata*, *Ascophyllum nodosum* and *Fucus vesiculosus*. I have observed that these three algæ appear in the order I have named them. *Pelvetia* may be found in rather exposed places, growing abundantly for instance on rocks on the west coast of Syderö, at Vaag's Ejde, at a height of about 5 metres above the sea-level (see fig. 154). The place where it grows is, however, always somewhat sheltered. It is, for instance, never found on rocks facing the open sea, but on rocks facing the land, or at least in places sufficiently sheltered from the strongest surf. At Vaag's Ejde, a very exposed place, *Ascophyllum nodosum* is also found on the most sheltered, inmost rocks, but I have not seen *Fucus vesiculosus* there.

Even the most sheltered places here are not calm enough for this alga. When the wind blows on the shore, the sea washes over the rocks, in hard weather, flowing over the »Ejde« itself.

I have not met with any description of such a *Fucus*-vegetation growing on an exposed coast. Simmons, who found *Fucus distichus* in its well-known habitat, the west coast of Syderö, writes (l. c. p. 254): »Wo an der Westküste von Suderö *Fucus distichus* auftritt,

Fig. 154. *Pelvetia canaliculata*, and below that, *Fucus spiralis*. Illustration of a rock from Vaag's Ejde at Syderø. (F. B. phot.).

könnte man vielleicht am richtigsten eine besondere Formation unterscheiden, die dann die *Fucus distichus-Porphyra*-formation zu nennen wäre. *Fucus distichus* bewohnt nämlich mit Vorliebe abschüssige Felsen in der Nähe der Ebbengrenze und wächst da mit *Porphyra laciniata* vermischt.« Judging by these words, Simmons seems hardly to have got any distinct idea of this characteristic formation. Nor have I met with any description of it from Norway, where it may, however, be supposed to grow. It has therefore been very interesting to me, to receive the following report from Mr. Norum in Haugesund. »A *Fucus*-formation corresponding exactly with those

from the Færöes is likewise found here in the most exposed places. It consists of *Fucus spiralis* (most probably f. *nana*) and *Fucus inflatus* f. *disticha*[1]. They are most often attached to the *Balanus*. They grow partly intermingled, partly with *Fucus spiralis* extending a little higher up than *Fucus inflatus*. *Fucus spiralis* disappears where the surf is the most vigorous. Thus *Fucus inflatus* is also here the *Fucus* which is the best fitted for resisting the dashing of the waves.« According to this description, this Norwegian vegetation seems to correspond perfectly with that of the Færöes.

It is true that Boye (l.c. p. 25) speaks of a *Fucus*-formation growing on the outer side of the rocks; he says, that »even in the most exposed localities a very luxuriant *Fucus*-vegetation is usually found.« As members of this vegetation, he mentions, however, *Fucus serratus* f. *elongata*, and two forms of *Fucus vesiculosus*, which makes it quite clear, that his *Fucus*-vegetation is widely different from the Færöese. *Fucus serratus* is nowhere found in the Færöes, and *Fucus vesiculosus* grows here essentially on the inner side of rocks; it is the species of *Fucus* which I have mentioned before as disappearing first in passing from sheltered to exposed coasts. I am on the whole rather dubious as to the correctness of Boye's report. During a journey in Norway in 1904 I stayed for a few days at Christianssund, in order to observe the algæ-vegetation, and I found *Fucus vesiculosus* only in sheltered places. Mr. Norum also kindly informs me, that *Fucus vesiculosus* is never found in very exposed places in the neighbourhood of Haugesund, whilst *Fucus serratus* can grow on a very exposed coast immediately below the *Balanus*-belt.

Nor does Kleen (51) mention any such *Fucus*-vegetation; yet it must be supposed that a formation similar to that of the Færöes is found in Nordland.

Mag. Jónsson reports, that a *Fucus*-formation, very much like this, is found in Iceland on exposed coasts, and Strömfelt writes (80, p. 10): »On the cliffs of Seley which are constantly washed over by the surf, a particular *Fucacé*-formation is found. It consists of *Fucus spiralis*, *Fucus evanescens* **dendroides*, which are through many intermediate forms connected with f. *nana* of **arcticus* and f. *contracta* of **norvegicus* that are likewise found here[2]«. This vege-

[1] Mr. Norum has kindly presented me with specimens of both species, fully agreeing with those from the Færöes.

[2] På de af ständiga bränningar öfverspolade strandklipporna på Seley uppträdde en egendomlig *Fucacé*-formation, bildad af *Fucus spiralis*, *Fucus evanescens*

tation must certainly greatly resemble that of the Færöes, as all the forms named by Strömfelt are, according to my definition of species, similar to or at least closely connected with *Fucus inflatus* f. *disticha* (compare Jónsson 41, p. 184).

As to Greenland, Rosenvinge writes (71, p. 199) as follows: Where the coast is exposed to the dashing of the waves, the vegetation bears a totally different stamp. The *Fucaceæ* are either entirely absent or limited to deeper clefts in the rocks or to pools *(Fucus inflatus)*«.

It has since been said by Simmons (66, p. 178), that this circumstance may be due to the ice. This may possibly be true in some cases, but probably not in all.

In describing the algæ vegetation of the Murman Sea, Kjellman writes (44, p. 59), after pointing out that all littoral algæ are low: »*Fucus evanescens*, welche am häufigsten innerhalb des litoralen Gebietes angetroffen wird, scheint mir mit Recht den Namen (f. *nana*) zu verdienen, den ich ihr gegeben, denn sie ist selten über 6 ctmr. hoch und immer sehr schmal«. There must likewise be some resemblance between this and the Færöese vegetation.

It may be supposed, that *Fucus spiralis* is found on the Orkneys in localities resembling those in the Færöes (see Traill, 81, p. 316, who calls it *Fucus platycarpus*). If *Fucus anceps*, as I think[1], ought to be regarded as a form of *Fucus inflatus* f. *disticha*, the two characteristic forms of the Færöese formation are found on the west coast of Ireland. At Biarritz Sauvageau[2] has found some quite small specimens of *Fucus spiralis*, which certainly grew on an exposed coast there. On the northern side of Kullen, on steep rocks a little above the sea level, I have met with a dwarfish form of *Fucus spiralis*, that is, a very similar vegetation, only that *Fucus inflatus* f. *disticha* is also wanting here.

The Callithamnion-Association.

The above-mentioned types of vegetation have their habitats above the easily distinguishable white line formed by *Balanus* and bivalves. We shall deal next with an association growing in and about this »animal association«, which is found at about the highest water

**dendroides* genom en mängd former förbunden med de äfvenledes derstädes uppträdande f. *nana* af **arcticus* och f. *contracta* af **norvegicus*.

[1] Judging by a few small specimens kindly sent me by Mr. Batters.

[2] Sauvageau, C. Note préliminaire sur les algues marines du golfe de Gascogne, p 6—7 and p. 22—23. (Extrait du Journal de Botanique, XI, 1897).

mark in the Færöes, and, according to Boye, at the same height on the west coast of Norway.

This association is typically represented by *Callithamnion arbuscula* and *Ceramium acanthonotum*, which are almost always found together on exposed coasts and which are about equally common. On more sheltered coasts, *Callithamnion arbuscula* is often wanting, as it clearly prefers an exposed coast; and Simmons, who declares himself (78, p. 250 and 273), that he has not had much opportunity of investigating exposed coasts, and who has therefore not met with *Callithamnion arbuscula*, consequently calls this association the *Ceramium*-formation.

These algæ form small, dense, reddish-brown tufts, 2 to 4 inches long, and are attached either to the *Balanus* or to the rock itself, now forming a scattered growth, now a dense covering. On account of their ample ramification and their dense, compact growth, they look almost spongeous, and at high tide they really absorb water which is retained by their capillary action during low tide. After having been laid bare for several hours, they are still so full of water that it can be wrung from them as from a sponge. Kjellman has already (46, p. 479) briefly mentioned this fact. Berthold speaks in a similar way about *Callithamnion granulatum*, which has been found a few times on the coasts of the Færöes, together with *C. arbuscula* and much resembling the latter in its habits. He writes in the following way about it (5, p. 406): »Bemerkenswerth sind in dieser Hinsicht die dichten Thallome von *Callithamnion granulatum* mit sparrig gespreizten Ästen, welche sich wie ein Schwamm mit grösseren Wassermengen vollsaugen, wodurch ein Austrocknen auch nur der peripherischen zarten Spitzen vollständig verhindert wird.«

In less exposed places, this association hardly reaches above the highest tide mark, but in much exposed places it may extend far above it. At Viderejde on a rock lying off the landing place, I found a well-developed *Callithamnion*-association reaching to several feet above the extreme tide mark (see plate XV). Here it grew on steep, sloping rocks; besides the two characteristic algæ, a few *Porphyra umbilicalis* and several *Himanthalia lorea* grew here, the latter however being fructiferous only at the lower part of the association. There were, moreover, *Acrosiphonia albescens* and *Polysiphonia urceolata*, both fitted for retaining water by their dense, felt-like growth, together with *Ceramium rubrum*, *Dumontia filiformis*, *Scytosiphon lomentarius*, *Phyllitis zosterifolia*, a few small *Alaria esculenta* and,

as subvegetation, *Corallina officinalis* at the lowest part of the association. All these species and a few others are rather frequently found intermingled in this association.

A *Callithamnion*-association probably similar to this Færöese association has been found by Boye on the part of the west coast of Norway which has been especially investigated by him. Judging by his brief description it is probably quite similar to the Færöese one. According to Hansteen (38, p. 346), the *Callithamnion*-association in the neighbourhood of Bergen is formed of *Callithamnion arbuscula*, whilst nothing is said of *Ceramium acanthonotum;* there is however no reason to think that this species should be wanting there. At Christianssund, I have found a vegetation corresponding exactly with that of the Færöes, formed by the two characteristic algæ, and growing on steep rocks facing the open sea. It grew almost at the highest water mark. It has already been described by Ekman (17, p. 4) as being found in this place. Finally it may be supposed that a vegetation well agreeing with that of the Færöes may be found in Nordland (see Kleen 51, p. 9).

I have also met with this association on exposed coasts in Shetland, at Muckle Holm in Yell Sound.

As before mentioned, Simmons (p. 250) calls this association the *Ceramium*-formation, or, with regard to Nordland, the *Ceramium-Callithamnion*-formation. As that of the Færöes however corresponds with that of Norway, I have not considered it justifiable to change the name.

The Rhodymenia-Association.

A low, dense, dark, brownish-red vegetation, made up almost exclusively of *Rhodymenia palmata*, is found on sloping rocks on exposed coasts from a little below, or even a little above, high tide mark, down to a little above lowest tide mark. It grows very densely on the rocks, forming low tufts only a few inches high (see plate XVI and XVII). It is mostly a narrow-lobed form, related to f. *sarniensis*, which is found here, yet the typical form also occurs. Generally this association is not intermingled with other larger algæ, but a few *Fucus inflatus* f. *disticha, Acrosiphonia albescens*, etc. may be met with. On the other hand, there are many smaller epiphytes on the thallus of *Rhodymenia*, among which *Ectocarpus litoralis, E. tomentosus* and *E. fasciculatus, Myrionemaceæ, Chantransia virgatula, C. secundata* and others should be pointed out.

The *Rhodymenia*-association is widely spread on the Færöes. It seems to prefer places where fresh water oozes from the rocks, which is very common on the coasts. Even in places where small waterfalls fall from vertical or beetling rocks down on the littoral rocks, *Rhodymenia* grows abundantly. In such places it is of course soaked in fresh water at low tide, and this alga must be well adapted to resist great differences of salinity, for at high tide it is more or less flooded by the sea. The specimens are well developed even in such places; they are only of a paler colour, which perhaps indicates that circumstances are less favourable to them there. I imagine that *Rhodymenia* scarcely stands complete drying up and Rosenvinge is of the same opinion (71, p. 202). When *Rhodymenia*, however, is found on the coasts of the Færöes, rather far up on the beach, sometimes even above the highest water mark, the reason is, that it grows gregariously, and that it is always kept moist at ebb tide by the fresh water oozing from the rocks.

I have not found any description of a *Rhodymenia*-association quite agreeing with this vegetation which is so widely spread on the coasts of the Færöes. Still I feel inclined to believe that it will be found to be rather common on the coasts of the North Atlantic. According to Kleen (l. c. p. 9 and 17), it is probably also found in Nordland. It is true that Boye (l. c. p. 28) speaks of a *Rhodymenia*-formation on sheltered coasts growing in the *Ascophyllum-Fucus*-association, and on the the sheltered coasts of the Færöes *Rhodymenia* really often grows abundantly among and under the *Fucus* bushes. Lastly Kjellman mentions a sublittoral »*Rhodymenia*-region« (44, p. 67) on the coasts of Novaya Semlya and Spitzbergen. This agrees well with the fact that many littoral algæ elsewhere become sublittoral in Arctic countries. According to Rosenvinge (71, p. 202), it may however be found in the lowest part of the beach in Greenland, but usually only in small numbers. Simmons does not mention this association.

Besides forming this littoral association growing on rocks, *Rhodymenia* makes a characteristic littoral association close to, yet above the lowest water mark. On the parts of the *Laminaria hyperborea*-association which grows in such shallow water that the tops of the stipes rise above the surface of the sea at low tide, *Rhodymenia palmata* is found attached to the uppermost part of the *Laminaria* stalk, and often in such numbers, that the brown leaves of the *Laminariæ* are almost covered by the large, dark red *Rhody-*

menia-thallus. In the illustration (fig. 160, p. 756), a great part of the vegetation which is seen above the surface of the sea, is *Rhodymenia*. So this is really a littoral, but epiphytical association. *Rhodymenia* is often 2 feet long here and not short as when it grows on the rocks. Its thallus, especially the older parts of it, shelter a luxuriant vegetation of epiphytes, mostly species of *Ectocarpus* and *Myrionema, Chantransia*, etc. Simmons also mentions this littoral association (l. c. p. 256). In Trangisvaagfjord, he has found *Punctaria latifolia*[1] in numbers on the Laminæ of *Laminaria hyperborea* and *saccharina*; to this epiphytical association he moreover refers a great many other algæ, e. g. *Dictyosiphon foeniculaceus, D. hippuriodes,* species of *Ectocarpus*, and *Scytosiphon lomentarius*. They may certainly be found here exceptionally in more sheltered localities, but facing the open sea they are not common in this association, according to my observations.

The littoral Corallina-Formation

or the *Lomentaria-Corallina*-formation, will in much exposed places reach upwards into the *Callithamnion*-association, thus even passing the highest water mark. It however belongs mostly to the lower part of the littoral region, and *Corallina* is found together with sublittoral species far down in this region. In more sheltered places, *Corallina* hardly passes the lowest water mark, and is here limited to the more low-lying, littoral pools which it covers with a dense, pale-pink covering. As before mentioned, *Corallina* grows on the most exposed coasts, e. g. Lille Dimon and Store Dimon, Muletangen at Vaag's Ejde, Viderejde, Sumbö Holm, etc. In this respect, the occurrence of *Corallina* (48, p. 116) does not bear out Kjellman's words, that this alga »prefers sheltered places«[2].

In the more or less dense *Corallina*-vegetation, a great many small and scattered growing algæ are often sheltered. Larger algæ also find a favourable habitat here, occuring sometimes in such great numbers that they form their own associations, which will be described

[1] Called *P. plantaginea* by Simmons (compare my Algæ-Flora, 7, p. 436).

[2] It has been said by Wille (85, p. 14), that the chalky incrustation which he is undoubtedly right in considering as a means of protection from herbivorous animals, can hardly be supposed to afford any protection from the dashing of the waves. He founds this opinion on the observations of Kjellman and others. I cannot fully adopt this view. It seems to me that the firm construction of the thallus, together with the low, gregarious growth of the plant, must necessarily protect it from the dashing of the waves (cf. Wille p. 37).

later on (see table XXI). Of the many algæ-species which are found in the *Corallina*-formation, only some of the most important will be named here. One of the commonest and most characteristic is *Lomentaria articulata*, which grows in dense, dark reddish tufts, intermingled with *Corallina;* moreover, several forms of *Ceramium rubrum; Porphyra leucosticta*, *Polysiphonia urceolata*, and, especially in small littoral pools, also *P. Brodiæi*; moreover *Chondrus crispus, Scytosiphon lomentarius, Phyllitis fascia, Dumontia filiformis, Laurencia pinnatifida, Acrosiphonia, Himanthalia, Gigartina, Monostroma,* and many more. *Dermatolithon macrocarpum* f. *Corallinæ* is found epiphytically on *Corallina*; in more sheltered places *Leathesia difformis* is found; the latter is not common, but it is abundant in the few places where it grows, for instance at »Sundskær« in Kalbakfjorden. In this more sheltered place, *Chordaria flagelliformis, Dictyosiphon foeniculaceus* and *D. hippuroides* were also found.

It seems as if *Corallina* does not stand to be dried for a long time. This is clearly shown by the fact that in more sheltered places it grows luxuriantly in low-lying pools, but never outside of these. I have already mentioned that on a much exposed coast, e. g., Muletangen at Viderejde, it can stretch far up into the *Callithamnion*-association on sloping rocks, and even sometimes pass the highest water mark. But if the weather and the sea are calm in summer, it is also here discoloured, and it assuredly dies, if it is dried up for a long time. In such places *Corallina* is, however, protected from being dried, because it often forms a subvegetation under larger algæ. It is likewise not well fitted to stand fresh water; hence it is not found in places where fresh water oozes from the rocks; here the *Rhodymenia*-association occurs. As before mentioned, the *Corallina*-formation grows rather far down in the sublittoral region; this will be farther explained later on.

Boye (6, p. 26) seems to have found a very similar *Corallina*-vegetation on the part of the coast of Norway investigated by him.

It is to be supposed that a littoral *Corallina*-formation, very similar to this, is common along large stretches of the west coast of Norway; compare Hansteen's: »Broget-pelagiske-formation« (p. 348), which, as pointed out by Simmons (p. 260), includes about the same species as the formation from the Færöes. According to Kleen (51), it may also be supposed that a very similar *Corallina*-formation is found in Nordland, *Lomentaria articulata* however being rare and but badly developed there.

As to the Færöes, this formation has already been described by Simmons (78, p. 252), who points out that it is widely distributed here.

To the *Corallina*-formation I refer the following four characteristic and universally destributed associations.

The Monostroma Grevillei-Association.

On horizontal rocks or in very shallow, littoral pools where only very little water is left at low tide, *Corallina* will frequently be found at a height of a few feet above the lowest water mark, covered by a very dense, low spinach-green matting of the *Monostroma Grevillei.* Where *Corallina* sometimes is wanting, *Monostroma Grevillei* covers the rock itself. Its growth is so dense, that it is only exceptionally intermingled with other species, such as *Phyllitis fascia, Scytosiphon lomentarius, Dumontia filiformis,* etc.

On account of its dense and gregarious growth, the *Monostroma* is always kept moist by the great quantity of sea-water which it can retain, even when it grows on a slightly sloping substratum.

As *Monostroma Grevillei* is a spring and summer alga, this association disappears later in summer and the underlying *Corallina*-vegetation is now clearly seen or is covered by other algæ. The *Monostroma*-association is very common along the coasts of the Færöes and is found even in very exposed places, in spite of its apparently slight power of resistance against the surf.

The Acrosiphonia-Polysiphonia-Association.

This association which is formed of species of *Acrosiphonia,* especially *A. albescens,* and of *Polysiphonia urceolata* reaches from almost the lowest water mark to a few feet above it (part of this association is seen at the bottom of plate XVII). It grows on sloping rocks, which it covers with a very dense matting, generally green at the top and reddish-brown at the bottom, these two algæ frequently making unmixed facies, an *Acrosiphonia-facies* uppermost and a *Polysiphonia-facies* below it. They may however also be found intermingled. On account of their very ample ramification[1] they are both able to retain a great amount of sea-water at low tide, which protects them from becoming dried up.

[1] The littoral form of *Polysiphonia urceolata* is far more ramified than the plants that grow sublittorally (cf. Gran 37, p. 10).

Mingled with the characteristic algæ, we find e. g. *Ceramium rubrum, Cladophora rupestris,* and very rarely *Cladostephus spongiosus. Corallina* is usually absent in this association, as the dense growth of both species leaves no room for a subvegetation.

This association, which is very common in the Færöes, has not been described by Simmons, nor by any Norwegian investigator. It is however undoubtedly closely connected with Hansteen's »Broget-pelagiske-formation« (38, p. 348) and partly related to Boye's »Gigartinaformation« (6, p. 22—23).

The Gigartina-Association.

Somewhat above the lowest water mark, the height varying according to the exposure of the locality, a vegetation of *Gigartina mamillosa* (see plate XVIII and XXI), often dense and up to 6 inches high, is found in the *Corallina*-formation. This association often extends far horizontally, and on almost horizontal rocks, found within the level of this association, it is often widely distributed (see plate XVIII). Vertically it usually reaches only to a height of one or two feet; the height being the greatest on specially exposed coasts.

Epiphytes common on *Gigartina* are: *Chantransia virgatula,* very often forming a dense, velvety covering on the stalky part of the thallus, and *Dermatolithon macrocarpum* f. *fœroensis* which grows on it in smaller or larger pale pink incrustations. *Ceramium rubrum, Chondrus crispus, Polysiphonia urceolata, Acrosiphonia albescens,* and frequently some younger or older plants of *Himanthalia lorea,* besides *Corallina officinalis,* are found mingled with *Gigartina.* But generally these algæ are only few in numbers, or they may be totally wanting, so that the dark reddish-brown colour of the *Gigartina* predominates. *Gigartina mamillosa* grows luxuriantly in the most exposed places. Its tough, cartilaginous character probably makes it well fitted for resisting the surf. It is hardly exposed to any drying process, as it generally grows at the lower part of the littoral region.

According to Hansteen (38, p. 348), and Boye (6, p. 22), a similar *Gigartina*-association is found along the west coast of Norway. It seems to differ from the Færöese association only in its colour. Boye writes: »It (the formation) is easily distinguishable at a long distance as a light yellowish green belt, immediately above the lowest water mark, because the algæ inviduals are faded by the

sun«[1]. But on the coasts of the Færöes, *Gigartina* always keeps its dark reddish-brown colour.

Simmons does not set apart any special *Gigartina*-association. In reference to Boye's *Gigartina*-formation, he writes (p. 260): »Die letztere könnte wohl auch auf den Färöern unterschieden werden, ich bin aber geneigt, sie nur als eine lokale und zufällige Ausbildung der Corallinaformation zu betrachten, wo Gigartina überwiegend ist.« Opinions may of course differ on this matter, but as *Gigartina* can be found as an unmixed growth and often of considerable extent, I agree with Boye in maintaining a special *Gigartina*-association.

I have found the *Gigartina*-association beautifully developed on the northern side of the entrance of Trangisvaagfjord, where *Gigartina* (see plate XVIII) forms extensive growths on horizontal rocks.

On Sumbö Holm, the *Gigartina*-association was found on a very exposed coast, at a height of 2—4 feet, and on Myggenæs Holm I have seen it at a height of at least 10 feet above the lowest water mark. It is, on the whole, one of the commonest associations on the coasts of the Færöes.

Directly below this association,

The Himanthalia-Association

is found. The peculiar and characteristic *Himanthalia lorea*-association (see plate XIX) is very common on the exposed coasts of the Færöes. It grows from immediately above the lowest water mark down to the sublittoral *Alaria*-association. On flat rocks, the *Himanthalia*-association will stretch very far horizontally, but vertically, only to one foot as a rule. On sloping rocks which are constantly washed over by the sea, it may reach somewhat higher, sometimes even to the *Callithamnion*-association. For instance, on rocks at Viderejde I have observed well-developed specimens with receptacles (see plate XV), at a height of at least 6—7 feet above low water mark. On the other hand, the characteristic buttonlike or often globular, inflated, yellowish-brown, young plants are frequently found rather far above its special level, sometimes even above high water mark. But they

[1] »Den (formationen) er meget iøinefaldende paa lang afstand som et lyst gulgrønt belte straks over nederste vandstandsmærke; de enkelte algeindivider er nemlig aldeles afblegede i sollyset.

cannot produce receptacles in this unfavourable habitat. The *Himanthalia*-association is so characteristic on exposed coasts, that a luxuriant growth of this alga is a sure sign of the presence of surf. It is an association particularly fitted for resisting the dashing of the waves; the surf constantly washes over the association at low tide, and the metre-long, pliable, elastic receptacles of the *Himanthalia* follow resistlessly the movement of the sea. *Himanthalia* cannot stand to be dry for any length of time; when found

Fig. 155. The *Himanthalia*-association. Besides plants with receptacles, young plants are seen. The subvegetation consists of *Gigartina mamillosa, Polysiphonia urceolata, Acrosiphonia, Corallina*, etc. The illustration is taken from Midvaag. (F. B. phot.)

on a sheltered coast, where however it is rare, it always grows sublittorally in low water and often has another appearance. The receptacles are uneven, sometimes inflated, and the colour of the plant becomes a lighter yellowish-brown.

As a subvegetation to the *Himanthalia*-association, *Gigartina mamillosa, Acrosiphonia, Polysiphonia urceolata*, and others often occur besides *Corallina* (see fig. 155). *Elachista scutulata* has occasionally been found growing on the receptacles, and on the old plants a great many epiphytes are sheltered, especially species of *Ectocarpus* e. g. *E. fasciculatus, E. Hincksiæ, E. tomentosus* and *E. litoralis*, species

of *Myrionema*, etc. Simmons reports that he has found *Ectocarpus velutinus*, the parasite peculiar to *Himanthalia*.

The association seems to correspond with Hansteen's and Boye's description of their »*Himanthalia*-formation« on the west coast of Norway. They both refer it to the littoral region. Hansteen characterizes it as follows (38, p. 350): »This formation forms a sort of transition between the purely littoral and the purely sublittoral formations, as it is most often found both above, and especially below, the low tide mark.« This, however, seems to imply that it grows at a somewhat lower level on the west coast of Norway than on the Færöes.

Boye's remark (6, p. 24) that the formation »seems to avoid localities that are directly exposed to the surf«, does not agree with what I have observed, as I have found it in places as exposed as e. g. Store Dimon, Lille Dimon, Viderejde, Sumbö Holm, the western and northern coasts of Strömö, etc. At Christianssund in Norway I saw the *Himanthalia*-association growing on a very exposed coast and agreeing in all particulars with that from the Færöes. As pointed out by Hansteen, Kjellman has already (45, p. 34) mentioned the *Himanthalia*-association on the west coast of Norway. With regard to the Færöes this association has been briefly described by Simmons (l. c. p. 254).

THE ALGÆ-VEGETATION OF THE POOLS AND CAVES.

The algæ-vegetation of the littoral pools, and that of the caves, which are so abundant along the exposed coasts of the Færöes, must be described separately. In both places the algæ grow under very different conditions from those enjoyed by the other algæ-vegetation found at the same level.

The Algæ-Vegetation of the littoral Pools.

These pools must first be divided into two groups. 1) The pools found at a height to which the sea cannot reach at high tide, and which therefore cannot have their water renewed constantly. 2) The pools within the limits of high and low tide, and which are therefore connected with the sea at high tide for a shorter or longer time. Consequently these two groups of water-pools offer very different biological conditions to the algæ. In the low-lying littoral pools, the water will be continually renewed,

and the temperature and salinity will be constant or vary only slightly. It is quite different in the littoral pools where the water is but rarely renewed, perhaps even only in very stormy weather in winter. Through the heat of the sun, the temperature of the water may rise considerably and become lukewarm. The salt water will gradually be replaced by fresh water and become brackish or almost fresh. The water is usually anything but clean, as fragments of dead algæ are very often found in great quantities in the high-lying pools. These fragments have been washed up by the surf, and soon putrefy.

But even if the algæ of the littoral pools come in many respects under different biological conditions, in one respect, however, and that, of great importance, the conditions are similar, namely the algæ are always covered by water. In this respect they are under similar conditions to those of the sublittoral algæ and differ from the other littoral algæ-vegetation, which is laid dry for a shorter or longer time at low tide. Several otherwise sublittoral algæ are also found in the lower lying littoral pools. The light is certainly somewhat stronger here than in the sublittoral region, but to the sublittoral algæ which grow near the low water mark the difference will not be of great consequence. In the littoral pools, where the light is darkened by fallen rocks, one may even find some sublittoral algæ which are otherwise generally found at a great depth. In the low lying pools we find e. g. species of *Delesseria, Porphyra miniata, Rhodomela lycopodioides, Lomentaria clavellosa, Chætomorpha Melagonium, Ulva Lactuca*, etc. Rosenvinge has also reported these facts (71, p. 204) and in this connection he discusses the question, whether the littoral algæ which are regularly laid bare at low tide can also grow in littoral pools that are always filled with water.

To this he answers as follows: »Observations now tell us that a great many, perhaps most of the species that live in the littoral region outside the pools, can also grow in the pools.« This agrees with what has been observed on the coasts of the Færöes. But as pointed out by Rosenvinge, there are some littoral algæ which are never found in the pools. He mentions 8 species of this kind, 7 of which are also found on the Færöes. These 7, viz.: *Pilinia maritima, Calothrix scopulorum, Urospora mirabilis, Rhizoclonium riparium, Bangia fuscopurpurea, Porphyra umbilicalis* and *Ulothrix flacca*, I never found in pools on the Færöes, nor the following littoral algæ: *Callithamnion arbuscula, Plumaria ele-*

gans, Rhodochorton Rothii, Pelvetia canaliculata, Ceramium acanthonotum, Prasiola crispa **marina, Prasiola furfuracea* and *Prasiola stipitata.* There are moreover several littoral algæ which grow but rarely in littoral pools, and when found there, are only imperfectly developed. In littoral pools between Thorshavn and Höjvig I have often found e. g. *Gigartina mamillosa*, which was hardly more than one inch long. Species of *Fucus*, e. g. *Fucus spiralis* and *Fucus inflatus* become paler in the littoral pools, the thallus likewise becoming thinner, and the plants are relatively small. This is the case with several littoral algæ. Evidently, some of them do not thrive when they are constantly in water; it seems as if they require to be laid bare for a shorter or longer space of time. Rosenvinge is also very probably right, when he supposes (71, p. 191) that certain littoral algæ perform part of their work of assimilation at low tide.

In the highest pools with their more or less fresh, luke-warm, and often half polluted water, where circumstances are very unfavourable to the algæ, only an *Enteromorpha*-vegetation is found, mainly consisting of forms of *E. intestinalis.* It is the only alga which can live under such unfavourable circumstances. It may be found far above the level of the sea, e. g. at Bosdalafos on Vaagö where it grows luxuriantly in small pools which are more or less inundated by small fresh water streams. In this connection it may also be mentioned, that I have found forms of *Enteromorpha intestinalis* at a height of about 600 feet (cf. 7, p. 242—245 and 8, p. 492).

A little lower, where the water is cleaner, other forms of *Enteromorpha* occur, e. g. var. *compressa*, var. *prolifera* and species of *Cladophora* e. g. *C. gracilis* and *C. sericea. Hildenbrandia* gradually gives a reddish hue to the sides of the pools, and several brown algæ appear, e. g. forms of *Fucus spiralis* and *Fucus inflatus* f. *linearis;* the latter has hitherto only been found at Famien on Syderö. Forms of *Ectocarpus litoralis, Scytosiphon lomentarius, Phyllitis fascia* and others moreover occur. Still farther down, where the water is regularly renewed at high tide, large, uneven brown crusts of *Ralfsia verrucosa* are found intermingled with the red *Hildenbrandia.* The bottom may also be covered by a dense matting of *Corallina officinalis*, sometimes mingled with *Phymatolithon polymorphum.* On *Corallina* one may also find crusts of *Dermatolithon macrocarpum* f. *Corallinæ.* Mingled with *Corallina*, several different algæ may be found e. g. *Dumontia filiformis, Rhodomela lycopodioides, Polysiphonia urceolata* and *P. Brodiæi, Lomentaria clavellosa,*

Furcellaria fastigiata, Chondrus crispus, Laurencia pinnatifida, Halosaccion ramentaceum, Ceramium rubrum, Chætomorpha Melagonium, Porphyra miniata and *P. leucosticta, Alaria esculenta, Laminaria digitata* and *L. saccharina*, especially f. *Phyllitis*, species of *Delesseria*, etc. and in general several algæ which otherwise grow only in the sublittoral region.

Thus it is evident, that a great many different species may be found in the pools; especially in the low lying basins. To show how rich in species such pools may be, we may mention that, according to Rattray (67, p. 428) Traill has found 67 different species in a relatively small littoral pool in the Firth of Forth.

It may be pointed out that it is peculiar to the algæ-vegetation growing in the pools that the different species often grow irregularly mingled with each other. This is surely due to the absence of tides. In larger littoral pools one may however see the algæ forming very distinct belts; various green algæ uppermost: *Enteromorpha, Cladophora* etc., and farther down *Polysiphonia, Rhodomela, Chondrus, Delesseria* etc. In a littoral pool above the highest water mark, but with clean water, *Enteromorpha intestinalis* for instance was found along the edge, next to that a belt of *Cladophora rupestris* and *Cladophora sericea*, below that a dense matting of *Corallina* with small *Monostroma fuscum*, and lastly *Laurencia pinnatifida* in great quantities.

This distribution is most clearly seen in large, deep pools found so far up in the littoral region that the waves can reach them only in stormy weather. In the summer in calm weather, the uppermost layer of water will turn brackish by the supply of rain and the different layers of water will be distinctly indicated by the vegetation.

In his report of the littoral rock pools on the west coast of Norway, Boye (6, p. 26) also calls our attention to the great differences in the vegetation which correspond with the different heights at which the basins are found. He moreover emphasizes that only *Enteromorpha intestinalis* is found at the greatest height. He also says that Hansteen's »*Ulvaceen*-formation« (38, p. 346) probably belongs in part to this vegetation.

Simmons, who does not give any special report of the vegetation of littoral pools, says (78, p. 253), when speaking of the »*Corallina*-formation«, that the *Corallina* may abundantly cover the bottom of such pools.

The Algæ-Vegetation of the Caves.

On almost all the coasts of the Færöes, facing the open sea, large or small concealed caves are found, where the sea often makes its way far into the rock. In stormy weather, when the sea is rough, these caves are more or less filled by the surf rushing in

Fig. 156. Cave in the rocks facing the sea. Illustration from Bordö: Arnefjord. (F. B. phot.)

with a noise like thunder. Now one might expect to find a luxuriant littoral algæ vegetation in these caves, which are always fresh and cool, and where there is less danger of the drying process than in the open air. But the dim light is a factor which very soon prevents the greater part of the littoral algæ from thriving here. These algæ are mostly such as seek the light and are accustomed to grow in full daylight. They are therefore only found at the entrance of these caves, and most of them soon disappear.

The algæ which cover the walls farther in the cave are either such littoral algæ as would be found in the open air on the beach in cracks and clefts or otherwise sheltered from strong light, or sublittoral algæ which here approach the surface of the water as the light grows fainter. Some of the latter may even be found at such a height, that they are dry at low tide. Among these there are several *Florideæ* which are usually only found at a great depth in the open sea. When rowing into such a cave, a condensed but exact picture is obtained of the algæ-vegetation that grows on a vertical rock in the open air, moving from the top downwards. Immediately at the entrance there are of course littoral algæ, but they soon disappear, as before mentioned, and so does the *Alaria*-association. The *Laminaria hyperborea* is found a little farther in, but it also soon disappears, and only *Florideæ* are left.

By closer observation of the algæ-vegetation, we find that, as mentioned above only a few specifically littoral algæ grow here. The alga which is most widely distributed and found at the greatest height is *Rhodochorton Rothii*. Far stretching vegetations of it like a dense, low, brownish-red felt cover the walls and ceilings of the caves (cf. the *Rhodochorton*-association, page 718). Even in the mighty caves on Troldhoved it is certainly this alga which gives the more than 50 feet high rocky vaults their redish hue. At the entrance of the caves and close to the level of the sea it grows on the rock in small, firm lumps of the size of a pea.

From about the highest water mark downward, a dense, almost blackish covering of *Plumaria elegans* is often found in the caves. In the Færöes I have only met with this alga in these places. Together with *Plumaria*, a dense covering of *Delesseria alata, Ceramium rubrum, Polysiphonia urceolata*, and others, are also found. They form a dark red, tangled vegetation which is often joined by *Cladophora rupestris* closer to the entrance of the cave. In a cave on the northern side of Kvalböfjord on Syderö, a low, red covering of a small *Phyllophora* (8, p. 359) was found, some way into the cave. A little above the lowest water mark, the elegant little *Callithamnion scopulorum* is abundant, and *Callithamnion arbuscula* may also sometimes be found in the caves. It partly changes its appearance here, becoming less ramified and of a lighter reddish colour. Whilst the *Corallina* is most often the subvegetation at the entrance of the caves, it is replaced by the *Phymatolithon polymorphum* farther into the cave. At the entrance of the caves, for

instance at Troldhoved, the *Phymatolithon*-formation (see page 750) is found at about low water mark or a little above; but on rowing into the cave, it will be found to extend further and further up, till far above the highest water mark. This alga is of a fine pink colour in the cave, and, as far as I have seen, reaches further into the cave than any other alga; darkness of course gets the better of it at last. Together with *Phymatolithon*, we often find *Cruoria pellita* forming large, shining, dark reddish incrustations, even far above the lowest water mark. Other sublittoral algæ found here are *Delesseria sinuosa* and even *Delesseria sanguinea* the thallus of which is torn by the surge into narrow lobes. One may moreover find *Odonthalia dentata, Plocamium coccineum, Lomentaria clavellosa, Ptilota plumosa*, *Euthora cristata*, and, just below the lowest water mark, the beautiful *Pterosiphonia parasitica* and many more sublittoral algæ.

As mentioned above (page 701, footnote), some sublittoral algæ may hardly ever be found at the level of the sea, not even in the caves, and as likewise pointed out at the same place, this must be ascribed most probably due to the surge, as several of these algæ are found in other places at the lowest part of the littoral region.

This peculiar circumstance, that a deep water-flora can be found at the level of the sea in caves, has however already been pointed out by several algologists. In the introduction to his algæ-flora (18, p. 220—221) Falkenberg speaks of a »Grotta del Tuono« in the neighbourhood of Naples, with only very shallow water, which was constantly renewed by its connection with the sea. He says: »Trotz des niedrigen Wasserstandes in diesem Bassin finden sich hier an den dunkelsten Stellen Algen, die sonst als charakteristische Pflanzen einer Tiefe von etwa 50—60 Meter im Golfe sich finden.« And after having named a certain number of the algæ found in this place, he continues: »So zeigt diese kleine Grotte mit flachstem Wasserstande in ihrer Algenvegetation je nach dem grösseren oder geringeren Grade von Dunkelheit einen ähnlichen Wechsel, wie er im freiem Meere bei dem Uebergang aus grösserer in geringere Tiefe stattfindet«. In the section on the influence of the different degrees of the intensity of light on the distribution of the marine algæ, Berthold points out that the algæ without exception must, as independent assimilating plants, require a certain intensity of light, yet different

for each species. He further writes: (5, p. 414) »In den beschatteten Grotten, in welchen *Lithophyllum Lenormandi, Callithamnion elegans, Derbesia Lamourouxii* die äussersten Grenzen der Vegetation bezeichnen, verschwinden diese Formen schon vollständig in geringen Entfernungen vom Eingange. Ist es erlaubt aus den Befunden an der Oberfläche auf das Verhalten in grösseren Tiefe zu schliessen — die Berechtigung dazu dürfte kaum bestritten werden können, denn die Algenformen sind an den entsprechenden Örtlichkeiten theils ganz dieselben, theils nahe verwandt —, so muss die Lichtintensität auch hier bei vorhandenem Pflanzenwuchs noch eine ziemlich beträchtliche sein«. If it were possible to measure in some way the amount of light that reaches the algæ growing in the innermost parts of the caves, this might certainly, as suggested by Berthold, serve as a measure of the intensity of the light at the depth where the algæ-vegetation disappears[1].

b. Sheltered Coasts.

The Chlorophyceæ-Formation.

Here this formation is chiefly represented by an *Enteromorpha*-association, but sometimes we also find others of the different associations belonging to this formation on exposed coasts e. g. the *Prasiola stipitata*-association.

The *Enteromorpha*-association grows highest, often somewhat far above the highest water mark and stretches down to a little below it. It is often found on moist rocks and in clefts and cracks, where fresh water oozes from the rock, and consequently it does not form any continuous belt, but larger or smaller patches in these places. It may moreover be found at the inner end of bays and inlets, where the bottom is covered with gravel or stones, and here it may often partly replace the *Fucaceæ*-formation. It is, for instance, richly developed in the innermost part of Kalbak- and Kollefjord, in Skaalefjord etc. Different forms of *Enteromorpha intestinalis*

[1] In order to try if any result might possibly be obtained, I used in 1900 Wynne's actinometer, which serves for photographic purposes to indicate the exact term of exposure in a certain place (cf. Johs. Schmidt: Bidrag til Kendskabet om Skuddene hos den gamle Verdens Mangrovetræer, København 1903, p. 11). But in these caves, where the light is faint and the term of exposure consequently long, the instrument proved less useful. With an instrument constructed by Dr. Steenstrup (cf. Meddelelser om Grønland. 25, page 1) to measure the intensity of the light, a satisfactory result might possibly be obtained.

are met with here: var. *micrococca* uppermost, next to that var. *genuina*, especially the forma *cornucopiæ*. Together with *Enteromorpha*, *Ectocarpus litoralis* is also often found, especially the form *rupincola*.

This association is closely related to the *Enteromorpha*-association, which has been mentioned as characteristic on exposed coast (p. 714), and to the *Enteromorpha*-vegetation which is found in the highest littoral pools. It seems to correspond exactly with the »*Enteromorpha*-formation« found by Hansteen (38, p. 358) at the head of the Vindefjord.

The Fucaceæ-Formation.

On sheltered coasts, especially in the littoral region, a very characteristic and luxuriant vegetation is found both on rocks and stones and consists almost entirely of the *Fucaceæ*: *Pelvetia canaliculata* uppermost, next to that *Fucus spiralis*, *F. vesiculosus*, *Ascophyllum nodosum*, and lastly *Fucus inflatus*, which grows a little above and sometimes a little below the lowest water mark. As these five *Fucaceæ* are differently adapted to resist the dashing of the waves or the supply of fresh water, they are not always found together. In the most sheltered places *Pelvetia*, *Fucus vesiculosus* and *Ascophyllum* will generally predominate, whilst *Fucus spiralis* and *F. inflatus* are absent entirely or only represented by a few scattered individuals. Where the coast begins to be more exposed, the two last-mentioned algæ appear. At the same time, *Fucus vesiculosus*, and later *Ascophyllum* totally disappear. *Pelvetia* may still be found in rather exposed places, but in the most exposed it likewise disappears, so that only *Fucus spiralis* and *Fucus inflatus* are left. These two algæ may be typically developed on a somewhat exposed coast, but the more exposed it is, the smaller the *Fucus*-species. Thus they pass easily into the above-mentioned *Fucacé*-formation found even on the most exposed coasts.

With regard to the species found on the coasts of Greenland, *Fucus vesiculosus*, *Ascophyllum nodosum* and *Fucus inflatus*, these observations agree well with Rosenvinge's report (71, p. 197). I also entirely agree with Rosenvinge, when he declares, that *Fucus vesiculosus* grows the farthest into the fjords, where the water may be almost fresh because of the inflow of rivers. Yet *Ascophyllum* may sometimes be found growing at the outlet of rivulets, where the alga at low-tide is irrigated by fresh water, but

this takes place generally nearer the mouths of the fjords, where the sea-water inundates its habitat at high tide.

As mentioned already *Pelvetia* grows uppermost. On a sheltered coast and at or a little above the highest water mark, it constitutes an association which may spread far horizontally, but which is vertically most often only one foot broad (see plate XXII). When moist, it is of a light yellowish, olive-brown hue, but in calm weather it is often liable to be dried; *Pelvetia* may be found quite dry and stiff, and is then of a blackish hue. In tideless bays, it is of course very liable to be drained, and circumstances are on the whole less favourable to it here than in places which are subject to a regular tide. This is quite clear from its slighter development; specimens from the Kalbakfjord for instance, especially those growing highest, were often but one inch long and consisted almost entirely of receptacles, a form which has been called f. *minima* by Simmons. Yet this dwarfish growth here in the fjords, may perhaps be partly due to the great amount of fresh water which flows constantly from the rivers, and which makes the surface-water with which *Pelvetia* comes in contact, very fresh. On coasts subject to the tide, a much more vigorous and better developed *Pelvetia*-association is found. Other algæ are but rarely found in the *Pelvetia*-association as Simmons (p. 251) has pointed out, probably because only a few algæ are able to grow so far above the level of the sea in sheltered places. *Ulothrix flacca* and *Ectocarpus litoralis* are however sometimes found epiphytically on *Pelvetia*, on the rock we find a subvegetation of *Verrucaria* and *Hildenbrandia rosea*, and in cracks in the rock, *Rhodochorton Rothii* and *Ectocarpus litoralis*.

Below this association, a *Fucus vesiculosus-Ascophyllum nodosum*-association grows on a sheltered coast. It is very common and on slightly sloping rocks it is widely distributed horizontally; a specially luxuriant growth of these algæ seems to be found on coasts with boulders and fragments of rocks of different sizes. On these stones, *Fucus vesiculosus* generally grows uppermost, in large dense clumps and facing landward; below, *Ascophyllum* hangs down the sides of the stones (see plate XXIV). Yet *Ascophyllum* may also be found growing above *Fucus vesiculosus*. This I have seen in the Vestmanhavnbugt, for instance. Strömfelt likewise writes (80, p. 10), that *Ascophyllum* grows uppermost, and *Fucus vesiculosus* farther down[1], whilst Rosenvinge reports that *Fucus vesiculosus* grows uppermost

[1] According to Jónsson's observations (41, p. 192—193), it is usually the reverse.

in Greenland. It seems to me most likely that the somewhat different occurrence of these two species, also in the Færöes, may be explained thus, that *Fucus vesiculosus*, as mentioned before, requires to be more sheltered than the other; therefore, this alga in a somewhat exposed place grows facing landward and uppermost, whilst it may grow nearer to the sea and farther down in a locality as sheltered as Vestmanhavn.

Fig. 157. *Fucus inflatus*-association at a small, low-lying pool on the beach. Illustrations from rocky coast at Thorshavn. (F. B. phot.).

Elachista fucicola is a very common epiphyte on *Fucus vesiculosus*, and *Polysiphonia fastigiata* is hardly ever sought in vain on *Ascophyllum nodosum*. Besides these, other epiphytes are sometimes found e. g. *Ectocarpus litoralis*, *Ectocarpus tomentosus*, *Ceramium rubrum*, *Rhodymenia palmata* etc. on both algæ. Below the dense tufts of seaweeds several red algæ are often found, e. g. *Gigartina mamillosa*, *Chondrus crispus*, *Hildenbrandia rosea*, *Rhodochorton Rothii*, etc.

On a somewhat more exposed coast, *Fucus vesiculosus*, as before mentioned, soon disappears and is replaced by *Fucus spiralis* which forms an association at about the same height as *Fucus vesiculosus*, or a little higher. Below *Ascophyllum nodosum*, *Fucus*

inflatus occurs. On a more exposed coast, the latter forms an extensive association (figs. 157 and 158). Both in the *Fucus spiralis*- and the *Fucus inflatus*-associations, *Elachista fucicola* is a very common epiphyte. On *Fucus inflatus*, several species of *Ectocarpus* e. g. *Ectocarpus tomentosus, Ectocarpus fasciculatus,* etc. are often found. On the rocks and stones, below and among these algæ, especially in the lowest *Fucus inflatus*-association, one may find a great many different algæ, e. g. *Porphyra umbilicalis, Urospora mirabilis, Cladophora rupestris, Acrosiphonia albescens, Polysiphonia urceolata, Ceramium rubrum, Gigartina mamillosa, Chondrus crispus,* etc.

In order to characterize the *Fucaceæ*-formation more closely, I shall give a description of some of the localities in which I have met it at its greatest development. In Vestmanhavn, and a little north and south of this gulf, in the Vestmannasund, between Vaagö and Strömö, a specifically well-developed *Fucaceæ*-formation is found, on sheltered coasts. The tide rises rather high here, about 6—8 feet, and at low tide the formation is laid perfectly bare. We find *Pelvetia* uppermost as a light yellow belt, almost a foot broad, showing up the high water mark with an almost perfectly straight line. Below this, we have some *Fucus spiralis*; this alga is abundant only on somewhat more exposed coasts. The *Fucus-Ascophyllum*-association, which comes next, is however very luxuriant. As shown in plate XXIII, the coast in certain places consists of large stones which are completely covered by these algæ. This vegetation is found as far down as the lowest water mark, where some few *Fucus inflatus* may occur.

On the east coast of Strömö, between Thorshavn and Höjvig, the *Fucaceæ*-formation is of a somewhat different appearance. The coast is here rather exposed and rugged, with several larger or smaller islands girding the coast. In one of the inlets, called Volgaravik, which forms a little natural harbour, having but a small opening towards the sea, a well-developed *Fucaceæ*-vegetation was found (see plate XXIV). Near the land, the coast was composed of boulders of different size which were covered by a dense *Fucus*-vegetation; a little farther out, in a more exposed position, *Fucus vesiculosus* disappeared making way for a luxuriant *Ascophyllum*-vegetation, which was replaced by a well-developed *Fucus inflatus*-vegetation at the greatest distance from the shore and at a lower level. Here, on the stones lying farthest from the shore, the position is rather exposed, and in a strong sea making towards the land the surf

dashes heavily into the inlet. This *Fucaceæ*-vegetation was widely distributed horizontally, but not vertically, as was easily observed on the perpendicular walls of the inlet, where all three species grew together, forming a belt hardly more than a few feet broad. It should not be forgotten, however, that ebb and flow are scarcely perceptible on this part of the coast.

Fig. 158. *Fucus inflatus.* A small part of the *Fucus inflatus*-association illustrated in fig. 157. (F. B. phot.).

From Thorshavn, which has rather an exposed situation, southward to Arge, a *Fucaceæ*-vegetation is moreover found, with *Fucus spiralis* uppermost, *Fucus inflatus* lowest (see figs. 157 and 158). To these must be added *Ascophyllum nodosum* in somewhat sheltered places, and *Fucus vesiculosus* in the most sheltered. At Glivernæs, still more toward the South, and further on in the same direction, the coast becomes more exposed and only the dwarfish forms of *Fucus spiralis* and *F. inflatus* are found.

Examples of the above-mentioned *Fucaceæ*-formation will be

found almost anywhere on the coasts of the Færöes. The formation constantly adapts itself to the more or less exposed situation of the locality and by aid of the *Fucaceæ*-vegetation, it may as a rule be easily determined whether a certain locality is sheltered or exposed.

The *Fucaceæ*-formation of the Færöes seems to agree well with Rosenvinge's of the coasts of Greenland. According to Strömfelt's somewhat scanty description (80, p. 10), a very similar vegetation must be found on the coasts of Iceland. If we compare the *Fucaceæ*-formation of the coast of Norway, described among others by Hansteen (38, p. 351—52) and Boye (6, p. 27), we at once observe that they are essentially different from a floristical point of view, as *Fucus serratus*, which is very common on the west coast of Norway, is absent on the Færöes; œcologically there likewise seems to be a great difference between them. Boye writes (l. c. p. 25): »Even in the most exposed localities, a very luxuriant *Fucus*-vegetation is usually found«; he mentions moreover two forms of *Fucus vesiculosus*, besides a f. *elongata* of *Fucus serratus* as being found there. This is quite contrary to what we observe on the Færöes, where *Fucus vesiculosus* is absent on exposed coasts. The only *Fucus*-species that will thrive here are *Fucus spiralis* and *F. inflatus*. As before-mentioned (p. 724) I doubt, however, whether Boye's observations are perfectly correct.

In the northern part of Norway, where *Fucus inflatus* is common, the *Fucus*-vegetation hardly differs from that of the Færöes in anything but this, that *Fucus serratus* is frequent. The Færöese *Fucus*-vegetation also much resembles that of the Shetland Isles, except that a luxuriant growth of *Fucus serratus* occurs on the shores of the latter. What makes the resemblance still greater is, that *Fucus inflatus* has been found here (cfr. 9, p. 5). Simmons mentions (78, p. 251 and 253) a *Pelvetia*-formation and a *Fucus-Ascophyllum*-formation found on the Færöes.

2. The Sublittoral Region.

As mentioned before, I agree with Rosenvinge in determining the upper boundary line of this region at about low water mark, at neap-tide. In the Færöes the boundary line is almost identical with the distinct upper line of the *Alaria*-association. Kjellman determines the lower limit of this region at the curve of 20 fathoms, and he calls the area covered by algæ below this, the elittoral re-

gion. The reason why he chooses this curve for the lower limit is, that the algæ-vegetation at and below 20 fathoms becomes uniform and poor in species, as the greater part of the sublittoral algæ will not thrive at so great a depth. He himself points out, that this limit is »weniger scharf oder wenigstens nicht so auffallend« between these regions as between the littoral and the sublittoral. In agreement with Rosenvinge (45, p. 237), I therefore think, that it is unadvisable to determine the boundary line between two regions so arbitrarily, as the number of species and the luxuriancy of the vegetation are in reality reduced regularly and gradually from a certain depth downward. Moreover the sublittoral species growing at the lowest depth are likewise often found in the upper part of the sublittoral region. No other species are introduced here that might change the appearance of the vegetation. When moving downwards from the surface of the sea, the brown algæ first disappear, and at last hardly anything but *Florideæ* are left[1].

Finally, the curve of 20 fathoms may serve as a boundary line only in the northern seas, where the light does not reach far down. In the Mediterranean Sea, a vigorous vegetation is still found at a depth of more than 40 fathoms, and in the Tropics we may be sure to find a rich algæ-vegetation still farther down. It does not seem to me natural therefore to maintain this boundary line, as the algæ-vegetation is luxuriant down to a certain depth, (in the Færöes to about 15 fathoms, as far as my observations go) and then leaves off slowly and gradually, as the depth increases. When Kjellman objects (45, p. 8—9) to Ørsted's division of the algæ-vegetation in the Sound, that the boundary line between the brown and the red algæ is indistinct, it seems to me that the same objection might be applied to Kjellman's division into a sublittoral and elittoral region. If the sublittoral region must be divided, it is probably Ørsted's division that ought to be maintained, as it would seem

[1] In connection with this I shall refer to Rosenvinge's summary of the species (71, p. 231) found at a depth of at least 10 fathoms; algæ found at a still greater depth, at 15 fathoms and more, are printed in thick type. As pointed out by Rosenvinge (l. c. p. 232), it is evident from the list that the red algæ increase in number with the depth. There is hardly any doubt, that here also an almost pure *Florideæ*-formation will be found, shortly before the vegetation ceases. It is true that Rosenvinge in the same connection (p. 236) speaks of a *Desmarestia aculeata*, found at a depth of about 30 fathoms, near Upernivik. But I doubt whether this alga was adhering to any substratum.

most natural to determine the boundary line where the brown algæ leave off, and where only a pure or almost pure *Florideæ*-vegetation is left. But while we still know so little of the algæ-vegetation at greater depths, it seems to me most natural, as mentioned before to determine the sublittoral region as one, and, in agreement with Rosenvinge (l. c. p. 237), »to move the lower boundary line of the sublittoral region from the curve of 20 fathoms to the limit where the algæ-vegetation disappears. Thus the elittoral region will include that part of the bottom of the sea which is destitute of algæ«[1].

a. Exposed Coasts.

The Phymatolithon-Association.

This association begins at about the lowest water mark, or a little above, and probably extends down to a depth of several fathoms. My observations are, however, not exact, as *Phymatolithon polymorphum* which forms this association is almost always covered by the *Alaria*, etc. and is therefore not easily observed. Still I have seen that it may be found in caves several fathoms below low water mark as well as at and even over the highest water mark. It covers the rock with a whitish or slightly pink, glabrous crust, but as mentioned before it is mostly covered by various larger algæ, especially the *Alaria*.

This association grows on the most exposed coasts. Its stone-like consistency, and its firm hold on the rocks, serve to protect it from the surf. Simmons mentions a *Lithothamnion*-formation (p. 251) which probably agrees with this association. It is true that, according to his report, it is found almost only in the littoral region (»ausnahmsweise bis an die Fluthgrenze hinaufreichend und sich bis an oder zuweilen etwas unter die Ebbengrenze streckend,«) but later he has corrected this.

The sublittoral Corallina-Formation.

The littoral *Corallina*-formation stretches sublittorally, as mentioned before, down to a depth of several fathoms[2]. Here the *Co-*

[1] »at flytte den lavere Grænse for den sublitorale Region fra 20-Favne Kurven til den nedre Grænse for Forekomst af Algevegetation overhovedet, saa at den elitorale Region kommer til at omfatte den Del af Havbunden, der er blottet for Vegetation«.

[2] In my flora (8, p. 402), I have stated this depth as 1—2 fathoms. According to my later observations, it may however reach to at least 4 fathoms.

rallina is however often replaced by the above-mentioned *Phymatolithon polymorphum*-association.

Like the littoral *Corallina*-formation, the sublittoral shelters a great many different algæ, either epiphytically on the *Corallina*, or on the rock among the latter. Some of these are e. g. *Chondrus crispus*, *Delesseria alata*, *D. sinuosa*, *Chætomorpha Melagonium*, *Lomentaria clavellosa*, *Ptilota plumosa*, *Porphyra leucosticta*, *P. miniata*, etc. In smaller group of rocks, where the habitat is somewhat sheltered but the coast still exposed, e. g. on the east coast of Strömö, from the redoubt near Thorshavn northward, to Hvidenæs, or at Ejde on Naalsö, large associations of the gregarious *Furcellaria fastigiata* are often found in the *Corallina*-formation, besides large or small associations of *Ahnfeltia plicata*. A common epiphyte on the *Corallina* in these places is *Ceramium rubrum* subf. *secundata*. *Ulva Lactuca* and *Monostroma fuscum* are likewise found here. The *Corallina*-formation is moreover partly the subvegetation of the *Alaria*-association.

The Laminariaceæ-Formation.

This, the most widely distributed formation on the coasts of the Færöes is naturally divided into several well-defined associations. On an exposed coast, the *Alaria*-association is uppermost, which is sometimes replaced by a *Laminaria digitata*-association; a *Laminaria saccharina*-association is more seldom found, and lowest of all a *L. hyperborea*-association. On a sheltered coast we moreover find a *Laminaria fœroensis*-association, but of this and the *Laminariaceæ*-formation as a whole we will give further details later on.

This *Laminariaceæ*-formation corresponds with Kjellman's Laminariaceen-formation (45, p. 34).

The Laminaria digitata-Association.

This association, which gradually merges into the *Laminaria hyperborea*-association, growing below it, is found on open coasts on slightly sloping rocks. In localities where the sea is particularly turbulent and therefore constantly washing the rocks, this association may reach to several feet above the lowest water mark. On the southern and eastern coasts of Syderö, from Sumbö Holm to Vaagfjord, and on Vaagö and Troldhoved on Sandö, I have seen this association beautifully developed (see plate XX).

The *Laminaria digitata* is well adapted to resist the violence of the waves. Both leaf and stalk are of a tough, yet pliable character

and the stalk is, as pointed out by Wille (85, p. 9—10), very extensible, in contrast to *Laminaria hyperborea* which has a very stiff stalk. The stalk being often much compressed at the top, adds to its flexibility, which is also mentioned by Wille (p. 6). The plant is moreover firmly fastened to the rock by vigorous haptera, and if one tries to pull it up, generally only the stalk is broken, whilst the haptera are left. On coasts where the rocks project vertically into the sea, this association, however, is usually entirely absent, or a single *Laminaria digitata* at most may now and then be found. It is the form *stenopylla* which is represented here, but where the association is well developed, all transitional forms besides the main form are found. As a subvegetation, we find *Corallina, Gigartina, Polysiphonia urceolata, Cladophora rupestris, Phymatolithon polymorphum,* etc. and on the *Laminariæ* themselves, some smaller epiphytes which grow on the stipes or sometimes also on the margin of the lobes of the thallus. Among the latter *Ectocarpus fasciculatus, E. tomentosus* and *E. Hincksiæ* are the most important. Early in spring a dense covering of the parasitical *Ectocarpus tomentosoides* is invariably found (compare 8, p. 415).

The *Laminaria digitata*-association grows at about the same height as the *Himanthalia*-association which is usually absent where the former is well developed.

In connection with this I may say that I have also, though but rarely, found a *Laminaria saccharina*-association growing a little above and a little below the lowest water mark. On Sumbö Holm, a little above the lowest water mark, I have found a vegetation of *L. saccharina* represented by a form which I think might be referred to f. *linearis* (see the illustration of this alga in my flora, 8, p. 453). This form was smaller, the thallus narrow, thick, leathery and very wrinkled, probably an adaption to its very exposed habitat. On the lamina a great many epiphytes were often found, especially *Pogotrichum filiforme,* which made the alga resemble an ostrich feather when floating.

The Alaria-Association.

This association generally grows uppermost in the sublittoral region directly below the *Himanthalia*-formation, as pointed out by Hansteen. Thus it begins at about the lowest water mark at neap-tide; at spring-tide, part of it, one foot or more, is laid bare. In very exposed places, in clefts, or on sloping rocks that are constantly

Fig. 159. *Alaria*-association on the beach at Myggenæs Holm.
(F. B. phot.).

washed by the sea, *Alaria esculenta* may exceptionally be found up to several feet above the lowest water mark, as at Myggenæs Holm, where it grows up to at least 10 feet above the lowest water mark, that is to say, it passes above the highest water mark (see fig. 159). Other places where it grows under the same conditions, are e. g. Lille Dimon, Mölen at Ejde, etc. (see also plate XXI).

The *Alaria*-association prefers steep or perfectly vertical rocks in the most exposed places, and covers these rocks with a dense covering, often many feet thick, at varying but hardly ever very great depths. Yet the *Alaria* may be found at a depth of several fathoms, as in sounds where there is a rapid current. Here the *Alaria* is often richly represented in the *Laminaria hyperborea*-association.

The *Alaria* is excellently adapted to the violence of the waves; its elastic leaves constantly follow the motion of the water, as their great flexibility makes them utterly unresisting. In spite of this, the uppermost part of its lamina clearly shows traces of the force of the sea on exposed coasts, as it is torn and rent into small lobes, and lastly nothing but the bare, thin, much-worn midrib is left (see the illustration of this alga in my flora, p. 449).

Generally the association consists solely of the *Alaria esculenta*; the *Alaria Pylaii* seems to prefer somewhat more sheltered coasts, and it may be supposed that this species is rare, as only a few specimens of it have been found. It is therefore of no importance in reference to the composition of the *Alaria*-association. On the other hand, the *Litosiphon Laminariæ*, which is almost always found abundantly on the leaves of the *Alaria*, and the *Chantransia Alariæ*, which covers the lamina with a very dense, purple, velvet mat, are very characteristic in the association. I have however only seen the latter a few times on the coasts of the Færöes. On old stems of *Alaria* a number of different epiphytes are found; some of these are *Ectocarpus fasciculatus*, *E. Hincksiæ* and *E. tomentosus*, *Rhodymenia palmata*, *Porphyra umbilicalis*, *Ulothrix flacca*, etc.

Larger algæ but rarely belong to the association; however, *Laminaria saccharina* f. *linearis* may be found more or less abundantly, as well as *Laminaria digitata* f. *stenophylla*, which may in some places be found on slightly sloping rocks even far up in the littoral region, as will be mentioned below. In narrow inlets of shallow water lying between rocks and small islands, »Skærgaarde«, e. g. those mentioned before on the east coast of Strömö, north of the redoubt, large numbers of *Laminaria saccharina* f. *bullata*

are often found intermingled with the *Alaria*. Circumstances are, however, always somewhat altered where other species are intermingled. In places favourable to the *Alaria*-association, that is, on steep or vertical rocks on exposed coast, this association may be found almost unmixed for miles.

The *Alaria*-association in the Færöes which has already been shortly described by Simmons (78, p. 254) seems to agree well with Hansteen's (l.c.) and Boye's (6, p.4—5) *Alaria*-formation. Yet we may suppose according to Boye that »*Laminaria stenophylla*« Harv. must be somewhat more common in the association on the coast of Norway than at the Færöes.

The Laminaria hyperborea-Association.

This characteristic algæ-association is widely distributed on the coasts of the Færöes. It grows abundantly from a depth of about 1 fathom down to 10—15 fathoms, and it is most luxuriant at 5—10 fathoms, forming large submarine forests. It prefers horizontal or slightly sloping rocks, on stony ground. In such localities, the very dense vegetation of *Laminaria hyperborea*, with its brown, pendulous, fan-like laminæ swaying with the waves, may be seen when the water is clear. Close to the land, in gulfs and inlets, it often grows in such shallow water that the uppermost part of the lamina are seen above the surface of the sea at low tide (see fig. 160).

It is here that the above-mentioned epiphytical *Rhodymenia*-vegetation has its habitat.

On account of its vigorous haptera, the *Laminaria hyperborea* is able to cling to even the most exposed places. This algæ is however not much exposed to the surf; it generally grows at too great a depth, and when it grows in shallow water it is most often in rather sheltered inlets and gulfs, as mentioned before. Its solid and comparatively not very flexible stalk would certainly make it unfit for resisting a strong surge. On the other hand, it is much exposed to and also excellently fitted for resisting the strong pull of the rolling waves. When the sea is rough, the effect of this pull is felt far down, as is seen from the fact that a stormy sea can break at more than 10 fathoms of water.

On a small rock outside of the »redoubt« near Thorshavn there is a dense vegetation of *Laminaria hyperborea* at a depth of 3—4 fathoms. During a tempest from the south and a rough sea, I have

seen how the lamina of the *Laminaria hyperborea* was sucked into the waves and kept swaying to and fro when they rushed over the rock; it is certainly exposed to a very strong pull here. But *Laminaria hyperborea* is excellently constructed for resisting this attack of the sea, its stalk being both thick and stiff at the bottom but becoming thinner and more elastic towards the apex, so that the flexible lamina can easily follow the motion of the water. It is firmly attached to the bottom by aid of the strong haptera. It is

Fig. 160. *Laminaria hyperborea* with numerous epiphytical *Rhodymenia palmata* rising above the surface of the sea at low tide. Illustration from the neighbourhood of Thorshavn. (F. B. phot.)

a well-known fact to anyone who has dredged among the *Laminaria hyperborea*, that only by a very strong pull, or by the teeth of the dredge cutting through the haptera more often through the stalk itself, can the plant be torn from the bottom. I have often tried from a boat to pull up the plants that grew in shallow water, but I have hardly ever succeeded in loosening them without cutting through the haptera. Thus the plant may resist a very strong pull without being detached from the bottom. Its gregarious growth also helps to protect it from the attack of the sea.

This association covers large areas with an almost unmixed growth of its characteristic alga. It would therefore look very uniform but for the very luxuriant subvegetation of epiphytes, mainly the

Florideæ. It is the haptera and especially the stalk which are almost densely covered by large or small algæ (see fig. 161). The lamina however is mostly destitute of epiphytes, most likely because it is changed every year. Various species, however, e. g. *Rhodymenia palmata*, *Ectocarpus tomentosoides*, which would probably be very common in spring, *E. tomentosus*, *E. fasciculatus*, and some others, may be found growing on the lamina, especially in shallow water.

Among the many epiphytes that grow on the stalk and the roots, the following species may be pointed out: *Polysiphonia urceolata*, *Chantransia Daviesii*, *Callophyllis laciniata*, *Euthora cristata*, *Rhodophyllis dichotoma*, *Lomentaria clavellosa*, *L. rosea*, *Plocamium coccineum*, *Delesseria alata*, *D. sinuosa*, *D. sanguinea*, *Polysiphonia elongata*, *Odonthalia dentata*, *Ptilota plumosa*, *Pt. pectinata*, *Antithamnion floccosum*, *Ceramium rubrum*, *Rhodochorton Rothii*, *Cruoria pellita*, *Lithophyllum Crouani*, *Dermatolithon macrocarpum* f. *Laminariæ*, *Peyssonelia Dubyi*, *Sphacelaria furcigera*, *Desmarestia aculeata*, *D. viridis;* that is to say, scarcely any but *Florideæ*. Most of these epiphytes may be found even in rather shallow water in the semi-darkness under the *Laminariæ* which also afford some protection from the violence of the waves.

In describing the algæ-vegetation of the Mediterranean Sea, Berthold points out (5, p. 422) that the epiphytes on a *Cystosira granulata* grow in a certain fixed order. Those that require more light grow on the top of the *Cystosira*, those that want less grow under the latter. The epiphytes on the stalks of the *Laminaria hyperborea* likewise grow in a certain fixed order from the top downward, according to the degree of light required by each alga; those that want much light grow uppermost, the others lower down. The colour of the water can hardly be of any consequence where the distance from the top to the bottom only means the length of the stipes. At the top of the stipes we find *Ceramium rubrum*, *Polysiphonia urceolata*, *Delesseria alata*, *Polysiphonia elongata*, and from these algæ downward, we find *Odonthalia dentata*, *Delesseria sinuosa*, *Plocamium coccineum*, *Ptilota plumosa*, *Lomentaria clavellosa*, *Sphacelaria furcigera*, *Rhodochorton Rothii*, *Cruoria pellita*, *Dermatolithon macrocarpum* f. *Laminariæ* etc. On the lowest part of the stipes, and especially on the haptera, *Callophyllis laciniata*, *Rhodophyllis dichotoma* and *Euthora cristata* are found.

The *Laminaria hyperborea*-association reaches its finest development in the course of the summer. The lamina is changed in winter,

and the old fronds are thrown off in spring, at which time of the year they are washed up on the beach in great numbers by the heavy storms. Even in May and June, however, specimens may be found which still have the old lamina attached.

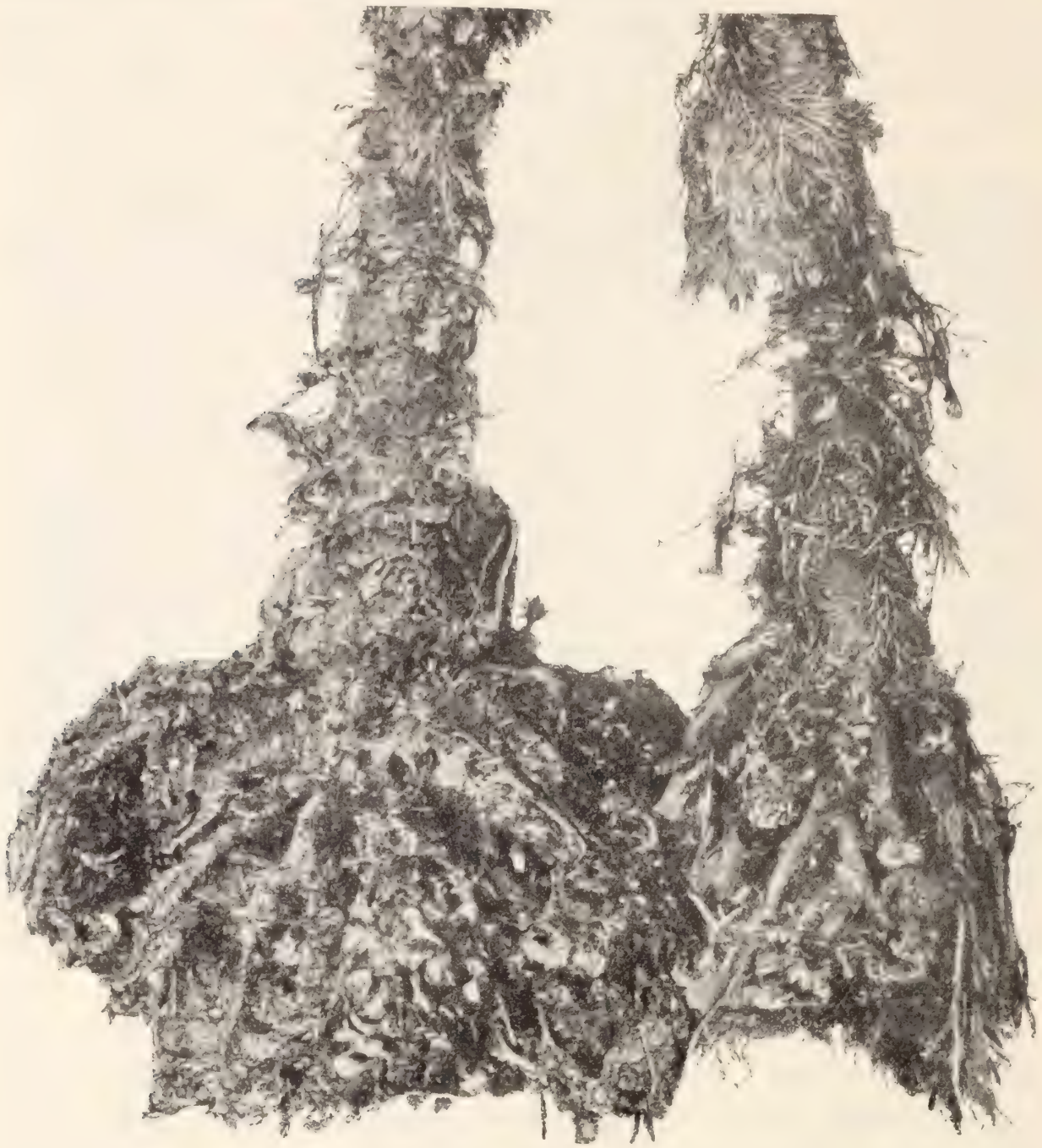


Fig. 161. Stipes and haptera of *Laminaria hyperborea* with a dense covering of epiphytes. On the stipes, *Plocamium coccineum* is prominent; on the haptera, *Callophyllis laciniata* and *Euthora cristata*. Uppermost on the stipes we find *Ceramium rubrum*, *Polysiphonia urceolata*, *Delesseria alata*, *Polysiphonia elongata*. (F. B. phot.

The *Laminaria hyperborea* association grows more or less densely in all suitable localities down to a depth of 10—15 fathoms[1] (Simmons gave 25 meters). Besides the above mentioned epiphytes,

[1] It is hardly probable that the *Laminaria hyperborea* should be found forming an association below this depth; but a single specimen may well be dredged now and then from a still greater depth.

which are common and peculiar to the *Laminaria hyperborea* itself, a number of large and some small algæ are found in the *Laminaria hyperborea*-association, where the latter is less abundant. Thus a rich growth of the *Alaria esculenta* is often found in places with a rapid current, down to a depth of about 5—6 fathoms. At about the same depth, I have found enormous specimens, a fathom long, of *Chorda tomentosa* in the rapid current where Haraldssund is narrowest.

On stones and rocks below and among the *Laminaria hyperborea*, we often meet with different red algæ e. g. *Porphyra miniata, Phyllophora Brodiæi, Odonthalia dentata*, and several of the algæ that grow epiphytically on *Laminaria hyperborea*. Lastly *Desmarestia aculeata* and *D. viridis* may be found abundantly down to a depth of about 10—15 fathoms. So far as may be judged from the dredgings, these algæ form often an almost pure *Desmarestia*-association.

The *Laminaria hyperborea*-association has already been mentioned in connection with the Færöes by Simmons, who likewise writes that the »*Laminaria hyperborea*-formation« is the most common on the coast of these Isles. It is indeed only absent where the bottom is sandy right up to the beach. With the exception that the epiphytic vegetation presents slight differences, the *Laminaria*-vegetation of the Færöes corresponds exactly with the *Laminaria*-formation on the west coast of Norway described by Boye (6, p. 5) and Hansteen (38, p. 351); compare also Ekman (17, p. 4—5 and p. 10). On the Shetland Isles I have had an opportunity of seeing a *Laminaria*-vegetation which corresponds with this association. Strömfelt does not give any special account of the Icelandic *Laminaria hyperborea*-association; but most likely a similar vegetation must be found on the southern and western coasts of Iceland.

The Lithoderma-Association.

On the coasts of the Færöes, I have not seen this association so typically developed as has been described by Kjellman (23, p. 66) and Rosenvinge (45, p. 223).

The reason is, probably, that the bottom in deeper water is otten of sand or mud and therefore destitute of plants. In the places where I found this association, the bottom was covered by pebbles. *Lithoderma fatiscens* grew here together with some other algæ, especially *Florideæ*, which made the vegetation look somewhat variegated.

Near Gliversnæs, at a depth of about 10—15 fathoms, on a bottom of pebbles and shells, a vegetation was found consisting of the following algæ: *Antithamnion Plumula, Polyides rotundus, Porphyra miniata, Phyllophora Brodiæi, Callophyllis laciniata, Ulva Lactuca, Ectocarpus Hincksiæ, Desmarestia viridis, Laminaria saccharina*, and the following crust-like algæ: *Lithoderma fatiscens, Peyssonnelia Dubyi*, and less abundantly, *Lithothamnion læve* and *Phymatolithon lævigatum*. The calcareous shells found among the pebbles had here, as everywhere in the sublittoral region, a green or reddish hue from the *Conchocelis rosea, Gomontia polyrhiza, Ostreobium Queketti* and *Hyella*. At Hvidenæs, at a depth of about 10 fathoms, a similar vegetation was found; yet the following algæ: *Odonthalia dentata, Delesseria sinuosa, Derbesia marina, Polysiphonia Brodiæi* and *P. elongata* occurred in addition to the majority of the above-mentioned algæ from Gliversnæs. This vegetation seems to correspond with Kjellman's and Rosenvinge's descriptions except for some floristical differences. The characteristic alga is however not so common on the coasts of the Færöes as in Greenland and in the »Murman Sea«.

In connection with this, we must also point out that the Færöes seem to be perfectly destitute of the *Lithothamnion*-formation elsewhere very common in the northern seas. With the exception of *Phymatolithon polymorphum*, which is very common on rocks from the lowest water mark downward into the sublittoral region, the *Lithothamnion*-species are relatively few on the Færöes. The specimens found there are, according to what Mr. Foslie kindly tells me, often stunted and badly developed. Most likely the reason is, that the bottom is in deep water most often of sand or mud, and therefore not suitable to the requirements of these algæ.

Simmons, who once dredged with me at Gliversnæs, gives a description of some of the algæ from that place (p. 257) yet without drawing any final conclusion as to the character of this vegetation.

The sublittoral Florideæ-Formation.

The brown algæ which grow deepest e. g. *Laminaria hyperborea* and *Desmarestia aculeata*, already become scarce at 15 fathoms, and most likely disappear at 20 fathoms. At this depth hardly anything but *Florideæ* are found. At the curve of 20 fathoms

the bottom on the coasts of the Færöes is most often of soft material, either sand or mud, and therefore destitute of plants. I have however happened to meet with some small stretches covered with plant-life. In Nolsöfjord, for instance, outside Gliversnæs, at a depth of 20—25 fathoms, I found a somewhat luxuriant vegetation on larger or smaller stones, quantities of which came up in the dredge together with the algæ.

The following species were found here: *Delesseria sinuosa, D. sanguinea, Callophyllis laciniata, Rhodophyllis dichotoma, Euthora cristata* and *Ptilota plumosa.* Among the algæ were several *Bryozoa* which had a more or less reddish hue from the *Rhodochorton membranaceum* and the *Rh. penicilliforme.* Small crusts of species of *Lithothamnion* also grew on the stones, but only imperfectly developed. The calcareous shells scattered among the stones had likewise a reddish hue from the *Conchocelis rosea* and the *Hyella cæspitosa* var. *nitida,* and some had become green from the *Ostreobium Queketti.* As may be seen from this enumeration, this vegetation was rather rich in species.

It must be pointed out further, that all the algæ, with the exception of the *Ostreobium*, were red, which agrees with the theory of Engelmann, (cp. Gaidukow, 35). If Nadson is right, as seems likely, in declaring that *Conchocelis rosea = Ostreobium Queketti,* all the algæ found here may justly be called red algæ, as it seems quite natural, that an alga which takes on, now a red, now a green hue, according to the surrounding conditions, may also be found in both forms at one time.

Below 25 fathoms the individuals became very weak and were overgrown by *Bryozoa*, and at a depth of 30 fathoms no algæ were found. In Klaksvig, I have found *Phyllophora Brodiæi* on pebbles, at a depth of about 20 fathoms.

Moreover it must not be forgotten that all these algæ are common North Atlantic sublittoral species, growing especially in the deeper parts of this region. No species characteristic for these depths have been found either here or anywhere else.

This association agrees with the sublittoral *Floridea*-formation found by Rosenvinge in Greenland (p. 222); floristically however it differs somewhat.

b. Sheltered Coast.

The Stictyosiphon-Association.

At the low water mark and below, and on non-tidal coasts directly below the surface of the sea to a depth of from 4 to 6 feet, in some places even still farther down, we meet with an association which consists of a great many different species of algæ. It corresponds to the *Corallina*-formation on exposed coasts; the *Corallina officinalis* is moreover often found scattered in the vegetation. On account of the great difference between the algæ belonging to this association, the colour of the vegetation varies greatly according to which algæ predominate at each place. It may be sometimes the *Ulvaceæ*, sometimes the brown, sometimes the red algæ. Their ample ramifications and bushy form are characteristic of the algæ which grow here. Where these marks are absent, they at least grow gregariously, in dense tufts. This tuft-like growth is also due perhaps to the fact, that this association grows on a stony bottom, especially on pebbles. Most often one stone carries one alga, its neighbour another.

Green algæ typical of this association are: *Enteromorpha Linza, Acrosiphonia albescens, Urospora Wormskioldii, Enteromorpha intestinalis, Monostroma fuscum* etc.; brown algæ: *Chordaria flagelliformis, Dictyosiphon foeniculaceus, Stictyosiphon tortilis, Scytosiphon lomentarius, Phyllitis fascia, Punctaria plantaginea,* different forms of *Ectocarpus litoralis*; *Ectocarpus siliculosus, Castagnea virescens, Chorda filum, Fucus inflatus*, and sometimes *Laminaria saccharina* and *Leathesia difformis* epiphytically on *Corallina officinalis.* Amongst the red algæ are: *Ceramium rubrum, Cystoclonium purpurascens, Rhodomela subfusca* and *R. lycopodioides, Polysiphonia Brodiæi* and *P. urceolata, Dumontia filiformis, Chondrus crispus, Rhodymenia palmata,* and, more rarely, *Halosaccion ramentaceum, Antithamnion floccosum* and *Laurencia pinnatifida.*

At Strender in Skaalefjord, which is not subject to high and low tides, this association is beautifully developed. There is a large flat area covered with shallow water, from 2 to 6 feet deep. In the immediate vicinity of the land, I found a rather broad belt of *Acrosiphonia albescens*, which was partly laid bare on the day when I visited the place, the water being extremely low and the weather fine and calm. Next to that, there came a variety of algæ of different colours, with the *Corallina officinalis* as a fairly frequent subvegetation. There were large, red tufts of *Ceramium rubrum, Rhodomela lycopodioides, Dumontia filiformis, Cystoclonium purpurascens* etc., together with some

brown tufts of *Dictyosiphon foeniculaceus*, *Chordaria flagelliformis*, *Stictyosiphon tortilis*, *Ectocarpus siliculosus* and *E. litoralis* together with gregarious growths of *Phyllitis fascia* and *Scytosiphon*. Among these darkish algæ the fresh green *Enteromorpha Linza* lightened up the vegetation, in which *Urospora Wormskioldii*, *Monostroma fuscum* and other green algæ were still intermingled. A little farther out in a few feet of water large specimens of *Laminaria saccharina* were found mixed with the association.

On the banks of the »Sundene« between Thorsvig and Kvalvig, a very similar vegetation is found. The bottom here is of sand with large stones and pebbles. From the lowest water mark down to a depth of from 3 to 6 feet we find an assemblage of algæ of many colours e. g. *Cystoclonium purpurascens*. *Castagnea virescens*, *Punctaria plantaginea*, *Ectocarpus siliculosus* and *E. litoralis*, *Dumontia filiformis*, *Chorda filum*, *Enteromorpha Linza* and several of the above mentioned species. At a short distance from the land, where the water is from 4 to 6 feet deep, the *Laminaria færoensis*-association covers the bottom.

Neither of the two above mentioned tracts are tidal, but a tidal locality with a similar vegetation from the lowest water-mark downwards to a depth of from 4 to 5 feet is found on the coast of the Vestmanhavn. This vegetation includes: *Monostroma fuscum*, *Ceramium rubrum*, *Porphyra miniata*, *Rhodymenia palmata*, large »clouds« of *Ectocarpus litoralis*, *Enteromorpha clathrata*, *Dumontia filiformis*, *Chorda filum*, the upper part of whose thallus floats on the surface of the water, and many more.

In Vestmanhavn and likewise in Klaksvig, where the vegetations much resemble each other, *Halosaccion ramentaceum*, otherwise very rare in the Færöes, is found. In Klaksvig it grows abundantly on stones to a depth of a few feet at low water, and it is most often much overgrown by green algæ e. g. *Enteromorpha*, *Acrosiphonia*, etc.

In the Danish edition I have called this association »The variegated Association«, because of its very motley appearance, due to the many different species which belong to it. But as this name has already, as pointed out by me (10, p. 70), been used by Kjellman (45, p. 24) I have found it more convenient to change the name, since the association of the Færöes is quite different from that of Bohuslän.

According to my definition of this association, it may perhaps partly agree with the Ulvaceenformation described by Simmons (p. 251). He at least says so himself (66, p. 174); but it seems to me, that his formation agrees mostly with the *Monostroma-Enteromorpha*-association mentioned below. Simmons declares, however, that his formation belongs to the littoral region, though he remarks that it may be found as far down as about 2 meters below ebb mark. Referring here to my statement on p. 710 I need only mention, that it seems very unnatural to call a vegetation littoral, when it is found below the lowest water mark in a locality subject to ebb and tide, and on the whole below the littoral algæ-vegetation, even though most of these algæ may also be found in the littoral region.

According to the descriptions of the algæ-associations on the coasts of Norway, I think, that this association shows no small similarity to the *Dictyosiphon-*, *Spermatochnus-* and *Corallina*-formations, described by Boye.

The Monostroma-Enteromorpha-Association.

This association reaches from the surface of the sea down to a depth of a few fathoms. The transition from the previously mentioned association is often smooth, as the *Chlorophyceæ* under certain conditions gradually become predominant. The association is especially luxuriant in the bottom of the fjords, where the outflow of the rivers turns the water more or less brackish. It mostly grows on a bottom of stones or gravel in shallow water, but it may also be found drifting on the surface of the sea.

Among the species characteristic of this association *Monostroma fuscum* ought to be mentioned, as it is often predominant and may be found as a pure facies covering large spaces of the bottom. Usually, various species of *Enteromorpha*, especially *E. clathrata* and forms of *E. intestinalis*, are, however, intermingled. The latter species may grow in the freshest water, especially var. *genuina* and var. *prolifera* which often form large entangled masses at the mouths of rivers, for instance in Kalbakbotn.

Further, varieties of *Monostroma undulatum* are found in the association. In Klaksvig, in the direct vicinity of the land, great numbers of *Chætomorpha tortuosa* and an *Acrosiphonia* spec. are found, besides the above-mentioned algæ.

Together with *Ectocarpus litoralis* these algæ form tough, entangled, loose-lying masses in shallow water. Besides these algæ we find *Chorda filum, Scytosiphon lomentarius, Ceramium rubrum, Halosaccion ramentaceum* and sometimes also other species belonging to the above mentioned *Stictyosiphon*-association. As already mentioned this association together with the *Stictyosiphon*-association perhaps answers to Simmons's Ulvaceenformation.

The Halidrys-Association.

As this association is but rarely found at the Færöes, it is of minor importance there. It has only been found attached to the bottom within a very limited region at Glibre in Skaalefjord on Østerö, but as this alga is rather abundant in this locality and agrees quite well with Hansteen's (38, p. 353), Boye's (6, p. 8) and Gran's (36, p. 19) descriptions of their *Halidrys*-formation, I think that it ought to be mentioned here. It grows here on a stony bottom at a depth of from $^1/_2$ to 1 fathom, forming a narrow belt at no great distance from the coast. The specimens are enormous, almost one fathom long. It grows together with scattered specimens of *Laminaria digitata, L. hyperborea* and *L. fœroensis* and *Chorda filum*.

When I visited the tract in May 1898, I found several small specimens of *Punctaria latifolia, Chordaria flagelliformis, Ectocarpus litoralis, Stictyosiphon foeniculaceus, Dictyosiphon* and a great many Diatoms growing epiphytically on the *Halidrys*.

In August (?) Simmons found it densely overgrown by *Dictyosiphon hippuroides;* he therefore calls it »the *Halidrys-Dictyosiphon*-formation«.

The Laminariaceæ-Formation on sheltered coasts.

The *Laminariaceæ*-formation varies much on sheltered coasts. Where there is no current, *Laminaria fœroensis* grows abundantly, forming widely spread associations. But where there is a rapid current, as in most sounds between the islands, *L. fœroensis* is wanting and is replaced chiefly by *L. hyperborea*.

Let us first consider the *Laminaria fœroensis*-association which grows on sheltered coasts. This alga necessarily requires a habitat where the sea is never disturbed. The large lamina which is often several fathoms long and easily broken would soon be torn by the surf. The slender haptera and the brittle stalk would not long be able to resist the strain caused by the current.

I have found this association at its finest development in the Sounds between Strömö and Österö, and especially between Thorsvig and Kvalvig. The tides are wanting here, consequently there is no current, and even during a storm the water is only slightly troubled in this narrow sound. Huge specimens of *L. fœroensis* grow abundantly here in shallow water near the coast forming dense »forests«.

The stalk which is often nearly two fathoms long and thin below, is fastened by several haptera to stones on the bottom. Its uppermost part is thick, hollow and full of air; it often measures some inches in diameter and serves as an air-bladder. These may be seen side by side on the surface of the water, the huge lamina hanging down from them. This agrees perfectly with Rosenvinge's description (71, p. 211) of *L. longicruris* on the coasts of Greenland, which species in the whole mode of its life seems to be closely related to *L. fœroensis*.

L. fœroensis fructifies in summer, and probably then reaches its highest development. The changing of the lamina is hardly restricted to any special season. According to my observations it may be supposed, that the lamina grows more or less evenly for the greater part of the year, and gradually decays at the apex.

As mentioned before, *Laminaria fœroensis* grows down to a depth of about 10 fathoms; in deep water it is, however, most often somewhat smaller. Far out in the fjords, where there is some current and more troubled water, the lamina becomes narrower, almost lanceolate and the stalk less swelled. I call this form f. *saccharinifformis*, as it is very much like *L. saccharina*, from which it may, however, be easily distinguished by its hollow stalk.

The stalks of *L. fœroensis* are generally without epiphytes. According to Rosenvinge (l. c. p. 212), this is also most often the case with *L. longicruris* in Greenland. In »Sundene«, in shallow water, I have however sometimes met with plants with the stalks densely overgrown with some green and brown algæ, e. g. *Monostroma fuscum*, *Ectocarpus litoralis*, *Ectocarpus* spec., etc. The stones on which it grows are likewise often covered by large, dark red crusts of *Cruoria pellita*. In deep water various red epiphytes, e. g. *Polysiphonia urceolata, Lomentaria clavellosa, Ptilota plumosa, Delesseria sinuosa*, etc. are also found on the stalk. It very commonly occurs also, that young specimens of *Laminaria fœroensis* are attached to the stalks of old specimens. In deeper water the *Laminaria*

hyperborea is often found in the association. The lamina of *L. hyperborea* in this sheltered place is often only slightly divided, sometimes even perfectly whole as with f. *cucullata* of *L. digitata*, which species may also be found belonging to the association especially in shallower water.

The *Laminaria færoensis*-association has also been found at the bottom of Trangisvaag and Vaagfjord on Syderö, and in Kalbakfjord and Kollefjord on Strömö, and in Skaalefjord on Österö, that is, in the most sheltered localities, but nowhere so luxuriantly developed as in the »Sundene«.

This vegetation is however quite wanting in places where there is a current or surf from the sea. Here we find a *Laminaria hyperborea*-association which essentially resembles that of exposed coasts. The rapid current makes up for the troubled sea and constantly carries clean water to the algæ. In these conditions we therefore find an epiphytical vegetation on the stalk of *L. hyperborea*, as luxuriant and well developed as on exposed coasts. *Laminaria digitata* is often found intermingled in the upper part of the association, and both here and lower down *Laminaria saccharina* and *Alaria esculenta* may be found.

Simmons mentions a *Laminaria longicruris*-formation (78, p. 256) which he calls this association, following my former determination of *Laminaria færoensis*.

The Desmarestia-Association.

Here and there, where the bottom is stony, at a depth of about 10 fathoms, we find an association which mainly consists of *Desmarestia aculeata* with *Desmarestia viridis* intermingled. To judge from the dredgings, this association was well developed at the entrance of the gulf at Klaksvig, where it has also been observed by Simmons. *Phyllophora Brodiæi*, *Polyides rotundus*, *Porphyra miniata*, *Antithamnion Plumula*, and some few *Laminaria saccharina* and *L. hyperborea* were also found here on stones. Simmons mentions *Ph. rubens* and *Ph. membranifolia* in this locality, but my observations (8, p. 358) indicate that this must certainly be a mistake. In the »Sundene« I have met with a similar *Desmarestia*-association; and *Porphyra coccinea* was found growing on *Desmarestia aculeata* which may be perfectly hidden by this beautiful, little rosy alga.

On the coasts of the Færöes this *Desmarestia*-association is attached to the bottom, even in sheltered places. Some loose speci-

mens may of course be sometimes found, but not in great numbers, what is, however, the case on the coasts of Greenland, according to Rosenvinge (71, p. 218). The name »formation of loose-lying Algæ« may in the Færöes only be used of the above mentioned loose masses of algæ, which mainly consist of species of *Enteromorpha, Chætomorpha tortuosa, Acrosiphonia, Monostroma,* etc.

The Vegetation on soft bottom. The Zostera-Association.

With the exception of the *Characeæ*, which may be found in brackish water, algæ from the northern seas will not usually thrive on a bottom of sand or mud[1], which is therefore destitute of vegetation. Only here and there, where stones are found, may algæ be met with, but as a soft, loose bottom is rather common in the sounds between the islands and in the fjords, at any rate in deep water, somewhat large, naked regions occur with only a few loose drifting algæ. What makes the tracts still more naked is, that the *Zostera marina*, which has its habitat in shallow water (down to a depth of from 6 to 7 fathoms in our seas) in this kind of ground with loose bottom, is almost totally wanting at the Færöes. It has only been found at the bottom of Vaag Fjord. In a small limited territory it makes an association here at a depth of about 1 fathom, and at low tide, its leaves may be seen floating on the surface of the sea. The *Zostera* here as elsewhere shelters a number of different epiphytes, e. g. species of *Enteromorpha, Ectocarpus litoralis, Chantransia virgatula* and *C. secundata, Microsyphar Zosteræ, Scytosiphon lomentarius*, and so forth.

3. The lower limit of the Algæ-vegetation. The elittoral Region.

As mentioned before, I agree with Rosenvinge in determining the elittoral region as that part of the bottom of the sea where no vegetation grows on the bottom; I shall therefore leave this region out of consideration. At far greater depths than those at which the fixed algæ grow, we may of course find loose-lying algæ which have been carried by the current away from their habitats. Such portions of algæ may perhaps live for some time by consuming their reserve stores, but when these are used up they must

[1] In the tropics however we find an algæ-vegetation which is often quite dense and fastened on a bottom of sand or mud.

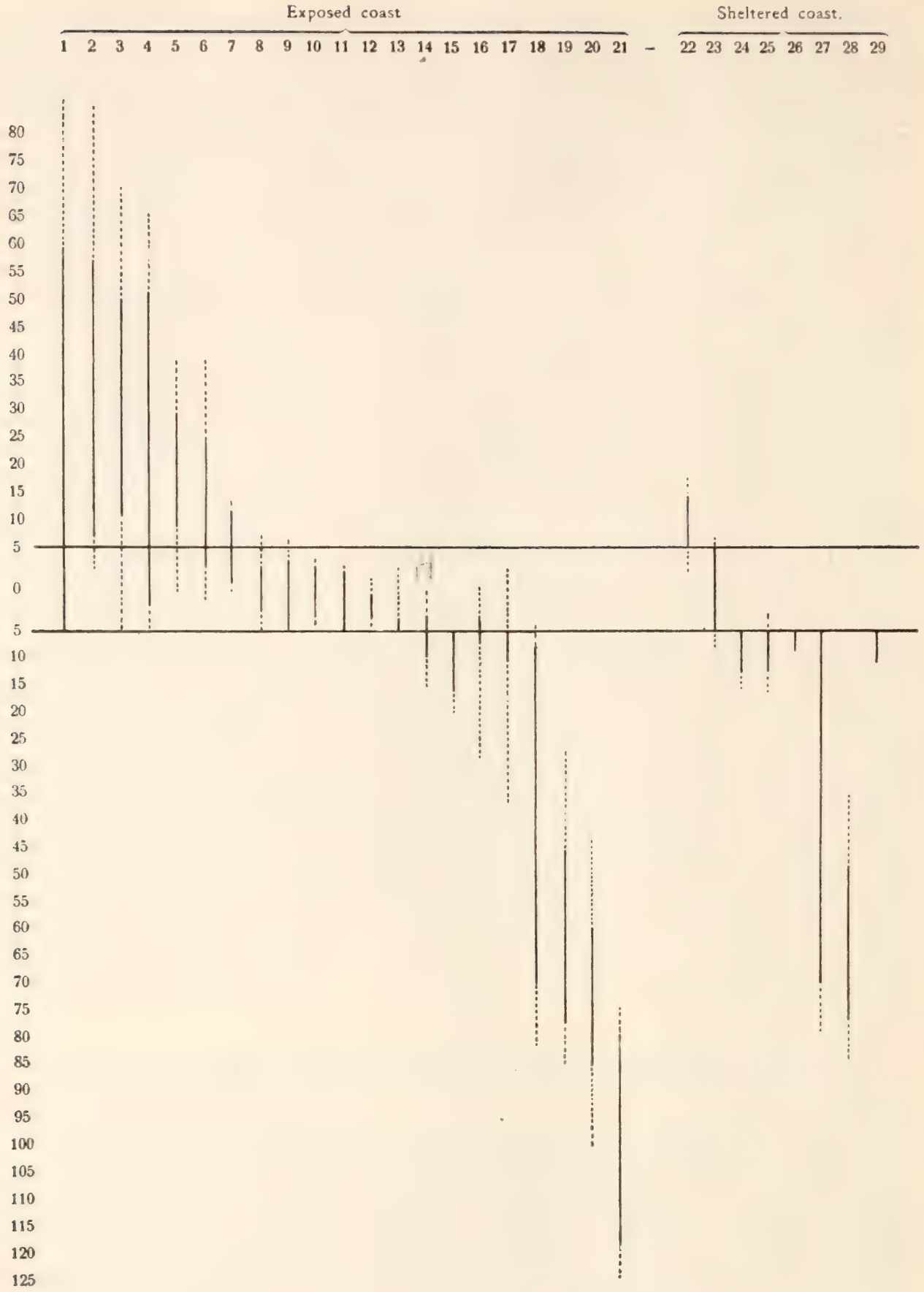
of course perish. They are, however, of no importance for the determination of the lowest depth at which the algæ-vegetation may be found; in this connection we are only interested with the fixed algæ-vegetation. It is, however, difficult to determine how deep this limit is. It varies much in the different seas and depends on how far down a sufficient amount of light may reach. The light reaches farthest down in the tropics, where the rays of the sun strike the surface of the sea almost vertically. In higher latitudes the rays strike the surface more and more slantingly, and therefore do not reach so far down. According to Berthold, a rich vegetation of deep water algæ was still found at a depth of about from 120 to 130 metres in the gulf at Naples, and according to Rodriguez, the very lowest limit of the vegetation is 160 meters at Minorca (compare Sauvageau: Remarques sur les Sphacélariacées, p. 235). In the tropics the algæ-vegetation probably grows at a still greater depth.

According to Rosenvinge, the lower limit of the algæ-vegetation in Greenland is about the curve of from 20 to 30 fathoms. As I have before indicated, this almost agrees with what has been observed at the coasts of the Færöes. Naturally, local conditions often cause the vegetation to disappear above this depth; there may for instance be plenty of Plankton, or the bottom may at a certain depth turn into mud or sand, which makes it unfit for the algæ. This is perhaps the case on the coasts of Bohuslän, where the algæ-vegetation, according to Kjellman, hardly grows any farther down than a depth of 20 fathoms.

III.

GENERAL CHARACTER OF THE ALGÆ-VEGETATION.

Upon the whole the algal vegetation on the Færöese coasts must be considered specially vigorous and luxuriant. That stunted forms may be found in unfavourable localities, such as the upper part of the beach or the heads of inlets, where the water becomes brackish or almost fresh, is of no consequence in comparison with the luxuriance which otherwise characterizes the vegetation. We could not easily imagine any locality better fitted for developing a vigorous algæ-vegetation than the Færöes, where the nature of the coast, the situation in the midst of a large ocean, and the climate, all serve to facilitate the growth of the algæ.



Explanation of the diagram:

The accompanying diagram will serve to display the occurrence of the different algæ-formations and algæ-associations on the coasts of the Færöes. The numbers to the left indicate the number of feet respectively above

or below the sea level at middle height of the water (0). The beach, which is represented by the distance between the two horizontal lines, is somewhat enlarged, in order to make it more distinct. The vertical lines indicate the level at which each algæ-formation and association mostly occurs, the dotted parts of the lines that they may be found beyond this level, though more scattered.

The numbers above the vertical lines indicate as follows:

1. *Hildenbrandia*-Formation with lichens.
2. *Chlorophyceæ*-Formation on exposed coast.
   Prasiola crispa-Association. *Rhizoclonium*-Association. *Enteromorpha*-Association. *Prasiola stipitata*-Association.
3. *Porphyra*-Association.
4. *Rhodochorton*-Association.
5. *Bangia-Urospora*-Association.
6. *Fucaceæ*-Formation on exposed coast.
   Fucus spiralis-Association. *Fucus inflatus*-Association.
7. *Callithamnion*-Association.
8. *Rhodymenia*-Association.
9. The littoral *Corallina*-Formation.
10. *Monostroma-Grevillei*-Association. } These four associations belong to the littoral *Corallina*-Formation.
11. *Acrosiphonia-Polysiphonia*-Association. }
12. *Gigartina*-Association }
13. *Himanthalia*-Association. }
14. *Phymatolithon*-Association.
15. The sublittoral *Corallina*-Formation.
16. *Laminaria digitata*-Association } *Laminariaceæ*-Formation on exposed coast.
17. *Alaria*-Association. }
18. *Laminaria hyperborea*-Association } *Laminariaceæ*-Formation on exposed coast.
19. *Desmarestia*-Association on exposed coast.
20. *Lithoderma*-Association.
21. The sublittoral *Florideæ*-Formation.
22. *Chlorophyceæ*-Formation on sheltered coast.
    Enteromorpha-Association.
23. *Fucaceæ*-Formation on sheltered coast.
    Pelvetia-Association. *Fucus vesiculosus-Ascophyllum*-Association. *Fucus inflatus*-Association.
24. *Stictyosiphon*-Association.
25. *Monostroma-Enteromorpha*-Association.
26. *Halidrys*-Association.
27. *Laminariaceæ*-Formation on sheltered coast.
    Laminaria færoensis-Association. *Laminaria hyperborea*-Association.
28. *Desmarestia*-Association on sheltered coast.

(29. *Zostera*-Association.)

Lastly, it should be pointed out, that the heights refer to the coast as a whole, not to any special locality; thus the space within which an association may be found is represented larger than would be the case if we examined any single locality.

From even far above the highest water mark down to a depth of about 15 fathoms, we may often find a dense, well developed algal vegetation, which is divided naturally by the tides into two regions: the littoral and the sublittoral. At few places is there, I think, a littoral vegetation so luxuriant as that of the Færöes. This is certainly due in the first place to the very favourable climate, secondly to the situation in the open sea, where the surf constantly washes on the coast and thus enables the algæ to grow far above the highest water mark. Nevertheless the vegetation of exposed coasts hardly ever becomes as luxuriant as the *Fucaceæ*-vegetation in more sheltered places. But even this abundant, littoral vegetation is far surpassed by the sublittoral vegetation of the *Laminariaceæ* which covers a large area of the bottom of the sea with »forests« of almost a man's height, and a vigorous undergrowth of epiphytes.

As almost everywhere in the cold temperate seas, the brown algæ predominate in size as well as in number on the coasts of the Færöes, both in the sublittoral region with its *Laminariaceæ* and other algæ sheltered by these, and also in the littoral. As to the latter, this is only the case, however, so far as the *Fucaceæ*-vegetation of sheltered coasts is concerned, on exposed coasts the vegetation becomes more varied, both red, brown and green algæ crowd together, and sometimes green algæ, e. g. *Enteromorpha* and *Acrosiphonia*, sometimes red, e. g. *Porphyra* and *Rhodymenia* predominate over large tracts. Even in the size of the plants, the red algæ may rival the brown algæ. With the exception of some *Laminariæ* and *Alariæ* which in favourable places sometimes extend into the littoral region, only *Himanthalia* attains any considerable height.

In connection with this brief description of the general character of the algal vegetation I endeavour to give in the diagram above a general view of the different algæ-formations and algæ-associations, the different levels at which they occur, and the manner in which they replace each other; thus, it will be clearly seen that the number of algæ-associations reaches its height in the littoral region and then gradually decreases on each side.

IV.

THE PHYTO-GEOGRAPHICAL POSITION OF THE ALGÆ-FLORA OF THE FÆRÖES.

I. The constituent parts of the Færöese Algæ-flora.

Before entering on a comparison between the marine algæ-flora of the Færöes and that of neighbouring countries, we may first of all review the species occurring at the Færöes.

In my paper on the Færöese marine algæ 212 species are mentioned, with 4 whose genus only was determined. On renewed investigation, however, I have come to the conclusion that one of the latter, *Chilionema* spec. may be referred to *Ch. reptans.* Thus we have 213 + 3 species. From this number, again, *Dermatolithon Corallinæ* (see my »Flora« p. 402) must be withdrawn as, according to Mr. Foslie's latest investigations, kindly placed at my disposal, it should be referred to *Dermatolithon macrocarpum,* or, as he now calls it, *Litophyllum macrocarpum.* Moreover *Acrosiphonia Binderi* must be omitted, renewed examination of the present material having proved that some imperfectly developed curved branches occur, though but rarely, and this convinces me that it should be referred to *A. albescens.*

Thus the number is reduced to 211 + 3, but to these must be added *Choreolax Polysiphoniæ,* which I have discovered later[1].

In order to give a general view of the 212 + 3 species, and in order to discuss more closely the elements of which the Færöese algæ-flora consists, I have divided them, in accordance with the division made by Jónsson and myself (12, page XV—XXI), into the 4 groups: the subarctic, the boreal-arctic, the cold-boreal and the warm-boreal group (the arctic group is entirely wanting in the Færöes). As to the limitation of these groups, I may refer the reader to the above-mentioned paper. It should not be forgotten, however, that any such division must inevitably suffer from a certain

[1] Besides these alterations, the name of the species, or of the genus, or of both have been altered in the following list of Færöese algæ in the case of the following species: *Clathromorphum circumscriptum* which, according to Mr. Foslie, should be referred to *Phymatolithon compactum, Acrosiphonia flaccida,* which I refer to *A. hystrix* (Strömf.) Börgs., as already pointed out by me (8, p. 512). The form which I gave provisionally as *Spongomorpha lanosa,* and which I supposed to be related to *Sp. bombycina* (Kjellm.), I have found on renewed examination to be *Spongomorpha vernalis.*

arbitrariness, partly because we know so very little as yet about the distribution of many algæ, partly because several algæ are distributed so as to make it almost equally justifiable to refer them to different groups. Whilst Reinke and Kuckuck leave the *Chlorophyceæ* and the *Cyanophyceæ* out of consideration, as our knowledge of these plants is especially defective, I side with Rosenvinge's opinion, however, that it is more correct to mention them here, as the species belonging to these orders are as important from a phytogeographical point of view as those of the *Rhodophyceæ* and *Phæophyceæ*. The species hitherto found only on the Færöes are all referred to the cold-boreal group.

SUMMARY OF THE FÆRÖESE MARINE ALGÆ.

I. Rhodophyceæ.

83 species.

A. The arctic group.

0 species.

B. The subarctic group.

Subdivision 1. 6 species.

Rhodophyllis dichotoma.
Halosaccion ramentaceum.
Ptilota pectinata.
Rhodochorton penicilliforme.
Phymatolithon compactum.
Lithothamnion læve.

Subdivision 2. 14 species.

Porphyra miniata.
Conchocelis rosea.
Chantransia efflorescens.
— virgatula.
Harveyella mirabilis.
Phyllophora Brodiæi.
Actinococcus subcutaneus.
Euthora cristata.
Rhodymenia palmata.
Delesseria sinuosa.
Rhodomela lycopodioides.
Odonthalia dentata.
Ptilota plumosa.
Lithothamnion glaciale.

C. The boreal-arctic group.

10 species.

Bangia fuscopurpurea.
Porphyra umbilicalis.
Chantransia secundata.
Ahnfeltia plicata.
Polysiphonia elongata.
Antithamnion Plumula.
Ceramium rubrum.
Rhodochorton membranaceum.
— Rothii.
Hildenbrandia rosea.

D. The cold-boreal group.

38 species.

Erythrotrichia ceramicola.
Porphyra coccinea.
Chantransia Alariæ.
— Daviesii.
Choreocolax Polysiphoniæ.
Gigartina mamillosa.
Phyllophora membranifolia.

Callocolax neglectus.
Sterrocolax decipiens.
Cystoclonium purpurascens.
Lomentaria rosea.
Delesseria alata.
— sanguinea.
Polysiphonia urceolata.
— violacea.
— fastigiata.
— atrorubescens.
— nigrescens.
Rhodomela subfusca.
Callithamnion polyspermum.
— arbuscula.
Plumaria elegans.
Antithamnion floccosum.
Ceramium acanthonotum.
Rhodochorton seiriolanum.
Dumontia filiformis.
Furcellaria fastigiata.
Polyides rotundus.
Cruoriella Dubyi.
Rhododermis elegans.
Phymatolithon lævigatum.
— polymorphum.
Lithothamnion Lenormandi.
Lithophyllum Crouani.
— incrustans.
— macrocarpum.
— hapalidioides.
Corallina officinalis.

E. The warm-boreal group.

15 species.

Porphyra leucosticta.
Chondrus crispus.
Callophyllis laciniata.
Lomentaria clavellosa.
— articulata.
Plocamium coccineum.
Nitophyllum laceratum.
Laurencia pinnatifida.
Polysiphonia Brodiæi.
Pterosiphonia parasitica.
Griffithsia setacea.
Callithamnion scopulorum.
— corymbosum.
— granulatum.
Cruoria pellita.

II. Phæophyceæ.

72 species.

A. The arctic group.

0 species.

B. The subarctic group.

Subdivision 1. 8 species.

Lithoderma fatiscens.
Sorapion Kjellmani.
Myrionema globosum.
Ectocarpus æcidioides.
Spacelaria britannica.
Chætopteris plumosa.
Laminaria færoensis.
Alaria Pylaii.

Subdivision 2. 17 Arter.

Ralfsia clavata.
Ectocarpus tomentosoides.
Leptonema fasciculatum.
Elachista fucicola.
Punctaria plantaginea.
Isthmoplea sphærophora.
Litosiphon filiforme.
Stictyosiphon tortilis.

Dictyosiphon hippuroides.
— foeniculaceus.
Desmaresta viridis.
— aculeata.
Chordaria flagelliformis.
Chorda filum.
— tomentosa.
Laminaria digitata.
Fucus inflatus.

C. The boreal-arctic group.
7 species.

Ectocarpus littoralis.
— confervoides.
— siliculosus.
Scytosiphon lomentarius.
Phyllitis fascia.
Fucus vesiculosus.
Ascophyllum nodosum.

D. The cold-boreal group.
35 species.

Petroderma maculiforme.
Ralfsia verrucosa.
Myrionema vulgare.
— Corunnæ.
— foecundum.
— færoense.
— speciosum.
Chilionema reptans.
Microsyphar Polysiphoniæ.
— Zosteræ.
Ectocarpus Stilophoræ.
Ectocarpus velutinus.
— lucifugus.
— tomentosus.
— dasycarpus.
— fasciculatus.
— granulosus.
— Hincksiæ.
Elachista scutulata.
Sphacelaria cæspitula.
— furcigera.
— cirrhosa.
Cladostephus spongiosus.
Desmotrichum undulatum.
Litosiphon Laminariæ.
Phæostroma parasiticum.
Phyllitis zosterifolius.
Dictyosiphon Ekmani.
Castagnea virescens.
Laminaria saccharina.
— hyperborea.
Alaria esculenta.
Fucus spiralis.
Pelvetia canaliculata.
Himanthalia lorea.

E. The warm-boreal group.
5 species.

Punctaria latifolia.
Asperococcus echinatus.
Desmarestia ligulata.
Leathesia difformis.
Halidrys siliquosa.

III. Chlorophyceæ.
44 species.

A. The arctic group.
0 species.

B. The subarctic group.
Subdivision 1. 6 species.

Chlorochytrium inclusum.
Monostroma undulatum.
— fuscum.
Ulothrix consociata.
— pseudoflacca.
Acrosiphonia hystrix.

Subdivision 2. 18 species.

Codiolum gregarium.
Percursaria percursa.
Monostroma Grevillei.
Ulothrix flacca.
Bolbocoleon piliferum.
Pilinia maritima.
Ulvella fucicola.
— confluens.
Pringsheimia scutata.
Urospora mirabilis.
— Wormskioldii.
Chætomorpha Melagonium.
Spongomorpha vernalis.
Acrosiphonia incurva.
Cladophora rupestris.
— sericea.
Ostrobium Queketti.
Vaucheria coronata.

C. The boreal-arctic group.
7 species.

Enteromorpha intestinalis.
— clathrata.
Ulva Lactuca.
Chætomorpha tortuosa.
Rhizoclonium riparium.
Cladophora gracilis.
Gomontia polyrhiza.

D. The cold-boreal group.
11 species.

Codiolum pusillum.
Prasiola crispa *marina.
— furfuracea.
— stipitata.
Endoderma Wittrockii.
Acrochæte repens.
Acrosiphonia albescens.
— flagellata.
— grandis.
Derbesia marina.
Valonia ovalis.

E. The warm-boreal group.
2 species.

Enteromorpha Linza.
Bryopsis plumosa.

IV. Cyanophyceæ.

13 species.

A. The arctic group.
0 species.

B. The subarctic group.

Subdivision 1. 0 species.

Subdivision 2. 1 species.

Pleurocapsa amethystea.

C. The boreal-arctic group.
3 species.

Spirulina subsalsa.
Calothrix scopulorum.
Rivularia atra.

D. The cold-boreal group.
2 species.

Dermocarpa Farlowii.
Hyella endophytica.

E. The warm-boreal group.
7 species.

Chlorogloea tuberculosa.
Dermocarpa violacea.
Hyella cæspitosa.
Phormidium autumnale.
Lyngbya lutea.
Microcoleus tenerrimus.
Calothrix æruginea.

It is clear from this summary that the *Rhodophyceæ* are most numerous, contributing almost $^2/_5$ of all the species collected. The *Phæophyceæ* are a little less numerous, about $^1/_3$ of all the marine algæ-species of the Færöes; next come the *Chlorophyceæ*, which only amount to a little above $^1/_5$, and lastly the *Cyanophyceæ*, of which only a few species have been collected.

Rosenvinge (71, p. 173) has given a summary in per centages of the number of species belonging to each of the four classes of algæ, as they occur in the algæ-floræ of Greenland, the British Isles and in the Spanish-Canary region. If the numbers that represent these groups in the Færöese algæ-flora are placed in this summary, and if, at the same time, the numbers representing the Greenland algæ are altered to agree with the latest contributions concerning the latter, and the numbers from the British Isles are calculated from Batters's latest list (4), the result will be as follows:

	Greenland	The Færöes	The British Isles	The Spanish-Canary Reg.
Rhodophyceæ	26.0 %	38.6 %	42.3 %	60.4 %
Phæophyceæ	40.0 %	34.0 %	27.8 %	18.7 %
Chlorophyceæ	30.0 %	20.9 %	17.9 %	14.8 %
Cyanophyceæ	6.0 %	6.5 %	12.0 %	6.1 %
Total number of species	169	215	744	492

As clearly shown by the figures, the Færöes hold an intermediate position between Greenland and the British Isles; the *Rhodophyceæ*, which are in the majority in England, to say nothing of the Spanish-Canary region, are still predominant on the Færöese coasts; whereas the *Phæophyceæ*, which are vastly in the majority in Greenland almost reach to the same number.

The *Chlorophyceæ* likewise hold an intermediate position as regards number of species between the British Isles and Greenland, where they are relatively more numerous; the same may be said of the *Cyanophyceæ*, only inversely, as these are more numerous in the British Isles and less numerous in Greenland. That only a relatively small number of the latter have been found in the Spanish-Canary region, is certainly due to the fact that this region (as regards the *Cyanophyceæ*) has hitherto been but very little investigated.

It is, on the whole, a well-known fact that the *Phæophyceæ*

predominate in the northern countries both in growth[1] and in number of species (see Rosenvinge's table 71, p. 174); whether the same may be said of the *Chlorophyceæ*, as the table above seems to indicate, appears to me, however, rather doubtful. At any rate they are very numerous in the littoral and the upper sublittoral regions of the West-Indies and seemingly predominate there[2].

After these remarks we may consider how the Færöese species are grouped in the above-mentioned five groups. We have the following result:

0	arctic species or	0 %
70	subarctic species or	32.55 %
27	boreal-arctic - -	12.55 %
89	cold-boreal - -	41.4 %
29	warm-boreal - -	13.5 %

It is clear from this table that the cold-boreal species are in the majority in the Færöes, as not far from one half of the Færöese algæ belongs to this group. Next to that come the subarctic species, including nearly one third of all the Færöese algæ. Of species occurring in more southern regions, the warm-boreal species, the Færöes have a little more than 13 %; almost the same number of species must be referred to the boreal-arctic group, which is, however, of less interest from this point of view, as all these species are widely spread and often ubiquitous, and at any rate common in all five groups.

If we leave the *Chlorophyceæ* and *Cyanophyceæ* out of consideration, as they possibly make the result less reliable, the result is nevertheless much the same. 156 red and brown algæ in all are found at the Færöes; that is:

45	subarctic species or	28.9 %
17	boreal-arctic - -	10.9 %
74	cold-boreal - -	47.4 %
20	warm-boreal - -	12.8 %

In order to show more plainly in which of the surrounding countries we meet with an algæ-flora having a composition very closely connected to that of the Færöes, and to demonstrate the

[1] Cf. Kjellman, F. R., Ur polarväxternes lif (Nordenskiöld, Studier och Forskningar, p. 544).

[2] Cf. Kjellman, F. R., l. c. p. 540 where he says: »Ett utmärkande drag för algvegetationen i Ishafvet är fattigdomen på gröna alger«.

phyto-geographical position of this flora on the whole, I give a summary of the *Rhodophyceæ* and *Phæophyceæ* of these countries in the following table; the numbers are taken from the table prepared by Jónsson and myself (12, p. XXII)[1].

Rhodophyceæ and *Phæophyceæ*	Scotland	West Norway	The Shetl. Isles	The Færöes	Nordland	South West Iceland	Finmark	North East. Iceland	The Murman Sea	West Greenland
Number of Species	184+128 = 312	101+89 = 190	49+38 = 87	83+72 = 155	70+53 = 123	65+60 = 125	65+60 = 125	45+55 = 100	37+35 = 72	41+63 = 104
arctic	»	0.5	»	»	0.8	1.6	5.5	8.9	15.3	17.3
subarctic 1	3.8	3.16	«	8.9	9.7	15.2	16.6	18.8	18.0	26.0
— 2	9.9	14.2	17.2	20.0	16.2	24.0	23.8	*29.7*	*30.0*	*27.8*
boreal-arctic ...	5.7	8.4	16.0	11.0	13.0	13.6	14.3	15.8	18.0	16.3
cold-boreal.....	25.8	*38.0*	*40.0*	*47.1*	*49.6*	*38.4*	*36.5*	25.7	18.0	12.5
warm-boreal 1 .	6.7	9.47	18.4	13.0	10.6	6.4	4.0	0.9	»	»
— 2 .	*28.4*	26.3	8.0	»	»	0.8	»	»	»	»
— 3 .	19.0	»	»	»	»	»	»	»	»	»

It is evident from this table, that the Færöes come next to the Shetland Isles and Nordland. Scotland has a considerable percentage of warm-boreal species, no arctic and only very few subarctic species. West Norway has a much smaller number of warm-boreal, ½ % of arctic (*Turnerella Pennyi* found in Trondhjemsfjord by Foslie), and a little higher percentage of subarctic species. The Shetland Isles likewise have a smaller number of warm-boreal species, but apparently an equally large number of subarctic species as West Norway; this is, however, certainly due to the fact, that these Isles have not been sufficiently investigated, for it is clear, that if the subarctic group 1 is represented by 3.8 % in Scotland, it must reach to the same amount at least in the Shetland Isles, where none of these species have been found hitherto. Of the Færöese algæ, only 13 % are warm-boreal, almost one half are cold boreal and 29 % subarctic. Nordland has not quite so many warm-boreal species, that is, only a little more than 10 %; one half of the species are cold-boreal; the subarctic group is a little smaller than at the Færöes, but on the other hand a small arctic element is found here. In

[1] The numbers belonging to the Færöes differ a little from those above, as *Ectocarpus* spec. is left out of consideration here.

South West Iceland, the warm-boreal group is again reduced (to a little more than 7 %) and the cold-boreal group is likewise diminished; on the other hand the subarctic group is much increased amounting to more than 39 %, and here we meet with almost 2 % of arctic species. If only South Iceland is taken into consideration, however, the agreement with the Færöes becomes still more evident, as arctic species are totally wanting and the subarctic group is much reduced in numbers. As Jónsson, however, is preparing a paper on the Icelandic algæ-vegetation in which he intends to give a further account of the different smaller groups into which the algæ-flora of Iceland is naturally divided, I shall not enter on this matter here, the more so, as this examination requires a very thorough knowledge of the algal vegetation of Iceland. In Finmark the warm-boreal group is further reduced (to 4 %) and the cold-boreal is likewise a little reduced; the subarctic group is only a little richer in species than that of South West Iceland, but here we meet with $5^1/_2$ % of arctic species. In North East Iceland, we see that the warm-boreal species do not even reach to 1 %; the cold-boreal species are considerably reduced; the subarctic group amounts to almost one half (48.5 %) of the algæ of this area, and lastly, almost 9 % of arctic species are found here. On the coasts of the Murman Sea, no warm-boreal species are found, and only 18 % of cold-boreal species; almost one half (48 %) are subarctic, and there are more than 15 % of arctic species. Lastly, as to West Greenland, warm-boreal species are likewise totally wanting; there are only 12.5 % of cold-boreal species, more than one half of all the species are subarctic (53.8 %), and more than 17 % arctic.

As will be clearly seen from the table, the Færöes and Nordland must be called the habitat of the cold-boreal algæ, as in both places almost one half of the algæ belong to this group; next to these countries must be named, on one side the Shetland Isles, on the other South West Iceland.

2. Comparison with the adjacent Countries.

A more thorough comparison shows us a good many difficulties of various kinds, especially caused by the fact, that the algal vegetations of the different countries have not all been equally thoroughly investigated. It is no wonder, therefore, that the results obtained may suffer from small and large errors.

In order to show some of the most important causes of errors, I shall point out, that several of the species, which have been found on the coasts of Greenland, the Færöes and Iceland, according to papers published during the latest years, e. g. Rosenvinge's on the marine algæ of Greenland, my own paper on the Færöese marine algæ, and lastly Jónsson's on the marine algæ of Iceland, also will be found in the surrounding countries on renewed investigations. In Batter's recently published list of the marine algæ of Great Britain we thus find many of Rosenvinge's new Greenlandic species mentioned. Another source of error is naturally the different authors' varying opinions of species; and even if we try ever so conscientiously to make out the different synonyms, there are still, according to our present knowledge, a great many genera — I need only mention promiscuously *Lithothamnion, Sphacelaria, Myrionema, Acrosiphonia, Spongomorpha, Cladophora, Enteromorpha, Ulothrix* — of which it is almost impossible to make any statement with certainty. On the whole, it is especially the classification of the *Chlorophyceæ* which causes the greatest difficulties; and as the plants of this group thrive in very extreme conditions, which quality they have in common with the *Cyanophyceæ*, for instance they are well fitted for standing a mixture with fresh water, it would perhaps be most correct to side with Kuckuck who says (56, p. 10): »Bei pflanzengeographischstatistischen Zusammenstellungen scheinen mir daher die Chlorophyceen und Cyanophyceen eher geeignet, das Resultat zu trüben als zu klären, und aus diesem Grunde will ich auch hier von einer Berücksichtigung jener Pflanzengruppe absehen.« But as it cannot be denied, however, that there are several species, even among the *Chlorophyceæ* and *Cyanophyceæ*, which are of no small importance from a phyto-geographical point of view, I have used them here as far as possible for the sake of comparison.

Further, it is naturally of great importance in a comparison of this nature, to exclude the species which by mistake have been included previously in the flora of a country, when closer investigations have shown that it is only by erroneous determination or for some other reason, that they have been included, and thus do not belong to the flora at all. As to Greenland, so many species had been incorrectly admitted, according to Rosenvinge (71, p. 154) that the phyto-geographical character of the algæ-flora has been essentially altered by their omission; also, with regard to the Færöes we have been obliged to exclude several of the species

previously admitted in botanical works. But in spite of all this, there are still some few species of which it is doubtful, whether they have any right to belong to the Færöese algæ-flora[1].

Of the 215 species (compare p. 773) found at the Færöes, 6 species besides a few new varieties and forms have been described as new; there are moreover an *Ectocarpus* spec. and a *Hypheothrix* spec., of which no statement could be given with certainty because of defective material, and which therefore by closer examination may possibly be referred to species already known, and lastly, Lyngbye's *Palmella adnata* which I think may be referred to the genus *Pleurococcus*, as I have examined Lyngbye's old material, but cannot determine any closer. In the comparison I leave these 3 species out of consideration[2].

As to the 6 new species, it is hardly probable, however, that they should be endemic at the Færöes; the 5 species: *Dermocarpa Farlowii, Hyella endophytica, Myrionema færoense*, and *M. speciosum* together with *Phæostroma parasiticum* are small forms, that are easily overlooked; one of them, *Myrionema færoense* has besides already been found at Iceland, and according to what Dr. Bornet reports (cf. my flora, 8, page 523) *Dermocarpa Farlowii* is found in Japan and must therefore be supposed to be widely spread. *Laminaria færoensis*, on the other hand, is a tall plant, quite the tallest found on the Færöese coast. On one side it is connected with the Greenland—North-American *Laminaria longicruris*, and on the other side closely with *Laminaria saccharina;* it has already been found at Iceland, but it is rather doubtful if it is to be found on other European coasts, as it has not already been found there; still it is of course not impossible. The bottoms of the fjords in northern Norway would most naturally be the places to look

[1] Of such species I need only mention: *Phyllophora membranifolia*, of which I have only seen a small fragment which had been found by Ostenfeld in a plaice-net on board the cruiser »Ingolf« in Trangisvaagfjord; as the ship had, however, just come from the Sound, and as there had most likely been some fishing there, it is very probable, that this fragment had been left in the net and thus carried on. Another species which only doubtfully belongs to the Færöes is *Chætopteris plumosa*; in Rostrup's herbarium we find good specimens sent to him by Mr. Randropp of Thorshavn, but as this alga was never found by other investigators, we have a right to doubt whether these specimens really belong to the Færöes.

[2] The *Chilionema* spec., mentioned in my flora (8, page 427), must, I think, as mentioned above, be referred to *Chilionema reptans*.

for it. During my short visit at the Shetland Isles I sought it in vain, still it might possibly grow there.

From these introductory remarks I now pass to the proper comparison of the marine algæ-flora of the Færöes with that of the adjacent countries. In order to make such a comparison, a list of the algæ-flora of the particular countries, as correct as possible and critically revised, is of course indispensable. Helgi Jónsson I and have prepared a list (12), which we hope to be serviceable, and I have used it as a basis for the following comparison, which therefore appears somewhat altered from that of the Danish issue.

We may first consider the countries which are nearest to the Færöes, that is Scotland with the Orkneys and the Shetland Isles. In Batters's recently published lists (4) of the British marine algæ, where these countries are treated as a whole, about 430 species are stated as belonging to Great Britain. Of these, 163 species are also found at the Færöes. The total number will certainly be considerably increased by renewed investigations, a few species which I found during my short visit at the Shetland Isles, have already been added, namely: *Fucus inflatus, Sphacelaria furcigera, Prasiola crispa* subsp. *marina, Ulvella fucicola* and *Derbesia marina*[1]; to these must be added *Sphacelaria britannica* which is stated by Sauvageau as found in Scotland; the total number is thus increased to 169 or 79 % of the marine algæ of the Færöes. Of the remaining species we may certainly suppose, that the following species also occur in Scotland with the Orkneys and the Shetland Isles: *Chantransia efflorescens,* found in South England; *Chantransia Alariæ* found, besides at the Færöes, also at North-America, at Iceland, on the coast of Norway at Haugesund and in 1904 by myself at Christianssund, and in the same year by J. Adams at Portrush in North Ireland (Journal of Botany 1904, p. 351), and which probably has the same distribution as *Alaria esculenta; Rhodochorton seiriolanum* which has been found in West-England; *Callithamnion scopulorum* which according to Batters' list has not hitherto been found at the British Isles, but which must be supposed to be there, if Agardh's determination of its occurrence in the Mediterranean is correct; *Rhododermis elegans,* a variety of

[1] Batters mentions *D. tenuissima* as occurring in Scotland; judging from a specimen kindly sent me by Mr. Batters, I think that it most likely is *Derbesia marina.*

which, v. *polystromatica*, has been found in North England, and the closely related species *Rh. parasitica* also in Scotland; *Phymatolithon compactum* f. *circumscripta* (Strömf.) Fosl. is according to Batters (4, p. 97) found in West Ireland, and must therefore also be supposed to be found for instance at Shetland; *Ectocarpus dasycarpus*, found in South England; *Ectocarpus lucifugus*, a few years ago mentioned from Heligoland, but which must be supposed to be more widely destributed as it has now been found at the Færöes; *Ectocarpus Stilophoræ* found in South England; *Myrionema foecunda* which is perhaps closely related to *M. Corunnæ*; *Microsyphar Polysiphoniæ* found in North England; *Microsyphar Zosteræ*, originally mentioned from Heligoland; *Sorapion Kjellmani*, most likely the same as *Sorapion simulans* (see Rosenvinge, 71, p. 161, note) which has been found in South England; *Petroderma maculiforme* stated from Heligoland; *Sphacelaria cæspitula* which according to Batters has been found in North England, but is, however, possibly doubtful, as it has not been given by Sauvageau; *Prasiola furfuracea*, found for instance in Germany and on the north coast of Norway; *Ulothrix pseudoflacca* and *U. consociata* which have but recently been described by Wille as found in Kristianiafjord and of which we therefore know but little as to how far they are distributed; *Pilinia maritima* which is known from Greenland and the Færöes and has lately been found by Sauvegeau in the gulf of Gascony; *Ulvella confluens* found in South England but which Batters supposes to be common: *Codiolum gregarium*, in Batters' list only stated from South England, but which is mentioned as »not uncommon« in the same author's »List of the marine Algæ of Berwick-on-Tweed«; *Codiolum pusillum* which is possibly found in Scotland (see Batters p. 9), but which is, however, not stated from Scotland in Jónsson's and my own list, as we have felt doubtful as to the correctness of the determination because of the synonyms mentioned by Batters; *Chlorogloea tuberculosa*, lately described by Wille and probably widely distributed; *Pleurocapsa amethystea* found at South England; *Phormidium autumnale* found in North England; *Microcoleus tenerrimus* found in South England.

All these 26 species which are mostly small and therefore only to be discovered by thorough investigation, can with some certainty be supposed to occur on the coasts of Scotland and the surrounding isles, and can therefore for comparison be included in the total number. The total number of species thus becomes 195.

Of the remainding 20 species, 6 are the above mentioned new species and 3 are forms only determined as to the genus, and of which we know nothing concerning their eventual occurrence on the coasts of Scotland. It is, however, most probable, that at any rate some of them will be found to grow there. Of the remainding 11 species, 5 belong to *Acrosiphonia* and *Spongomorpha* which should be left out of consideration because of the uncertain classification of these genera; most likely they will all be found, however, on the coasts of the British Isles, with the exception perhaps of *A. hystrix*, a northern species uncommon even in the Færöes and not found there either in its typical form. We thus have a remainder of 6 species: *Rhodophyllis dichotoma, Halosaccion ramentaceum, Ptilota pectinata, Rhodochorton penicilliforme, Lithothamnion lœve* and *Alaria Pylaii.*

These 6 species are essentially typical to northern regions; they all belong to the coldest portion of the subarctic group and thus are species having their greatest distribution in the Polar Sea proper. Whether any of these species may be found at the British Isles is certainly very doubtful, but even if they do not grow there and some few of the above mentioned Færöese algæ, which have not yet been found in Scotland, should really be wanting there, it is, however, but a very small number of species found at the Færöes which are not found in Scotland or at any rate may not be supposed to grow there.

Any further examination dealing with the great number of species found in Scotland and the surrounding isles, but not at the Færöes, has but little interest here. It is a matter of course, that a much greater number of species must be found in a territory of such an extent, than at the Færöes, and it is likewise evident that a great number of more southern forms will appear there on account of the more southern situation of Scotland. Of the species (about 250) found there, but not at the Færöes, more than one half have hitherto only been found in the southern part of Scotland, comprising the east coast about the Firth of Forth (Fife, Haddington, Berwick) and the west coast reckoned from Argyle to the English boundary; of red and brown algæ there are no less than 68 species (see Börgesen and Jónsson 12, p. XXI, group E 3). Of the remainding species (as to the red and brown algæ compare the group E 2, in the above-mentioned paper (12) p. XIX and XX) we may be sure that a great many do not grow so far north as the Shetland Isles.

As the Shetland Isles are of about the same size as the Færöes and lie nearest to the latter (the distance is almost 300 kilometers), a comparison between the marine algæ-flora of these two groups of islands would be particularly interesting. It is therefore to be regretted, that the marine algæ-vegetation of the Shetland Isles has been but little investigated. The most important contribution to our knowledge of these algæ is to be found in Edmonston's Flora of the Shetland Isles (16) with a list of the marine algæ known at that period. Since then no other contribution had been published, so far as I know, until 1902 when I paid a short visit to the islands. In a small paper (9) I have published my discoveries and added the species mentioned by Edmonston. The number of species known from the Shetland Isles is about 108, as I include *Enteromorpha clathrata* and *Callithamnion tetragonum* var. *brachiatum*, whilst *Gelidium cartilagineum* must be left out, as it does not belong to the flora of the islands. Of these 108 species, about 88 are also found at the Færöes; of *Rhodophyceæ* and *Phæophyceæ* 87 have hitherto been known, of which 72 are common to both countries. But as already emphasized by me in dealing with the flora of Scotland and adjacent islands, there is hardly any doubt, that by far the greater part of the algæ-species of the Færöes will be found there, especially on the islands that are the nearest. The only species which have less likelihood of being found there are the above mentioned 6 subarctic species, to which perhaps may be added a few more, e. g. *Laminaria fœroensis, Phœostroma parasiticum* etc. Of the 20 species found at the Shetland Isles but not at the Færöes we must first mention *Fucus serratus* which is very common at the Shetland Isles but is, strangely enough, wanting at the Færöes; the other 19 are: *Helminthora divaricata, Chylocladia kaliformis, Nitophyllum Bonnemaisonii, Spermothamnion Turneri, Callithamnion tetragonum, Ceramium diaphanum, C. ciliatum, Dilsea edulis, Asperococcus bullosus, Myriotrichia clavæformis, Mesogloia vermiculata, Saccorhiza bulbosa, Cutleria multifida, Fucus ceranoides, Acinetospora pusilla, Chætomorpha ærea, Cladophora Hutchinsiæ, Dermocarpa prasina* and *Calothrix confervicola*. It is not impossible, that some of these species may grow on the Færöese coasts, but most of them are forms from more soûthern countries, most likely having their northern limit at the Shetland Isles.

It appears from this, that the Færöese algæ-flora must be regarded as a rather poor selection of the algæ of Scotland and adjacent is-

lands, as almost all the Færöese algæ are found on the coasts of Scotland, whereas Scotland has on the other hand a very great number of species, which are wanting at the Færöes. The greatest resemblance is between the Færöese algæ-flora and that of the Shetland Isles; the Færöes have a few, perhaps no more than 6, specially northern species which will most probably not be found on the Shetland Isles; on the other hand the Shetland Isles have a number (how many can only be stated when a more thorough investigation of the algal vegetation of these islands has been undertaken) of forms from more southern countries which do not grow any farther north than the Shetland Isles.

From the British Isles the comparison most naturally passes to the west coast of Norway. Boye (6) has given a list of the algæ found by him at a part of the coast, round Sulen north of Bergen. This part of the coast is at about the same degree of latitude as the Færöes, and consequently of special interest; but unfortunately Boye's list is rather defective, as is clearly proved by the fact that such species as *Fucus spiralis, Desmarestia viridis, Odonthalia dentata, Enteromorpha Linza* and others, are not mentioned. I have therefore made an attempt to supplement Boye's list, partly by including the species mentioned by Areschoug in his well-known work: »Phyceæ scandinavicæ marinæ« (3), even if these algæ are not specifically stated as belonging to Bergen and its neighbourhood but only from some locality on the Norwegian west coast south of Trondhjem, partly by adding the species which Hansteen mentions in his paper (38). Further, several species from the west coast of Norway are mentioned in different papers by Foslie (e. g. 25, 27); and Mr. E. Norum of Haugesund, who has been investigating the algæ-vegetation in this neighbourhood, has kindly placed his still unpublished list of brown algæ from this part of the west coast at my disposal. Lastly, *Chantransia Alariæ* has been found by Rosenvinge at Haugesund and by me at Christianssund. Of the species mentioned in Boye's list (according to my calculation about 165, which number will certainly be much increased on further investigation), 97 are found at the Færöes, but if we include the species, which are stated by the various authors mentioned as found on the west coast of Norway, the total number of common species is increased by at least 40, which makes in all about 137 species or about 64 % of the Færöese algæ. If we exclude the green and bluish-green algæ, 190 *Rhodophyceæ* and *Phæo-*

phyceæ have been found in West Norway, according to our list; of these species 114 or more than 73 % are found at the Færöes. There is, however, hardly any doubt, that the greater part of the many Færöese algæ which have hitherto not been found on this part of the coast, that is about 80 species, will certainly be found there. It seems unnecessary to name all these species, but I may mention some Færöese species which may be supposed not to occur on this part of the west coast of Norway: *Halosaccion ramentaceum*, *Ptilota pectinata*, *Rhodochorton penicilliforme*, *Alaria Pylaii*, *Laminaria færoensis*, and possibly some few more. These species all belong to colder regions. Of the great number of species found at Norway and not at the Færöes (of red and brown algæ 76 species[1]) the greater part are of a more southerly distribution, but some few are more northern algæ, for instance: *Turnerella Pennyi*, which is arctic, and *Lithothamnion tophiforme* and *Haplospora globosa* which are subarctic.

From West Norway we pass on to Nordland. On account of the Gulf Stream the algæ-flora here has a much more southern character than might be expected so far north; a great many Færöese species are also found here.

For our knowledge of Nordland's algæ-flora we are especially

[1] According to our list they are divided in the following way into different groups:
The arctic group: *Turnerella Pennyi.*
The subarctic group: *Lithothamnion tophiforme, Haplospora globosa.*
The cold-boreal group: *Spermothamnion Turneri, Callithamnion Hookeri, C. roseum, Ceramium Deslongchampsii, C. circinnatum, C. diaphanum, Dilsea edulis, Lithothamnion intermedium, L. fornicatum, L. norvegicum, Ectocarpus Turnerellæ, E. Pringsheimii, E. terminalis, E. penicillatus, E. draparnaldioides, Myriotrichia filiformis, Dictyosiphon Chordaria, Mesogloia vermiculata, Spermatochnus paradoxus, Fucus ceranoides* and *Fucus serratus.*
The warm-boreal group: *Nemalion multifidum, Gelidium crinale, G. latifolium, Phyllophora rubens, Catenella opuntia, Rhodophyllis bifida, Chylocladia kaliformis, Nitophyllum punctatum, Bonnemaisonia asparagoides, Polysiphonia spinulosa, P. simulans, Brongniartella byssoides, Monospora pedicellata, Pleonosporium Borreri, Callithamnion tetragonum, Compsothamnion thuyoides, Ceramium flabelliferum, Gloiosiphonia capillaris, Halarachnion ligulatum, Lithothamnion membranaceum, L. Sonderi, L. calcareum, Lithophyllum orbiculatum, L. pustulatum, Melobesia farinosa, M. Lejolisii, M. minutula, Corallina rubens, Ralfsia pusilla, Myrionema intermedium, Chilionema ocellatum, Ascocyclus orbicularis, Microspongium gelatinosum, Ectocarpus sphæricus, E. globifer, Myriotrichia repens, M. clavæformis, Myriactis Haydeni, Elachista stellaris, Giraudia sphacelarioides, Sphacelaria bipinnata, Asperococcus bullosus, A. compressus, Litosiphon pusillus, Striaria attenuata, Myriocladia Zosteræ, Chordaria divaricata, Stilophora rhizodes, Saccorhiza bulbosa, Cutleria multifida, Tilopteris Mertensii, Dictyota dichotoma.*

indebted to Kleen (51); but Kjellman (48) has furnished us with important information. We know 123 species of *Rhodophyceæ* and *Phæophyceæ* together with about 20 *Chlorophyceæ* from Nordland, that is very nearly 150 species. 113 of these species are also found at the Færöes, that is, 75 % of the species of Nordland and 52. 8 % of the Færöese species. Nordland has 123 red and brown algæ, 95 of these are also found at the Færöes, that is, 61 % of the Færöese algæ of these groups. The 28 species which are found at Nordland but not at the Færöes are the following: *Turnerella Pennyi* (A)[1], *Brongniartella byssoides* (E 1), *Spermothamnion Turneri* (D), *Callithamnion Hookeri* (D), *Callithamnion roseum* (D), *Ceramium Deslongchampsii* (D), *C. circinnatum* (D), *C. diaphanum* (D), *Dilsea edulis* (D), *Petrocelis cruenta* (D), *Lithothamnion intermedium* (D), *L. fornicatum* (D), *L. tophiforme* (B 1), *L. norvegicum* (D), *Ralfsia deusta* (B 1), *Ectocarpus Turnerellæ* (D), *E. terminalis* (D), *E. borealis* (D), *E. ovatus* (B 1), *E. penicillatus* (D), *E. draparnaldioides* (D), *Myriotrichia filiformis* (D), *Sphacelaria racemosa* (B 1), *Mesogloia vermicularis* (D), *Spermatochnus paradoxus* (D), *Cutleria multifida* (E 1), *Fucus ceranoides* (D), *F. serratus* (D). With the exception of some few warm-boreal species (E 1), the greater part of these algæ belong to the cold-boreal group (D); we are therefore justified in expecting that some of them may perhaps be found at the Færöes; the other species are arctic or subarctic, and can scarcely be expected there.

On the other hand, the following 60 species are found at the Færöes: *Porphyra leucosticta, P. coccinea, Conchocelis rosea, Chantransia Alariæ, Ch. efflorescens, Ch. virgatula, Choreocolax Polysiphoniæ, Harveyella mirabilis, Phyllophora Brodiæi, Actinococcus subcutaneus, Callophyllis laciniata, Callocolax neglecta, Sterrocolax decipiens, Lomentaria rosea, Nitophyllum laceratum, Laurencia pinnatifida, Polysiphonia atrorubescens, Rhodomela subfusca, Griffithsia setacea, Callithamnion scopulorum, C. granulatum, Rhodochorton seiriolanum, Rh. membranaceum, Rhododermis elegans, Phymatolithon lævigatum, Lithophyllum incrustans, L. hapalidioides, Lithoderma fatiscens, Petroderma maculiforme, Sorapion Kjellmani, Ralfsia clavata, Myrionema Corunnæ, M. foecundum, M. globosum, M. færoense, M. speciosum, Microsyphar Polysiphoniæ, M. Zosteræ, Ectocarpus æcidioides, E. Stilophoræ, E. velutinus, E. lucifugus, E. tomentosoides, E. dasycarpus, E. granulosus, E. Hincksiæ, Leptonema fasciculatum, Elachista scutulata, Sphacelaria britannica, Sph. cæspitula, Sph. furcigera, Sph. cirrosa,*

[1] For explanation of the letters see: Börgesen and Jónsson (12, p. XV—XXI).

Desmotrichum undulatum, *Punctaria latifolia*, *Litosiphon filiforme*, *Phæostroma parasiticum*, *Phyllitis zosterifolia*, *Desmarestia ligulata*, *Chorda tomentosa*, *Laminaria færoensis*. It is most probable, that a great many of these species will be found in Nordland on further investigation, the remainding species are partly some that grow in more southern regions and most probably do not occur in Nordland, partly the species hitherto found at the Færöes only, of whose occurrence outside the Færöes we know nothing as yet. Of green and bluish-green species 40 have been found at the Færöes but not hitherto at Nordland, namely: *Chlorochytrium inclusum*, *Codiolum gregarium*, *C. pusillum*, *Enteromorpha Linza*, *Prasiola crispa* **marina*, *P. furfuracea*, *Ulothrix consociata*, *U. pseudoflacca*, *U. flacca*, *Endoderma Wittrockii*, *Acrochaete repens*, *Pilinia maritima*, *Ulvella fucicola*, *U. confluens*, *Pringsheimia scutata*, *Urospora Wormskioldii*, *Spongomorpha vernalis*, *Acrosiphonia flagellata*, *A. incurva*, *A. grandis*, *A. hystrix*[1], *Cladophora sericea*, *Gomontia polyrhiza*, *Ostreobium Queketti*, *Derbesia marina*, *Vaucheria coronata*, *Valonia ovalis*, *Chlorogloea tuberculosa*, *Dermocarpa violacea*, *D. Farlowii*, *Pleurocapsa amethystea*, *Hyella cæspitosa*, *H. endophytica*, *Spirulina subsalsa*, *Phormidium autumnale*, *Lyngbya lutea*, *Microcoleus tenerrimus*, *Calothrix æruginea*, *C. scopulorum*, *Rivularia atra*. Most probably a great number of these species will likewise be found in Nordland.

What we know of the algæ-flora of Finmark is mostly due to papers by Foslie; Kjellman, however, has also contributed important information. According to our list, 125 red and brown algæ have been found there. Of these algæ 50 red and 41 brown algæ are common to the Færöes and Finmark, that is 91 in all or 58 % of the Færöese algæ and 72 % of those of Finmark. The 34 species which are found at Finmark but not at the Færöes are as follows: *Chantransia microscopica*, *Turnerella Pennyi*, *Polysiphonia arctica*, *Spermothamnion Turneri*, *Ceramium Deslongchampsii*, *C. cincinnatum*, *Petrocelis Middendorffi*, *Peyssonnelia Rosenvingii*, *Phymatolithon investiens*, *Lithothamnion flavescens*, *L. foecundum*, *L. intermedium*, *L. fornicatum*, *L. tophiforme*, *L. norvegicum*, *Lithoderma lignicola*, *Ralfsia deusta*, *Ectocarpus terminalis*, *E. nanus*, *E. ovatus*, *E. penicillatus*, *Myriotrichia filiformis*, *Sphacelaria racemosa*, *Phæo-*

[1] Kleen, however, mentions both a *Cladophora arcta* and a *Cl. uncialis*, which are most probably identical with some of the species of *Acrosiphonia* and *Spongomorpha* mentioned here.

saccion Collinsii, Delamarea attenuata, Coiledesme bulligera, Dictyosiphon Chordaria, D. corymbosus, D. hispidus, Saccorhiza dermatodea, Laminaria Agardhii, L. nigripes, Haplospora globosa, Fucus serratus. Almost half of these species are arctic and subarctic, and may not be expected to grow so far south as the Færöes; the others, however, are of a more southern distribution, and some of them may therefore also be found possibly at the Færöes. The majority of the 65 Færöese species absent at Finmark are the same as were wanting at Nordland; some Færöese species not found at Nordland are, however, found here, but on the other hand Finmark lacks the following 19 species: *Erythrotrichia ceramicola, Phyllophora membranifolia, Pterosiphonia parasitica, Callithamnion arbuscula, C. polyspermum, C. corymbosum, Ceramium acanthonotum, Lomentaria articulata, Plocamium coccineum, Polysiphonia violacea, P. Brodiæi, Cruoria pellita, Cruoriella Dubyi, Rhododermis elegans, Ralfsia verrucosa, Ectocarpus tomentosus, Cladostephus spongiosus, Litosiphon Laminariæ, Himanthalia lorea.* As already pointed out with reference to Nordland, there is hardly any doubt, that some of the wanting Færöese species may also be found at Finmark though probably in lesser number.

As to the green and bluish-green algæ, 37 Færöese species (I take it for granted, that *Acrosiphonia hamulosa* belongs to *A. albescens*) are also found at Finmark; some more species have been found here, but as the determinations in many cases greatly need to be revised, I shall not deal with them any more in this connection.

From this comparison it is seen, that Finmark has a somewhat smaller number of species in common with the Færöes than Nordland has, and that it has a much greater number of arctic species than the latter country.

From Norway we pass on to Iceland, and here our comparison has the advantage of the up to date list worked out with much care by Jónsson, in his paper on the marine algæ-flora of this country. As already pointed out by Strömfelt, the algæ-flora of the coasts of Iceland varies greatly. He divides it into two territories: North-East Iceland with an algæ-flora of an essentially arctic character, and South-West Iceland with a north-atlantic flora. This great difference has been confirmed by Jónsson, who, however, has kindly communicated to me, that the flora ought to be further subdivided, as the flora of the southern part of the country is purely

cold-boreal, that of the eastern part arctic, whilst that of the western and northern parts is a mixed flora. As Jónsson intends to enter more fully into a comparison with the adjacent countries, in his paper on the algæ-vegetation of Iceland using this division as basis I may avoid too much detail here and simply keep to the two principal divisions: North-East and South-West Iceland.

The total number of species mentioned by Jónsson from Iceland is 195[1], Of these 195 species, 121 *Rhodophyceæ* and *Phæophyceæ* and 44 *Chlorophyceæ* and *Cyanophyceæ*, in all 165, are found on the southern and south-western part of the country, that is, from Lónsheiði on the south-east coast to Látrabjarg on the north-west coast. From Látrabjarg to Hornbjarg on the adjacent coast of North-West Iceland with mixed flora, we further find the following 7 species: *Ceratocolax Hartzii, Phyllophora Brodiæi, Actinococcus subcutaneus, Punctaria plantaginea, Monostroma groenlandicum, Acrochæte repens* and *Bolbocoleon piliferum,* which have hitherto not been found in more southerly places in Iceland. With the latter species the total number becomes 172. 134 of these species and 5 from the adjacent coast, 139 in all[2], are also found at the Færöes.

The 76 Færöese species which are not found at South-West Iceland can be divided into the following groups:

I. Species found at North-East Iceland:
Laminaria færoensis, Petroderma maculiforme, Codiolum gregarium, C. pusillum, Phormidium autumnale.

II. Species found at Greenland:
Chantransia efflorescens, Harveyella mirabilis, Polysiphonia elongata, Rhododermis elegans, Sorapion Kjellmani, Ulothrix consociata, Pilinia maritima, Ulvella confluens, Vaucheria coronata, Calothrix scopulorum.

III. Species found on the coast of North Norway:
Erythrotrichia ceramicola, Chantransia Daviesii, Polysiphonia violacea, Polysiphonia Brodiæi, Rhodomela subfusca, Callitham-

[1] According to Mr. Foslie's latest determination, *Lithothamnion circumscriptum* must be excluded from the number of species, whilst on the other hand *Chantransia microscopica* and *Vaucheria sphærospora* must be included (compare Börgesen and Jónsson, 12).

[2] Of *Phyllophora Brodiæi* only the subspecies *interrupta* has been found at Iceland, but the Færöese specimen is very much like it; as to *Acrosiphonia,* I consider *A. flaccida* as belonging to *A. hystrix* (8, p. 512), and *Spongomorpha lanosa* to be the same as *Sp. vernalis* (12, p. XXV).

nion corymbosum, C. polyspermum, Furcellaria fastigiata, Polyides rotundus, Cruoriella Dubyi; Chilionema reptans, Sphacelaria cirrosa, Cladostephus spongiosus, Asperococcus echinatus, Halidrys siliquosa, Himanthalia lorea, Acrosiphonia flagellata, A. grandis, Bryopsis plumosa, Derbesia marina; to this group we may most probably also refer *Sterrocolax decipiens*, which has certainly not been found farther north than the Færöes, so far as I know, but which may be supposed to grow in the same regions as *Ahnfeltia.*

VI. Southern forms, not found hitherto north of the Færöes and West Norway:
Porphyra leucosticta, Callophyllis laciniata, Callocolax neglecta, Lomentaria articulata, Nitophyllum laceratum, Laurencia pinnatifida, Polysiphonia atrorubescens, Griffithsia setacea, Callithamnion granulatum, Rhodochorton seiriolanum, Phymatolithon lævigatum, Lithophyllum incrustans, L, hapalidioides, Ectocarpus dasycarpus, E. granulosus, E. lucifugus, E. velutinus, Myrionema foecundum, Microsyphar Zosteræ, Sphacelaria cæspitula, S. furcigera, Elachista scutulata, Punctaria latifolia, Desmotrichum undulatum, Litosiphon Laminariæ, Valonia ovalis, Chlorogloea tuberculosa, Dermocarpa violacea, Hyella cæspitosa, Lyngbya lutea, Microcoleus tenerrimus, Calothrix æruginea and *Choreocolax Polysiphoniæ.*

Lastly, we have the 6 new Færöese species, and the 3 which are only determined as to the genus. Of these, *Myrionema fœroense* has been found at South-West Iceland and is thus already included in the total number, and *Laminaria fœroensis* has been taken at North-East Iceland and is included in the first group; thus there are only 7 species left, of which nothing[1] is known as to their occurrence outside the Færöes, but of which some at least may probably also be found at Iceland.

As to group I, it seems to me, that the 5 species it includes must also be supposed to occur at South-West Iceland. I likewise think it most likely, that the 10 species belonging to group II, may be met with at Iceland. As to the 21 species of group III I think there is some probability at any rate, that some of them may be found at South-West Iceland, as they have been able to grow so far north as the coast of Norway.

[1] *Dermocarpa Farlowii* excepted.

Lastly there are the more southern forms belonging to group IV. With the exception of some few species, especially those of which we know very little as to their distribution, we can in general take it for granted, that they are most likely not found at Iceland; thus their north western boundary is at the Færöes: in Norway, however, several of them grow much farther north.

As to the 33 species found at South-West Iceland, but not at the Færöes, they can be divided into the following groups; I retain the designations used in the preceding section.

I. Arctic species: *Ceratocolax Hartzii, Polysiphonia arctica, Cruoria arctica, Monostroma groenlandicum;* 4 species in all.

II. Subarctic species:
Subdivision 1: *Peyssonnelia Rosenvingii, Lithothamnion tophiphorme, Coilodesme bulligera, Ralfsia ovata, R. deusta, Myrionema Laminariæ, Saccorhiza dermatodea, Acrochæte parasitica, Urospora Hartzii* and *Chlorochytrium Schmitzii;* 10 species in all.
Subdivision 2: *Phaeostroma pustulosum, Chlorochytrium dermatocolax, C. Cohnii* and *Cladophora hirta;* 4 species in all.

III. Cold-boreal species: *Dilsea edulis, Rhodochorton minutum, Petrocelis Hennedyi, Rhododermis parasitica, Ectocarpus penicillatus, Dictyosiphon Chordaria, Fucus serratus, Sphacelaria radicans, S. olivacea, Codiolum Petrocelidis, Cladophora glaucescens* and *Vaucheria sphærospora;* 12 species in all.

IV. Warm-boreal species: *Bonnemaisonia asparagoides;* 1 species.

Lastly we have the 2 new species: *Rhodochorton repens* and *Acrosiphonia flabelliformis*, the distribution of which is unknown outside of Iceland.

Firstly as to *Bonnemaisonia asparagoides*, it must be pointed out, that it is not perfectly certain that this species really grows on the coasts of Iceland (compare Jónsson, 41 p. 141).

Of the species mentioned in group III it is probable, that some of them at any rate, especially the smaller species, will also be found to grow at the Færöese coasts. With the exception of some few species, there is, however, only a slight possibility that some of the species belonging to group II should be found on the Færöese coasts, and as to the 4 arctic species there is certainly no doubt that they are absent at the Færöes.

Thus we see that even if there is an important, though not very great, difference between the flora of South-West Iceland and

that of the Færöes, in so far that 4 species belonging to the arctic group, which is quite wanting at the Færöes, have been found at Iceland, as also that many more subarctic species occur there than at the Færöes, the difference is much reduced, if we make the comparison between the algæ-flora of South Iceland proper and that of the Færöes. At South Iceland 82 red and brown species and 26 green and bluish-green have been found, 108 species in all. The following 12 of these species are wanting at the Færöes:

Subarctic species: *Lithothamnion tophiphorme, Ralfsia deusta, Urospora Hartzii, Cladophora hirta;*

Cold-boreal species: *Rhodochorton repens* (endem.), *Petrocelis Hennedyi, Rhododermis parasitica, Sphacelaria radicans, S. olivacea, Fucus serratus, Acrosiphonia flabelliformis* (endem.);

Warm-boreal species: *Bonnemaisonia asparagoides,* which does not belong perhaps to the flora.

As mentioned above, there is hardly any doubt, that at any rate some of these species will also be found at the Færöes, just as, on the other hand, several of the species wanting at the Færöes may most likely be found at this part of Iceland, especially perhaps at the Vestmanöer. Some of the latter however can hardly be considered to occur there, as for instance some of the most important: *Porphyra leucosticta, Callophyllis laciniata* with *Callocolax neglectus, Lomentaria articulata, Nitophyllum laceratum, Polysiphonia violacea* and *P. Brodiæi, Griffithsia setacea, Cladostephus spongiosus, Punctaria latifolia, Himanthalia lorea, Halidrys siliquosa, Bryopsis plumosa, Valonia ovalis* etc. The algæ-flora of South-Iceland must be regarded as a poorer selection of the Færöese algæ-flora, particularly as some of the warm-boreal species, found at the Færöes, are wanting there.

When we turn to North-East Iceland, we see that the difference between the algæ-flora there and that at the Færöes is much greater, as might well be expected. From North- and East-Iceland proper, that is, if we count from the head of Huna-Floi to Lónsheiði on the south-east coast of Iceland, we have 92 red and brown species and 34 green and bluish-green; east of Hornbjarg along the adjacent north-western coast, we have moreover 8 brown and red algæ, and 9 green and bluish-green species, namely: *Chantransia microscopica, Cystoclonium purpurascens, Polysiphonia nigrescens, *Ralfsia ovata, Ascocyclus islandicus, *Leptonema fasciculatum, *Sphacelaria britannica, Leathesia difformis, *Chlorochytrium dermatocolax, Codiolum pusillum, Enteromorpha aureola, *Ulva Lactuca, *Ochlo-*

*chæte ferox, Cladophora rupestris, *C. sericea, Plectonema norvegicum* and **Spirulina subsalsa.* If we add these to the above-mentioned number[1], we have 143 species. Of these, 111 are also found at the Færöes. Thus North-East Iceland has 23 species less in common with the Færöes than South-West Iceland.

Firstly, as to the 32 species found at North-East Iceland and not at the Færöes, they may be divided into the following groups:

I. The Arctic group: *Turnerella Pennyi, Delesseria Baerii, Polysiphonia arctica, Lithothamnion flavescens, L. foecundum, Omphalophyllum ulvaceum, Dictyosiphon corymbosum, Laminaria nigripes* and *Monostroma groenlandicum;* 9 species in all.

II. The Subarctic group:
Subdivision 1: *Peyssonnelia Rosenvingii, Lithothamnion tophiforme, Ralfsia deusta, R. ovata, Coiledesme bulligera, Saccorhiza dermatodea, Ulothrix subflaccida, Pseudendoclonium marinum, Urospora Hartzii, Acrosiphonia penicilliformis;* 10 species in all.
Subdivision 2: *Phæostroma pustulosum, Chlorochytrium dermatocolax;* 2 species in all.

III. The Boreal-arctic group: *Chantransia microscopica.*

IV. The Cold-boreal group: *Petrocelis Hennedyi, Lithothamnion norvegicum, Ascocyclus islandicus, Ectocarpus penicillatus, Sphacelaria radicans, Dictyosiphon Mesogloia, D. Chordaria, Enteromorpha aureola, Ochlochæte ferox, Plectonema norvegicum;* 10 species in all.

If we compare these species with those that are not common to South-West Iceland and the Færöes, we at once perceive a very distinct difference in that the arctic group is much increased[2]. It is not likely that any of these 9 species will be found at the Færöes; and as to the subarctic species of the subdivision 1, it is likewise improbable that they will be found there, a few species perhaps excepted. On the other hand the species of subdivision 2 may probably also be found on the Færöese coasts, and this is certainly also the case with the greater part of the cold-boreal species.

[1] It is, however, doubtful, whether they may all be found at North and East Iceland proper; the 8 species marked with asterics and which have all been found much farther north, for instance at Greenland, must, however, be supposed to occur at North Iceland, and especially at East Iceland.

[2] This group will most probably be still more increased on renewed investigations, as we may certainly suppose, that the two arctic species at any rate, *Cruoria arctica* and *Ceratocolax Hartzii,* found at the other side of Hornbjarg, also grow there.

The 104 Færöese species which have not been found at North-East Iceland are divided into the following groups:

The subarctic group: *Chantransia efflorescens, Ch. virgatula, Harveyella mirabilis, Sorapion Kjellmani, Percursaria percursa, Pilinia maritima, Ulvella confluens, Pringsheimia scutata, Spongomorpha vernalis.* All these 9 species will most likely be found at North-East Iceland.

The boreal-arctic group: *Polysiphonia elongata* and *Rivularia atra*, both of which will certainly also be found at North-East Iceland.

The cold-boreal group includes the great majority, namely, 66 species, but I need not mention themhere; some of them may perhaps be found at North-East Iceland, but most of them probably not.

Lastly, the warm-boreal group includes 27 species, none of which probably are to be found on the coasts of North-East Iceland.

If we now pass on to Greenland, we find, according to Rosenvinge (71, p. 166—172), that the total number of species is 167, when the algæ-flora of both West and East Greenland is included. To this number must be added *Actinococcus subcutaneus* which Rosenvinge did not accept as a species, according to Darbishire's view at that time. According to Jónsson (42), we must further add 7 species, firstly *Microsyphar Polysiphoniæ*; then Rosenvinge's *Spongomorpha arcta* includes *Acrosiphonia incurva, A. hystrix* and *A. penicilliformis*; also 3 species of *Ulothrix* must be added: *U. pseudoflacca, U. scutata* and *U. subflaccida*, whilst *U. consociata* is partly the same as Rosenvinge's *U. implexa.* Lastly, Rosenvinge's *Sphacelaria olivacea* includes *Sphacelaria radicans* and *Sph. britannica.* Thus the number of species we know from Greenland becomes 176. According to my judgment of the species, *Enteromorpha prolifera* must, however, be withdrawn, and according to Foslie's latest views the 12 species of *Lithothamnion* mentioned by Rosenvinge must be reduced to 6[1]; the total number of species thus becomes 169. At the Færöes we meet with 104 of these species. The Færöes have 108 species (+ 3 only determined as to the genus) that are not found at Greenland, but on the other hand, we find 65 species there that do not grow at the Færöes; thus 49% of the 212 Færöese algæ are common to both countries.

[1] *Lithothamnion botryoides, L. flabellatum, L. colliculosum* and *L. varians* being referred to *L. glaciale,* and *L. circumscriptum* to *L. compactum. L. investiens* is doubtful at Greenland and *L. fruticulosum* is the same as *L. intermedium.*

As to the 111 Færöese species wanting at Greenland, they are mostly species also wanting at Iceland (namely the 54 species mentioned as belonging to group III and group IV p. 793—94), and in addition the following 57 species: *Porphyra coccinea, Chantransia Alariæ, Chondrus crispus, Gigartina mamillosa, Phyllophora membranifolia, Ahnfeltia plicata, Cystoclonium purpurascens, Lomentaria rosea, L. clavellosa, Plocamium coccineum, Delesseria alata, D. sanguinea, Polysiphonia fastigiata, P. nigrescens, Pterosiphonia parasitica, Odonthalia dentata, Callithamnion arbuscula, C. scopulorum, Plumaria elegans, Ptilota plumosa, Ceramium acanthonotum, Dumontia filiformis, Cruoria pellita, Phymatolithon polymorphum, Lithothamnion Lenormandi, Lithophyllum Crouani, L. macrocarpum, Corallina officinalis, Petroderma maculiforme, Myrionema vulgare, M. Corunnæ, M. færoense, M. speciosum, Ectocarpus tomentosus, E. fasciculatus, E. Hincksiæ, Phæostroma parasiticum, Dictyosiphon Ekmani, Desmarestia ligulata, Leathesia difformis, Laminaria færoensis, L. hyperborea, Fucus spiralis, Pelvetia canaliculata, Codiolum pusillum, Enteromorpha Linza, E. clathrata, Prasiola furfuracea, P. stipitata, Acrochæte repens, A. albescens, Dermocarpa Farlowii, Hyella endophytica, Phormidium autumnale,* besides the 3 referred only to the genus. These 111 species are almost all of a more southern distribution and belong to the warm-boreal and cold-boreal groups.

As to the 65 species found at Greenland and not at the Færöes, they can be referred to the following groups:

The arctic group: *Ceratocolax Hartzii, Callymenia sanguinea, Turnerella Pennyi, Delesseria Baerii, D. Montagnei, Polysiphonia arctica, Dilsea integra, Petrocelis polygyna, Cruoria arctica, Lithothamnion foecundum, Ectocarpus pycnocarpus, Omphalophyllum ulvaceum, Kjellmania subcontinua, Coelocladia arctica, Dictyosiphon corymbosum, Myriocladia callitricha, Laminaria solidungula, L. cuneifolia, L. groenlandica, L. nigripes, Monostroma groenlandicum, M. leptodermum, Ulothrix scutata, Arthrochæte penetrans, Chætobolus gibbus, Urospora crassa;* 26 species in all.

The subarctic group:

Subdivision 1: *Peyssonnelia Rosenvingii, Lithothamnion tophiforme, Ralfsia ovata, R. deusta, Myrionema Laminariæ, Ectocarpus helophorus, E. ovatus, Sphacelaria racemosa, Phæosaccion Collinsii, Symphyocarpus strangulans, Delamarea attenuata, Coilodesme bulligera, Dictyosiphon hispidus, Saccorhiza dermatodea, Laminaria longicruris,*

Agarum Turneri, *Chlorochytrium Schmitzii*, *Ulothrix subflaccida*, *Acrochæte parasitica*, *Urospora Hartzii*, *Rhizoclonium pachydermum*[1], *Acrosiphonia penicilliforme;* 22 species in all.

Subdivision 2: *Phæostroma pustulosum*, *Haplospora globosa*, *Chlorochytrium Cohnii*, *Ch. dermatocolax*, *Cladophora hirta;* 5 species in all.

The boreal-arctic group: *Chantransia microscopica*, *Oscillatoria amphibia*, *O. tenuis*[1]; 3 species in all.

The cold-boreal group: *Lithothamnion intermedium*, *Ectocarpus Pringsheimii*, *E. penicillatus*, *Sphacelaria radicans*, *Dictyosiphon Chordaria*, *Epicladia Flustræ*, *Ochlochæte ferox*, *Vaucheria intermedia*, *V. sphærospora;* 9 species in all.

Thus we see, that by far the greater part of these species belongs to the arctic and the coldest subdivision of the subarctic group; it is not probable that any of these species will be found at the Færöes. On the other hand, some of the few species referred to the other groups will no doubt be found to grow there.

This comparison thus leads to the conclusion that the Færöese algæ-flora includes a great number of southern forms wanting at Greenland, whilst Greenland has a great number of arctic species not found at the Færöes.

Lastly we may make a comparison with the algæ-flora of North-America. It is a well-known fact that in spite of the great distance separating the algæ-flora of North-Europe from that of the North-American coast of the North-Atlantic Ocean, they still have a great many species in common. Our knowledge of the North-American algæ-flora we owe firstly to Farlow's well-known paper (20) which is now somewhat antiquated, however, as it is 25 years since it was published, secondly to later works of Farlow, Collins and others. The latter author published in 1900 a list (13) of the North-American algæ, which has been used together with Farlow's above-mentioned paper as a basis for this comparison. Of the species mentioned in this list about 130 are also found at the Færöes, that is, more than one half (60 %) of all the Færöese species. Farlow has already called our attention to the great resemblance between the algæ-flora of both sides of the North-Atlantic Ocean; he likewise mentions (20, p. 4) some of the commonest species that grow both east and west of the Ocean.

[1] Found in freshwater at the Færöes.

However, many widely distributed North-European species are, as is well-known, wanting at North-America, e. g. *Callophyllis laciniata, Lomentaria clavellosa* and *L. articulata, Delesseria sanguinea, Laurencia pinnatifida, Polysiphonia Brodiæi, Griffithsia setacea, Callithamnion scopulorum* and *C. arbuscula, Dumontia filiformis, Ptilota plumosa,* etc. On the other hand, the coast of North-America has some species that are wanting at the European coast; of these I may mention: *Grinellia americana, Polysiphonia vestita, P. Olnei* and *P. Harveyi, Callithamnion Baileyi, Ceramium Hooperi, Ectocarpus Chordariæ, E. lutosus, Stictyosiphon subsimplex, Dictyosiphon Macouni, Scaphospora Kingii;* to these must also be added *Agarum Turneri* and *Laminaria longicruris* which are both very common on the coasts of North-America and Greenland, but have not been found further to the east. It is true, that *Laminaria longicruris* is stated to have been washed ashore at certain places of the European coasts, but it has never been found growing on any substratum, and it is indeed very probable that these hollow stalks of *Laminaria* are fragments of the very similar *Laminaria færoensis,* and have come from the Færöes or Iceland.

To what result does this comparison lead? As our knowledge of the floræ of several of the countries we have dealt with is deficient, the result can only be somewhat hypothetical. First of all it must be emphasized that the algæ-flora of the Færöes is to be regarded as a scanty selection of that of North-Scotland, with the addition of some few, more northern species not found at the British Isles. If we had a more thorough knowledge of the algæ-flora of the Shetland Isles, the flora of these islands and that of the Færöes would certainly be found to agree well, just as the algæ-vegetation of the Shetland Isles, at any rate the littoral vegetation, agrees well, with that of the Færöese coasts (compare 9). The Færöese algæ-flora moreover much resembles that of South-West Iceland; the algæ of this part of Iceland must be regarded as a somewhat poorer selection of the algæ of the Færöes, still with a few more northern forms than at the Færöes; lastly there seems to be considerable resemblance between the algæ-flora of the Færöes and that of Nordland.

When the Danish issue of this paper was published, I did not have the revised list of algæ which I have prepared later together with Mr. Jónsson, and without which a thorough examination of

the relation between the different algæ-flora is impossible; on account of this, my comparison of that time led to the result, that »the Færöese algæ-flora mostly resembles that of the nearest parts of the British Isles, less that of West Norway, South Iceland and Arctic Norway, still less that of North-East Iceland, least of all that of Greenland, and a little more that of the North-American coast of the North-Atlantic Ocean«.

This result has been criticized by Simmons. Founding his opinion on his list of algæ published in »Botaniska Notitser«, 1904 (compare Porsild and Simmons, 66, p. 203) he comes to the conclusion that the countries, judged by the degree of resemblance between their algæ-floræ and that of the Færöes should be named as follows: South-West Iceland, North Norway, West Norway, Scotland, North Iceland, America, Greenland.

The difference however is not very great, when we consider that Simmons takes all Scotland as a whole, which tends to reduce the resemblance with the Færöes considerably, and that I expressly deal with the British Islands closest to the Færöes, that is, the Shetland Isles. Moreover, whilst Simmons only deals with the numbers (that his list is wanting in accuracy, and his numbers therefore not to be relied upon, has already been mentioned above), I have proceeded more hypothetically, as we know very little of the algæ-flora of many of the particular countries, and have therefore tried to point out which species we may still expect to find in the flora of the different countries; thus my result necessarily becomes less precisely formulated.

I do not wish naturally to deny all importance to these numbers, on the contrary, I think that Simmons's method might be rather instructive, for instance his table l. c. p. 219, and I therefore add one of the same kind (see next page), calculated from the list prepared by Jónsson and myself. Simmons's method is this: he adds up the number of the species of two floræ, calculates the percentage of those species common to both and of those peculiar to each flora. Like Simmons I have in the following table only dealt with *Rhodophyceæ* and *Phæophyceæ*, and likewise only with the species that we know with certainty to be found in the particular countries. The relative order is, as will be seen from the table, therefore as follows: South-West Iceland, Nordland, West Norway, Finmark, North-East Iceland, the Shetland Isles, Scotland, North-America, Greenland.

The Færöes	Common species	South-West Iceland
52	103	22
30 %	58 %	12 %
The Færöes	Common species	Nordland
60	95	28
33 %	52 %	15 %
The Færöes	Common species	West Norway
14	114	76
18 %	49 %	32 %
The Færöes	Common species	Finmark
64	91	34
34 %	48 %	18 %
The Færöes	Common species	North-East Iceland
78	77	22
44.5 %	43 %	13 %
The Færöes	Common species	The Shetland Isles
83	72	15
50 %	42 %	8 %
The Færöes	Common species	Scotland
25	130	182
7.5 %	38.5 %	54 %
The Færöes	Common species	North-America
57	98	104
22 %	38 %	40 %
The Færöes	Common species	Greenland
87	68	43
44 %	34 %	22 %

As mentioned before, I do not think it justifiable to attach any great validity to this table, until the flora of the particular countries have been thoroughly investigated; it may serve as a hint, perhaps a correct one, but no more.

In agreement with my first thesis (cp. 10, p. 123), the algæ-flora of the Færöes may thus for the present be regarded as most closely related to that of the northern coasts of the British Isles (the Shetland Isles), also to that of West Norway (especially Nordland), and to that of South-West Iceland. This likewise agrees well with the result attained in the preceding chapter, namely, that the Færöes, Nordland, South-West Iceland, and the Shetland Isles are especially the habitats

of the cold-boreal algæ. It is certainly very probable that the greatest resemblance will be found to exist between the Færöese algæ-flora and that of South-West Iceland, more specially with that of South Iceland, as the numbers of the table above tend to show, but until the Shetland Isles have been more thoroughly investigated nothing can be said with certainty.

3. Floristic Differences in the Marine Algæ-Flora of the Færöes.

It is evident that no great floristic differences can be met with within a territory so small as the Færöes, which in their greatest extent from north to south only extend over a little more than one latitude, and where the hydrographic conditions are so very uniform.

Thus the vegetation is in similar localities everywhere almost perfectly homogenous in its composition, and it is only on closer observation that a few disagreements between the northern and southern parts of the islands become discernible. These disagreements are probably caused by the East-Icelandic Polar current which is naturally of great influence on the north coast of the islands. Nevertheless, the Polar current has at the Færöes already, partly been heated by mixture with water from the Atlantic Ocean, partly become more saline, to such a degree, that, according to Ostenfeld (65, p. 610) no arctic plankton has been found at the Færöes; on account of this, the influence of the Icelandic Polar current must likewise be supposed to be relatively small on the fixed algæ-vegetation.

According to the division made by Jónsson and myself, no arctic species are to be found at the Færöes, as already mentioned. Among the subarctic species there is one, however, belonging to the coldest division of this group, which is somewhat more interesting; it is *Halosaccion ramentaceum* a circumpolar species very common in the Polar Sea. It is usually found on the south and west coasts of Iceland, is frequent at the northern coasts of Norway, but does not grow south of Nordland where it has only been found at a few places. At the Færöes, where the southern limit of this alga is most likely found, a supposition already mentioned by Rostrup (72, p. 16), it has been found at 3 places; namely, in addition to the well-known habitat in Klaksvig, also at »Havnen« on the west coast of Svinö, and in Vestmanhavn. Thus the two habitats are found on the Nordreöer, which likewise shelter most of the arctic inland plants, the third on Nordströmö.

In Klaksvig and Vestmanhavn it grows under exactly similar outer conditions; in both places, especially in Vestmanhavn, much fresh and cold water streams down the rocks into the sea, and the temperature of the sea can be fairly low in winter, especially in the upper water layers. At Svinö it grows on an exposed coast but at a high level in a large water basin which is only inundated by the sea at high-tide and by rough seas; here also the temperature of the water can of course be somewhat reduced in the winter.

Whilst this species has thus only been found in the northern territories of the islands, there are also some few others which have only been found at the southern and western coast. *Griffithsia setacea*, for instance, has only been found in Trangisvaagfjord on Syderö, likewise *Polysiphonia violacea; Laurencia pinnatifida* has only been gathered in Trangisvaagfjord and at Höjvig on Strömö; very stunted specimens of *Nitophyllum laceratum* on the west coast of Strömö, south of Kvivig and, according to Simmons, *Ectocarpus velutinus* in Kvalböfjord on Syderö, but it is certainly not excluded, that these and a few other forms, hitherto only found at the southern and western half of the islands, may also be found farther north.

In this connection it should be pointed out, that the Færöes form the southern limit[1] of several species of northern distribution, as well as the northern limit of several species of southern distribution.

Among the former should be mentioned, besides the above mentioned *Halosaccion ramentaceum*, also *Ptilota pectinata, Rhodochorton penicilliforme, Rhodophyllis dichotoma*, which is, however, reported as found at Bergen in Norway, that is, almost as far southward, and a few more. Of species having their north-western limit here (the real northern limit of several of these species is on the west coast of Norway) the following should be mentioned: *Porphyra leucosticta, Callophyllis laciniata, Callocolax neglecta, Nitophyllum laceratum, Griffithsia setacea, Callithamnion granulatum, Rhodochorton seiriolanum, Lithothamnion lævigatum, Lithophyllum incrustans, Ectocarpus lucifugus, E. velutinus, Himanthalia lorea, Valonia ovalis*, and several others.

4. The Origin of the Marine Algæ-flora of the Færöes.

Kjellman (48, p. 58—77) and Reinke (68, p. 96—99) are certainly right in supposing that both the European and American

[1] Several of these species are, however, found still farther south on the east coast of America on the Atlantic Ocean.

algal flora of the North Atlantic have originated from a mixture of Atlantic and Arctic species. I shall briefly explain the main reasons for this conclusion.

There is hardly any doubt, that in tertiary times there has been a land-connection, reaching from Europe by means of the Færöes and Iceland to America. This explains the great resemblance that exists nowadays between the algal floræ on both sides of the ocean. The flora north of the land-connection differed much from that which grew south of it. The Arctic flora has gradually developed from that north of the land-connection, and as pointed out by Kjellman, it is an old flora, which has developed in the seas about the Pole and has been very rich in endemic species. But when the land-connection was broken, which probably happened in the later Tertiary period, a comingling of the species from the two formerly separated territories began and continued into the Glacial Period. During the latter, when the Polar Sea and the northern part of the Atlantic Ocean were covered by great masses of ice the algal flora was forced to go southwards, so that a flora of Arctic character probably occurred as far down as the coasts of South England and North France. On its way south, however, this Arctic flora met and became intermingled with the species of the Atlantic flora, which had been able to resist the climatic changes.

When the ice again receded after the Glacial Period, this algal flora, now composed of species from two different territories, again wandered towards the North, yet a few Arctic forms, which were able to adapt themselves to the higher temperature, remained on the coasts of England and France, whilst others withdrew to the Polar Sea proper. On the other hand, several more southerly Atlantic forms likewise followed northwards, and in such quantities, that they still occur so numerously as to stamp the character of the algal flora in places where circumstances were favourable to their growth, for instance, on the northern coast of Norway. In some such manner as this we may suppose, that the algal flora of the northern part of the Atlantic Ocean has originated. At the end of the Glacial Period its general appearance must have been much the same as it is to-day: a comingling of old Atlantic and Arctic elements.

The flora of the Færöes and with it the oceanic algal flora were probably completely destroyed during the Glacial Period. How have the Islands again recovered their flora, and in what manner especially has the immigration of the marine algæ taken place?

In reference to these questions opinion is divided into two sharply opposing camps; the one finds the explanation in a postglacial land-bridge, which makes the immigration of the flora apparently easy to understand. The other maintains, that this land-bridge is very problematic and not necessary to explain the immigration of the flora of the islands.

I shall not further discuss what has already been said concerning this question, but merely call attention to Warming's treatise on this matter[1] and to his paper (83) published (p. 660) in this work. In the latter paper Warming again takes up the discussion of this question, and on the one hand emphasizes the improbability of the existence of a postglacial land-bridge, on the other declares that the plant-immigration may have taken place by aid of the following factors: (1) birds; (2) the wind; (3) ocean currents; (4) floating ice, floating timber, etc. and finally (5) man's agency. In reference to great distances, thus also to the Færöes, Warming thinks that the birds, the ocean currents, and the floating timber, etc. are of small importance or none at all. On the other hand he assigns great importance to the influence of the wind and the agency of man.

Shortly after this, in the spring of 1904, I published in Danish my treatise on the marine alga-vegetation of the Færöes (10), in which I likewise tried to explain the occurrence of the marine algæ on the coasts of the Færöes by means of factors at work to this day, without having recourse to the theory of the postglacial land-bridge. This hypothesis was, as already mentioned in the introduction, attacked by Porsild and Simmons, who both adopt Ostenfeld's view (64) and assume, that there has been a postglacial land-bridge by means of which the flora immigrated to the islands. They maintain moreover, that as natural conditions are now, the algal flora could not possibly traverse the sea; Porsild for example thinks it a »physical impossibility«, that the algæ should be able to cross the Gulf Stream.

I have already replied (11) to this attack, quoting amongst other arguments, several hydrographers e. g. Komm. Holm, Doc. M. Knudsen, Prof. Mohn, Prof. Fr. Nansen, Kapt. Ryder, and Admiral Wandel, well-acquainted with the course of the currents in the North Atlantic, to prove that there is nothing to prevent floating ar-

[1] Warming, Eug., Om Grønlands Vegetation (Meddelelser om Grønland, København, 1888).

ticles from being transported to the Færöes from all sides under favourable winds.

I have likewise quoted what has been published since Warming's paper against the theory of a postglacial land-bridge by A. C. Johansen[1], Helgi Pjetursson[2] and also a discussion by Fridtjof Nansen who refers especially to his own works[3]. But the most important article concerning this matter is of recent date and due to Prof. Th. Thoroddsen.

In a paper published in February 1905[4] he sets forth arguments against a postglacial land-bridge from a geological point of view. At my request, Prof. Thoroddsen has very kindly given me a short resumé of his paper, which I give here:

»A land-bridge of basalt existed across the Atlantic from Scotland to the Færöes, Iceland and Greenland at the beginning of the Miocene period, but the tectonic features of Iceland, the displacements of the basalt-sheets and the relation of the beds of »Surtarbrand« to the lines of faults show, that the country was not much larger at the end of the Miocene period than it is now. The land-bridge had sunk into the sea. During the Pliocene period Iceland's systems of valleys and rivers were formed in the basaltic regions. These systems conformed closely to the present form of the country. Thereafter doleritic, later striated lava-streams flowed down into the valleys, and at the time these doleritic lava-beds were laid down, the basaltic regions had pretty much the same essential contours as at present. The doleritic, striated lava-streams are either preglacial or glacial, that is, they date from an earlier period than that during which the land was last covered by ice. The pliocene valleys and fjords are continued by deep channels out to the edge of the submarine plateau, and at east Iceland even on to the submarine ridge. These channels are no doubt older than the last ice period in Iceland and younger than the submarine ridge. The Red-Crag-beds in North-Iceland show also, that there was no connection between Iceland and Greenland

[1] A. C. Johansen: »Om den fossile kvartære Molluskfauna i Danmark og dens Relationer til Forandringer i Klimaet«, København 1904, p. 42.

[2] Helgi Pjetursson: »Om nogle glaciale og interglaciale Vulkaner paa Island«, (Oversigt over d. kgl. danske Videnskabernes Selskabs Forhandlinger 1904, n:o 4), p. 266.

[3] Fr. Nansen: The Oceanography of the North Polar Basin (The Norwegian N. P. Expedition, vol. III, Nr. 9 pp. 419—420). Fr. Nansen: »The bathymetrical features of the North Polar Seas with discussions of the continental shelves and previous oscillations of the shore line (Ibid. Vol. IV. 1904).

[4] Th. Thoroddsen: Hypotesen om en postglacial Landbro over Island og Færøerne set fra et geologisk Synspunkt (»Ymer«, 1904, H. 4, Stockholm).

at the end of the Pliocene period, that the sea-level was 80—100 meters above the present high water-mark and that the contours of the coast were almost the same as now. At the close of the glacial period, when almost the whole country was covered by inland ice, the level of the sea was at the coast 80—130 meters above the present high water-mark and gradually sank down to 30—40 meters, when the animal life at the coast had become the same as it is now. Raised beaches are to be seen all round the coast in every inlet. It seems to me for these reasons, that Iceland cannot possibly have been connected with other countries during a postglacial period.«

With regard to the immigration of the flora on the whole, reference may be made to Warming's above-mentioned, detailed work, and I shall now pass on to discuss the possibilities of immigration as regards the algæ, especially the marine algæ. The latter, which live in the sea, are of course widely different from the land flora, so far as the present question is concerned. In my paper on the fresh-water algæ of the Færöes (7) I have pointed out, as already mentioned, that the supposition is at least tenable, that the fresh-water algæ have been transported to the islands by birds or the wind. As to several marine algæ, especially littoral algæ, it also seems to me most probable, that birds have contributed to their distribution. It is now said, however, that migratory birds not only journey with stomachs empty but are on the whole clean (comp. Ostenfeld p. 116); yet small crusts of mud and similar substances have frequently been found on the beaks and feet of the birds. Spores and resting cells can very well be hidden in these crusts (comp. Winge's observations in Warming's paper (83, p. 676)).

The birds which might be supposed to carry the algæ, for instance, from Shetland to the Færöes need not, however, be migratory birds only. The distance between these two groups of islands is only about 300 kilometres, and numerous birds journey everywhere across the sea between them. When fogs and tempests suddenly arise, the birds may very easily be blown off from one coast to another, and it is even very probable, that some of the many sea birds, perhaps particularly the wading birds which live on the coasts of Shetland and the Færöes sometimes visit the one coast, sometimes the other. Even halfway between the islands large flocks of gulls, fulmars and gannets may be met with, and it cannot be supposed that these birds always return to the same coast.

In order to have an opinion from a competent authority on

this matter I applied to Mr. Winge, Vice-Inspector at the Zoological Museum, who has very kindly supplied me with the following report: »Small crusts of mud, clay, etc., may be found on the beaks and feet of the birds[1], that are killed at the Danish light-ships during migration and I consider such birds as *Charadrius pluvialis*, *Hæmatopus ostreologus*, *Numenius phæopus*, *N. arquatus* which are frequent both on the shore and inland, particularly fitted for carrying about spores of algæ etc. They fly excellently; they may be able to travel the distance from Shetland to the Færöes in about four hours when the weather is favourable[2]; and they wander

[1] Mr. Winge has afterwards sent me the feet of two larks which had fallen down on the light-ship of Gedser in the autumn of 1904. I scraped 120 milligrammes of mud from these. Further a wing covert of a female blackbird, fallen at the light-house of Skagen on the second of Nov. 1904, on which two things had stuck, one of them a *Betula*-fruit, which must probably have been carried from Norway.

On March 3rd, 1905, I at length received a sample of earth from Inspector Winge, with the following information: »Earth and fragments of plants from the feet of a lapwing, fallen on the light-ship of Horns Reef, March 5th, 1905. The earth most likely is from England or Holland.« When I received the sample its weight was 360 mgr. Shortly after, I placed it in a Petri-glass under a hand-glass on filter-paper moistened with well-boiled water. During the summer, some algæ were developed, and Professor Wille, to whom I sent the sample, has kindly stated them to be the following species:

Nostoc sp. (most likely *N. Linckiæ* (Roth) Born.).
Anabæna sp. (most likely *A. variabilis* Kütz).
Ulothrix sp. (belonging to the *flaccida*-group).
Cystococcus humicola Nægl.
Navicula sp.
Moss-protonema (large and well developed) and hyphae of fungi.

As it is of the greatest importance to know whether the birds had been soiled during the transport from the light-ship to the Zoological Museum of Copenhagen, I applied to Mr. Winge for information, and he kindly reported: »From the letters of conveyance I learn that all birds sent from the light-ship of Horns Reef during the spring arrived in »boxes in paper«, that is small, tight, square, nailed wooden boxes, made on board the ship and wrapped up in cap-paper. The boxes were packed on the light-ship, lying in the North Sea about 21 Eng. miles west of the coast of Jutland, and were not opened until they had arrived in my study at the Zoological Museum. With the end of a clean knife I here knocked off the earth that stuck to the lapwing's feet, and wrapped it up in a paper which was left unopened till you opened it yourself. Mould and the like might possibly occur in the Museum but certainly nothing else.«

I likewise think, that the species which developed in the earth cannot possibly have been conveyed to the sample in my study at the Botanical Museum. Mould and the like might also have been conveyed to the sample here, but such forms were not developed at all. The species found were all earth-plants, and we can certainly take it for granted therefore that they were present in the sample, when the bird fell on the light-ship.

[2] Compare Wille: »Færøernes Ferskvandsalger« p. 18.

about a great deal, the whimbrel perhaps most of all.« Mr. Winge further states that »a great many migratory birds really go to the Færöes, not only those that are breeding there but also many on their passage north- or southward.«

It seems to me very probable, that several, especially littoral algæ have been carried across the sea by the agency of these migratory birds. How easily may not the filament of a *Rhizoclonium* or a *Bangia* stick to a bird's feathers, feet or beak. These filaments are, as is well known, so elastic and roll up so easily, that they may readily become entangled in the feathers of a bird. A small portion of an alga, e. g. *Porphyra*, *Enteromorpha*, *Monostroma*, *Ulva*, *Ulothrix*, *Urospora* or *Prasiola* may also easily stick to the beak or the foot of a bird, and thus be carried off. It is of course only smaller algæ as a rule, or species of which a fragment is sufficient to develop new individuals, that we can suppose have been carried across the sea in this way.

As to the wind, it is certainly not incredible that small fragments of algæ may be swept up and carried across large distances, as has been shown for both organic and inorganic substances (see Warming, 83, p. 678—679[1]); but I think, that no great importance can be assigned to the wind as a means of transporting marine algæ. As to the freshwater algæ it is quite different. They often live in places that dry up, from which they may easily be carried a long way with the dust as resting cells or spores.

But the factor of greatest importance in the distribution of the marine algæ is naturally the sea currents, and in the following pages we must examine which of the currents are the most important in this connection. We should naturally suppose that the greatest supply of fragments of algæ, resting cells or spores is furnished by the countries which are nearest to the Færöes; namely 1) the coasts of Ireland and Scotland, 2) the west coast of Norway and 3) Iceland. Each of these countries may be examined from this point of view.

The coasts from which first of all the immigration would be expected, are those of Ireland and Scotland, as they are the nearest to the Færöes.

It cannot, however, be denied that the first view of a map of the currents of the Northern Atlantic is somewhat disappointing, if information is expected regarding the currents of these regions, as

[1]) Cp. also: Warming, Eug., Den danske Planteverdens Historie efter Istiden. Kjøbenhavn 1904.

they do not seem to flow in any direction favourable to the immigration. As pointed out by Ostenfeld (64, p. 115) a broad arm of the Gulf Stream flows south east round the islands and seems to prevent all immigration from Europe. As it comes from the open Atlantic and has not touched any country after the West Indies and tropical North America, it can, as Ostenfeld says, only carry tropical fruits and seeds[1]. These circumstances are seemingly unfavourable, and Ostenfeld also declares, that in his opinion the current can never carry species that will thrive in the Færöes.

This is however scarcely quite right; even if the circumstances are far from favourable, it seems to me it cannot be denied that marine algæ, which will thrive at the Færöes, can be carried there by currents. If we look at one of the latest of the current maps of the northern part of the Atlantic, as for instance Ryder's (73, table 11) which represents the seas between Norway, Scotland and Greenland, and of which fig. 162 represents a photographic reproduction, it must be acknowledged, that as to the parts of the British Isles which are nearest to the Færöes, the direction of the current is anything but favourable, as it flows from the Færöes in an almost straight line towards the Shetland Isles. Circumstances are however totally different as to the west coast of Ireland.

In order to understand this, an ordinary, theoretical map of the currents is not sufficient; one must study a detailed chart, for instance, the excellent »Monatskarte für den Nordatlantichen Ozean« prepared by the »Deutsche Seewarte«, on which are indicated all the directions of the currents observed during one month[2]. Also in a paper on Rockall (Notes on Rockall Island and Bank etc. Transactions of the Royal Irish Academy, vol. 31, Dublin 1896—1901) the observed directions of the currents (all possible directions!) and

[1] Such fruits and seeds are frequently washed ashore on the Færöes. Lyngbye even mentions this in »Tentamen Hydrophytologiæ« p. 60. I myself have also found and received from inhabitants of the Færöes fruits and seeds of *Cocos, Entada gigalobium* and *Guilandina*, all well known from the beach woods of the West Indies.

[2] In order to prevent any misunderstanding, I may give a report of what Commodore G. Holm, the director of the chart-archives, has kindly communicated to me, concerning the meaning of the arrows (compare figs. 163—4). »The arrows indicate the observed directions of the currents. They are most likely compiled from the journals of ships, and are the mean of the directions caused by a current. Most likely these directions are immediately due to the wind, but in this they do not differ from other currents, for most currents are originally produced by the agency of the wind. The arrows must indicate surface currents extending down more than several feet. several fathoms at least.

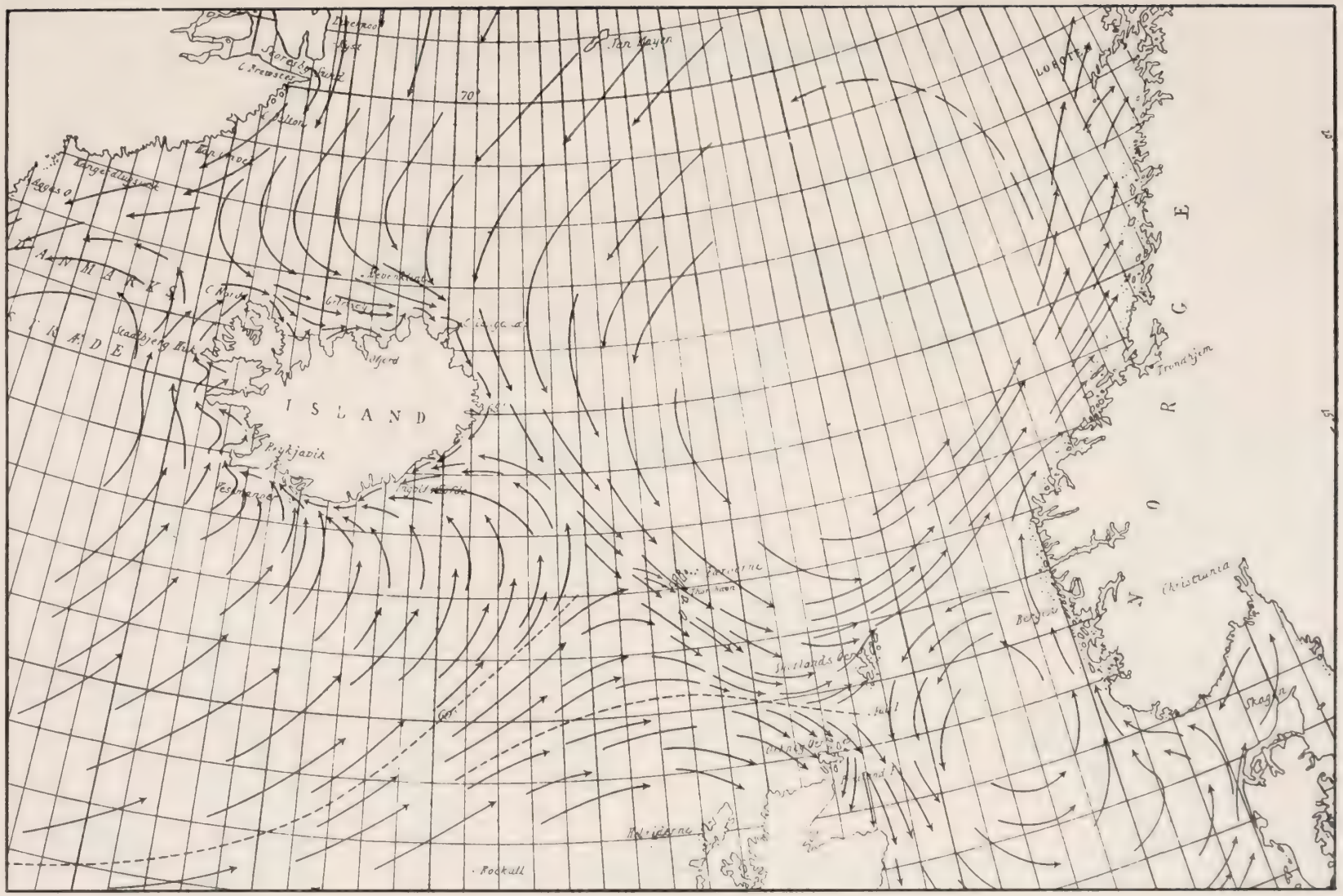


Fig. 162. Reduced, photographic reproduction of Ryder's chart of the North Atlantic Ocean.

their rapidity (sometimes almost nil, sometimes rapid) may be seen in the two charts (Pl. XIII and XIV) accompanying the paper.

Thus it is evident, that even far out in the Gulf Stream, where the current might be expected to flow to a certain degree regularly, it may go, so to speak, in all directions. This is of course due to the fact, that the Gulf Stream flows very smoothly here, so that strong winds may give rise to currents in all directions, even across

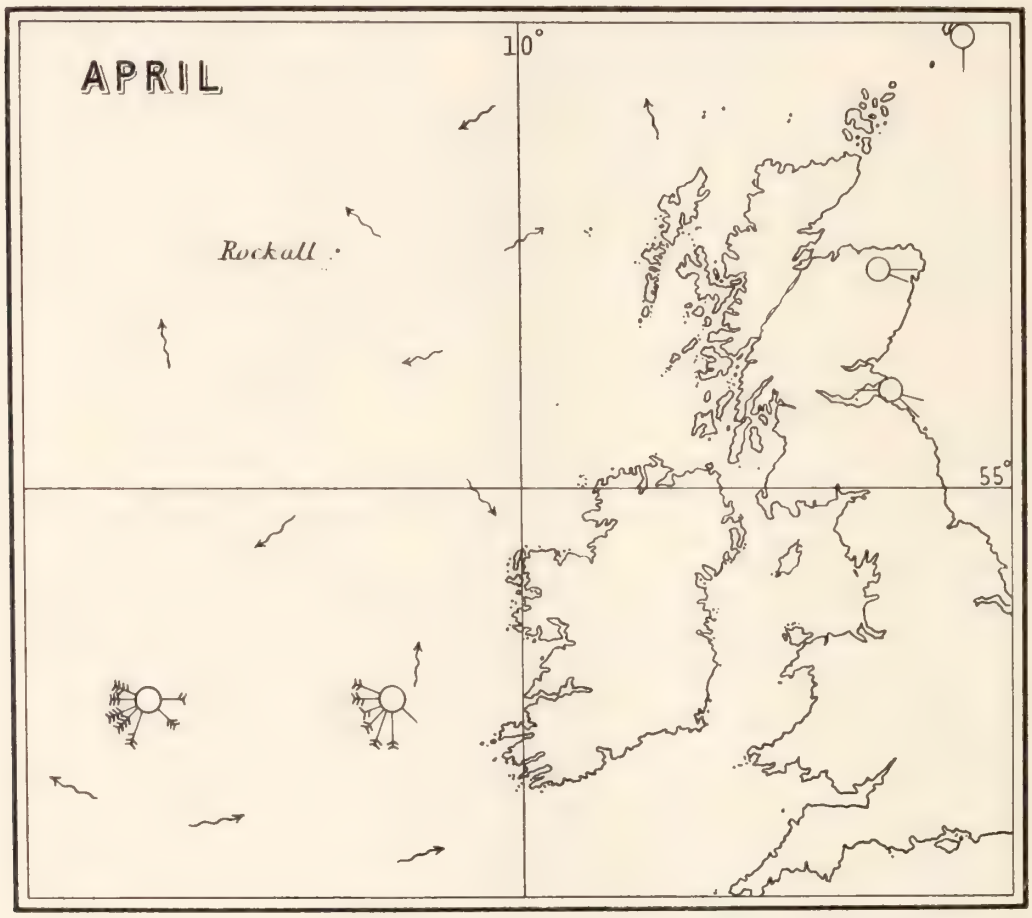


Fig. 163. Chart showing the observed directions of currents in April 1903. (From Deutsche Seewartes Monatskarte.)

it. In the accompanying figs. 163 and 164 I have given portions of two charts from the year 1903; the arrows indicating the observed directions of the currents.

Even if it is far from usual, it cannot, however, be denied, that algæ, floating timber, etc. may be carried as far as the Færöes by strong winds from the East or the South, which are very frequent, at any rate in the spring, and by the above-mentioned changes in the direction of the currents. They may even be carried as far as Iceland, which happened to the bottle No. 12 thrown overboard north-west of Rockall by the »Thorvaldsen« (see Ryder l. c. p. XLII). Another bottle, No. 11, which was thrown overboard by the »Skálholt« was washed ashore on the Færöes. The latter bottle (see also »Ceres« bottle No. 6) proves

the irregularity of the setting of the current. The same can be said, for instance, of the bottles No. 32, 33 and 26 of the »Tejo« 1899. These bottles were thrown overboard to the south of Iceland; under ordinary circumstances they would have been carried westwards, but on account of the heavy winds from the west they were hurried eastwards to the west coast of Norway. How very irregular the direction of otherwise constant currents can be on the whole

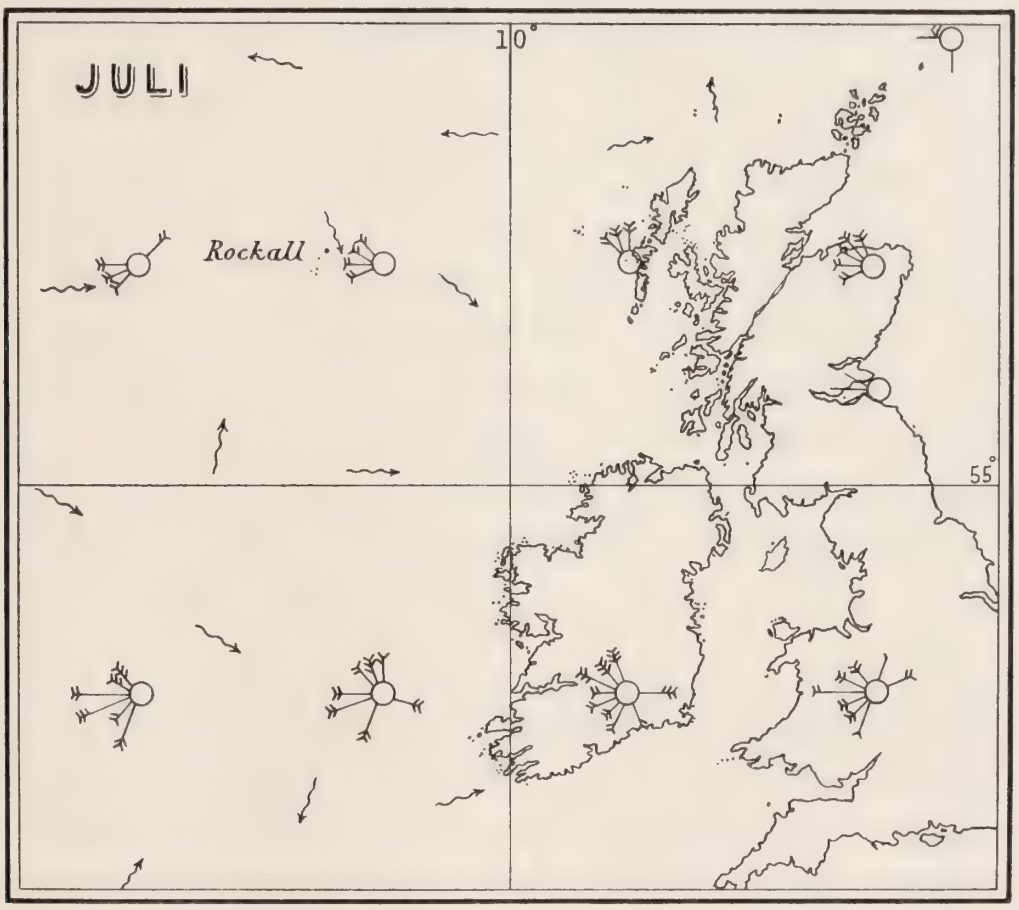


Fig. 164. Chart showing the observed directions of currents in July 1903. (From Deutsche Seewartes Monatskarte.)

(comp. Boguslawski and Krümmel: Handbuch der Ozeanographie, vol. II, for instance p. 374—375) is also proved by the fact, that the current of the North Sea went in an opposite direction from the usual in December 1896 and January 1897[1].

I cannot but believe therefore that floating algæ, floating timber to which algæ are attached, etc. can be carried to the Færöes sometimes when the wind is favourable, probably not only from the coasts of Ireland, but also from the Hebrides and the west coasts of Scotland.

But it is not only from these parts of the British Islands that

[1] Fulton, T. W. The Currents of the North Sea, and their Relation to Fisheries. (Fifteenth Annual Report of the Fishery Board for Scotland for the year 1896. Edinburgh. 1897.)

things may be carried to the Færöes, but also from the west coast of Norway. According to Rŷder we must suppose that there is a large circulation north of the Færöes between Iceland and Norway. This circulation is formed by the East Icelandic Polar Current to the west and the current along the coast of Norway to the east. Ryder thinks, that the northern part of the circulation is formed by a current which goes from the northern part of Norway at about Lofoten in a north-westerly and westerly direction towards Jan Mayen, and then southward along the east coast of Iceland (the East-Icelandic Polar Current), and finally south westwards to the Færöes. From here the current again runs in a north-easterly direction to the west coast of Norway, after having touched the Shetland Isles. It is also very probable, that the great distance which the algæ have to float, if they are carried round the whole circle, can be much shortened, when the winds are favourable. If we look at Ryder's map of bottles thrown overboard from the »Antarctic«, we find, that a bottle (No. 15) thrown out at about 250 miles N. E. of Langanes is believed by Ryder to have been carried first in a south-westerly, then in a south-easterly direction, in a large curve close past the Færöes, and to have been washed ashore on the north coast of Norway.

If algæ can now be carried from the west coast of Norway out into the North Sea, some of them may have a chance of being carried to the Færöes. Fortunately Prof. H. H. Gran has kindly communicated to me an observation made by him during his expedition in the North Sea (from May to June 1904). He writes that he found floating seaweed with epiphytes all over the North Sea. He has sent me extracts from his journal regarding some of the places between 67° 44′—62° 57′ N. Lat. and 11° 10′ W. L.—6° 22′ E. L., that is to say, midway between Iceland and Norway, and on both sides of the route which Ryder supposes the above mentioned bottle to have taken. There can hardly be any doubt, that such algæ floating far out in the North Sea can be carried to the Færöes, if the wind is favourable.

As to the third possibility for the immigration of algæ, namely from Iceland, the currents are even highly favourable. As will be seen on Ryder's map, the current from East Iceland goes straight down to the Færöes, and algæ can thus easily be carried from East Iceland to the Færöes. But as the hydrographic conditions differ greatly on this part of the coast of Iceland from those at the Fær-

öes, the immigration of algæ from there is probably of but small importance. It is probable, however, that the Færöese species of a more northern distribution e. g. *Halosaccion ramentaceum* and *Ptilota pectinata*, which are distributed more specially in the northernmost part of the islands have been carried this way to the Færöes.

It is my opinion therefore that 1) circumstances are somewhat favourable to marine algæ being carried across and over the sea to the Færöes from the west and north coasts of Ireland, from the west coast of Scotland, from the Hebrides, etc., 2) that algæ can possibly be carried from the west coast of Norway, and 3) that algæ can very well be introduced from East Iceland (probably also from other parts of this island).

Having thus discussed the possibility, that objects floating in the sea can be carried to the Færöes from the coasts of the adjacent countries, when circumstances are favourable, we may enquire into what enables the algæ to float for a long time in the sea. One reason is, that they are in themselves able to float for a long while; another, that they are attached to floating timber, etc.

As to the first reason, there are not a few algæ, especially littoral algæ, with air-bladders or with a thallus partly inflated with air[1], which keep them on the surface of the water for some length of time. Almost everywhere in the sea one can meet with floating seaweed (comp. the above-mentioned observation made by Gran) often far from their habitats. Kjellman says (48, p. 73), that he has found *Ascophyllum nodosum* and *Fucus vesiculosus* floating in the sea at different latitudes between Norway and Spitzbergen; and on the south coast of Spitzbergen he has collected *Ascophyllum* with numerous *Polysiphonia fastigiata*. He has not found these algæ fixed to any substratum, but others have stated that they grow there; at any rate they must have been carried there by the Gulf Stream. It

[1] Of the algæ from the Færöes there are in the first place nine brown algæ which are either always or at any rate more or less frequently supplied with air-bladders: *Ascophyllum nodosum, Fucus vesiculosus, F. inflatus, F. spiralis, Himanthalia lorea, Halidrys siliquosa, Laminaria færoensis, Scytosiphon lomentarius* and *Chorda filum*. Moreover, there are the species of *Enteromorpha* and perhaps a few more brown and red algæ. Here the *Zostera* must also be mentioned; it is well known that its thallus floats excellently. These species, which are almost all rich as to numbers, float easily, and on these different algæ and *Zostera* there often, indeed almost always, grow a great many different epiphytes and endophytes, which are likewise carried about in the sea.

is such a well-known fact, and it has so often been proved, that sea-algæ are capable of floating far out to sea, that further discussion of the matter is scarcely needed[1]; nevertheless I may illustrate this by some examples.

A great many algæ are washed ashore on the sandy and therefore in many places barren west coast of Jutland. Dr. L. Kolderup Rosenvinge has recently stated at the »Botaniske Forening«, that about 40 species have hitherto been washed ashore there; several of these species do not grow on the west coast of Jutland, some of them not in all Denmark. Among these algæ some perfectly well-preserved, fruit-bearing specimens are found, e. g. of *Himanthalia lorea*, which must be supposed to have been carried probably from the English coast.

I do not know for certain, whether there are algæ which are not air-inflated and yet able to drift or perhaps only hang suspended in the water for some length of time; but I am inclined to believe that such algæ do exist, some however sink down quickly, some even very quickly e. g. *Fucus serratus*. It seems, however, very probable, that several filiform and much ramified algæ must be able to float for a long time in the sea. Dr. Johs. Schmidt for instance informs me, that he has met with species of *Ectocarpus* and other higher forms of algæ floating near the surface of the sea east of Iceland. In this connection I may also mention, that Hesselman (Bot. Notiser, 1897) found, in addition to some larger algæ *(Chorda filum, Fucus vesiculosus* and *Enteromorpha intestinalis)* also some smaller forms, which unfortunately are not named, in Nortälge skärgård amongst drift. And in »Botanische Untersuchungen der Pommerania-Expedition« vom 3. bis 24. August 1871, p. 77, Magnus declares that at a distance of 4 miles from the east coast of Gotland

[1] I may further mention a few examples: *Gelidium cartilagineum* from the southern part of the Atlantic has been washed ashore on the coast of Scotland), it is therefore also mentioned in early botanical works e. g. Edmonston: Flora of Shetland), and on the coast of Norway, where it was found for instance by *Gunnerus* (comp. Sernander: Den skandinaviske vegetationens spridningsbiologi. Upsala 1901, p. 120). The American *Laminaria longicruris* has an inflated stalk, by aid of which it can be carried a long distance; it has been found for instance on the west coast of Jutland, at Bohuslän and Finmark (comp. Sernander l. c.). Still it is not excluded, that some of these inflated stipes of *Laminaria*, if not all, which have been found, came from the Færöes or Iceland, as *Laminaria færoensis* which grows there has similar inflated stipes, though without mucous canals. Possibly it might, however, be the American species which has been carried across the Atlantic. If that is so, the immigration of algæ from America to the Færöes is certainly not excluded.

he has met with *Rhodomela subfusca, Ceramium diaphanum, Sphacelaria cirrhosa* and other algæ floating about in the sea.

But even if the algæ cannot of themselves float about in the sea for a long time, they can nevertheless be carried about by adhering to floating timber or other objects floating on the surface of the sea.

Between Shetland and the Færöes I have several times seen floating timber completely covered by a dense vegetation of algæ. In Nolsöfjord near Thorshavn, I once saw a large beam quite overgrown by algæ. Amongst these were a great many well-developed *Alaria esculenta*, carrying numerous *Litosiphon Laminariæ* on their lamina, several species of *Ectocarpus*, small forms of *Enteromorpha*, Diatoms, etc. Another time I found a piece of cork with a dense, velvet-like vegetation, consisting of *Callithamnion scopulorum*. Finally, algæ destitute of air-bladders can be carried a long distance by the sea-currents, either by growing on species provided with bladders or only entangled among such algæ.

To the factors contributing to the distribution of the algæ one must be added which is certainly of no small importance nowadays, that is: man's agency. There can hardly be any doubt, that a great many species of algæ are carried far by the aid of navigation. It is a well-known fact that ships which lie near to land very quickly become green below the water-line. The reason is, that the part of the ship which is under the surface of the sea is covered after a short time by a great many animals and plants, which thrive excellently on account of the movement of the ship, and the ensuing constant renewal of water. On a ship one can meet with a vigorous algæ-vegetation, rich in different species[1].

[1] The following species were for instance collected by me on the 13th of June 1900 from the »Guldborgsund«, which had been scraped and scrubbed on the 15th of May of the same year, according to the journal of the ship. The species were: large, vigorous *Alaria esculenta*, several specimens more than one foot long; they preferred the most »exposed» parts of the ship, some specimens for instance grow on the screw, where however the lamina were somewhat torn and split. Of *Laminaria*, there were *Laminaria saccharina* and *L. digitata*, ca. half a foot long. Further fairly large specimens of *Porphyra miniata*, smaller specimens of *Chordaria flagelliformis*. Of green algæ there were *Monostroma fuscum*, small *Enteromorpha* and a great many quite small specimens of different species, Diatoms, etc. which I did not get an opportunity of examining. This comparatively luxuriant vegetation had thus been produced during about one month. It must of course not be left out of consideration, that if the bottom of a ship is ever so thoroughly cleaned, it will never become perfectly clean, unless it is taken into dock. In the above mentioned case, however, one may take it for granted, that only small specimens or fragments of algæ had been left. As to the transport of algæ by ships see also Kjellman (48, pag. 59).

When we see, that a ship can become overgrown to such a degree during so short a time, as is shown by the case mentioned in the foot-note, the algæ must often have a chance of being transported by ship and thus of being carried to other countries, where they can fix themselves, but of course only where there are suitable conditions of life[1].

If we may now assume that the algæ can float far across the seas, another question presents itself, viz. if they can also stand the changes of temperature and salinity which a long passage involves.

As to the first, it may at once be said, that the changes of temperature and salinity in the seas we speak of are relatively small, and we may therefore also suppose that as a rule they have hardly any injurious influence on the algæ. It must not be forgotten, that the changing of temperature proceeds very slowly during the passage, and that the algæ are very well fitted to these changes within certain limits[2]. On the other hand, the algæ are usually very sensible to sudden changes of temperature and salinity, as previously mentioned by me, still by no means so very sensible as was formerly assumed. In a paper (Notizen über die Cultur und Lebensbedingungen der Meeresalgen, Flora 1895) Oltmanns has already pointed out that freshly gathered marine algæ were much better fitted to resist changes of salinity, than algæ which

[1] That this supposition is right is confirmed by the fact, that we frequently meet with algæ, belonging to very remote territories, on harbour moles, just as is the case with the inland flora found in harbours and on wharfs. In »Bulletin de la soc. bot. de France« vol. 35, 1888, p. 364, Bornet for instance mentions 3 *Laminariaceæ* which have been met with a few times in and near harbours of the Mediterranean, but which were otherwise never found there. The *Fucus inflatus* which I found on Lerwick mole (8) and the two isolated habitats of *Fucus serratus* found in Iceland (Jónsson, 41) can probably also serve as examples.

Finally, Dr. Bornet has kindly informed me by letter of some interesting discoveries. *Chorda filum* has been found at the entrance to the harbour of Nice; the species was never observed at other places in the Mediterranean. *Helminthocladia purpurea* was found at the harbour of La Nouvelle, likewise in no other place in the Mediterranean. *Bonnemaisonia hamifera* which is distributed on the coasts of Japan and California has been found on the coasts of England and later also of France (Cherbourg). The plant is dioecious, and only the female plant has been imported; it propagates by aid of buds which are found at the top of the branches like hooks. *Hypnea musciformis* has been found in the Channel; its true habitat is more towards the south.

[2] Cp. for instance: Porter, H. C., Abhängigkeit der Breitling- und Unterwarnow-Flora vom Wechsel des Salzgehaltes. (Arch. Ver. Nat. Meckl., 1894).

had been cultivated for a long time. And in a paper (Verhalten einiger mariner Algen bei Änderung des Salzgehaltes. Oesterr. bot. Zeitschrift, 1904) Karl Techet in his »Übersicht« comes to the following conclusion: »Die individuelle Anpassungsfähigkeit — um diese handelte es sich bei den angeführten Versuchen — an Änderungen des Salzgehaltes ist bei marinen Algen eine ziemlich weitgehende und zwar sowohl bei spontaner Erhöhung als spontaner Verminderung der Salzintensität.«

With regard to change of salinity, I may also call attention to the different observations mentioned in my description of the vegetation. I have met with algæ, even *Florideæ*, growing at the mouths of rivers, where they were completely covered by fresh water at low tide, and by salt water at high tide[1]. These are sudden changes.

With regard to the temperature, the algæ seem specifically unfit for resisting changes from cold to warm water. They can probably stand the reverse change much better, within certain limits of course[2].

Algæ carried about by a ship are naturally much more exposed to the danger of sudden changes in the temperature and salinity, and if such changes occur the algæ simply perish[3]. But for short distances, as for instance between the Shetland Isles and the Færöes, the difference is too small to hurt the algæ.

It is very probable, that the white light on the surface may hurt some of the algæ, which usually grow deepest down, when they happen to be carried near the surface of the sea, but we know nothing for certain. We may however suppose, that they are sometimes protected against the white light; for instance by growing on the under side of wrecks or by being entangled between larger algæ. The motion of the waves also perhaps serves to protect them in some way, as it constantly makes them turn another side to the light. We may also suppose that sublittoral algæ which have become attached as spores to floating timber, etc. are perhaps better

[1] See also Gomont, Sur la végétation de quelques sources d'eau douce sousmarines. (Bull. soc. bot. Fr., t. 51, 1904).

[2] Cf. Kjellman, Norra Ishafvets Algflora, p. 73.

[3] I may briefly illustrate this by an example. In the summer of 1899, the »Guldborgsund« was more than usually foul, and was therefore ordered to go in dock at Copenhagen. But when it arrived there, the bottom of the ship was perfectly clean, all the algæ had perished and dropped from the ship, as soon as it had entered the warm and less salt water of the »Sound«.

fitted to stand a strong light, than an alga which is suddenly torn from its habitat in deep water.

But even if the alga is destroyed by unfavourable biological conditions, the reproductive cells (tetraspores, carpospores etc.) which it possibly carries may be able to survive the transport.

If an alga has finally surmounted these various difficulties and been washed ashore, it is still far from being settled among the flora of the island. In order to become so, it must be able to fix itself. A great many algæ are certainly able to do so; I may just mention such species as *Ceramium*, *Polysiphonia*, *Callithamnion*, *Ectocarpus*, *Sphacelaria*, *Cladophora*, *Acrosiphonia* etc.

There is hardly any doubt, that all species belonging to these very rich genera are normally supplied with rhizoids, or at any rate are very apt to form them. If therefore one of these algæ when it is washed ashore, sticks to something or other, for instance to an alga growing there, it will perhaps only be a short time before it forms rhizoids, which can fasten the plant to its subtratum. Even very small fragments of several algæ seem to be able to produce new individuals. Thus Oltmanns mentions (l. c.), that he has cut shoots of *Polysiphonia* and *Ceramium* into very small pieces which quickly formed rhizoids and gradually developed into small plants. In different papers Tobler[1] also tells us that even one cell of some *Rhodomelaceæ* can develop into new individuals. By cultivating a *Dasya elegans* he observed, that the alga divided after a short time into many small pieces, which gradually developed into small plants in the culture-glass. He therefore supposes that the algæ must sometimes have a similar reproductive power in the sea.

On the other hand there certainly are many algæ which cannot take root again, when they have once been torn from their subtratum. That it may be possible for such algæ to immigrate into another region, they must necessarily carry reproductive cells within them. When an alga with more or less ripe tetraspores, carpospores, etc. is torn from its habitat, nothing prevents us from supposing, that after having floated for a shorter or longer time it can succeed in carrying the spores to another habitat. In the new region the spores can thrive, if the external conditions are suitable to the species.

[1] Tobler, F., Zerfall und Reproduktionsvermögen des Thallus einer Rhodomelacee. (Berichte d. deut. bot. Ges. Bd. 20, 1902.)

— — Ueber Eigenwachsthum der Zelle und Pflanzenform. Versuche und Studien an Meeresalgen. (Pringsh. Jahrb. Bd. 39, 1904.)

After having thus taken into consideration what serves to support the theory of the transport of algæ across the sea, we must, however, admit that on the whole we know very little with certainty about the matter — and so far, our conclusions must necessarily be hypothetical. Taking everything into consideration, however, it seems probable to me, and at least not incompatible with the real conditions, that perhaps all the algæ of the Færöes have been transported across the sea by the agency of the currents. They can either have floated by themselves or have been fixed to various objects floating in the sea. The agency of birds must perhaps also be taken into account. Floating ice has also perhaps contributed to the distribution of the algæ towards the end of the glacial period and shortly after. Nowadays the floating ice is of no importance to the Færöes.

There is one further evidence, which indirectly but strongly confirms the hypothesis concerning the immigration by sea — viz. the fact, that hardly any island has not got its algæ-vegetation, even those at the greatest distance from the coast and of volcanic origin or built by corals. Jan Mayen serves to prove this by its algal vegetation, which is certainly very poor, so far as we yet know, but still has species not only from shallow, but also from deep water.

It is naturally more difficult for algæ to pass across the sea than to travel along a coast. This serves to explain the fact, that several species common on the coasts of the adjacent countries, are wanting on the coasts of the Færöes, it likewise seems to me to very clearly refute the hypothesis of a postglacial land-bridge. *Fucus serratus* for instance is totally wanting on the coasts of the Færöes, and this is the more worth mentioning, because this alga is very common along all the coasts of North Europe. On the Shetland Isles for example, which are nearest to the Færöes, it grows abundantly. That this species has not spread so far as to the Færöes is certainly solely due to its want of air-bladders, which prevents it from floating by itself on the surface of the sea. The species of *Fucus* found in the Færöes are on the other hand always or at least sometimes provided with air-bladders and are thus able to float. It cannot surely be denied, that the Færöes offer an excellent locality for *Fucus serratus*, if it should succeed in reaching so far. It is therefore probable, that it would have grown

there abundantly, if a postglacial land-bridge had existed, by aid of which it might easily have made the passage.

Several sublittoral algæ e. g. *Chætopteris plumosa, Phyllophora rubens, Dilsea edulis, Brongniartella byssoides*, etc. are also wanting at the Færöes, though they are more or less frequent in the surrounding seas.

When everything is taken into account, the algæ-flora from the deeper sea has perhaps had the greatest difficulty in reaching the islands. This perhaps explains, why some sublittoral algæ which might reasonably be expected to grow at the Færöes are not found there. The sublittoral algæ which grow deep down are probably the least fitted for floating a long time, and as to their adhering to algæ from the littoral region or to floating timber as a means of transport, this likewise seems to occur only rarely. On the other hand we know but little about the first stages of development of many of these algæ. We especially want to know whether the different reproductive organs are able to float for a long time in the sea apart from the mother-plant. They may possibly be carried far about as plankton[1]. Finally if the algæ spores cannot float far either by themselves or by the agency of the sea currents, it is however probable, that they can stick to the mucilage of larger algæ, or to the mucus of fishes, and thus be carried off.

It is hardly probable, that any of the sublittoral algæ have been able to survive the glacial period, according to Geikie[2]. He

[1] In connection with this it may be pointed out, that the late Prof. Cleve, the well-known Swedish plankton-investigator, thinks it probable that algæ-spores can be carried about by the agency of marine currents. He has even expressed the opinion, that the stunted forms of algæ from the Polar Sea met with in the Baltic can have been carried there together with Arctic plankton (see Botaniska Notiser, 1898, p. 269). If it is so, the short distance from the English coast to the Færöes is nothing by comparison. It should however be observed that these forms of algæ in the Baltic must rather be considered as »relicts« as pointed out by Svedelius (Studier öfver Östersjöns Hafsalgflora, p. 68—69).

A remark by Oltmanns should also be mentioned here. In a paper »Notizen über die Cultur- und Lebensbedingungen der Meeresalgen« (Flora 1895), after having emphasized the necessity or at least the desirability of having sterilised sea water for culture-experiments, he writes: »Die Steriliserung ist aber auch besonders dann unerlässig, wenn man kleine Ectocarpeen einigermassen rein cultiviren will, weil das Seewasser fast zu jeder Jahreszeit und an jedem Ort eine recht erhebliche Anzahl von Schwärmsporen der verschiedensten Species enthält, welche alle neben den ausgesäten Formen keimen würden.« (The emphasis is mine.)

[2] Geikie, James, Prehistoric Europe. A Geological Sketch. London 1881, p. 663.

writes: »but the ice was so thick that it filled up all the fjords and sounds between the various islands of the archipelago, thus forming one compact *mer de glace* which flowed outwards in all directions from the dominant points, and discharged its icebergs into the surrounding ocean«. But as the Færöes lie so far out in the Atlantic Ocean, they cannot have been far from the open sea, and possibly there may then as nowadays have been strong currents at the coasts, and for this reason the ice may not have reached everywhere to the bottom of the sea in the sublittoral region, some of the sublittoral algæ thus being spared.

In accordance with what I have previously said about the possibilities of immigration of the fresh-water algæ (7), it seems to me that there cannot be any doubt, that the marine algæ-flora has likewise been able to immigrate to the islands across the sea from the coasts of North Europe, and by the agency of factors which are at work to this day. Thus, the possibility of immigration always exists, and a postglacial land-bridge is not at all necessary to explain the occurrence of the algæ-flora.

In perfect agreement with Warming's view regarding the land-flora, I may therefore conclude by saying that the marine algæ of the islands have also been able to immigrate after the glacial period across the sea from the nearest countries, especially from the British Islands, but also from Norway and from Iceland.

V.

SOME BIOLOGICAL OBSERVATIONS.

It is a well-known fact, that at different seasons of the year, no small difference is discernible in the appearance and luxuriance of the algal vegetation in the northern seas. This has been mentioned by Kjellman (49) with reference to Bohuslän, and other authors e. g. Gran (37, p. 15) and Rosenvinge (71) have expressed the same view for other regions of the sea. On the Færöese coasts the development and luxuriance of the algal vegetation likewise vary according to the seasons. Unfortunately, I myself have only spent some months of the spring and summer on the Færöes and have therefore only been able to make an incomplete study of the development of the vegetation throughout the year; but this want has been greatly helped out by the collection of algæ from

the autumn months of 1897, brought home by Mr. Helgi Jónsson, as well as by the information he has also given me. With these as basis we may safely conclude, that the algal vegetation of the Færöes is much richer and more luxuriant in summer than in winter; the greater development probably begins early in spring and continues into July or August, when the greatest luxuriance is reached, then it decreases again. But on account of the great uniformity of the Færöese climate, the variability of which, particularly as to temperature, is regulated in the sea itself, this varying development according to the seasons is hardly so great here as in many other places with a cold temperate climate.

The algal vegetation of the Færöes agrees well, as regards the richer development in summer, with what is known even in Arctic seas, where the period for the growth of the algæ is at the brightest time of the year, for instance, on the coasts of Greenland, whilst their resting period begins at the beginning of winter (see Rosenvinge 71, p. 239). On the other hand the algal vegetation of more southern countries is much less developed in summer. This may be remarked even on our own coasts, where the vegetation in shallow water is more luxuriant during the months of spring and autumn, but less so during the warmest summer days; and in the Mediterranean Sea the littoral algæ-vegetation is, according to Berthold (5, p. 426), very poor in summer, but rich and well developed during the months of winter and spring.

DURATION OF LIFE. PERENNIAL, ANNUAL AND SHORT-LIVED SPECIES.

As on the coasts of Greenland, the algæ growing on the Færöese coasts are for the most part certainly perennial. It is impossible for the time being, however, to make any reliable comparison between the perennial and the annual species, as our knowledge of the developmental history of a great many species is still very imperfect.

On the other hand, several species are certainly or most probably annual. To these belong: *Porphyra umbilicalis* and probably other species of *Porphyra*, *Chantransia (?)*, *Erythrotrichia (?)*; of brown algæ may be mentioned: *Chorda filum* and *C. tomentosa*, *Castagnea virescens*, *Scytosiphon lomentarius*, *Dictyosiphon Ekmani*, *Punctaria plantaginea*, *Leathesia difformis*, *Phyllitis fascia* and *Ph.*

zosterifolia, *Isthmoplea sphærophora*, *Himanthalia lorea*, which is, however, most likely hapaxanthic (see 8, p. 480), several species of *Ectocarpus* and others; of green algæ may be mentioned several species of *Enteromorpha*, *Monostroma Grevillei* and *M. undulatum*, (whereas *M. fuscum*, as pointed out by Rosenvinge (p. 238) can most likely live for more than one year), the species of *Ulothrix*, *Acrochæte repens*, *Bolbocoleon piliferum*, *Pringsheimia scutata*, *Urospora mirabilis* and *U. Wormskioldii*, *Codiolum*, *Cladophora sericea* and *Cl. gracilis*, *Acrosiphonia (?)* and others.

Several of these species are certainly capable of producing more than one generation in a year; as pointed out by Gran (37, p. 9), those short-lived species (e. g. *Porphyra umbilicalis*, forms of *Enteromorpha intestinalis*, species of *Ulothrix*, possibly *Monostroma Grevillei* etc.) only belong to the littoral region, the reason probably being that only algæ growing in full daylight are able to go through all stages of development in so short a time; we may likewise suppose with some reason that the rapid development of the short-lived algæ, as pointed out by Gran, is an adaptation to the often very unfavourable biological conditions under which the littoral algæ live, especially those growing at the highest level, just where the short-lived algæ are met with.

With regard to Greenland, Rosenvinge has remarked that the low temperature of the sea prolongs the lifetime of many annual algæ, and just in the same way the low summer temperature of the Færöes, together probably with the small amount of direct sunshine, has a preserving and prolonging influence on the annual algæ of spring and summer. For example, a great many species, which are only found towards the end of winter and during the months of spring in the Danish and adjacent seas, grow luxuriantly during the whole summer in the Færöes.

Thus *Porphyra umbilicalis* forms well developed associations during the whole summer, whilst, according to Kjellman, it only forms associations in winter on the coasts of Bohuslän. Vigorous specimens of *Dumontia filiformis*, which in the Danish seas grows in spring and beginning of summer, are found during the whole summer on the Færöese coasts. *Fucus inflatus* f. *disticha* is found in the summer at Haugesund according to a report from Mr. Norum; but the specimens are only badly developed at that season, though vigorous when found during the months of December to March. At the Færöes, however, it

is well developed in the summer. According to Reinke (68, p. 61)[1], *Phyllitis fascia* in Kiel Bay is an âlga of the winter and spring, and only rare in summer, whilst it is luxuriant and very common during the whole summer on the coasts of the Færöes[2]. *Monostroma Grevillei* is likewise well developed at the Færöes during the greater part of the summer, whereas, according to Rosenvinge (71, p. 238), it only lives from the end of the winter to April or May in the Danish seas. According to Batters (4, p. 57) *Porphyra miniata* grows in spring and early summer on the coasts of England; at the Færöes it is found during the whole summer and far into the autumn.

Gran calls our attention to the fact (37, p. 15), that the annual, littoral algæ usually have a shorter or longer resting period, but whilst this period is at the warmest time of the year (July-August) in Kristianiafjord, it most likely occurs at the Færöese coasts only in the autumn, and probably lasts for the greater part of the winter, as these algæ do not come to life again until early in spring.

THE PERIOD AND CONDITIONS OF GROWTH AND TIME OF FRUCTIFICATION.

A great many of the perennial algæ of the Færöes are certainly capable of growth all the year round even if their vital functions are somewhat reduced during the darkest time of the year. This is most probably the case, for instance, in the *Fucaceæ* and the *Laminariaceæ*, but, on the other hand, we must suppose, that the last months of the year, as also January and perhaps February, form a resting period for several Færöese algæ, and that their proper vegetative period is the months of spring and summer. Judging from the material I have at hand, I believe that many algæ begin to develop new shoots even towards the end of winter. The material collected by Jónsson during the months of autumn mainly consists of badly developed specimens, whose apices are often dead or dropped; only a few species, e. g. *Phyllophora Brodiæi* and some specimens of *Fucus* had begun to form some few new shoots. In April, however, I found a great many species which already had large, vigorous shoots, e. g. *Odonthalia dentata, Delesseria sanguinea*

[1] See also Simmons: Algologiske Notiser II. Einige Algenfunde bei Dröbak (Bot. Notiser, 1898, p. 118).

[2] In the Danish seas it is, however, also common in the autumn; it may be found well developed even in August.

and *D. sinuosa*, *Callithamnion arbuscula*, *Furcellaria fastigiata* and many others. In the course of winter, especially towards its end, and during the first months of spring, the new lamina appears in the periodically lamina-changing species of *Laminariaceæ*, e. g. *Laminaria digitata*, *L. hyperborea* and *L. saccharina*, and the old laminæ are thrown off during the months of spring, at which time huge masses of the latter are washed ashore on the beach.

As the vegetative period for several species is much prolonged in Greenland, the same may be said though to a less extent of several species on the Færöese coasts, compared with what is the case on our Danish coasts. Besides the above-mentioned annual algæ, which live somewhat longer, as just stated, we may find, e. g. *Desmarestia aculeata* with new shoots and densely covered with assimilating hairs as late as June and July, whilst in Denmark it is often hairless already at this time of the year. *Rhodomela lycopodioides* likewise grows for the greater part of summer on the Færöese coasts, whilst *Rhodomela subfusca*, which is closely related to the latter, stops developing at the beginning of the summer on the Danish coasts. On the whole, several algæ which at a certain moment stop developing in our seas, seem to be able to throw out shoots much later in the year on the Færöese coasts; but whether their vegetative period is really prolonged or whether it is due to the fact, that this period begins later and thus likewise ends later than on the Danish coasts, I cannot say as yet. The latter seems at any rate rather probable.

As to the time of fructification, it sets in at very different periods of the year for the different species; in my paper on the Marine Algæ of the Færöes I have stated the time of fructification of each species, so far as it is known. As a general rule it may be stated, that the greater part of the Færöese algæ seem to fructify during the summer season.

Some species, however, have only been found with reproductive organs at other times of the year; e. g. *Delesseria sanguinea*, found with cystocarps and tetraspores during the last months of the year; *Halidrys siliquosa* which is sterile in summer, but which had young receptacles in October; *Furcellaria fastigiata* of which I have seen specimens with tetraspores in great quantities in November-December, whilst specimens with antheridia or cystocarps did not occur in the material, as they are most probably developed during the winter months, as on our own coasts.

Some species begin to develop their organs of fructification in

winter, and fructify the next summer. *Ascophyllum nodosum*, for instance, has young receptacles in December: it has been found with ripe receptables in April, and fructifies constantly during the summer; just the same seems to be the case with *Fucus inflatus* and *Fucus vesiculosus; Himanthalia lorea* has been found with young receptacles in April, and they become perfectly ripe in July-September.

Other species e. g. *Ectocarpus lucifugus*, *Sphacelaria cirrhosa*, *Elachista scutulata*, *Desmarestia aculeata* etc. have only been found with ripe sporangia during the months of autumn, others, e. g. *Ectocarpus tomentosoides* in the end of the winter and more rarely in spring; species of *Urospora, Monostroma Grevillei* etc. during the months of spring and early in summer.

Lastly, it seems as if a great many algæ are able to fructify all the year round; several of the above mentioned short-lived species, e. g. *Porphyra umbilicalis*, also *Chantransia secundata*, *Callophyllis laciniata, Euthora cristata, Delesseria sinuosa, Ectocarpus litoralis, Elachista fucicola*, and probably many more may serve as examples.

Just as the period of life and growth of several algæ is prolonged under the influence of the Færöese climate, the fruit-bearing period is often likewise of longer duration here than in more southern countries; this is similar to what Rosenvinge has observed in Greenland. As illustrations of this may be mentioned: *Rhodochorton Rothii* which in Denmark only fructifies during the winter months, but which has been found with tetraspores even in June and July on the Færöes; *Ascophyllum nodosum* which here in Denmark only fructifies during the winter, but which has ripe reproductive organs all the summer on the Færöes as in Greenland, and *Delesseria sinuosa* of which the same may be said.

On the whole, the fruit-bearing period seems, as regards several species, to occur at other seasons than in more southern countries, and the Færöes seem also in this to occupy an intermediate position between Greenland, where still greater differences are observed according to Rosenvinge, and more southern countries.

Before closing this treatise I would here express my grateful thanks to Professor Warming and Dr. L. Kolderup Rosenvinge, my »Opponenter« *ex officio*, who by their thorough criticism of the Danish issue of my work have greatly contributed to improve the present edition.

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Porphyra-association growing on a rock of about 30 feet high, at the north coast of Viderö. (F. Börgesen phot.

Fucus spiralis and below it *Fucus inflatus* (transitional form to f. *disticha*) on a slightly sloping rocky coast at Gliversnæs on the east coast of Strömö. *Porphyra umbilicalis* is found between the *Fucus*-plants and among the balani we see *Ceramium acanthonotum* and *Callithamnion arbuscula*; at the bottom to the left lastly the *Gigartina*-association. (F. Börgesen phot.)

Callithamnion-association consisting of *Callithamnion arbuscula* and *Ceramium acanthonotum* on a precipitous rock at Viderejde on Viderö. Among the principle algæ we find *Corallina* together with large and small *Himanthalia* plants some of which also with receptacles besides balani. At the top of the plate *Porphyra umbilicalis* is seen. (F. Börgesen phot.)

Rhodymenia-association on a sloping rock near Gliversnæs on the east coast of Strömö. Among the *Rhodymenia* we find uppermost *Fucus spiralis* f. *nana*, and farther down a few *Fucus inflatus* f. *disticha*. (F. Börgesen phot.)

Illustration of a rocky coast near Midvaag on Vaagö. Uppermost we see *Porphyra umbilicalis* hanging down the rocks. Under the belt of balani a large *Rhodymenia*-association and at the bottom of the plate to the left *Acrosiphonia albescens* close by the littoral pool (F. Börgesen phot.)

Gigartina-association on horizontal rocks near Frodebö on Syderö. Among *Gigartina* we see button-like *Himanthalia*-plants and in or a little above the surface of the sea appear *Alaria esculenta* and *Laminaria hyperborea*. (F. Börgesen phot.)

Himanthalia-association on a precipitous rock at Viderejde on Viderö. The sea may break on the outer rock at the top of the plate to the left. Among the *Himanthalia* are young *Alaria esculenta*, and to the right, among the balani, *Callithamnion arbuscula*.
(F. Börgesen phot.)

Laminaria digitata-association on a rocky coast near Midvaag on Vaagö. On the rocks to the right is *Rhodymenia* and below it *Gigartina*. To the left *Laminaria hyperborea* appears above the surface of the sea. (F. Börgesen phot.)

Corallina-formation on a rock at the entrance of Arnefjord on the coast of Bordö. *Gigartina* and *Alaria esculenta* are seen among *Corallina*, in the littoral pool to the left is *Laminaria digitata*. (F. Börgesen phot.)

Pelvetia canaliculata and below it *Fucus vesiculosus* on a stone at Glibre in Skaalefjord (Österö). (F. Börgesen phot.)

Ascophyllum nodosum on stones in Vestmanhavn on Strömö. *Fucus vesiculosus* is seen uppermost on the stone in the middle of the plate and also on the stone to the right. (F. Börgesen phot.)

Fucus vesiculosus and below it *Ascophyllum nodosum* on a sloping coast between the rocks of the small inlets on the east coast of Strömö between Thorshavn and Höjvig. (F. Börgesen phot.)