ACTA NATURALIA ISLANDICA

21

GENERAL FEATURES OF THE BENTHIC ALGAL ZONATION AROUND THE ICELANDIC COAST

IVKA MUNDA

NÁTTÚRUFRÆÐISTOFNUN ÍSLANDS
MUSEUM OF NATURAL HISTORY
REYKJAVÍK 1972

ACTA NATURALIA ISLANDICA

ISSUED BY THE ICELANDIC MUSEUM OF NATURAL HISTORY
(NÁTTÚRUFRAEDISTOFNUN ÍSLANDS)

The Museum has published two volumes of Acta Naturalia Islandica in the period 1946–1971, altogether 20 issues. From 1972 each paper will appear under its own serial number, starting with no. 21.

ACTA NATURALIA ISLANDICA is a series of original articles dealing with botany, geology and zoology of Iceland.

ACTA NATURALIA ISLANDICA will be published preferably in English and will appear at irregular intervals.

ACTA NATURALIA ISLANDICA may be obtained:

1: on basis of institutional exchange at Museum of Natural History, P. O. Box 5320, Reykjavik.

2: as separate copies on request (charges including mailing costs) at Snaebjörn Jónsson, The English Bookshop, Hafnarstraeti 4, Reykjavik, Iceland.

General features of the benthic algal zonation around the Icelandic coast

IVKA MUNDA
Slowene Academy of Science and Arts, Biological Institute, Ljubljana, Jugoslavia

Abstract. A survey is given of the main features of benthic algal zonation in the south, south west, north west, north and east of Iceland. Differences in the zonation pattern between the investigated areas seem to be closely correlated to the varying hydrographic conditions around the Icelandic coast. They proved to be most outstanding in the lower littoral zones of exposed, rocky sites, which are in direct contact with the ocean.

These differences proved to be less pronounced in the upper and middle littoral levels but rather conspicuous in the tide pools. In the lower littoral, *Gigartina stellata-, Callithamnion arbuscula-* and *Corallina officinalis* belts proved to be outstanding for the south, south west and north west, *Halosaccion ramentaceum* belts for the north, and *Porphyra linearis-, Chordaria flagelliformis-* and *Acrosiphonia* spp. belts for the east. An increase in vertical extension of the upper littoral *Ulothrix-Urospora* belts was observed in the northeastwards direction.

INTRODUCTION

The benthic algal vegetation around the Icelandic coast is rather heterogenous, reflecting the different hydrographic conditions, created by the reigning ocean currents.

The South Icelandic coast is strongly influenced by the Gulf Stream. This influence diminishes in the direction north and northeastwards, and the North Icelandic coastal area is according to Stefánsson (1962b) influenced by three primary water masses: Atlantic water, Polar water and Arctic Bottom water. The distribution and mixing of the primary and secondary water masses along this part of the Icelandic coast has also been thoroughly studied by Stefánsson (1962b). The East Icelandic coast is, on the other hand, under the influence of the East Icelandic Current, which is of Artic origin.

The changing hydrographic conditions around the Icelandic coast are reflected in a most variable composition of the benthic algal vegetation and in different patterns of the algal zonation.

Strömfelt (1886b) was first to point out the striking difference between the algal vegetation in the South and West Iceland on one hand, and that of the East Iceland on the other.

Later, Helgi Jónsson (1901, 1903, 1910, 1912) made a thorough investigations of the algal growth around the Icelandic coast.

Some earlier data on the algal vegetation around Iceland are found in the works of Zoëga (1772), Mohr (1786), Müller (1770), Hooker (1813), Mackenzie (1810), Hjaltalín (1830), Vahl (1840), Lindsay (1861), Kjellman (1879), Grönlund (1879) and Rosenvinge (1879).

Besides, various scientists have made sporadic collections of algae, mainly in the last century, e. g. Ostenfelt (1895–1896) in connection with the Ingolf-expedition, Jensen (1890), Lundenbeck (1892), Davídsson (1897), Steenstrup (1840), Faber (1819) and others.

Recent collections of benthic marine algae in Iceland include those of Sigurdur Jónsson, who has primarily studied the colonization at the island Surtsey (1966, 1970), those of Adey (1968) of crustose Corallines and finally of the present author.

My work has been supported by grants from the Icelandic Science Foundation and began in 1963. Since then, the summers have been spent in investigating the benthic algal vegetation at different parts of the Icelandic coast.

The purpose of this work is to make as detailed review of the benthic algal flora of the Icelandic coast as possible. Different areas of the Icelandic coast were investigated thoroughly in each successive year.

Since the features of the algal zonations in the various parts of the Icelandic coast present such distinct differences, a general preliminary review of the most conspicous algal belts, as found in selected biotopes around Iceland, will be given.

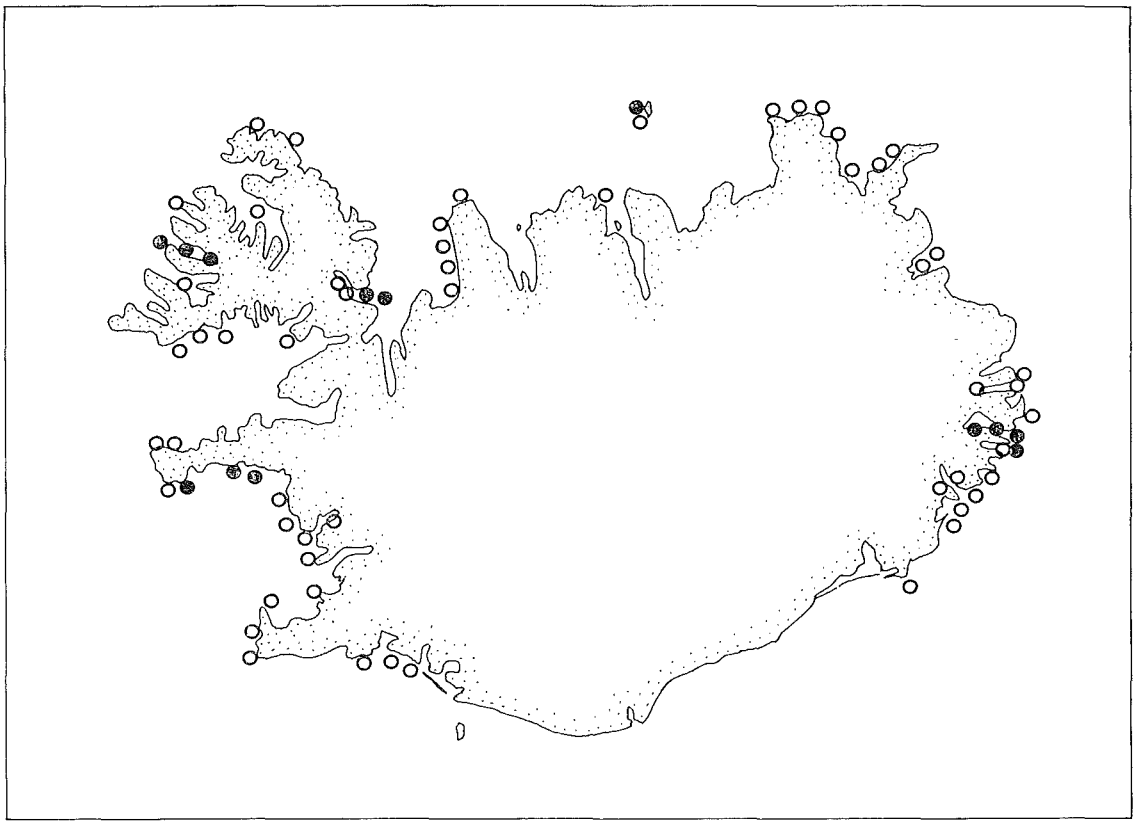
The algal belts, belonging to different littoral levels are given in their vertical sequence in all the profiles, described in this paper.

Only the dominant species, characteristic for the algal zones in the various biotopes will be treated here.

Smaller accompanying species, belonging to the undergrowth as well as the epiphytes, will be discussed later.

Detailed descriptions of selected regions around Iceland, as observed in succesive years, will be published separately.

The material collected is most extensive and is still under investigation. Reprensentatives of several genera still need a thorough revision, such as *Ceramium, Dictyosiphon, Enteromorpha, Cladophora* etc.



Dots: Locations of profiles 1 to 7 (Plates 1–7). *Open circles: All locations investigated around Iceland between 1963 and 1970.*

LITTORAL LEVELS

There are several different opinions regarding the definition and delimitation of the zones of marine organisms found on the sea shores.

Coastal conditions in places subjected to strong tidal influence were treated by early Scandinavian authors and apply to the North European coasts. Rosenvinge (1898) defines the upper limit of the littoral zone as the line were the marine vegetation begins. In Greenland, however, this line coincides with the lowest high-tide level. The same was true in the Faeroe Islands, in sheltered locations (Börgesen, 1905). The upper littoral limit was also similiarly demarcated by Helgi Jónsson (1912) and Kylin (1907).

Sernander (1917) defined this limit primarily from a pure physical point of view, thus by the high water level. The zone above was defined as supralittoral. Kylin (1918) pointed out that wave action and insolation are in addition to tidal factors decisive for the upper limit of the marine vegetation, this so-called „physiclogical high water line", being indentical with the „litus-line" defined by Sjöstedt (1908).

The demarcation between the littoral and supralittoral zone could also be decided by means of biological entities.

The lower limit of the littoral zone is less distinct and does not always coincide with the low-tide level. It is, however, highly dependant

on the degree of exposure of the location concerned. This limit is a natural physiological boundary, influenced by several other factors than the tidal ones.

In the present work, the ordinary definition of the algal zones will be applied, suitable for the North European areas, thus the division into a supralittoral, littoral and sublittoral zone. Along the Icelandic coast the limits between the zones are highly dependant on the configuration of the substratum and on the exposure to wave action and therefore do not exactly follow the low or high water lines.

In order to acquire a better basis for comparison between the different locations surveyed around Iceland, the author divides the littoral zone proper into an upper, middle and lower littoral.

The present investigations are mainly focused on the littoral zone itself. Only the upper boundary of the sublittoral zone was investigated.

Special attention was paid to the tide pool system occurring throughout the littoral slopes.

Differences in both, occurence and sequence, of algal zones in different parts of the Icelandic coast were studied, as well as local variations due to salinity and exposure conditions.

Finer variations on a smaller scale are the result of interaction of different, not yet completely known, ecological factors and are difficult to explain at the present state of knowledge.

Descriptions of the vegetation of the western and northern European regions yield comparative data of great values, concerning the littoral algal zonation.

In this connection the works of Börgesen (1904) on the Faeroe Islands, Kjellman (1906) on Jan Mayen, Rosenvinge (1893, 1898, 1910) and Lund (1954, 1959) on Greenland, Hygen and Jorde (1934), Levring (1937) and Wennberg (1950) in west Norway, Sundene (1953) in the Oslofjord, Printz (1926) in the Trondheimfjord, Kylin (1918) at the Swedish west coast and Svendsen (1959) on Spitzbergen could be mentioned.

Previous (Foslie, 1890, 1891) and recent (Jaasund, 1957, 1965) investigations of the Arctic area of Norway revealed a likeness with the vegetation features of the Icelandic coast.

Many authors disagree, however, with the terms *supralittoral, littoral* and *sublittoral.* More or less complicated systems have been established, based on hydrographical zones and vegetal ones.

Stephenson and Stephenson (1949) proposed a widely applicable system in which certain littoral levels should be characterised by the same type of organisms on all shores.

Recently Lewis (1964) suggested a modified terminology, based on biological entities. This authors general scheme of zonation reveals clearly the differences in the extension of zones in sheltered and exposed habitats and could be applicable for the highly exposed locations of the rocky shores of Iceland.

PATTERNS OF ALGAL ZONATION AROUND ICELAND

I. Southern Iceland

THE COASTAL AREA BETWEEN THE RIVERS ÖLFUSÁ AND THJÓRSÁ

The greater part of this coast line is formed by lava rocks, forming support to an about 1 km broad littoral zone which is interrupted by a whole system of tide pools and lagoons.

Sandy slopes encountered in the area, especially near the Thjórsá outlet, proved to be bare for any algal growth.

A **Supralittoral** algal growth was seldom observed in this area. Along the greater part of the coast line under discussion, the supralittoral level coincides with sandy slopes, but where we dealt with a faster substratum (e. g. area around Gamla Hraun and Stokkseyri) dwarfish *Pelvetia canaliculata* was found in company with *Rhizoclonium riparium* in between the grass. *Prasiola stipitata* was found together with the lichen *Xanthoria parietina* on rocky formations around Gamla Hraun.

In the littoral zone proper, the following zonation was the most usual:

Upper littoral: *Pelvetia canaliculata* was found around the high water mark and a belt of *Fucus spiralis* lower down the littoral. Where we had to do with a rocky substratum in the uppermost littoral, a narrow *Ulothrix spp.* — *Urospora spp.* belt found over *Pelvetia,* mainly being formed by *Ulothrix flacca.* A *Blidingia minima* zone could localy overlap with the belts of *Pelvetia* and of *Fucus spiralis.*

In between the belts of the above named two species of *Fucus,* tide pools covered by different still undefined growth forms of *Enteromorpha intestinalis* and *E. clathrata* as well as by *Cladophora spp.,* were found.

Verrucaria mucosa, Hildenbrandia prototypus, Rhodochorton and *Enteromorpha* species were found in the *Fucacean* undergrowth of this level.

Where we dealt with sandy slopes in the uppermost littoral, a *Pelvetia* belt was, however, lacking, the upper littoral growth being represented by *Enteromorpha spp. (E. intestinalis, E. clathrata, E. sp.), Ulva lactuca, Porphyra umbilicalis* f. *laciniata, Blidingia minima* and *B. marignata,* these species being attached to small stones. This girdle was followed downwards either by *Fucus spiralis* or directly by *F. vesiculosus.*

Middle littoral: Extensive fields of *Fucus vesiculosus,* mainly represented by f. *sphaerocarpus,* and of *Ascophyllum nodosum,* cover the lava rocks. On the lower fringe of the *Fucacean* fields, *Fucus distichus,* subsp. *edentatus* occurs in a relatively narrow zone.

On the *Fucus vesiculosus* level, the lichen *Verrucaria mucosa* as well as *Hildenbrandia prototypus,* dwarfish *Rhodymenia palmata, Blidingia minima, Enteromorpha intestinalis* and *Rhodochorton spp.* were the main elements in the undergrowth. As epiphytes, *Elachista fucicola, Enteromorpha intestinalis, E. prolifera , Ectocarpus confervoides, Pylaiella littoralis* and *Spongonema tomentosum* were the most common.

Lower down the littoral, on the *Ascophyllum-* and *Fucus distichus* level, *Ralfsia verrucosa, R. sp., Polysiphonia urceolata, Sphacelaria radicans, Plumaria elegans, Membranoptera alata, Lithothamnion spp., Phymatolithon spp., Cladophora rupestris, Acrosiphonia spp.* and *Rhodochorton spp.,* (mainly *R. purpureum)* joined the undergrowth.

Besides *Elachista fucicocla, Spongonema tomentosum, Ectocacrpus confervoides, E. siliculosus, Pylaiella littoralis* and *Enteromorpha spp. Poylsiphonia lanosa* proved to be the most common epiphyte on *Ascophyllum.*

Alng the lower boundary of the fucoid vegetaton, *Gigartina stellata* and *Ceramium rubrum* appeared in the undergrowth.

Lower littoral: Below the *Fucacean* vegetation different algal belts were found, mainly dependant on the degree of exposure.

In moderately exposed places, on gently sloping rocks, *Corallina officinalis* was found together with several accompanying species, e. g. *Chaetomorpha melagonium, Ceramium rubrum, C. areschougii* and *Dumontia incrassata.*

On semi – exposed sites on islets and cliffs, as well as in some spots of the mainland, an association of *Ceramium rubrum – Acrosiphonia spp.* was found, followed downwards by a pure growth of *Rhodymenia palmata.*

In exposed habitats *Gigartina stellata* was forming continuous belts. It was followed by *Rhodomela lycopodioides, Ceramium rubrum, C. shuttleworthianum, C. strictum, C. penicillatum, Scytosiphon lomentaria, Acrosiphonia spp.* and by epiphytic *Porphyra abyssicola.* The floristic composition of the *Gigartina* belt was however changing from place to place and an impoverishement in the number of accompanying species was found with the increasing surf. Under conditions of highest exposure this belt is going over to a pure *Callithamnion arbuscula* growth.

The later species was usually found on the outermost islets and shoals, being characteristic for extremely exposed sites of the Atlantic water regions of Iceland, up to Hornbjarg.

Sublittoral: The upper sublittoral fringe is in the south of Iceland most usually covered by a belt of *Laminaria digitata* f. *stenophylla.* In isolated spots, a zone of long and narrow *Alaria esculenta* was observed though it seems likely that the first-named species dominates in exposed locations in the south. Where the exposure appeared less severe, *Laminaria saccharina* f. *linearis* was replacing *L. digitata* in a rather prolific growth.

As accompanying species in this level, *Rhodymenia palmata, Rhodomela lycopodioides, Phymatolithon polymorphum, Lithothamnion spp., Corallina officinalis, Odonthalia dentata, Phycodrys rubens, Membranoptera alata, Ceramium rubrum, Chordaria flagelliformis, Giffordia hincksiae, Phyllophora membranifolia, Desmarestia ligulata* and *D. virdis* were the most outstanding.

Regarding the lower sublittoral levels, some data could be obtained during the extreme low tides. Further data are based on the driftweed.

Huge specimens of *Laminaria hyperborea* and *L. digitata* were dominating in the driftweed, together with a number of deep water species, the majority being found attached to *L. hyperborea* stipes. In addition to the above mentioned species, *Desmarestia aculeata, Delesseria sanguinea, Plocamium coccineum, Euthora cristata, Ptilota plumosa, Pt. pectinata, Lomentaria orcadensis* and *Lomentaria clavellosa* could be mentioned.

The species *Plocamium coccineum, Desmarestia ligulata, Giffordia hincksiae* and *Lomentaria orcadensis spp.* are, however, limited to the south Icelandic coast.

Tidal pools: A number of tidal pools was observed throughout the extensive littoral slopes.

In the upper littoral, at the *Fucus spiralis* and *Pelvetia canaliculata* level, tide pools, covered by *Enteromorpha* and *Cladophora* species were most usual. *Ulva lactuca* in company with *Porphyra umbilicalis* f. *laciniata* was found in some pools near Eyrarbakki.

On a mid-littoral level *Chondrus crispus* in its different growth forms, and *Ahnfeltia plicata* proved to be dominant species in the tidal pools. As accompanying species, *Rhodymenia palmata, Cystoclonium purpureum, Dumontia incrassata, Halosaccion ramentaceum, Ceramium areschougii, C. circinatum, C. penicillatum, C. strictum, C. spp., Ectocarpus confervoides, E. siliculosus, Dictyosiphon foeniculaceus, Chordaria flagelliformis, Rhodomela lycopodioides, Phyllophora membranifolia, Ccytosiphon lomentaria* and *Ulva rigida* were most common.

In some pools, pure populations of *Chondrus crispus* could be found, while *Ahnfeltia plicata,* as a rule, was followed by a number of epiphytes and accompanying species.

Lower down the littoral, though still on the

Ascophyllum-level, smaller rocky pools, covered by *Corallina officinalis* or by *Ceramium spp. (C. rubrum, C. areschougii, C. penicillatum, C. circinatum, C. shuttleworthianum)* were most common. *Chaetomorpha melagoninum, Ulva rigida, Cladophora rupestris, Enteromorpha linza* and *Ectocarpus spp.* could be found in the *Corallina*-pools.

In splash pools of the lower littoral *Chordaria flagelliformis* was rather common.

Lagoons: Two types of lagoons were observed in between the littoral slopes. The coastal lagoons, i. e. lagoons near the mainland, were usually covered by sand and mud, with turbid water of a relatively high temperature and low salinity. The considerable depth of such lagoons allows the development of a luxurious *Laminaria* — vegetation represented by *Laminaria saccharina* in its broad growth form. Other species found in such lagoons were: *Chorda filum, Dictyosiphon foeniculaceus, Asperococcus echinatus, Ectocarpus siliculosus, Pylaiella littoralis, Ulva lactuca, Enteromorpha intestinalis, E. prolifera* and *E. clathrata.*

Rocky lagoons in the lower and middle littoral proved to have the same water temperature and salinity as the surrounding sea. The algal growth in such lagoons was dominated by *Laminaria digitata* f. *cucculata* and *L. saccharina* f. *linearis.* In the shadow of the *Laminaria* fronds, a prolific growth of *Corallina officinalis, Rhodymenia palmata, Rhodomela lycopodioides, Odonthalia dentata, Phycodrys rubens, Phyllophora membranifolia, Membranoptera alata, Porphyra miniata, Halosaccion ramentaceum, Lithothamnion spp., Ahnfeltia plicata* and *Chaetomorpha melagoninum* was found.

Some shallow lagoons connected with the open sea, were observed in the lower boundary of the littoral zone. A prolific growth of a yellow *Rhodymenia palmata* and of *Ulva lactuca* was found in such biotopes.

In narrow channels between the outer lagoons the water is constantly streaming in either direction during low tide. Here a particular vegetation was found, dominated by *Laminaria saccharina* f. *linearis, Chorda filum* and *Chordaria flagelliformis.* As undergrowth, a dense carpet of *Corallina officinalis* and *Lithothamnion spp.* was usual. *Ulva lactuca, Enteromorpha linza, E. ahlneriana* and *Dictyosiphon foeniculaceus* were likewise found in such places.

Isolated cliffs: A particular zonation was observed on some smaller cliffs, lying on otherwise bare sandy slopes near the Thjórsá outlet: *Porphyra umbilicalis* f. *umbilicalis* in the upper littoral and *Fucus distichus* ssp. *anceps* lower down ,the rest of the littoral levels coinciding with a sandy ground.

REYKJANES PENINSULA

The coastal rocks around the peninsula of Reykjanes are rather steep and exposed to strong surf. Due to the relatively narrow littoral zone, if compared with the extensive lava slopes described above, greater variations in the zonation pattern were observed.

Blidingia minima, B. marginata, Pelvetia canaliculata and *Fucus spiralis* belts were common in the upper littoral levels of the area, the *Ulothrix-Urospora* belts being absent or poorly developed.

Porphyra umbilicalis f. *umbilicalis* could be found in some exposed locations in the uppermost littoral, and *Porphyra abyssicola* cf. in the mid-littoral.

In the mid-littoral, *Fucus vesiculosus* and *Ascophyllum nodosum* were found on gently sloping rocks, but where the rocks are rather steep, *Fucus distichus* ssp. *edentatus* or *F. d.* ssp. *anceps* could follow immediately below *Fucus spiralis.*

Characteristic for the area was a continuous and prolific *Gigartina stellata* belt (see Fig. 9), interrupted by patches of pure *Dilsea edulis* populations, this species being still absent in the coastal area, described above.

In the *Gigartina* level, patches of pure growth of *Polysiphonia urceolata,* of *Ceramium rubrum, C. strictum, C. shuttleworthianum* and *C. penicillatum* and of *Rhodomela lycopodioides* could ocur. The floristic com-

position of the *Gigartina* association showed great variations as a response to different degrees of exposure, finally going over to a *Callithamnion arbuscula* association, at maximal surfheight.

In sites, where the slopes are vertical and the exposure rather high, *Gigartina* is following immediately beneath the barnacle belt, without any *Fucacean* species in between.

On gently sloping rocks in the area around Hafnir the following zonation proved to be the most usual:

Upper littoral: *Blidingia minma — Pelvetia canaliculata — Fucus spiralis.*

Pools: 1) *Enteromorpha intestinalis,* 2) *E. clathrata-Cladophora oblitterata.*

Middle littoral: *Fucus vesiculosus — Porphyra abyssicola* — patches of *Enteromorpha clathrata, E. flexuosa* and *Cladophora rupestris* on the *Ascophyllum nodosum*-level, *Ulva lactuca — Enteromorpha ahlneriana — Fucus distichus* ssp. *edentatus.*

Lower littoral: *Ceramium rubrum* with *Cystoclonium purpureum — Gigartina stellata — Corallina officinalis.*

Sublittoral: *Laminaria digitata* f. *stenophylla,* under conditions of high exposure, or *L. saccharina* f. *linearis,* under conditions of moderate exposure.

The tide pool and lagoon vegetation (see Fig. 13) proved to be similiar as along the coast line, described at the beginning. Smaller pools, covered by *Cladophora rupestris, Acrosiphonia spp.* and *Asperococcus echinatus* were also observed.

In the area from Gardskagi and on, a broad *Fucus serratus* zone occupied the lower littoral slapes. This belt seems to be restricted to a part of the Icelandis south coast.

II. South West Iceland — Snæfellsnes Area

As to the features of algal zonation in South West Iceland, the Snæfellsnes peninsula, limiting Faxaflói from Breidafjördur, appeared to be especially variable and interesting. This peninsula is obviously some kind of a threshold, limiting the distribution of several species in either direction as e. g. *Pelvetia canaliculata* and *Chondrus crispus* have here their northern limit and the species *Polysiphonia nigrescens* and *Gloiosiphonia capillaris* their southern limit.

Compared with the south coast, both *Chondrus crispus* and *Ahnfeltia plicata* were relatively rare while *Halosaccion ramentaceum* became more essential for the vegetation pattern, this species having still a subordinate role in the south.

Extensive areas of the south coast of Snæfellsnes are sandy with basaltic rocky formations in between, the smooth basalt-rocks forming small peninsulas, islets and isolated cliffs.

The littoral slopes beneath Snæfellsjökull are, on the other hand, formed of lava rocks which give support to a rather broad littoral zone, interrupted by tide pools, crevices and holes.

Some characteristic profiles will be described.

Löngufjörur, an estuarine area with sandy ground (cf. Fig. 7):

Supralittoral: bare for any growth.

Upper littoral: *Enteromorpha intestinalis.*

Middle and Lower littoral: Mixed belt of: *Pylaiella littoralis, Ectocarpus siliculosus, E. confervoides, Enteromorpha ahlneriana, E. comressa, Dictyosiphon chordaria, D. foeniculaceus* and *Porphyra umbilicalis f. laciniata.*

Sublittoral: *Chorda filum* and *Ulva lactuca.*

Stakkhamar, basaltic rocky slope, going over to a sandy ground, extreme shelter:

Upper littoral: *Blidingia minima* and *B. mar-*

ginata — Enteromorpha intestinalis and *Pelvetia canaliculata — Fucus spiralis — Enteromorpha prolifera* with *E. sp.*
Middle littoral: *Fucus vesiculosus — Porphyra umbilicalis* f. *laciniata.*
Lower littoral: *Ulva lactuca* and *Enteromorpha linza.*
Sublittoral: *Laminaria saccharina* (broad form), *Chorda filum* and *Ulva lactuca.*

Stakkhamar, basaltic rocky formation — moderate slope, middle degree of exposure:

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix flacca* and *Urospora sp. — Blidingia minima.*
Middle littoral: *Fucus distichus* ssp. *edentatus.*
Lower littoral: *Acrosiphonia spp.* with *Pylaiella littoralis* — a belt of *Rhodymenia palmata, Dumontia incrassata, Cystoclonium purpureum, Ceramium spp., Halosaccion ramentaceum, Dictyosiphon foeniculaceus* — a belt of *Ulva lactuca* with *Enteromorpha linza.*
Under conditions of greater exposure:
Ceramium rubrum with *Acrosiphonia arcta — Rhodomela lycopodioides.*
Sublittoral: *Laminaria digitata* f. *stenophylla* with *Alaria esculenta.*

Löngusker, steep basaltic rocks, great exposure:

Supralittoral: *Prasiola stipitata* and *P. furfuracea — Bangia fuscopurpurea.*
Upper littoral: *Porphyra umbilicalis* f. *umbilicalis* (see Fig. 1) — *Ulothrix flacca, U. pseudoflacca* and *Urospora peniciliformis — Pylaiella rupincola* and *Petalonia fascia.*
Middle littoral: *Fucus distichus* ssp. *anceps — Acrosiphonia arcta.*
Tidal pools: 1) *Corallina officinalis,* 2) *Acrosiphonia spp.*
Lower littoral: *Gigartina stellata* with epiphytic *Porphyra abyssicola* (Accompanying species: *Ceramium rubrum, C. areschougii, C. strictum, C. shuttleworthianum, C. penicillatum, Cystoclonium purpureum, Rhodomela lycopodioides, Petalonia fascia, P. zosterifolia, Scytosiphon lomentaria, Dumontia incrassata, Acrosiphonia spp.*). Or: *Callithamnion arbuscula* under condition of extreme surf.
Sublittoral: *Alaria esculenta* (narrow form).

Löngusker, vertical cliffs, limiting to a sandy ground (see Plate 1):

Basaltic blocks, lying isolated on the sandy slopes were frequently observed in the area. A different zonation was found on the exposed side of such cliffs, turned towards the open sea, and on the sheltered side, turned towards the mainland and limiting to horizontal sandy slopes. On the top of such blocks, *Porphyra umbilicalis* f. *umbilicalis* was found.

SHELTERED SIDE:

Upper littoral: *Ulothrix flacca* with *Urospora pencilliformis — Blidingia minima — Fucus spiralis* (see Fig. 3).
Middle littoral: *Fucus vesiculosus — Porphyra abyssicola — Rhodymenia palmata.*
Lower littoral: bare sandy slopes: —
Pools: 1) *Enteromorpha linza-Cladophora oblitterata.* 2) *Cladophora rupestris — Chaetomorpha melagonium.*

EXPOSED SIDE:

Upper littoral: *Bangia fuscopurpurea — Ulothrix flacca* with *Urospora penicilliformis.*
Middle littoral: *Fucus distichus* ssp. *edentatus.*
Lower littoral: *Acrosiphonia arcta* — belt of *Ceramium spp.* and *Polysiphonia urceolata* — belt of *Gigartina stellata* with *Cystoclonium purpureum, Ceramium rubrum, C. areschougii, C. strictum, Dumontia incrassata* and *Ulva lactuca — Rhodomela lycopodioides* with *Rhodymenia palmata* and *Polysiphonia nigrescens* — belt of *Ulva lactuca.*

Sublittoral: *Alaria esculenta* (narrow form) with *Lithothamnion spp.* and *Phymatolithon spp.*

Hellnar, lava rock, great exposure, broad littoral interrupted by rocky caves, pools and crevices (see Plate 1):

Supralittoral: *Prasiola stipitata — Rhizoclonium riparium.*

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix flacca* with *Urospora penicilliformis — Blidingia minima* with *Pelvetia canaliculata — Fucus spiralis.*

Tidal pools: 1) *Enteromorpha intestinalis,* 2) *E. clathrata — E. flexuosa.*

Middle littoral: *Fucus vesiculosus — Ascophyllum nodosum* (undergrowth: *Hildenbrandia prototypus, Verrucaria mucosa, Rhodochorton spp., (R. purpureum* dominating), *Acrosiphonia sp.,* dwarfish *Rhodymenia palmata, Cladophora rupestris, Plumaria elegans) — Fucus distichus* ssp. *edentatus.*

Rocky caves: *Plumaria elegans, Membranoptera alata, Chaetomorpha melagonium, Cladophora rupestris, Chaetopteris plumosa, Sphacelaria radicans, Polysiphonia urceolata, Ceramium areschougii, C. rubrum.*

Tidal pools: 1) *Halosaccion ramentaceum* 2) *Rhodymenia palmata* with *Ulva lactuca* 3) *Cladophora rupestris* 4) *Acrosiphonia spp.*

Undergrowth of *Fucus distichus* ssp. *edentatus: Gigartina stellata, Phymatolithon polymorphum, Ralfsia verrucosa, Lithothamnion sp., Polysiphonia urceolata, Membranoptera alata, Plumaria elegans, Ulva rigida.*

Lower littoral: *Acrosiphonia spp. (A sonderi, A. arcta) — Halosaccion ramentaceum* with *Ulva lactuca* were found under conditions of moderate exposure. Under conditions of strong exposure: *Gigartina stellata* with *Dilsea edulis* (see Fig. 2) and *Leathesia difformis (Accompa*nying species: *Ceramium rubrum, C. areschougii, C. circinatum, C. shuttleworthianum, C. strictum, Dumontia incrassata, Scytosip- sp., Porphyra abyssicola)* — belt of *Rhodymenia palmata* with *Rhodomela lycopodioides* and *Cystoclonium purpureum.*

Tidal pools: 1) *Corallina officinalis* 2) *Ceramium spp.*

Sublittoral: *Alaria esculenta* (long and narrow form).

As in the south, the *Gigartina* zone shows wide variations in its floristic composition around Snæfellsnes. *Dilsea edulis* and *Leathesia difformis* were joining this association for the first time in the area around Hellnar.

An impoverishement in the number of accompanying species with increasing surf was observed also in this area, the *Gigartina* belt gradually going over to a *Callithamninon arbuscula* belt in highly exposed locations.

The outstanding variations in the features of algal zonation of the Snæfellsnes peninsula are mainly caused by the different substrata in this area, i. e. sandy slopes, steep basaltic rocks and extensive lava rocks.

These differences were obvious in a changing appearence of the *Fucacean* belts as well as in the lower littoral, where the *Gigartina* belt could be locally replaced by belts of *Ceramium rubrum-Acrosiphonia sp.,* by *Ulva lactuca-Enteromorpha linza* or by mixed populations, in which *Rhodymenia palmata, Halosaccion ramentaceum* and *Cystoclonium purpureum* were outstanding.

In the upper sublittoral a long and narrow form of *Alaria esculenta* seemed to replace the *Laminaria digitata* f. *stenophylla* belt, encountererd in exposed sites of the southern coast.

The *Ulothrix-Urospora* belt proved to be more prominent than along the southern coast.

In the tidal pools both *Chondrus crispus* and *Ahnfeltia plicata* were rather rare. The circumpolar species *Halosaccion ramentaceum* became, on the other hand, more prominent than in the south, both in the tidal pools and on the littoral slopes.

Cladophora oblitterata in company with *Enteromorpha linza* proved to bec ommon in shallow rocky pools along the southern coast

of Snæfellsnes, while *Cladophora rupestris* and *Chaetomorpha melagonium* occupied sandy pools in the area.

Among the sublittoral vegetation *Polysiphonia nigreseens, Gloiosiphonia capillaris* and *Phyllophora brodiaei* were joining while *Plocamium coccineum, Lomentaria orcadensis, L. clavellosa, Desmarestia ligulata, Giffordia hincksiae* and *Asperococcus echinatus* seemed to be limited to the southern coast.

III. North West Iceland

According to Helgi Jónsson (1910), the coastline between Látrabjarg and Hornbjarg is regarded as the north west part of the Icelandic coast. In this part of Iceland the algal vegetation of Dýrafjördur was studied in detail.

In order to be able to draw a comparison between the zonation in the north west and that, described in the first two chapters, observations should refer to open coastlines and outermost fjord areas. The growth conditions in the fjord proper are changing from place to place, due to the numerous river outlets and varying degree of exposure. Different features of algal zonation were, however, found in the inner, middle and outer area of the fjord under discussion. Some characteristic profiles will be outlined here.

DÝRAFJÖRDUR – INNER AREA

In the river outlet Botnsá inside Dýrafjördur a fresh water vegetation was still found *(Conjugatae, Vaucheria sp.)* and the transitional area towards salt water proved to be bare of any growth.

Some profiles of this area will be given in a sequence corresponding to the increasing distance from the estuary of the river Botnsá.

Botn, innermost estuarine area (see Plate 2):

Sandy slopes, corresponding to the upper and middle littoral level, the entire estuary being emerged during low tide:

Scattered growth without distinct zones: *Enteromorpha intestinalis, Fucus ceranoides* (see Fig. 8), *Fucus vesiculosus* (estuarine forms), *Dictyosiphon chordaria, Ectocarpus siliculosus, E. sp., E. confervoides, Enteromorpha prolifera, E. ahlneriana, E. clathrata, E. compressa, Ulva lactuca, Pylaiella littoralis.*

Hvammur, smaller estuaries along the coast:

The sea floor in such estuaries is formed by sand and small, voluble stones, to which the algal growth is attached.

Upper littoral: *Enteromorpha intestinalis.*

Middle littoral: Scattered growth, without distinct zones, of the following species: *Porphyra umbilicalis* f. *laciniata, Monostroma grevillei, M. undulatum, Ulvaria obscura, Ulva lactuca* and *Enteromorpha compressa.*

Lower littoral: Bare for algal growth.

Skeid, almost horizontal rocky slopes, going over to a sandy ground, increased salinity:

Upper littoral: *Blidingia minima* and *B. marginata – Enteromorpha intestinalis.*

Middle littoral: *Fucus vesiculosus – Ascophyllum nodosum* (accompanying species: *Verrucaria mucosa, Hildenbrandia prototypus, Enteromorpha intestinalis, E. prolifera Ectocarpus confervoides) – Fucus distichus* ssp. *evanescens.*

Lower littoral: Belt of filamentous algae:

Dictyosiphon foeniculaceus, D. chordaria, Chordaria flagelliformis, Enteromorpha clathrata, E. ahlneriana, Pylaiella littoralis, Eudesme virescens, Chaetomorpha capillaris, Ectocarpus siliculosus, E. confervoides, Cladophora fracta.

Sublittoral: *Chorda filum.*

The mentioned association of filamentous algae could also be found near some local estuaries immediately under a belt of *Enteromorpha intestinalis,* without any species of *Fucaceae* in between.

Skeid—Thingeyri, moderate rocky slope:

Upper littoral: *Ulothrix flacca, Urospora penicilliformis — Blidingia minima — Enteromorpha intestinalis — Fucus spiralis* with dwarf *Petalonia fascia.*

Middle littoral: *Fucus vesiculosus — Ascophyllum nodosum* (Accompanying species: *Verrucaria mucosa, Hildenbrandia prototypus, Rhodochorton spp. (R. purpureum* dominating), *Plumaria elegans, Polysiphonia urceolata) — Fucus distichus ssp. evanescens.*

Tidal pools: *1) Ceramium areschougii — C. spp. — Cystoclonium purpureum.* 2) *Cladophora oblitterata-Lithothamnion spp.*

Lower littoral: Belt of filamentous algae: *Chordaria flagelliformis, Dictyosiphon foeniculaccus, D. chordaria, Ectocarpus confervoides, E. siliculosus, Enteromorpha clathrata, Pylaiella littoralis, Ceramium areschougii, C. rubrum.* Belt of *Rhodymenia palmata-Rhodomela lycopodioides* and *Ulva lactuca.*

Sublittoral: *Laminaria saccharina* f. *latifolia* and *Chorda filum.*

As seen from the sequent profiles, the zonation into distinct algal belts gets more outstanding with the increasing distance from the innermost estuary, new belts gradually joining as e. g. the *Ascophyllum nodosum* one, that of *Fucus spiralis* and of *Ulothrix spp. — Urospora spp.*

The number of species gradually increases further outwards along the fjord coast.

These gradual changes in the composition of the littoral flora and in the sequence of the main algal belts could be a function of the changing salinity and exposure conditions.

DÝRAFJÖRDUR — MIDDLE AREA

Verbúd — Saltnes, moderate slopes (see Plate 2):

Upper littoral: *Ulothrix flacca, U. pseudoflacca* and *Urospora sp. — Fucus spiralis.*

Middle littoral: *Fucus vesiculosus — Ascophyllum nodosum — Fucus distichus* ssp.. *edentatus.*

Tidal pools: 1) *Ceramium spp. — Cystoclonium purpureum,* 2) *Corallina officinalis,* 3) *Dictyosiphon foeniculaceus,* 4) *Lithothamnion sp.-Cladophora oblitterata.*

Lower littoral: *Acrosiphonia spp. with Pylaiella littoralis* — filamentous algae: *Chordaria flagelliformis, Dictyosiphon foeniculaceus, Ectocarpus spp., Eudesme virescens, Enteromorpha flexuosa* — belt of *Rhodymenia palmata, Halosaccion ramentaceum* and *Rhodomela lycopodioides.*

Sublittoral: *Laminaria digitata* f. *cucculata* and *L. saccharina* f. *linearis.*

DÝRAFJÖRDUR — OUTER AREA

While the algal zonation in the middle fjord area proved to be rather uniform from place to place, greater variations in the sequence and appearence of the algal zones were again found in the outer fjord regions.

These variations may be caused by the gradually increasing exposure and by the changing configuration of the littoral rocks.

Some characteristic profiles will be given, in a sequence from the inner towards the outermost locations.

Sveinseyri, sheltered location with a moderate slope (see Plate 3):

Upper littoral: *Ulothrix flacca — Enteromorpha intestinalis.*

Middle littoral: *Fucus vesiculosus* (undergrowth: *Verrucaria mucosa, Hildenbrandia prototypus, Polysiphonia urceolata, Rhodochorton purpureum, Plumaria elegans, Membranoptera alata, Cladophora rupestris, Ralfsia verrucosa, R. fungiformis,* dwarfish *Rhodymenia palmata, Lithothamnion spp., Phymatolithon sp. Sphacelaria radicans, S. britannica, Chaetopteris plumosa)* — belt of *Fucus distichus* ssp. *edentatus* and *F. d. ssp. evanescens* (broad zone with still some undergrowth).

Tidal pools: 1) *Ceramium areschougii, C. circinatum* and *Cystoclonium purpureum,* 2) *Corallina officinalis* with *Callithamnion hookeri,* 3) *Ralfsia fungiformis, Eudesme virescens* and *Scytosiphon lomentaria.*

Lower littoral: Belt of *Rhodymenia palmata, Rhodomela lycopodioides, Halosaccion ramentaceum, Ulva lactuca* and *Ceramium rubrum.*

Sublittoral: *Laminaria digitata* f. *cucculata, L. saccharina* f. *linearis* and *Alaria esculenta* (broad form) with*Lithothamnion spp., Phymatolithon spp.* and *Polysiphonia arctica.*

Hálsar, semi — exposed location with steep slopes:

Supralittoral: *Prasiola stipitata.*

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix flacca* with *U. pseudoflacca* and *Urospora penicilliformis — Fucus spiralis.*

Pools: 1) *Enteromorpha spp.,* 2) *Fucus distichus* ssp. *distichus.*

Middle littoral: *Fucus vesiculosus — Ascophyllum nodosum* (See Fig. 6) — *Fucus distichus* ssp. *edentatus.*

Pools: 1) *Dictyosiphon foeniculaceus,* 2) *Acrosiphonia spp.,* 3) *Ceramium spp.* and *Cystoclonium purpureum.*

Lower littoral: *Acrosiphonia spp.* with *Pylaiella littoralis* and *Ectocarpus sp.* — belt of *Rhodymenia palmata, Rhodomela lycopodioides* and *Halosaccion ramentaceum.*

Sublittoral: *Laminaria digitata* f. *cucculata, L. saccharina* f. *linearis* and *Alaria esculenta.*

In the outer fjord area, *L. hyperborea* is joining the sublittoral growth together with a number of deep-water red algae, as e. g. *Odonthalia dentata, Phycodrys rubens, Delesseria sanguinea, Euthora cristata, Ptilota spp., Rhodophyllis dichotoma* etc. (see Fig. 12).

Lendingar, semi — exposed location with a moderate slope:

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix flacca* with *U. pseudoflacca — Enteromorpha intestinalis* and *Blidingia minima.*

Pools: *Enteromorpha intestinalis.*

Middle littoral: *Ascophyllum nodosum* (broad zone), accompanying species: *Hildenbrandia prototypus, Ralfsia fungiformis, R. verrucosa, Plumaria elegans, Membranoptera alata, Polysiphonia urceolata, Rhodochorton purpureum, R. sp., Sphacelaria radicans, Chaetopteris plumosa, Spongonema tomentosum, Cladophora rupestris,* the last named species being the dominant element in the undergrowth — belt of *Fucus distichus* ssp. *edentatus.*

Tidal pools: 1) *Corallina officinalis* with epiphytic *Spongomorpha aeruginosa,* 2) *Ceramium spp. (C. circinatum, C. areshougii)* and *Cystoclonium purpureum,* 3) *Acrosiphonia spp.,* 4) *Halosaccion ramentaceum, Rhodymenia palmata, Ulva rigida,* 5) *Ralfsia fungiformis, Petalonia, fascia, P. zosterifolia, Scytosiphon lomentaria,* 6) *Punctaria plantaginea,* 7) *Distyosiphon foeniculaceus* with *Chordaria flagelliformis.*

Lower littoral: *Chordaria flagelliformis* — belt of *Halosaccion ramentaceum, Rhodymenia palmata* and *Rhodomela lycopodioides.*

Sublittoral: *Laminaria digitata* f. *cucculata, L. saccharina* f. *linearis, Alaria esculenta, Lithothamnion spp., Phymatolithon sp. (Laminaria hyperborea, Desmarestia aculeata, D. viridis* and accompanying deep-water species).

Ytri Ófæra, highly exposed site, vertical slope (see Plate 4):

Supralittoral: *Prasiola stipitata — Rhizoclonium riparium* in rocky fissures.

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix spp.* with *Urospora penicilliformis — Bangia fuscopurpurea.*

Middle littoral: *Fucus distichus* ssp. *anceps*

Lower littoral: *Gigartina stellata* with *Leathesia difformis* (accompanying species: *Scytosiphon lomentaria, Rhodomela lycopodioides, Ceramium rubrum, C. areschougii, C. circinatum, C. strictum, C. shuttleworthianum, Cystoclonium purpureum).*

Sublittoral: *Alaria esculenta* (narrow form).

Ófæruvík, highly exposed site, moderate slope (see Plate 4):

Supralittoral: *Prasiola stipitata — Rhizoclonium riparium.*

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix spp.* with *Urospora sp.* — Bangia fuscopurpurea

Middle littoral: *Fucus distichus* ssp. *anceps* (narrow belt or absent) — *Acrosiphonia arcta* (locally replacing the *Fucus*-belt).

Lower littoral: *Acrosiphonia artca* — belt of *Gigartina stellata* with *Leathesia difformis* — — *Corallina officinalis* meadows.

Sublittoral: *Corallina officinalis* meadows and lower down *Lithothamnion spp.- Phymatolithon sp.*

In such locations, the *Corallina* vegetation proved to be extensive, reaching into the upper sublittoral and being followed downwards by extensive fields of crustose *Corallines,* while the *Laminarian* species were limited to the deeper levels.

Svalvogar, maximum exposure — area outside the fjord:

Supralittoral: *Prasiola stipitata* and *P. furfuracea — Rhizoclonium riparium* — pools with *Enteromorpha intestinalis.*

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix spp.* with *Urospora sp. — Bangia fuscopurpurea — Fucus spiralis* — pools with *Enteromorpha clathrata.*

Middle littoral: *Fucus distichus* ssp. *anceps* — on relatively sheltered edges: *Rhodymenia palmata* with *Cladophora rupestris.*

Tidal pools: 1) *Ceramium spp.,* 2) *Corallina officinialis* with *Callithamnion hookeri,* 3) *Acrosiphonia spp.,* 4) *Halosaccion ramentaceum — Rhodymenia palmata,* 5) *Lithothamnion spp. — Cladophora oblitterata,* 6) *Dictyosiphon foeniculaceus — Chordaria flagelliformis — Scytosiphon lomentaria,* 7) *Fucus distichus* ssp. *distichus.*

In the tidal pools only the dominant elements were mentioned.

Lower littoral: *Callithamnion arbuscula.*

Sublittoral: *Alaria esculenta* (narrow form).

Considering the characteristic profiles of the outer area of Dýrafjördur, several differences from the southern and southwestern part of Iceland could be stated concerning the algal zonation.

Látrabjarg represents obviously a further treshold, concerning the distribution of some species and the general features of the algal vegetation.

The diminshed influence of the Gulf Stream waters probably creates outstanding cold Boreal features of the algal vegetation in the northwest, as found in exposed locations, which are in contact with the oceanic water.

The *Ulothrix-Urospora* belt became more outstanding than in the south and southwest and species of *Acrosiphonia* were better represented in the tidal pools and on littoral slopes.

Corallina officinalis appeared as a dominant element in the vegetation of the tidal pools and on lower littoral slopes, this species obviously having its maximum luxuriancy along the northwest peninsula.

Sperciesof *Ceramium (C. rubrum, C. areschougii, C. circinatum, C. strictum, C. penicillatum, C. shuttleworthianum,* together with *Cystoclonium purpureum,* were outsanding in the middle- and lower littoral pools, this association differing somewhat from that encountered in the south, due to the different accompanying species.

As mentioned, *Chondrus crispus* was absent from the tidal pool vegetation.

Gigartina stellata, still outstanding in the lower littoral of exposed sites, was found in an asociation with *Leathesia difformis.*

Under conditions of less severe exposure, a belt of *Halosaccion ramentaceum-Rhodymenia palmata-Rhodomela lycopodioides* occupied the lower littoral slopes.

In the tidal pools, *Punctaria plantaginea, Stictyosiphon tortilis, Dictyosiphon spp., Petalonia spp.* and *Chordaria flagelliformis* were frequent enough.

In the fjord proper a non-typical vegetation was found, the floristic composition of the benthic vegetation and the sequence of the algal belts changing from place to place, as a response to salinity variations and different configurations of the substrata.

In the innermost, estuarine fjord area the algal vegetation still appears in a scattered growth and distinct belts are formed firstly in a certain distance from the river outlet.

Fucus vesiculosus and *Enteromorpha intestinalis* occur as the first in distinct belts, joined further out the fjord by *Ascophyllum nodosum* and even longer out by *Fucus spiralis* and *F. distichus* belts.

In the lower littoral, belts of different filamentous algae (species of *Enteromorpha, Cladophora, Ectocarpus* and *Dictyosiphon)* were found in the inner fjord regions, whereas outwards along the fjord, belts of *Acrosiphonia spp. — Pylaiella littoralis* and of *Rhodymenia palmata—Rhodomela lycopodioides-Halosaccion ramentaceum* were usual.

The sublittoral vegetation was represented by belts of *Chorda filum* in the inner fjord area, joined further out by a broad form of *Laminaria saccharina.*

In the middle area, belts of *Laminaria digitata* f. *cucculata-L.saccharina* f. *linearis-Alaria esculenta* followed the upper sublittoral level, whereas in the outermost regions the narrow and long form of *Alaria esculenta* was left. In selected spots, however, fields of crustose *Corallines* were solely found in this level.

Laminaria hyperborea, with its accompanying species, joins the sublittoral vegetation for the first time in the outer fjord area.

A marked increase in the number of species was found from the inner towards the outer fjord regions.

IV. North Iceland

The north part of the Icelandic coast, from Hornbjarg to Melrakkaslétta, revealed notable variations in the benthic algal zonation of exposed sites, since Hornbjarg still shows Atlantic features, similiar to those encountered in the north west, whereas Melrakkaslétta represents a transitional area leaning towards the Arctic conditions in the east.

The amount of the Atlantic water reaching the north coast probably has a marked influence on the occurrence and distribution of the littoral algal species.

As had already been established, before the turn of the century, the Irminger Current divides into a westerly and a easterly branch off North West Iceland, the easterly branch flowing clockwise along the north coast. Hydrographic investigations have revealed that there are great fluctuations in this influx, both seasonal and annual (Stefánsson, 1954b, 1962b).

The northward extension of the Atlantic water should be maximal in the middle of the North Icelandic coastal area or in regions

where the Icelandic submarine terrace is broadest. In the Grímsey basin, an anticlockwise flow of the current was suggested.

Further to the east the Irminger Current bends to the southeast joining the East Icelandic Current north of Melrakkaslétta (Stefánsson, 1962b).

The algal vegetation of the Húnaflói bay was investigated, both in Steingrímsfjördur and along the open eastern coast around Skagaströnd. Outstanding differences from the algal belts found in the northwest were observed, the eastern side of the Húnaflói bay having a more distinct Atlantic character than Steingrímsfjördur. This applies to the general features of the algal zonation as well as to the occurence of particular species.

This difference may be caused by differences in the distribution of the drift ice in the Húnaflói bay.

Only the algal vegetation of Steingrímsfjördur will be outlined here as well as that of the island Grímsey in Eyjafjardarsýsla, while the eastern part of Húnaflói and the transitional area of Melrakkaslétta will be treated in a separate paper.

STEINGRÍMSFJÖRDUR – INNER AREA

In the innermost estuarine area of Steingrímsfjördur similiar growth conditions and a similiar vegetation was found as in the inner part of Dýrafjördur.

Stadará river outlet innermost estuary:

No distinct zones were observed, *Fucus ceranoides, F. vesiculosus, Dictyosiphon chordaria, Enteromorpha intestinalis, E. prolifera, E. ahlneriana, Ulva lactuca, Cladophora fracta, Pylaiella littoralis* and *Ectocarpus spp.* occurring still in a scattered growth.

Thingstadur, further out the inner fjord area:

The following zonation was found:

Upper littoral: *Ulothrix flacca – Blidingia minima – Enteromorpha intestinalis – Fucus spiralis.*

Middle littoral: *Fucus vesiculosus – Ascophyllum nodosum – Fucus distichus* ssp. *evanescens.*

Lower littoral: Belt of filamentous algae: *Dictyosiphon foeniculaceus, D. chordaria Ectocarpus silicuosus, E. confervoides, Pylaiella littoralis, Eudesme virescens, Chaetomorpha capillaris, Enteromorpha prolifera, E. ahlneriana, E. clathrata, Cladophora flexuosa.*

Sublittoral: *Chorda filum.*

STEINGRÍMSFJÖRDUR – MIDDLE AREA

Brekkutún, steep rocky slopes in the upper littoral and moderate slopes on the lower levels:

Upper littoral: *Ulothrix flacca, Urospora penicilliformis – Bangia fuscopurpurea – Blidingia minima – Rhodochorton spp. – Fucus spiralis.*

Middle littoral: *Fucus vesiculosus – Ascophyllum nodosum – Fucus distichus* ssp. *edentatus.*

Tidal pools: 1) *Ceramium rubrum, C. strictum,* 2) *Enteromorpha spp.,* 3) *Dictyosiphon foeniculaceus* with *Chordaria flagelliformis,* 4) *Stictyosiphon tortilis.*

Lower littoral: *Acrosiphonia spp.* with *Pylaiella littoralis – Rhodymenia palmata, Rhodomela lycopodioides* and *Halosaccion ramentaceum* – belt of *Chordaria flagelliformis.*

Sublittoral: *Chorda filum – Laminaria saccharina* f. *latifolia.*

STEINGRÍMSFJÖRDUR – OUTER AREA

In the outer fjord regions, for the first time, outstanding differences from the algal zona-

tion as encountered along the north west part of Iceland were observed. These differences refer above all to the lower littoral levels of exposed sites.

Halosaccion ramentaceum is here the dominant element of the lower littoral, replacing as such the *Gigartina-* and *Callithamnion arbuscula* belts, encountered in the south, southwest and northwest (see Fig. 10 and 11).

A further characteristic feature was a *Chordaria flagelliformis* belt, occuring in some locations lower than *Halosaccion. Corallina officinalis* gets a subordinate role in the vegetation pattern, being mainly limited to the tidal pools.

Further differences from the northwestern vegetation refer to the *Fucacean* undergrowth, where *Plumaria elegans* and *Membranoptera alata* are lacking.

The *Ulothrix-Urospora* belts became even more outstanding and *Acrosiphonia* belts were locally found in the outer fjord area.

Observations revealed, however, that Hornbjarg most likely represents rather sharp limits, regarding both the distribution of single species and the general pattern of the algal zonation.

Moderatly exposed location with a moderate slope:

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix flacca* with *U. pseudoflacca* and *Urospora sp. — Blidingia minima* with *B. marginata* and *B. chadefaudii — Enteromorpha intestinalis — Fucus spiralis.*

Middle littoral: *Fucus vesiculosus — Ascophyllum nodosum* (undergrowth: *Hildenbrandia prototypus, Rhodochorton spp., Verrucaria mucosa, Ralfsia verrucosa, Lithothamnion spp., Polysiphonia urceolata, Cladophora rupestris,* dwarfish *Rhodymenia palmata, Sphacelaria radicans, S. britannica, Chaetopteris plumosa)* — belt of *Fucus distichus* ssp. *edentatus.*

Tidal pools: 1) *Dictyosiphon spp.,* 2) *Punctaria plantaginea,* 3) *Stictyosiphon tortilis,* 4) *Petalonia fascia-Eudesme virescens,* 5) *Cladophora oblitterata-Lithothamnion spp.*

Lower littoral: *Acrosiphonia spp. — Ceramium rubrum — Petalonia fascia* and *Scytosiphon lomentaria — Halosaccion ramentaceum* with *Myriactula lubrica* — belt of *Chordaria flagelliformis.*

Tidal pools: 1) *Corallina officinalis,* 2) *Ceramium spp.,* 3) *Acrosiphonia spp.*

Sublittoral: *Laminaria digitata, L. saccharina* f. *linearis, Alaria esculenta*

Highly exposed location with a moderate slope (see Plate 5):

Upper littoral: *Ulothrix spp. — Urospora penicilliformis — Bangia fuscopurpurea — Porphyra umbilicalis* f. *umbilicalis — Rhodochorton sp.* and *Pylaiella rupincola — Fucus spiralis.*

Tidal pools: 1) *Enteromorpha intestinalis,* 2) *Fucus distichus* ssp. *distichus,* 3) *Stictyosiphon tortilis.*

Middle littoral: *Fucus vesiculosus — Fucus distichus* ssp. *edentatus.*

Lower littoral: *Acrosiphonia spp.* — belt of *Ceramium rubrum, C. shuttleworthianum* and *C. areschougii — belt of Halosaccion ramentaceum-Cystoclonium purpureum* (or *H. r .— Rhodymenia palmata — Rhodomela lycopodioides)* — belt of *Chordaria flagelliformis.*

Pools: 1) *Corallina officinalis,* 2) *Ceramium spp.,* 3) *Acrosiphonia* spp., 4) *Ralfsia fungi formis.*

Sublittoral: *Alaria esculenta* (narrow form).

GRÍMSEY IN EYJAFJARDARSÝSLA

The coasts of the island Grímsey, situated on the Polar circle, are exposed to the strongest surf.

The algal vegetation still bears Atlantic features, though differing from the vegetation pattern of the mainland.

Some typical profiles will be outlined.

Steep and exposed rocky formations:

Supralittoral: *Prasiola stipitata* with *P. furfuracea* (about 5m broad belt) — *Rhizoclonium riparium* — *Ulothrix spp.*
Upper littoral: *Ulothrix spp.* with *Urospora penicilliformis* (broad zone) — *Porphyra umbilicalis* f. *umbilicalis.*
Pools: *Enteromorpha intestinalis, E. clathrata,* and *Cladophora sp.*
Middle littoral: *Fucus distichus* ssp. *anceps.*
Lower littoral: *Halosaccion ramentaceum* with *Rhodymenia palmata* and *Rhodomela lycopodioides* — belt of *Chordaria flagelliformis.*
Sublittoral: *Alaria esculenta* and *Laminaria digitata.*

Huge amounts of driftweed indicate a luxurious growth of *Laminaria hyperborea* on the lower sublittoral slopes.

Inlets with a moderate slope, limited by vertical rocky walls:

Supralittoral and upper littoral: *Ulothrix spp.* — *Rhodochorton spp.* (broad zones, covering the vertical slopes) — *Porphyra umbilicalis* f. *umbilicalis* and *Fucus spiralis* belts (on moderate slopes).
Middle littoral: (with moderate rocky slopes): *Fucus distichus* ssp. *edentatus* — *Scytosiphon lomentaria, Petalonia fascia* and *P. zosterifolia* belt.
Lower littoral: *Acrosiphonia spp.* — belt of *Halosaccion ramentaceum, Ulva lactuca, Rhodymenia palmata* and *Rhodomela lycopodioides* — *Chordaria flagelliformis* (narrow belt).
Sublittoral: *Alaria esculenta* (narrow form).

Steep basaltic formations were encountered at Grímsey, with algal zones developed on either side. A difference in the sequence of algal zones was found between the relatively sheltered and the exposed sides of such rocky walls (see Plate 5).
Supralittoral on rocky walls: *Prasiola stipitata* — *P. furfuracea. zones* were found on both sides and *Rhizoclonium riparium.*
Pools: *Enteromorpha intestinalis* and *E. clathrata.*

Sheltered sides of rocky walls:

Upper littoral: *Ulothrix spp.* — *Rhodochorton sp* .— *Porphyra umbilicalis* f. *umbilicalis, Fucus spiralis.*
Middle littoral: *Fucus vesiculosus* — *Fucus distichus* ssp. *edentatus* — *Scytosiphon lomentaria,* belt of *Petalonia fascia* — *P. zosterifolia.*
Pools: 1) *Acrosiphonia spp., 2) Ceramium rubrum* and *C. strictum,* 3) *Chordaria flagelliformis* — *Dictyosiphon spp.*
Lower littoral: *Acrosiphonia spp.* — *Halosaccion ramentaceum* and *Ulva lactuca* fields.
Pools: 1) *Corallina officinalis,* 2) *Ralfsia fungiformis.*
Rocky caves: *Chaetomorpha melagonium, Polysiphonia urceolata, Antithamnion floccosum, A. sp., Chaetopteris plumosa, Sphacelaria radicans.*
Sublittoral: *Alaria esculenta, Laminaria digitata* and *L. saccharina.*

Exposed side of rocky walls:

Upper littoral: *Bangia fuscopurpurea* — *Ulothrix spp.* with *Urospora penicilliformis* (these two belts extending into the supralittoral levels) — *Porphyra umbilicalis* f. *umbilicalis* (occupying horizontal surfaces in the rocks and occurring thus above or below the *Ulothrix* and *Bangia* zones).
Middle littoral: Dwarf *Petalonia fascia* and *P. zosterifolia* — dwarf *Fucus distichus* ssp. *anceps* (1—3cm).
Lower littoral: Dwarf *Rhodymenia palmata* and *Halosaccion ramentaceum*—belt of *Chordaria flagelliformis.*
Sublittoral: *Alaria esculenta* (narrow form).

Due to the strong surf, the algal vegetation of Grímsey exhibits particular features, differring from those on the mainland.

Extensive *Prasiola stipitata* belts occupy the supralittoral slopes. The outstanding *Ulothrix*

— *Urospora* and *Bangia* belts could locally reach into the levels of the spray zone.

On vertical walls, limiting small inlets, conspicous *Rhodochorton spp.* belts were developed under the *Ulothrix* zone.

A belt of *Petalonia fascia—P. zosterifolia* proved to be characteristic for the middle littoral, whereas in the lower littoral *Acrosiphonia* fields were found on moderate slopes, and lower down meadows of *Halosaccion ramentaaceum-Ulva lactuca.*

In sites, exposed to strongest surf, a particular zonation of dwarfish specimens of *Petalonia spp., Fucus distichus* ssp. *anceps* and *Rhodymenia palmata* was observed, such an extreme reduction of specimens not being found any other place around the Icelandic coast.

Due to the high exposure, the *Fucacean* growth is poorly developed on this island.

The tidal pool vegetation of the area still proved to bear typical Atlantic features, with both *Corallina officinalis* and several *Ceramium* species being represented.

V. East Iceland

The existence of an East Icelandic Current of Arctic origin had been postulated already before the turn of the century.

This current, having its origin in the Scoresby Sound, has a strong flow over the submarine terrace in the northeast and turns north of Melrakkaslétta towards the east (Stefánsson, 1962b).

In the region north of Gerpir, a rather sharp boundary between Atlantic and Arctic waters was found by the same author. Here, the North Icelandic Irminger Current, being cooled and diluted during its passage over the insulary shelf, leaves the coastal area.

South of Papey, approximately on the line between Eystrahorn and Vestrahorn, there is again a well defined boundary between Atlantic and Arctic waters.

These lines of demarcation are subjected to both seasonal and annual translocations.

The algal vegation of the East Icelandic coastal area was investigated in several places, in order to get an idea about the gradients in the vegetation patterns as created by the changing hydrographic conditions.

The changing vegetation features were observed on the line Melrakkaslétta — Langanes — Vopnafjördur — Mjóifjördur — Reydarfjördur — Stödvarfjördur — Berufjördur — Álftafjördur — Hvalnes — Lónsfjördur — Hornafjördur — Hrollaugseyjar.

The influence of the Arctic waters on the benthic algal vegetation seems to be the strongest in the mid east.

The general features of the algal zonation of East Iceland will be outlined on the example of Reydarfjördur, which has been investigated in detail, while the vegetation of the transitional areas will be treated in separate papers.

REYDARFJÖRDUR — INNER AREA

In the innermost, estuarine part of the fjord, around Búdareyri, a scattered growth was found on the sandy slopes, totaly emerged during low tide. The main species represented were: *Fucus ceranoides,* estuarine forms of *F. vesiculosus, Dictyosiphon chordaria, Pylaiella littoralis, Ulva lactuca, Enteromorpha intestinalis, E. prolifera, E. ahlneriana, Ectocarpus spp., Monostroma grevillei, Ulvaria obscura, Porphyra umbilicalis* f. *laciniata.*

In Dýrafjördur, *Porphyra — Monostroma* appeared as a separate association in local estuaries, whereas they seem to overlap with the rest of the estuarine growth in Reydarfjördur.

In a certain distance from the river outlet the algal belts became distinct, due to the faster substratum and increased salinity.

Krókur:

Upper littoral: *Blidingia minima — Enteromorpha intestinalis.*
Middle littoral: *Fucus vesiculosus — Fucus distichus* ssp. *evanescens.*
Lower littoral: Belt of filamentous algae: *Pylaiella littoralis, Ectocarpus siliculosus, Dictyosiphon foeniculaceus, D. chordaria, Chaetomorpha capillaris, Enteromorpha clathrata, E. ahlneriana, E. prolifera, Cladophora fracta.*
Sublittoral: *Chorda filum.*

REYDARFJÖRDUR — MIDDLE AREA

Gríma, moderate slope:

Upper littoral: *Ulothrix spp. — Urospora sp. — Enteromorpha intestinalis — Porphyra umbilicalis* f. *laciniata — Fucus spiralis.*
Middle littoral: *Fucus vesiculosus — Ascophyllum nodosum* (accompanying species: *Hildenbrandia prototypus, Polysiphonia urceolata, Chaetopteris plumosa, Sphacelaria radicans, Spongonema tomentosum, Ralfsia spp., Acrosiphonia sp.) — Fucus distichus* ssp. *evanescens.*
Tidal pools: 1) *Porphyra miniata,* 2) *Monostroma spp.*
Lower littoral: Belt of filamentous algae: *Dictyosiphon foeniculaceus, Chordaria flagelliformis, Eudesme virescens, Petalonia fascia, Ectocarpus siliculosus, E. confervoides, Chaetomorpha capillaris, Enteromorpha clathrata, E. ahlneriana, Cladophora flexuosa* — belt of *Rhodymenia palmata, Ulva lactuca* and *Halosaccion ramentaceum.*
Sublittoral: *Laminaria saccharina, L. digitata* and single *Chorda filum.*

Gríma, steep rocky slope:

Supralittoral: *Prasiola stipitata — Rhizoclonium riparium.*
Upper littoral: *Ulothrix flacca—U. sp. — Blidingia minima — Enteromorpha intestinalis — Fucus spiralis.*
Tidal pools: *Fucus distichus* ssp. *distichus.*
Middle littoral: *Ascophyllum nodosum — Acrosiphonia spp.*
Lower littoral: *Acrosiphonia spp.* with *Pylaiella littoralis* — belt of *Halosaccion ramentaceum, Rhodymenia palmata* and *Rhodomela lycopodioides* — belt of *Chordaria flagelliformis* and *Scytosiphon lomentaria.*
Tidal pools: 1) *Acrosiphonia spp.,* 2) *Fucus distichus* ssp. *distichus,* 3) *Porphyra miniata — Lithothamnion spp. — Leptophytum sp.*
Lagoons: *Laminaria digitata* f. *cucculata — Saccorhiza dermatodea.*
Sublittoral: *Alaria esculenta* (broad form).

REYDARFJÖRDUR — OUTER AREA

Firstly in the outer area zonation features, characteristic for East Iceland, became visible.

Some of the most characteristic profiles will be outlined here (see Plate 6 and 7).

Kolmúli, moderate exposure—gently sloping rocks:

Supralittoral: *Prasiola stipitata — Rhizoclonium riparium.*
Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix spp. — Urospora spp.* (broad belts) and accompanying species: *Scytosiphon pygmaeus,* dwarfy *Pylaiella rupincola* — belt of *Blidingia minima* and *B. chadefaudii — Fucus spiralis.*

A conspicuous belt of *Cyanophycean* species, containing mainly *Calothrix crustacea, C. scopulorum* and *Schizothrix calcicola* is overlapping with the *Porphyra umbilicalis* — and *Pylaiella rupincola*-zones.

This *Cyanophycean* zone seems to be outstanding for the upper littoral levels of the

North Icelandic coastal area and has likewise been found in the east.

Middle littoral: *Ascophyllum nodosum — Fucus distchus* ssp. *edentatus — Acrosiphonia spp. (A. sonderi, A. arcta, A. sp.)* meadows.

Lower littoral: *Scytosiphon lomentaria* — belt of *Halosaccion ramentaceum, Rhodymenia palmata* and *Rhodomela lycopodioides* — belt of *Ulva lactuca — Chordaria flagelliformis* with *Chorda tomentosa.*

Sublittoral: *Alaria esculenta, Laminaria digitata* and *Saccorhiza dermatodea* (driftweed from the lower sublittoral: *Alaria esculenta, Laminaria hyperborea, Ptilota species, Euthora cristata, Rhodophyllis dichotoma, Polysiphonia arctica, Porphyra miniata, Antithamnion boreale, Tunnerella pennyi, Desmarestia aculeata, D. viridis, Peyssonelia rosenvingii* etc).

Vattarnesbót, high exposure — moderate slopes:

Supralittoral: *Prasiola stipitata.*

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis — Ulothrix spp.* with *Urospora sp.* and *U. penicilliformis* (broad zone) — *Rhodochorton sp.* and *Pylaiella rupincola — Blidingia minima* with *B. chadefaudii — Acrosiphonia sp.*

Middle littoral: *Fucus distichus* ssp. *anceps* — fields of *Acrosiphonia spp.*

Tidal pools: 1) *Acrosiphonia spp.,* 2) *Fucus distichus* ssp. *distichus,* 3) *Clathromorphum circumscriptum — Leptophytum laeve — Porphyra miniata,* 4) *Ralfsia fungiformis — Coilodesme bulligera,* 5) *Stictyosiphon tortilis,* 6) *Dictyosiphon foeniculaceus — D. corymbosus — Chordaria flagelliformis,* 7) *Petalonia spp. — Scytosiphon lomentaria.*

Lower littoral: *Acrosiphonia spp.* with *Enteromorpha groenlandica — Halosaccion ramentaceum* f. *robustum* (or *Porphyra linearis*) — *Chordaria flagelliformis* with *Chorda tomentosa.*

Sublittoral: *Alaria esculenta* (narrow form).

With the increasing exposure, the strong surf may prevent the attachment of *Fucacean* species, the middle littoral level being covered by *Acrosiphonia spp.* fields where the slopes are moderate.

Vattarnes, high exposure — vertical slope:

Upper littoral: *Porphyra umbilicalis* f. *umbilicalis —Bangia fuscopurpurea — Ulothrix spp.* with *Urospora sp.* and *U. penicilliformis* pools with *Enteromorpha spp.* (different growth forms of *E. intestinalis* and *E. clathrata).*

Middle littoral: *Fucus distichus* ssp. *anceps, Rhodochorton purpureum* and dwarfy *Acrosiphonia spp.*

Lower littoral: *Porphyra linearis* (broad zone) — *Halosaccion ramentaceum, Rhodymenia palmata* and *Rhodomela lycopodioides* — belt of *Chordaria flagelliformis* and *Chorda tomentosa.*

Sublittoral: *Alaria esculenta* (narrow form).

Vattarnes—Hafnarnes, extreme exposure — vertical slopes (see Fig. 15):

Upper and middle littoral: Broad belt of *Ulothrix spp., Urospora sp.* and *U. penicilliformis.*

Lower littoral: *Porphyra linearis — Chordaria flagelliformis.*

Sublittoral: *Alaria esculenta* (narrow form), a part of the *Chordaria* zone reaching into the sublittoral.

Porphyra linearis- and *Chordaria flagelliformis* zones, found in steep and highly exposed sites, seem to replace the *Gigartina-* and *Callithamnion arbuscula* belts, encountered in similiar biotops in the Atlantic water regions up to Hornbjarg, as well as the *Halosaccion* belt, characteristic for the north coast.

An outstanding *Ulothrix spp.-Urospora spp.* belt and extensive *Acrosiphonia spp.* fields were further characteristic features of the algal zonation in East Iceland.

Due to the absence of several cold Boreal species, such as *Corallina officinalis, Ceramium spp., Cystoclonium purpureum, Gigartina stellata* and others, the vegetation pattern of the tidal pools appeared different.

Tidal pools, covered by different growth forms of *Fucus distichus* ssp. *distichus* and by different filamentous brown algae *(Dictyosiphon spp., Chordaria flagelliformis, Stictyosiphon tortilis),* were the most common, beside such covered by *Acrosiphonia spp.* and by *Clatromorphum circumscriptum, Leptophytum sp., Porphyra miniata, Coilodesme bulligera* and *Ralfsia fungiormis.*

The *Fucacean* zonation was changing from place to place, due to the varying degrees of exposure and configuration of the coastal rocks. In the outer fjord regions, *Fucus distichus* ssp. *edentatus* and *F. d.* ssp. *anceps* were dominating.

The floristic composition of the *Ascophyllum* zone exhibited likewise certain differences, due to the absence of some species in the undergrowth and the common epiphyte *Polysiphonia lanosa.*

In the sublittoral, *Saccorhiza dermatodea* was found together with *Alaria esculenta* and *Laminaria* species in sheltered sites, whereas under conditions of high exposure only the belt of narrow and long *Alaria esculenta* was left (see Fig. 14).

DISCUSSION

The general features of the algal zonation, as encountered in different parts of the Icelandic coastal area, show conspicous variations.

Regional variations.

Differences between the vegetation patterns of selected areas are most visible in exposed and open locations, which are in direct contact with the oceanic waters.

Algal belts, occurring in the lower littoral zone, thus on a level between the *Fucacean* and the *Laminarian* species, show the most outstanding differences between coastal areas where different hydrographic conditions are reigning.

Almost pure Atlantic waters surround the south and south west of Iceland, where also the annual temperature variations are minimal.

In the south, a *Gigartina stellata* belt was characteristic for highly exposed locations. Several species were found in between this belt, such as *Ceramium rubrum, C. penicillatum, C. areshougii, C. shuttleworthianum, C. strictum, C. penicilliatum, C. spp., Cystoclonium purpureum, Rhodomela lycopodioides, Acrosiphonia spp., Dumontia incrassata, Scytosiphon lomentaria* etc. Around Reykjanes and Snæfellsnes, *Dilsea edulis* is joining this belt.

With increasing exposure, an impoverishment regarding the number of accompanying species was found, pure *Gigartina* populations being left under conditions of strong surf.

In extremely exposed sites, *Gigartina stellata* was replaced by *Callithamnion arbuscula* belts, but where the exposure is moderate *Ceramium rubrum-Acrosiphonia spp.* belts were found on the same level.

A further characteristic feature were *Corallina officinalis* beds, occurring on gently sloping rocks lower than *Gigartina.*

The dominant tidal pool inhabitants of the southern coast were *Ceramium spp., Corallina officinalis, Chondrus crispus, Ahnfeltia plicata* and *Asperococcus echinatus.*

Around the Snæfellsnes peninsula, the *Gigartina* zone proved to be extremely prolific and joined by *Leathesia difformis,* beside the accompanying species, named above.

Both *Chondrus crispus* and *Ahnfeltia*

plicata proved to be more rare in the tidal pools, while *Asperococcus echinatus* disappeared from the vegetation.

Along exposed coast lines of the northwestern peninsula, *Gigartina stellata-Leathesia difformis* or *Callithamnion arbuscula* belts were still observed up to Hornbjarg.

In this area, *Corallina officinalis* is forming extensive meadows in the lower littoral and upper sublittoral, and is as well dominating in the tidal pools.

Since both the Snæfellsnes peninsula and Látrabjarg represent thresholds, limiting the distribution of several species, the vegetation of the northwestern part of Iceland shows some differences from that found in the south and southwest. The absence of *Chondrus crispus* in the tidal pools and of *Dilsea edulis* and *Dumontia incrassata* in the *Gigartina* zone is notworthy.

Temperature variations in this area are greater, being dependant on the heating effect of the Atlantic water (the amount of its influx varying both seasonally and annually) on climatic factors and on the distribution of drift ice.

Since changes in the zonation pattern of exposed locations between the south, southwest and northwest were not abrupt, but rather conspicous, a rather sharp threshold was found at Hornbjarg.

The algal vegetation of the surroundings of Hornbjarg still bears a likeness with the one observed in the northwest, while great changes were found in the Húnaflói bay.

In the outer reginos of Steingrímsfjördur, *Halosaccion ramentaceum* is replacing the *Gigartina* zone. This outstanding *Halosaccion* belt is following the entire north coast, up to the mid-east. *Rhodymenia palmata, Rhodomela lycopodioides, Cystoclonium purpureum* and *Ulva lactuca* could appear as the main accompanying species in this belt.

Jaasund (1965) found a similiar difference in the vegetation pattern in the Arctic part of the Norwegian coast, *Gigartina* belts in Troms being replaced by *Halosaccion* belts in Finnmark.

Along the North Icelandic coastal area, both *Gigartina stellata* and *Corallina officinalis* have a subordinate role in the vegetation pattern and Hornbjarg represents a further limit for the northeastwards distribution of several species, such as *Callithamnion arbuscula, Plumaria elegans, Membranoptera alata* and others.

Hydrographic conditions along this part of the Icelandic coast have been thoroughly investigated by Stefánsson (1962b).

As mentioned, the Irminger Current, conveying Atlantic water along the western coast of Iceland, divides into a westerly and easterly branch in the northwest. The east flowing Irminger Current appears as a moderately strong current near the slope of the coastal shelf in the north, while near the shore the current appears week and irregular. This current leaves the coastal area north of Gerpir in the east (Stefánsson 1962b).

Considerable temperature variations, found in this area, are however caused by the varying influx of Atlantic water which diminishes in the direction west to east as well as by the changing extension of drift ice and climatic factors. Changes in the extension of the East Icelandic Current and East Greenland Current are further decisive for the temperature conditions along the north Icelandic coastal area.

The transitional areas in the northeast, thus the coast line between Melrakkaslétta and Langanes, revealed a gradual change in the vegetation pattern.

In the mid-east, *Porphyra linearis* and *Chordaria flagelliformis* zones were outstanding in steep, exposed locations, whereas on gently sloping rocks extensive *Acrosiphonia spp.* meadows were found.

Along the East Icelandic coast, the East Icelandic Current, which is of Arctic origin, greatly influences the vegetation pattern. Most of the cold- and warm Boreal species are absent along the coast line between Vopnafjördur and Hrollaugseyjar (e. g. *Corallina officinalis, Ceramium spp., Cystoclonium purpureum, Gigartina stellata* and many others.

The outstanding differences between the algal vegetation of the east coast and the other parts of Iceland have already been emphazied by earlier authors (Helgi Jónsson, 1910, 1912; Strömfelt, 1886b).

Regional changes in the appearence of algal belts were less expressed in the middle and upper littoral levels. Regarding the uppermost littoral zone, an increase of the extension of the *Ulothrix-Urospora* belts was found in the northern and northeastern direction. This zone is still fragmentary or absent in the south and gets gradually broader and more expressed towards the northwest and north, being the most outstanding in the mid-east.

Pelvetia canaliculata, occupying uppermost littoral slopes in extreme shelter, was found up to the Snæfellsnes peninsula.

The *Fucacean* belts, occupying middle littoral slopes, showed rather changing sequences as a response to varying degress of exposure, configuration of the coastal slopes and tidal ranges in selected areas. The main differences between the *Fucacean* belts refer to the undergrowing species and epiphytes, among which *Plumaria elegans* and *Membranoptera alata* are following up to Hornbjarg and e. g. *Polysiphonia lanosa* and *Gigartina stellata* up to Langanes.

In the upper sublittoral, *Laminaria digitata* f. *stenophylla* was characteristic for exposed sites of the southern coast whereas in the rest of the coastal area *Alaria esculenta* seemed to dominate.

Notable differences in the tide pools vegetation of selected areas were found around the coast.

The differences in the algal zonation of exposed and open habitats, as found in various areas of the Icelandic coast, could be due to different hydrographic conditions, the temperature factor having presumably the greatest effect on both, the distribution of single species and the general appearence of the algal zones.

Salinity fluctuations on a smaller scale, as encountered in such open locations, are on the other hand less decisive for the features of the benthic algal vegetation, than the rest of the ecological factors involved.

Adey (1966, 1968), studying the distribution of crustose *Corallines* around Iceland and in the northern Atlantic as a whole, admits that high and low temperatures control the distribution of *Corallines* around Iceland, with minimum winter temperatures as limiting factor.

The crustose *Corallines,* limited to deep water layers, should according to Adey, reflect a 10 years water climate which is however more stable in the depth than in the surface layers.

The littoral algal vegetation is, on the other hand, submitted to great annual and seasonal variations, taking place in the upper water layers. Conditions in these layers are also dependant on the duration of rain periods, wind directions, ice conditions, thus a complex of factors which may, however, influence the appearence of annual species.

In order to be able to make more reliable conclusions on the reasons for the different vegetation patterns, found in exposed biotops around Iceland, annual studies of the same locations would be needed. Detailed studies of species, characteristic for limited areas should also be carried out, in order to clear up the causal relationship between the hydrographic boundaries and boundaries of the vegetation patterns.

Local variations.

Beside the pronounced differences, found in the zonation of exposed locations of different parts of the Icelandic coast, local variations in limited areas were also observed.

While the first named variations could be attributed to the influence of the reigning ocean currents and thus first of all to the temperature factor, local variations may be regarded as a response to salinity fluctuations on a rougher scale and to variations in exposure and physical nature of the substratum, as well as to other not fully known factors of the environment.

DÝRAFJÖRDUR August 1964			REYDARFJÖRDUR August 1965			STEINGRÍMSFJÖRDUR August 1966		
	T (°C)	Sal (‰)		T (°C)	Sal (‰)		T (°C)	Sal (‰)
Botn	7,8	9,85	Búdareyri	14,0	15,64	Stadará	14,1	11,20
Drangar	8,2	28,33	Krókur	11,2	20,54	Thingstadur	11,4	14,21
Skeid	8,7	32,78	Holtastadareyri	9,6	32,65	Brekkutún	10,1	33,94
Hólar	9,0	31,41	Gríma	6,5	28,07	Hólmavík	9,9	33,41
Saltnes	9,2	29,99	Thernunes	5,5	33,84	Vídidalsá	9,4	29,24
Hraun	9,4	33,78	Kolmúli	4,5	33,66	Birgistangi	8,8	33,76
Hafnarnes	9,2	34,25	Vattarnesbót	4,1	33,36	Kirkjuból	6,5	34,23
Ytri Ófæra	9,1	34,21	Vattarnestangi	3,5	34,01	Mannshöfdi	6,2	34,48
Svalvogar	9,5	34,65	Hafnarnes	3,0	34,66	Hellnanes	6,0	34,14

Hydrographic studies of the Icelandic waters made in the last decades, as well as recently, (Stefánsson, 1952, 54a, 54b, 62a, 62b) refer to oceanic waters surrounding Iceland.

Scanty data are, on the other hand, available about the temperature and salinity conditions of the surface water near the coast itself, inside the fjords and in land-locked areas.

Some temperature and salinity measurements were done concurrent with the ecological observations of the algal vegetation.

These data are of interest in studying the gradually changing vegetation pattern along the fjord coasts.

In river outlets, as found in the inner fjord areas, we deal as a rule with a rather rough scale of salinity variations which are reflected in the benthic algal growth, going gradually over from an estuarine to a typical marine one.

Algal zones, found in the fjord proper, proved to show a likeness all around Iceland. In the innermost estuarine fjord regions a scattered and non-typical growth was found, distinct algal belts being gradually formed with the increasing distance from the innermost river outlet.

Changing zonation features were observed throughout the fjord coasts, as well as a gradual increase of the number of species from the inner towards the outer fjord regions.

In the outer areas of the fjords, conspicous differences were observed between the three fjords discussed in the present paper, Dýrafjördur in the northwest, Steingrímsfjördur in the north and Reydarfjördur in the east.

Average salinity and temperature data for some characteristic spots of these three fjords will be given for a rough information.

All measurements were done during the month of August, though in sequent years.

All the measurements refer to the surface water and were made during low tide.

In Dýrafjördur, a progressing increase of temperature was found along the coast, while in Steingrímsfjördur and Reydarfjördur the trends proved to be opposite, the temperature drop being the most expressed in Reydarfjördur.

Salinity values in the inner fjord areas are however variable, dependant on the nearness of the fresh water effluxes.

Similiar growth conditions were fouund at the heads of all three fjords discussed, thus low salinities, relativelly high temperatures, extreme shelter and sandy-muddy substrata which cause the so-called „fjord-effect" on the algal growth (impoverishement of the flora and rise of the lower vegetation limit). Species of *Enteromorpha, Ectocarpus, Pylaiella, Cladophora* and *Dictyosiphon* together with *Fucus ceranoides, F. vesiculosus* and species of *Enteromorpha, Ectocarpus, Pylaiella, Cladophora* and *Dictyosiphon* together with *Fucus ceranoides, F. vesiculosus* and species of *Monostroma* and *Porphyra* were the main elements in such biotops. The pattern of the *Fucacean*

zonation along the fjord coasts is however changing from spot to spot.

Similiar changes in the vegetation pattern throughout the fjord coasts have been described by several authors, e. g. Printz (1926) for the Trondheimsfjord, Sundene (1953) for the Oslo-fjord, Jorde and Klavestad (1963) for the Hardangerfjord in Norway.

In the lower littoral, zones of different filamentous algae proved to be characteristic for the inner and middle areas, whereas belts of *Acrosiphonia spp.-Pylaiella littoralis* and *Halosaccion ramentaceum-Rhodomela lycopodioides-Rhodymenia palmata* for the middle areas solely.

The upper sublittoral growth was represented by *Chorda filum* in the inner fjord regions, this species being gradually joined by *Laminaria saccharina* and *Laminaria digitata* and disappearing in the outer fjord regions, where, finally, under conditions of high exposure only *Alaria esculenta* is left.

If comparing the three fjords in question, the following differences were most obvious in the algal zonation of their outer areas:

DÝRAFJÖRDUR	STEINGRÍMSFJÖRDUR	REYDARFJÖRDUR
Upper littoral: Fragmentary *Ulothrix — Urospora* belt.	**Upper littoral:** Well developped *Ulothrix — Urospora belt.*	**Upper littoral:** Broad and outstanding *Ulothrix — Urospora* belt.
Lower littoral: *Gigartina stellata* with *Leathesia difformis* or *Callithamnion arbuscula — Corallina officinalis* meadows.	**Lower littoral:** *Halosaccion ramentaceum — Chordaria flagelliformis* Patches of *Acrosiphonia spp.* fields.	**Lower littoral:** *Porphyra linearis — Chordaria flagelliformis.* Extensive *Acrosiphonia spp.* fields.
Tidal pools: *Ceramium spp.* with *Cystoclonium purpureum, Corallina officinalis* and *Enteromorpha linza.*	**Tidal pools:** *Ceramium spp.* with *Cystoclonium purpureum, Cor*allina officinalis (rare), *Acrosiphonia spp.* and filamentous brown algae.	**Tidal pools:** Filamentous brown algae, *Acrosiphonia spp., Porphyra miniata, Coilodesme bulligera* and *Ralfsia fungiformis.*

SUMMARY

1. The general features of benthic algal zonation in different areas of the Icelandic coast are described.

The algal belts, belonging to different littoral levels are given in their vertical sequence in all the profiles, described in this paper.

2. The heterogenity in the patterns of algal zonation, as observed in different regions, thus in the south, south west, north west, north and east of Iceland, could be due to the influence of different hydrographic conditions.

The influence of the Atlantic waters, being strongest in the south, diminishes in the northern and northeastern direction, whereas the East Icelandic coastal area is influenced by the East Icelandic Current, which is of Arctic origin.

3. Observations revealed that the algal belts, encountered in the lower littoral of exposed and open locations, were the most outsanding.

Gigartina stellata and *Callithamnion arbuscula* belts were found on this level in the south and west up to Hornbjarg, whereas in the north a *Halosaccion ramentaceum* zone was characteristic. In the east *Porphyra linearis*

and *Chordaria flagelliformis* belts appeared on this level.

Extensive *Corallina officinalis* meadows were observed in the Atlantic water regions up to Hornbjarg, and *Acrosiphonia spp.* fields in the east.

4. Smaller variations were found in the upper littoral levels. In the south, up to Snæfellsnes, a *Pelvetia canaliculata* zone was observed in the uppermost littoral.

The *Ulothrix-Urospora* zone, being narrow or even absent in the south, became gradually broader and better developed in the northern and northeastern direction. In the east, an outstanding green zone occupied the upper littoral slopes.

5. The *Fucacean* zonation showed variations from place to place, dependant on the degree of exposure and configuration of the littoral slopes.

6. The stronger the degree of exposure, the less algal zones were as a rule found throughout the littoral.

7. In limited areas, the sequence of algal zones could change from place to place as a response to local variations in the environmental conditions. In the fjords, the salinity factor has a profound influence on the appearence and sequence of algal zones.

8. Regional differences in the zonation patterns as observed in exposed and open locations, could at the present state of knowledge be regarded as a function of different temperature conditions around the Icelandic coast.

SPECIES NEW FOR ICELAND

As mentioned in the introduction only species which are likely to be the most outstanding for the vegetation pattern of different areas of the Icelandic coast are treated.

The collected material is under further investigation. Some biotic units, found during field observations, are still to be sorted and revised.

Studies of the algal vegetation of the Icelandic coasts will be continued in the coming years.

The present list, however, contains only a part of the algal species, occurring in Icelandic waters.

In accordance with present studies, which still are preliminary, the following species can be regarded as new for the Icelandic coastal areas

CHLOROPHYCEAE

Blidingia chadefaudii (Feldmann) Bliding, *Ulva rigida* (C. Ag) Thur, *Enteromorpha ahlneriana* Bliding, *Cladophora oblitterata* Söderström, *Cladophora fracta* (Vahl) *Kütz.* The last named species was found in the innermost fjord areas and shallow bays, influenced by fresh water. A record from 1856 is mentioned by van den Hoek (1963, pp. 204) but not mentioned by Helgi Jónsson (1910). The species *Blidingia minima* (Nägeli ex Kütz.) Kylin corresponds to *Enteromorpha intestinalis* f. *minima,* mentioned by Helgi Jónsson, and *Blidingia marginata* (J. Ag.) Dang. to *Enteromorpha intestinalis* f. *micrococca.*

Species belonging to the genus *Cladophora* need further revision.

PHAEOPHYCEAE

Asperococcus echinatus (Mert.) Grev was found in the area between Ölfusá and Thjórsá. It proved to be outsanding in the vegetation of the South Icelandic coastal area. *Punctaria latifolia* Grev., *Sphacelaria bipinnata* (Kütz.) Sauv., *Scytosiphon pygmaeus* Reinke, *Myriactula lubrica* (Rupr.) Jaasund (probably corresponding to *Elachista fucicola* f. *lubrica,* mentioned by Helgi Jónsson, 1903). *Pylaiella rupincola* (Aresch.) Kylin (by some authors regarded as a form of *P. littoralis*

(eg. West. 1967). *Fucus ceranoides* L., not mentioned by Helgi Jónsson (1903, 1910) is common and widespread in estuarine areas all around Iceland, especially in the innermost fjord areas. Following transplantation experiments in Norway (Munda, 1964) it might be possible that this species belongs to *F. vesiculosus*.

RHODOPHYCEAE.

Porphyra abyssicola Kjellm., *Gloiosiphonia capillaris* (Huds.) Carm. ex Berk., *Callithamnion hookeri* (Dillw.) S. F. Gray, *Callithamnion tetrargonum* (With.) S. F. Gray.

As mentioned in the introduction, the genus *Ceramium* still needs further investigation. Comparing my preliminary data with those of H. Jónsson (1912) the following species were additionally recorded: *Ceramium areschougii* Kylin, *Ceramium strictum* (Kütz.) J. Ag., *Ceramium secundatum* Lyngb. (after Kylin, 1944)). *Ceramium penincillatum* Aresch. (after Kylin, 1944) is according to several authors only regarded as a form of *C. fruticulosum*, while *C. pedicellatum* (Duby) J. Ag. corresponds to *C. rubrum* var. *pedicellatum*, this variety of *C. rubrum* not being mentioned by H. Jónsson (1912).

LIST OF SPECIES MENTIONED IN THE TEXT

CHLOROPHYCEAE

ULOTRICHALES

Ulotrichaceae

Ulothrix flacca (Dillw.) Thuret
Ulothrix pseudoflacca Wille
Ulothrix spp. (includes also U. subflaccida Wille, U. consociata Wille).

Ulvaceae

Blidingia marginata (J. Ag.) P. Dang.
Blidingia chadefaudii (Feldmann) Bliding
Enteromorpha intestinalis (L.) Link.
Enteromorpha compressa (L.) Grev.
Enteromorpha prolifera (Müll.) J. Ag.
Enteromorpha ahlneriana Bliding
Enteromorpha clathrata (Roth.) Grev.
Enteromorpha flexuosa (Wulf. ex Roth) J. Ag.
Enteromorpha linza (L.) J. Ag.
Enteromorpha groenlandica (J. Ag.) Setch. et Gardn. (Corresponds to Monostroma groenlandicum J. Ag. (ex Rosenvinge 1893)).
Ulva lactuca L.
Ulva rigida (C. Ag.) Thur.
Ulvaria obscura (Kütz) Gayral

Monostromataceae

Monostroma grevillei (Thuret) Wittrock
Monostroma undulatum Wittrock

PRASIOLALES

Prasiolaceae

Prasiola stipitata Suhr.
Prasiola furfuracea (Mert.) Menegh.
Prasiola sp.

CLADOPHORALES

Cladophoraceae

Rhizoclonium riparium (Roth.) Harvey
Cladophora rupestris (L.) Kütz.
Cladophora oblitterata Söderström
Cladophora flexuosa (Müll.) Kütz.
Cladophora fracta (Vahl) Kütz.
Cladophora glaucescens (Griff. ex Harvey) Harvey
Cladophora sp.

(The nomenclature and delimitation of species within this genus is treated from different aspects by recent authors (e. g. Söderström, 1963, van den Hoek, 1963). A part of my material has kindly been cheked by Söderström and the nomenclature used is in accordance with his aspects.)
Chaetomorpha melagonium (Web. et Mohr.) Kütz.
Chaetomorpha capillaris (Kütz.) Börg.

Acrosiphoniaceae

Urospora penicilliformis (Roth.) Aresch.

Urospora spp.
Spongomorpha aeruginosa (L.) Hoek
Acrosiphonia sonderi (Kütz.) Kornmann
Acrosiphonia arcta (Dillw.) J. Ag.
Acrosiphonia centralis (Lyngb.) Kjellm.
Acrosiphonia spp.

(All the Acrosiphonia material has not yet been determined with certainity, due to a wide range of morphological variations, obviously induced by different ecological factors. A part of dried and living material was sent to Kornmann and is under investigation).

PHAEOPHYCEAE

ECTOCARPALES

Ectocarpaceae

Ectocarpus confervoides (Roth.) Le Jol. (different forms)
Ectocarpus siliculosus (Dillw.) Lyngb.
Ectocarpus faciculatus Harv.
Ectocarpus spp.
Spongonema tomentosum (Huds.) Kütz.
Giffordia hincksiae (Harv.) Hamel

Ralfsiaceae

Ralfsia verrucosa (Aresch.) J. Ag.
Ralfsia fungiformis (Gunn.) Setch. et. Gardn.
Ralfsia spp.

Elachistaceae

Elachista fucicola (Vell.) Aresch.
Myriactula lubrica (Rupr.) Jaasund

Chordariaceae

Leathesia difformis (L.) Aresch.
Eudesme virescens (Carm. ex Harv. in Hook.) J. Ag.
Chordaria flagelliformis (O.F. Müll.) C. Ag.

DESMARESTIALES

Desmarestiaceae

Desmarestia aculeata (L.) Lam.
Desmarestia viridis (Müll.) Lam.
Desmarestia ligulata (Lightf.) Lam.

SPHACELARIALES

Sphacelariaceae

Sphacelaria radicans (Dillw.) C. Ag.
Sphacelaria britannica Sauv.
Sphacelaria bipinnata (Kütz.) Sauv.
Chaetopteris plumosa (Lyngb.) Kütz.

SCYTOSIPHONALES

Scytosiphonaceae

Scytosiphon lomentaria (Lyngb.) J. Ag.
Scytosiphon pygmaeus Reinke
Petalonia fascia (Müll.) Kuntze
Petalonia zosterifolia (Reinke) Rosenvinge

DICTYOSIPHONALES

Tilopteridaceae

Pylaiella littoralis (L.) Kjellm.
Pylaiella rupincola (Aresch.) Kylin

Striariaceae

Stictyosiphon tortilis (Rupr.) Reinke

Punctariaceae

Punctaria plantaginea (Roth.) Grev.
Punctaria latifolia Grev.
Asperococcus echinatus (Mert.) Grev.

Dictyosiphonaceae

Dictyosiphon foeniculaceus (Huds.) Grev.
Dictyosiphon corymbosus Kjellm.
Dictyosiphon chordaria Aresch. cf.
Dictyosiphon ekmani Aresch.
Dictyosiphon spp.
Coilodesme bulligera Strömf.

Chordaceae

Chorda filum (L.) Stackh.
Chorda tomentosa Lyngb.

LAMINARIALES

Laminariaceae

Laminaria digitata (Huds.) Lom.

„ f. stenophylla (Harv.) Foslie
„ f. cucculata Le Jol.
Laminaria hyperborea (Gunn.) Foslie
Laminaria saccharina (L.) Lam.
„ f. linearis J. Ag.
„ f. latifolia Kjellm.
Alaria esculenta (L.) Grev.
Saccorhiza dermatodea (De la Pyl.) J. Ag.

FUCALES

Fucaceae

Fucus vesiculosus L.
„ f. sphaerocarpus J. Ag.
Fucus ceranoides L.
Fucus serratus L.
Fucus spiralis L.
Fucus distichus L. emend. Powell
„ subsp. edentatus (De la Pyl.) Powell
„ subsp. anceps (Harv. et Ward ex Carruthers) Powell
„ subsp. evanescens (C. Ag.) Powell
„ subsp. distichus Powell
Ascophyllum nodosum (L.) Le Jol.
Pelvetia canaliculata (L.) Decne et Thur.

RHODOPHYCEAE

BANGIALES

Bangiaceae

Bangia fuscopurpurea (Dillw.) Lyngb.
Porphyra miniata (Lyngb.) C. Ag.
Porphyra abyssicola Kjellm. cf.
Porphyra linearis Grev.
Porphyra umbilicalis (L.) J. Ag.
„ f. umbilicalis (L.) J. Ag.
„ f. laciniata (Lightf.) Thuret
Porphyra spp.

ACROCHAETIALES

Acrochaetiaceae

Acrochaetium alariae (Jónss.) Born.
Rhodochorton purpureum (Lightf.) Rosenv.
Rhodochorton spp. (includes R. penicilliforme (Kjellm.) Rosenv., R. membranaceum Magnus, R. sp.

CRYPTONEMIALES

Dumontiaceae

Dumontia incrassata (Müll.) Lam.
Dilsea edulis Stackh.
Hildenbrandia prototypus Nardo

Corallinaceae

Corallina officinalis L.
Clathromorphum circumscriptum (Strömfelt) Foslie
Clathromorphum sp.
Phymatolithon polymorphum (L.) Foslie
Ph. spp. (includes Ph. lenormandii (Aresch.) Adey, Ph. rugulosum Adey, Ph. laevigatum (Foslie) Foslie)
Dermotolithon sp.
Lithothamnion glaciale Kjellm.
Lithothamnion tophiforme Unger
Lithothamnion spp.
Leptophytum spp. (includes L. laeve (Strömf.) Adey, L. foecundum (Kjellm.) Adey

The crustose, Corallines, collected in upper water layers of the Icelandic coast have not yet been determined as a whole. Only a part of the determined material is enumerated in the list, while in the text, most frequently only the genera are mentioned for locations where they proved to be outstanding in the vegetation pattern.

A part of my material was determined by Adey and my own determinations are based on Foslie's exicate as well as on a part of Adey's collection, which was kindly given to my disposition.

The crustose Corallines in deep-water layers around Iceland were studied by Adey (1968).

Kallymeniaceae

Euthora cristata (C. Ag.) J. Ag.

Squamariaceae

Peyssonelia rosenvingii Schm. in Rosenv.

Gloiosiphoniaceae

Gloiosiphonia capillaris (Huds.) Carm. ex Berk.

GIGARTINALES

Gigartinaceae

Chondrus crispus Stackh.
Gigartina stellata (Stackh.) Batters
Ahnfeltia plicata (Huds.) Fries
Rhodophyllis dichotoma (Lepech.) Gobi
Cystoclonium purpureum (Huds.) Batters.

Cruoriaceae

Petrocelis hennedyi (Harv.) Batters

Phyllophoraceae

Phyllophora membranifolia (Good. et Wood.) J. Ag.
Phyllophora brodiaei (Turn.) Endl.

Plocamiaceae

Plocamium coccineum (Huds.) Lyngb.

Soleriaceae

Turnerella pennyi (Harv.) Schmitz

RHODYMENIALES

Rhodymeniaceae

Rhodymenia palmata (L.) Grev.
Halosaccion ramentaceum (L.) J. Ag.

Lomentariaceae

Lomentaria orcadensis (Harv.) Coll. ex Taylor
Lomentaria clavellosa (Turn.) Gaill.

CERAMIALES

Ceramiaceae

Callithamnionm arbuscula (Dillw.) Lyngby.
Callithamnion hookeri (Dillw.) S. F. Gray
Callithamnion tetrargonum (With.) S. F. Gray
Antithamnion floccosum (O. F. Müll.) Kleen.
Antithamnion boreale (Gobi) Kjellm.
Antithamnion sp.
Plumaria elegans (Bonnem.) Schmitz.
Ptilota pectinata (Gunn.) Kjellm.
Ceramium rubrum (Huds.) C. Ag.
Ceramium areschougii Kylin
Ceramium penicillatum Aresch.
Ceramium circinatum (Kütz.) J. Ag.
Ceramium strictum Harv.
Ceramium shuttleworthianum (Kütz.) Silva
Ceramium spp. (includes several species, which still need further investigation, such as. Ceramium fruticulosum (Kütz.) J. Ag., Ceramium pedicellatum (Duby) J. Ag., Ceramium secundatum Lyngb., Ceramium arborescens J. Ag., Ceramium atlantium Petersen together with yet undetermined material).

Delesseriaceae

Membranoptera alata (Huds.) Stackh.
Delesseria sanguinea (Huds.) Lam.
Phycodrys rubens (L.) Batt.

Rhodomelaceae

Polysiphonia urceolata (Lightf. ex Dillw.) Grev.
Polysiphonia arctica J. Ag.
Polysiphonia nigrescens (Huds.) Grev.
Polysiphonia lanosa (L.) Tandy
Rhodomela lycopodioides (L.) C. Ag.
Odonthalia dentata (L.) Lyngb.

CYANOPHYCEAE

were not included in the present survey. Nevertheless the following species, which were outstanding and belt-forming in the north and east of Iceland are worth to be mentioned:

Calothrix crustacea Schousb. and Thur.
Calothrix scopulorum (/Web. et Mohr./ C. Ag.) Born. et Flah.
Petalonema sp.
Schizothrix calcicola (C. Ag.) Com.

This paper was received in October 1969 and accepted for publication in Acta Naturalia Islandica during 1970. The Editor.

ACKNOWLEDGEMENT

The author feels greatly indebted to the Icelandic Science Foundation, which has financially supported the present algological investigations around the Icelandic coast from 1963 up to this date.

Futher thanks are due to Mrs. Thórunn Thórdardóttir and Director Jón Jónsson, Marine Research Institute, Reykjavík, for offering me working facilities at the institute, as well as to Mr. Jóhannes Briem for his great help during my work.

Special thanks are due to Prof. Dr. T. Levring and Dr. J. Söderström, Marine Botanical Institute, University of Gothenbourg, to Dr. Carl Bliding, Borås, Dr. P. Kornmann, Biological Station of Helgoland, to Dr. Drouet, Academy of Natural Science Philadelphia, and to Dr. W. H. Adey, The Museum of Natural History, Whasington, for their help and advices.

The succes of the field work was greatly dependant on the help and assistance of many people living in the coastal areas investigated who gave me possibilities to live in their homes.

To all who have helped I express my sincerest thanks.

REFERENCES.

Adey, W. H. — 1966: The distribution of saxicolous corallines in the northwestern North Atlantic. Journ. Phyc. 2 (2), 49–54.

„ 1968: The Distribution of Crustose Corallines on the Icelandic Coast. Science in Iceland, Ann. Vol., Reykjavík, 1968.

Bliding, C. — 1944: Zur Systematik der schwedischen Enteromorpha. Bot. Notiser, 97.

„ 1963: A critical survey of European taxa in Ulvales. Part I. Opera Botanica, 8:3.

„ 1968: A critical survey of European taxa in Ulvales. Part II. Bot. Notiser, 121, 4.

Börgesen, F. — 1904: Om Algevegationen ved Færöernes Kyster. Köbenhavn og Kristiania. Gyldendals Forlag.

Börgesen, F. and Jónsson, H. — 1908: The distribution of marine algae in the Arctic sea and the northermost part of the Atlantic. Botany of Færöes. Part III. Köbenhavn.

Dixon, P. S. — 1960: Studies on marine algae of the British Isles: Ceramium shuttleworthianum (Kütz.) Silva. J. mar. biol. Assoc. UK, 39.

Eyjólfsson, F. — 1861: Brjef til J. Hjaltlíns. Íslendingur, 2, 4, 5.

Foslie, M. H. — 1890: Contribution to knowledge of marine algae of Norway, I. East Finnmarken. Tromsö Mus. Aarshefter 13.

„ 1891: Contribution to knowledge of marine algae of Norway II. Ibid. 14.

Grönlund, C. — 1879: Tillæg til Kjellmans Afhandling. Bot. Tidskr. B. 3, række 3.

Hjaltalín, O. J. — 1830: Íslenzk Grasafræði. Köbenhavn — Reykjavík.

Hoek, C. van den. — 1963: Revision of European species of Cladophora. Leiden.

Hooker, W. J. — 1813: Journal of a tour around Iceland in the summer of 1809. London.

Hygen, G. and Jorde, I. — 1934: Beitrag zur Kenntnis der Algenflora der norwegischen Westküste. Bergens Mus. Árbok 1934, Naturvidensk. Rekke N. 9.

Jaasund, E. — 1957: Marine algae from Northern Norway. Bot. Notiser, 110, 2.

„ 1965: Aspects of the marine algal vegetation of North Norway. Bot. Gothoburgensia IV.

Jónsson, H. — 1901: The marine algae of Iceland. I. Rhodophyceae. Bot. tidskr. Bd. 24.

„ 1903: Idem. II. Phaeophyceae, III. Chlorophyceae. Ibid. Bd. 25.

„ 1910: Om algevegetation ved Islands kyster. Thesis. Köbenhavn.

„ 1912: The Marine Algal Vegetation. The Botany of Iceland, Vol. I. 1, ed. by K. L. Rosenvinge and E. Warming. Copenhagen.

Jónsson, S. — 1966: Le commencement du peuplement bentique des côtes rocheuses du Surtsey, la nouvelle île volcanique dans l'Atalnti-

que Nord. C. R. Acad. Sci., France, 262, 915–918.

„ 1970: Studies on the Colonization of Marine Benthic Algae at Surtsey in 1968. Surtsey Research Progress Report V.

Jorde, I. and Klavestad, N. — 1963: The natural history of the Hardangerfjord. The benthonic algal vegetation. Sarsia 9. Bergen.

Kjellmann, F. R. — 1883: The Algae of the Arctic Sea. Kgl. Sv. Vet. Akad. Handl. Vol. 20. Stockholm.

„ 1879: Bidrag til kännedomen om Islands Hafsalgsflora. Bot. Tidskr. B. 3. Række 3. 3.

„ 1906: Zur Kenntnis der marinen Algenflora von Jan Mayen. Arkiv for Bot. Bd. 5.

Kornmann, P. — 1961: Zur Kennthiss der Porphyra Arten von Helgoland. Helgol. Wiss. Meeresundters. B.8.

„ 1962: Eine Revision der Gattung Acrosiphonia. Ibid. B.8.

„ 1964: Die Ulothrix Arten von Helgoland. Ibid. B 11.

Kylin, H. — 1907: Studien über die Algenflora der schwedischen Westküste. Akad. Avh. Upsala.

„ 1918: Svenska västkustens algregioner. Svensk. Bot. Tidskr. 12.

„ 1944: Die Rhodophycean der schwedischen Westküste. Lunds Univ. Årsskr. N. F. Avd. 2. B. 40. 2.

„ 1947: Die Phaeophyceem der schwedischen Westküste. Ibid. B. 43. 4.

„ 1949: Die Chlorophyceen der schwedischen Westküste. Ibid. B. 45. 4.

Levring, T. — 1937: Zur Kenntnis der Algenflora der norwegischen Westküste. Lunds Univ. Årsskr. N. F. Avd. 2. Bd. 33.

„ 1959: Distribution verticale de la végétation algale marine specialement en Scandinavie. Colloque Internat. C. N. R. S., 81, Paris.

Levring, T., Hoppe, H. A. and Schmid, O. J. — 1969: Marine Algae. Hamburg.

Lewis, J. R. — 1964: The ecology of rocky shores. London.

Lindsay, W. J. — 1861: The flora of Iceland. Edinb. New. Phil. Journ. Vol. 14 (64–101).

Lund, S. — 1959: The marine algae of east Greenland. II. Geographic distribution. Medd. om Grönland. Bd. 156, N. 2.

„ 1954: The algal zones in East Greenland and their ecological factors. Rapp. comm. 8 ème Congr. Internat. Bot. sect. 17. Paris.

Mackenzie, G. S. — 1812: Travels in the Island of Iceland, during the summer of the year 1810. Edinburgh.

Mohr, N. — 1786: Forsög til en Islandsk Naturhistorie. Köbenhavn.

Munda, I. — 1964: The quantity and chemical composition of Ascophyllum nodosum (L.) Le Jol. along the coast between the rivers Ölfusá and Thjórsá (Southern Iceland). Bot. marina Vol. VII, 1–4.

„ 1964: Observations on variation in form and chemical composition of Fucus ceranoides L. Nova Hedwigia. B. VIII.

„ 1969: Differences in the algal vegetation of two Icelandic fjords, Dýrafjördur (West Iceland), and Reydarfjördur (East Iceland). Proc. VIth Seaweed Symp. 1968.

„ 1970: Rannsóknir á botngróðri við strendur Íslands 1963 til 1968. Náttúrufrædingurinn. Vol. 40 (1–25).

„ 1970b: A note on the densites of benthic marine algae along a rocky slope in Faxaflói, Southwest Iceland. Nova Hedwigia. B. 19.

Müller, O. F. — 1770: Enumeratio Scirpium in Islandia Sponte crescentium. Nova Acta Acad, Nat. Curios. IV., pp 203–215.

Parke M., and Dixon, P. — 1964: A revised checklist of British marine algae. J. mar. biol. Assoc. UK, 44.

„ 1968: Check-list of British marine algae-second revision. Ibid. 48.

Printz, H. — 1926: Die Algenvegetation des Trondheimfjordes. Skr. Norske. Vidensk. Akad. I. — Mat. — Nat. Klasse, 5.

Rosenvinge, L. K. — 1879: Bidrag til Kundskapen om Slægterne Ulothrix og Conferva. Bot. Tidskr. B. 3, række 3.

„ 1893: Grönlands Havalger. Medd. om Grönland. Vol. 3.

„ 1898: Om Algevegetation ved Grönlands Kyster. Ibid. Vol. 20.

„ 1910: On the marine algae from the northeast Greenland. Medd. om Grönland, 43.

Sernander, R. — 1917: De nordeuropeiska hafvens växtregioner. Svensk. Bot. Tidskr. 11.

Sjöstedt, L. G. — 1928: Litoral and supralitoral studies on the Scanian shore. Lunds Univ. Årsskr. N. F. 24, N. 7.

Stefánsson, U. — 1954a: Surface temperature in Icelandic coastal waters during 1949–53. Fjölrit Fiskideildar, 4 (1–23).

„ 1952: Hydrographic conditions in the Iceland Sea 1951. Ann. biol. vol. 8 (27–30).

„ 1954b: Temperature variations in the North Icelandic coastal area. Rit Fiskideildar, Vol. II. N. 2 (1–27).

„ 1962a: Te salinity of the shores of the south west Iceland. Ibid. N. 9 (1–26).

„ 1962b: North Icelandic Waters. Ibid. vol. III (1–269).

Stephenson, T. A. and Anne. — 1949: The universal features of zonation between tide-marks on rocky coasts. Journ. Ecol. 37 (2).

„ 1961: Life between tide-marks in North America. Ibid. 49.

Strömfelt, H. F. G. 1886a: Einige für die Wissenschaft neue Meeresalgen aus Island. Bot. Centralbl. Bd. 26.

„ 1886b: Om algevegetation vid Islands kuster. Akad. Afh. Göteborg.

Söderström, J. — 1963: Studies in Cladophora. Botanica Gothburgensia, I.

„ 1965: Equivalent algal zones in Western Sweden and the British Isles. Bot. Gothoburgensis 3.

Sundene, O. — 1953: The algal vegetation of the Oslo fjord. Skr. Norske Vidensk. Akad. Oslo I. Mat. — Nat. Kl.

Svendsen, P. — 1959: The algal vegetation of Spitzbergen. Norsk Polarinst. Skr. N. 116.

Vahl, M. — 1840: Liste des plantes que l' on suppose d'exister en Islande. Paris.

Wennberg, T. — 1950: The distribution of certain marine algae on the Norwegian coast. Acta Hort. Gothob. 18.

West, J. A. — 1967: Pylaiella littoralis f. rupincola from Washington: the life — history in culture. J. Phycol. 3, (3).

Zoëga, J. — 1772: Flora Islandica. In E. Olafsson: Reise igiennem Island. Anden Deel. Soröe.

EXPLANATION OF PLATES

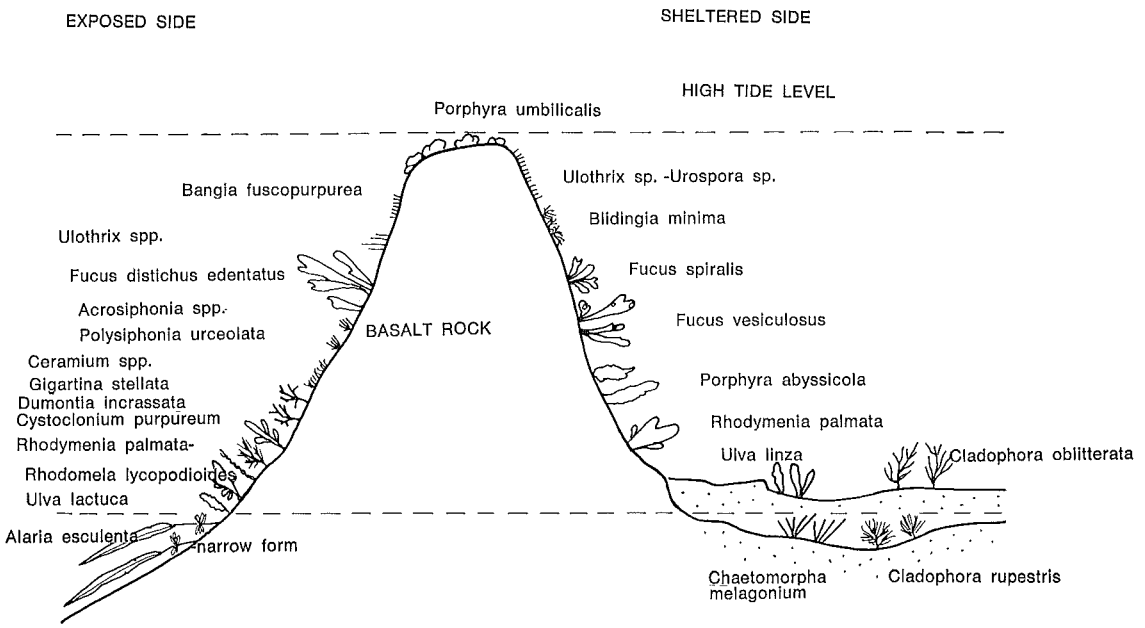
Plates 1–7: Profiles schemes 1–7:

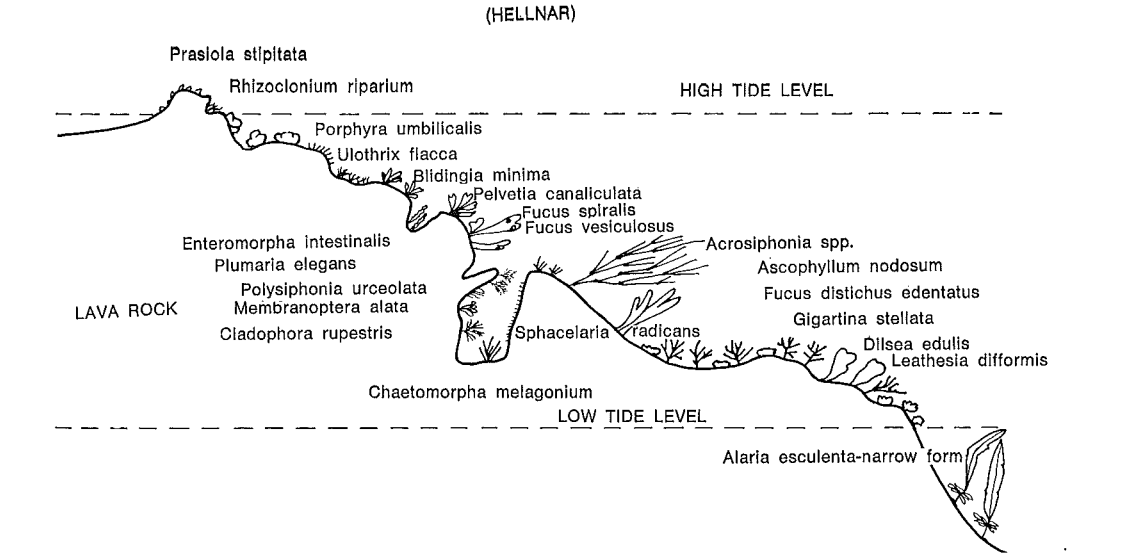
1 Snæfellsnes
2 Dýrafjördur – inner area
Dýrafjördur – middle area
3 Dýrafjördur – outer area
4 Dýrafjördur – outer area
5 Steingrímsfjördur – outer area
Grímsey
6 Reydarfjördur – outer area
7 Reydarfjördur – outer area

The profile transections, demonstrated on Plates 1–7, indicate the general feature of the algal zonation in selected areas and do not refer to particular locations.

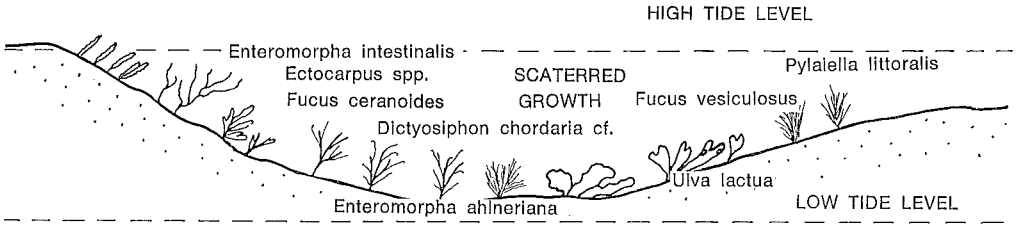
Plates 8–15: Figures 1–16:

Fig. 1. Porphyra umbilicalis belt of Snæfellsnes.
Fig. 2. Gigartina stellata zone below Ascophyllum nodosum at Hellnar, Snæfellsnes.
Fig. 3. Fucus spiralis and Fucus vesiculosus zones on rocky slopes at Snæfellsnes (Pylaiella rupincola under the barnacle belt).
Fig. 4. Detail from the same zones as Fig. 3: Pylaiella rupincola, Acrosiphoina spp., Scytosiphon pygmaeus and Rhodochorton spp. in the Fucus zone.
Fig. 5. Upper fringe of Ascophyllum nodosum zone in the outer part of Dýrafjördur (Ytri Ófæra).
Fig. 6. Upper fringes of Fucus vesiculosus and Ascophyllum nodosum zones in the same area as Fig. 5.
Fig. 7. Löngufjörur at Snæfellsnes. Filamentous algae (species of Ectocarpus, Enteromorpha and Dictyosiphon) with scattered Fucus vesiculosus on a sandy ground.
Fig. 8. Scattered Fucacean growth at Drangar in the inner part of Dýrafjördur (Fucus vesiculosus, Fucus ceranoides, Ascophyllum nodosum).
Fig. 9. Algal zonation at Reykjanes (Sandvík): Fucus spiralis – F. vesiculosus – Ascophyllum nodosum – Gigartina stellata – Corallina officinalis – Laminaria digitata f. stenophylla.
Fig. 10. Algal zonation in the outer part of Steingrímsfjördur: Fucus distichus ssp. edentatus – Halosaccion ramentaceum with accompanying species – Laminaria digitata f. cucculata.
Fig. 11. Fucus distichus ssp. edentatus – Halosaccion ramentaceum – Laminaria digitata belts from the same area as Fig. 10.
Fig. 12. Laminaria hyperborea in the outer part of Dýrafjördur.
Fig. 13. Laminaria saccharina f. linearis belt below Gigartina stellata at Reykjanes.
Fig. 14. Alaria esculenta belt (narrow form) at Vattarnes in Reydarfjördur.
Fig. 15. Extremely exposed rocky formations between Vattarnes and Hafnarnes outside Reydarfjördur.
Fig. 16. Acrosiphonia spp. and lower down Chordaria flagelliformis in the oouter part of Reydarfjördur.

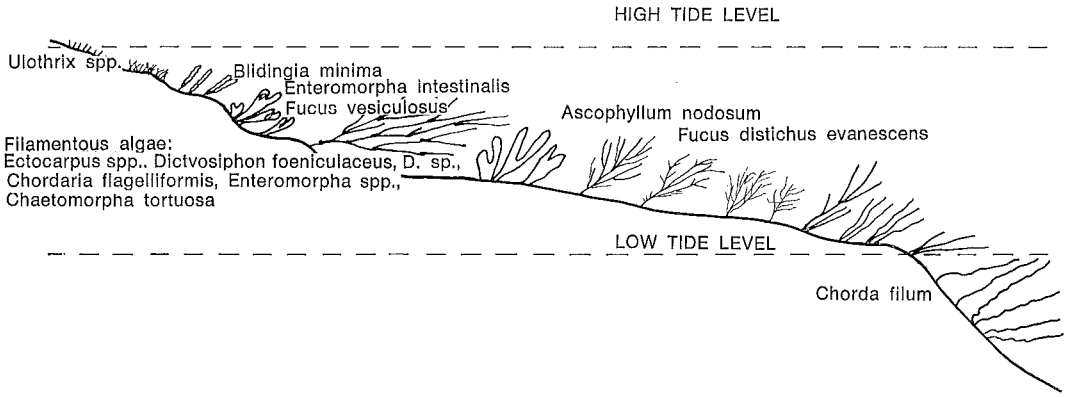

EXPOSED SIDE
SHELTERED SIDE
HIGH TIDE LEVEL
Porphyra umbilicalis
Bangia fuscopurpurea
Ulothrix spp.
Fucus distichus edentatus
Acrosiphonia spp.
Polysiphonia urceolata
Ceramium spp.
Gigartina stellata
Dumontia incrassata
Cystoclonium purpureum
Rhodymenia palmata
Rhodomela lycopodioides
Ulva lactuca
Alaria esculenta narrow form
BASALT ROCK
Ulothrix sp. -Urospora sp.
Blidingia minima
Fucus spiralis
Fucus vesiculosus
Porphyra abyssicola
Rhodymenia palmata
Ulva linza
Cladophora oblitterata
Chaetomorpha melagonium
Cladophora rupestris


(HELLNAR)
Prasiola stipitata
Rhizoclonium riparium
HIGH TIDE LEVEL
Porphyra umbilicalis
Ulothrix flacca
Blidingia minima
Pelvetia canaliculata
Fucus spiralis
Fucus vesiculosus
Enteromorpha intestinalis
Plumaria elegans
Polysiphonia urceolata
Membranoptera alata
Cladophora rupestris
LAVA ROCK
Acrosiphonia spp.
Ascophyllum nodosum
Fucus distichus edentatus
Gigartina stellata
Dilsea edulis
Leathesia difformis
Sphacelaria radicans
Chaetomorpha melagonium
LOW TIDE LEVEL
Alaria esculenta-narrow form

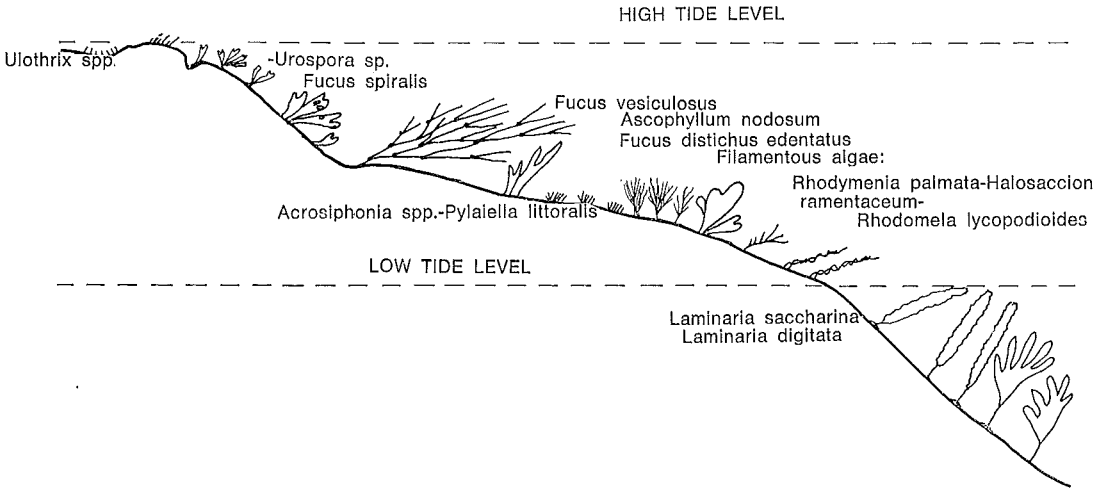
INNERMOST ESTUARY



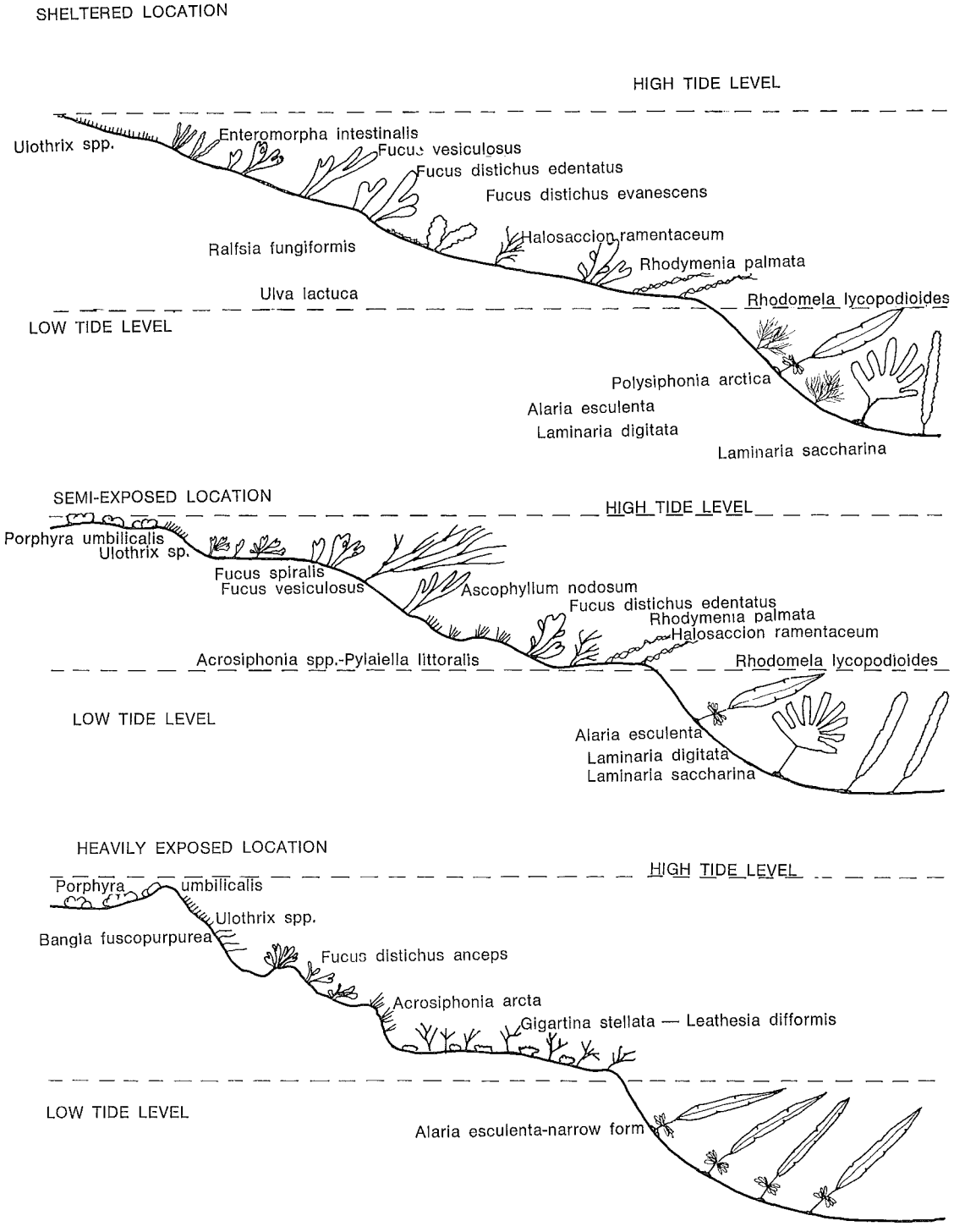
INNER FJORD AREA



MIDDLE FJORD AREA

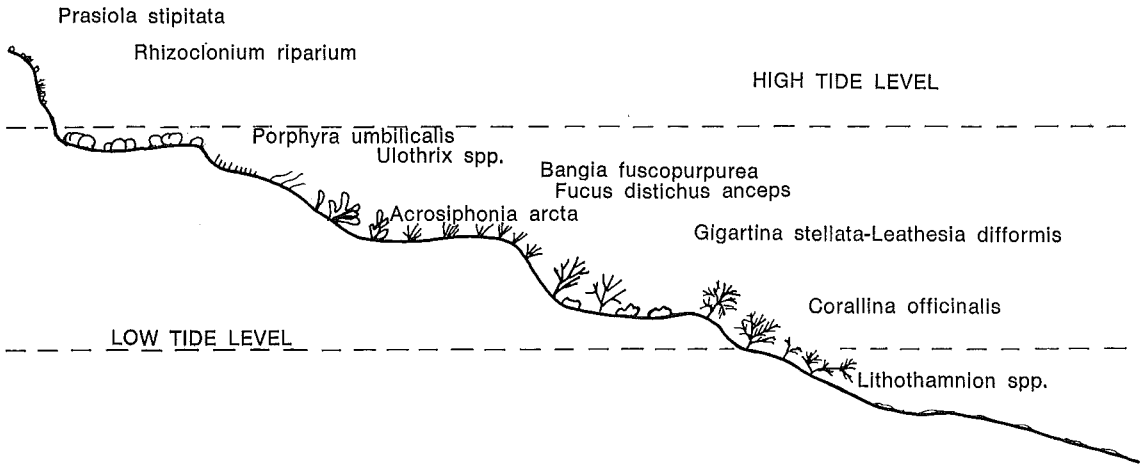


ZONATION — WESTERN FJORDS (DÝRAFJÖRÐUR)
OTHER FJORD AREA



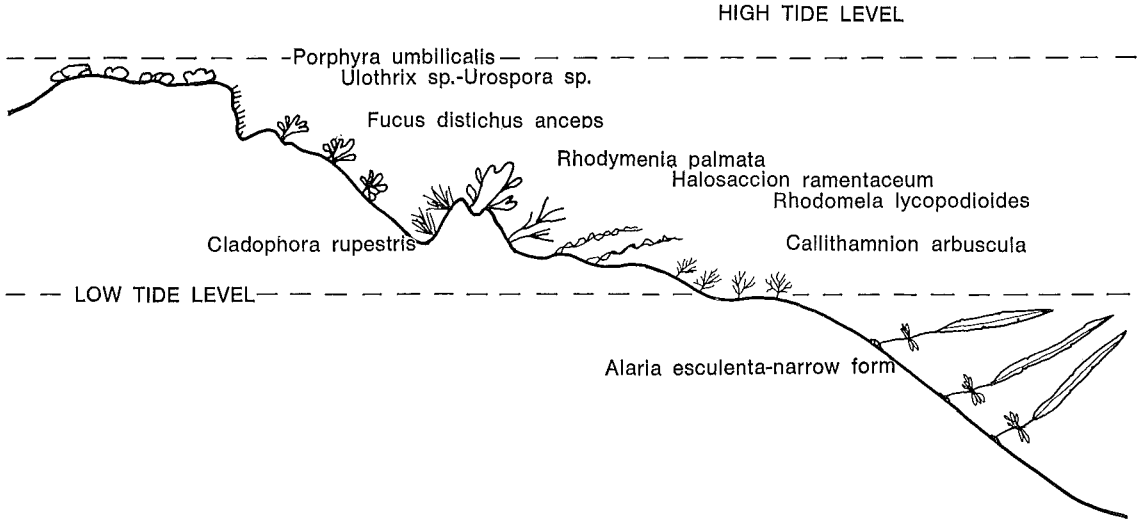
ZONATION — WESTERN FJORDS (DÝRAFJÖRÐUR)
OUTER FJORD AREA

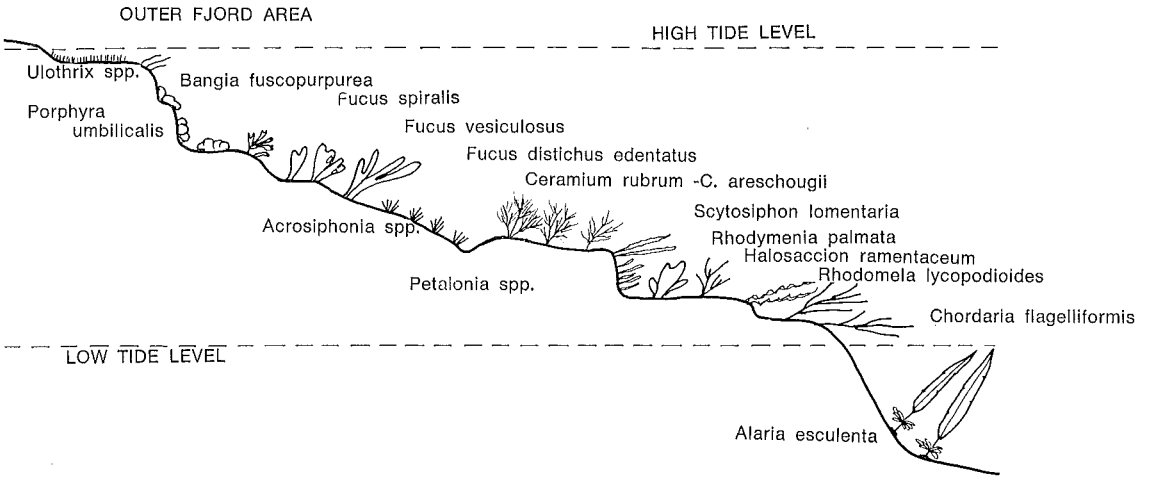
HEAVILY EXPOSED LOCATION



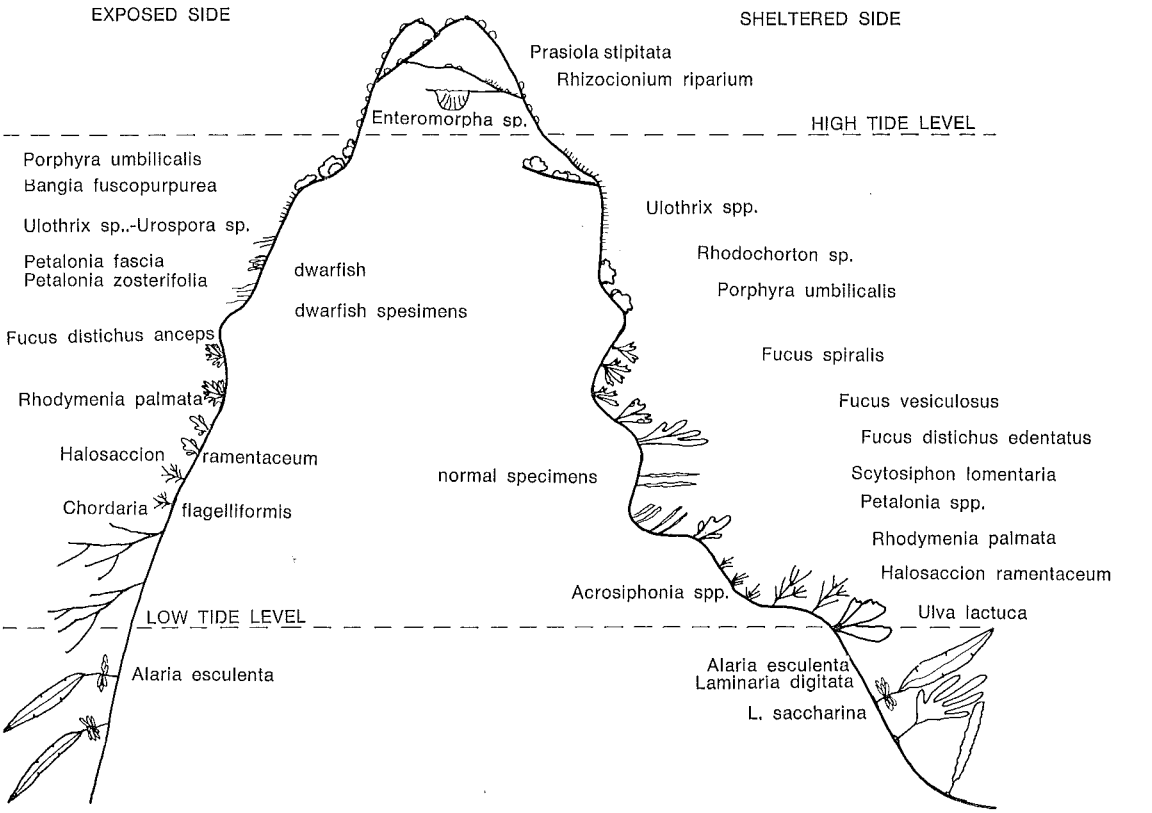
OPEN AREA

EXTREMELY EXPOSED LOCATION



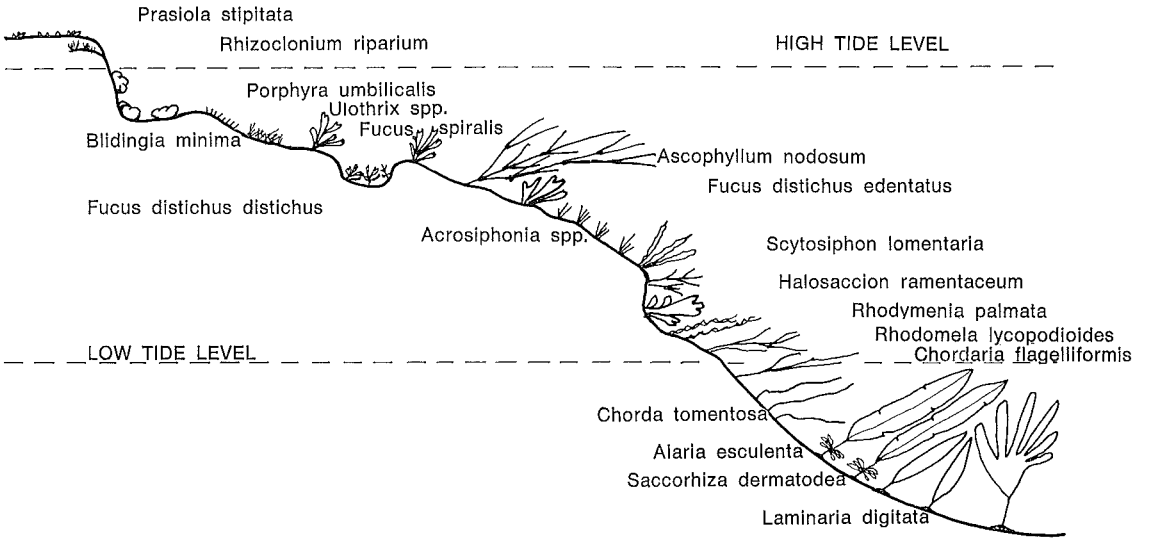


GRIMSEY OFF NORTHERN ICELAND

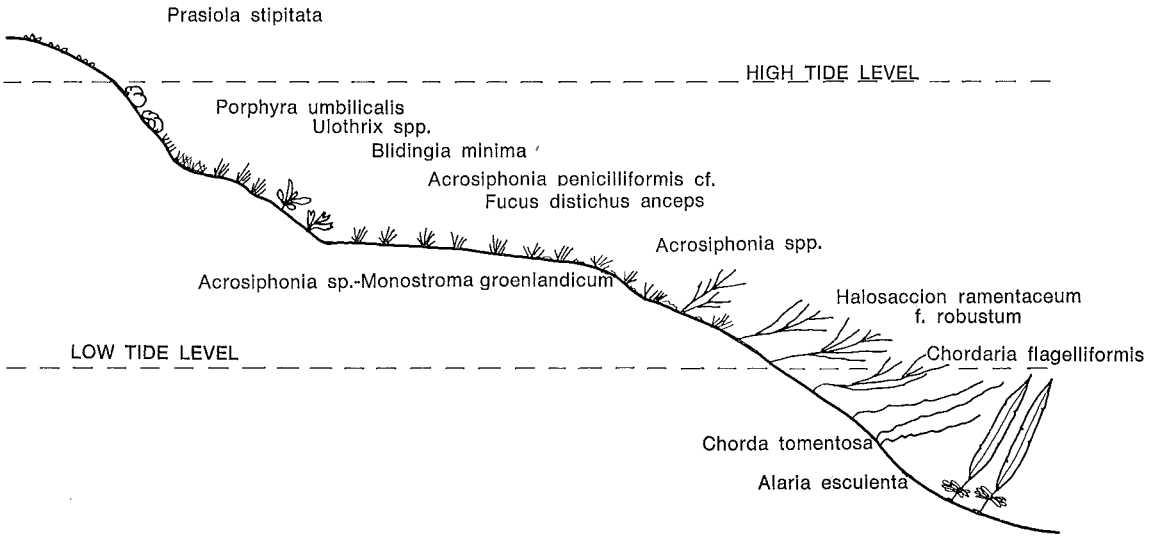


OUTER FJORD AREA

MODERATELY EXPOSED LOCATION

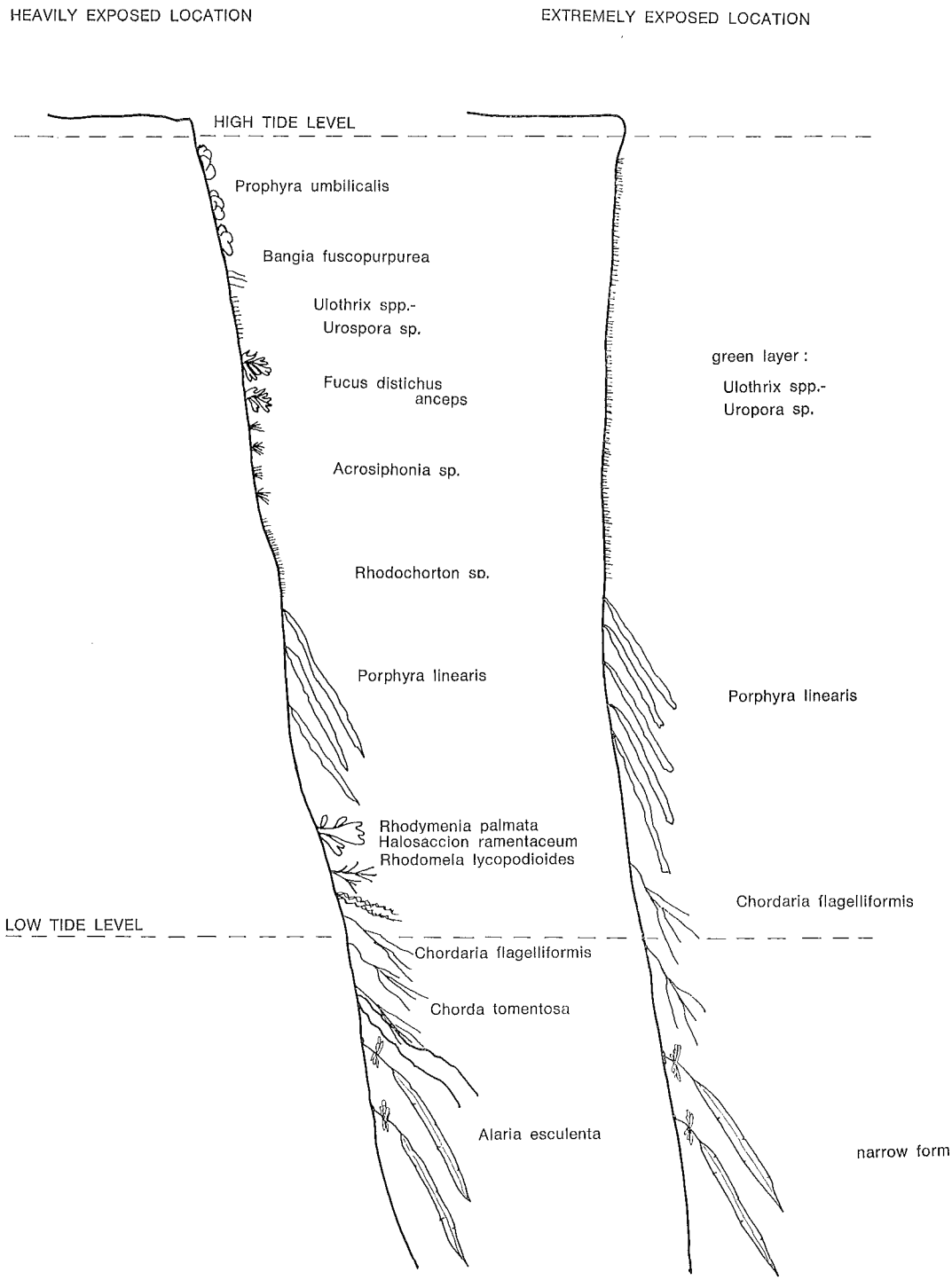


HEAVILY EXPOSED LOCATION



ZONATION — EASTERN ICELAND (REYDARFJÖRDUR)

OUTER FJORD AREA



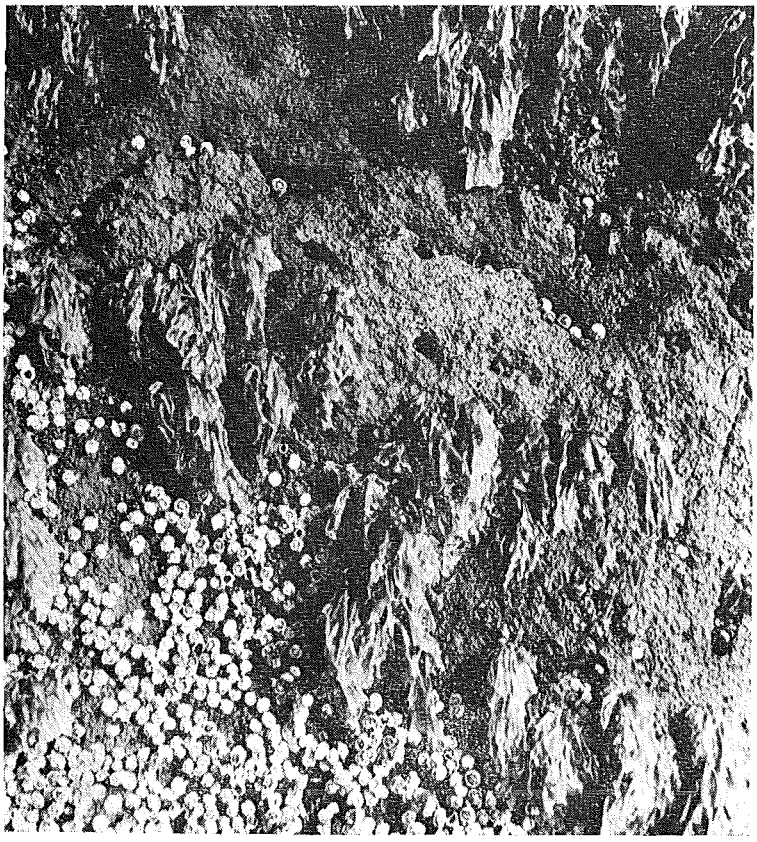


Fig. 1. *Porphyra umbilicalis* belt of Snæfellsnes.

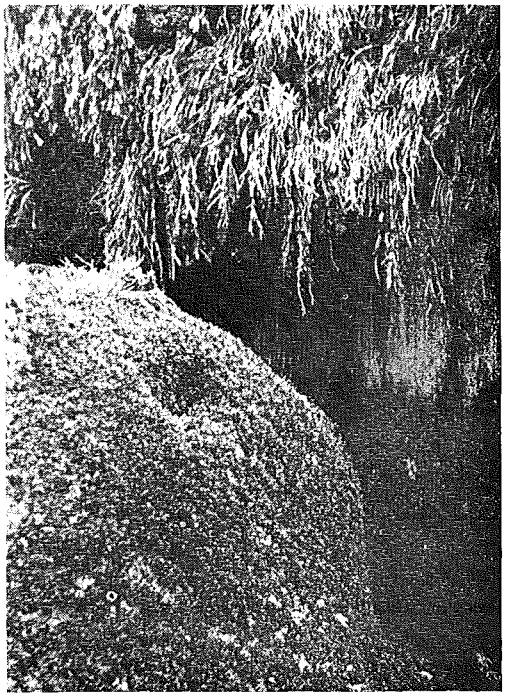


Fig. 2. *Gigartina stellata* zone below *Ascophyllum nodosum* at Hellnar, Snæfellsnes.

Fig. 3. *Fucus spiralis* and *Fucus vesiculosus* zones on rocky slopes at Snæfellsnes (*Pylaiella rupincola* under the barnacle belt).

Fig. 4. Detail from the same zones as Fig. 3: *Pylaiella rupincola, Acrosiphonia spp., Scytosiphon pygmaeus* and *Rhodochorton spp.* in the *Fucus* zone.

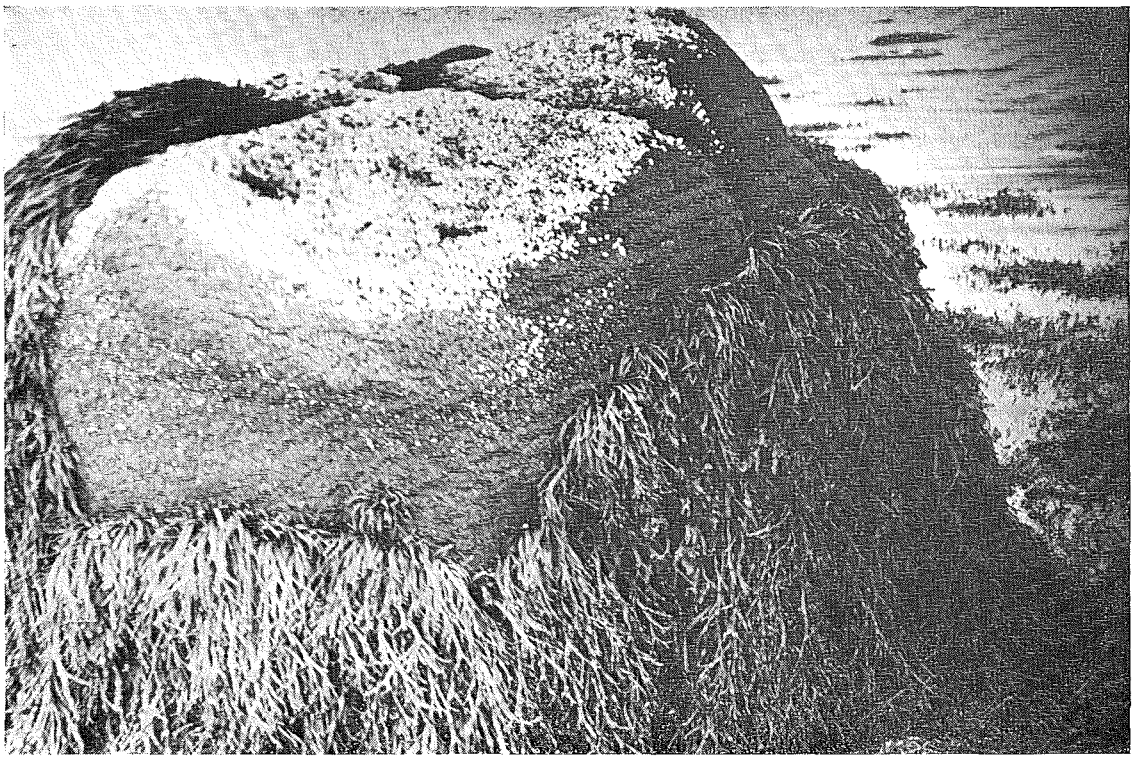


Fig. 5. Upper fringe of *Ascophyllum nodosum* zone in the outer part of Dýrafjördur (Ytri Ófæra).

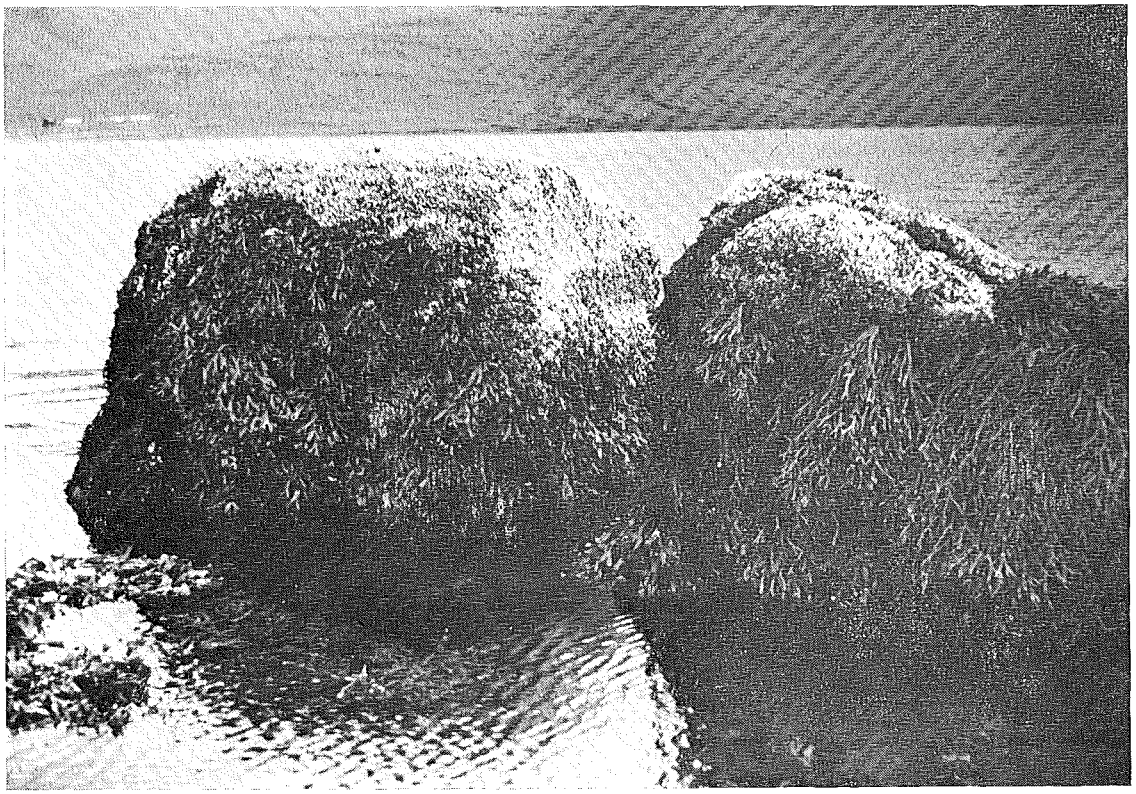


Fig. 6. Upper fringes of *Fucus vesiculosus* and *Ascophyllum nodosum* zones in the same area as Fig. 5.

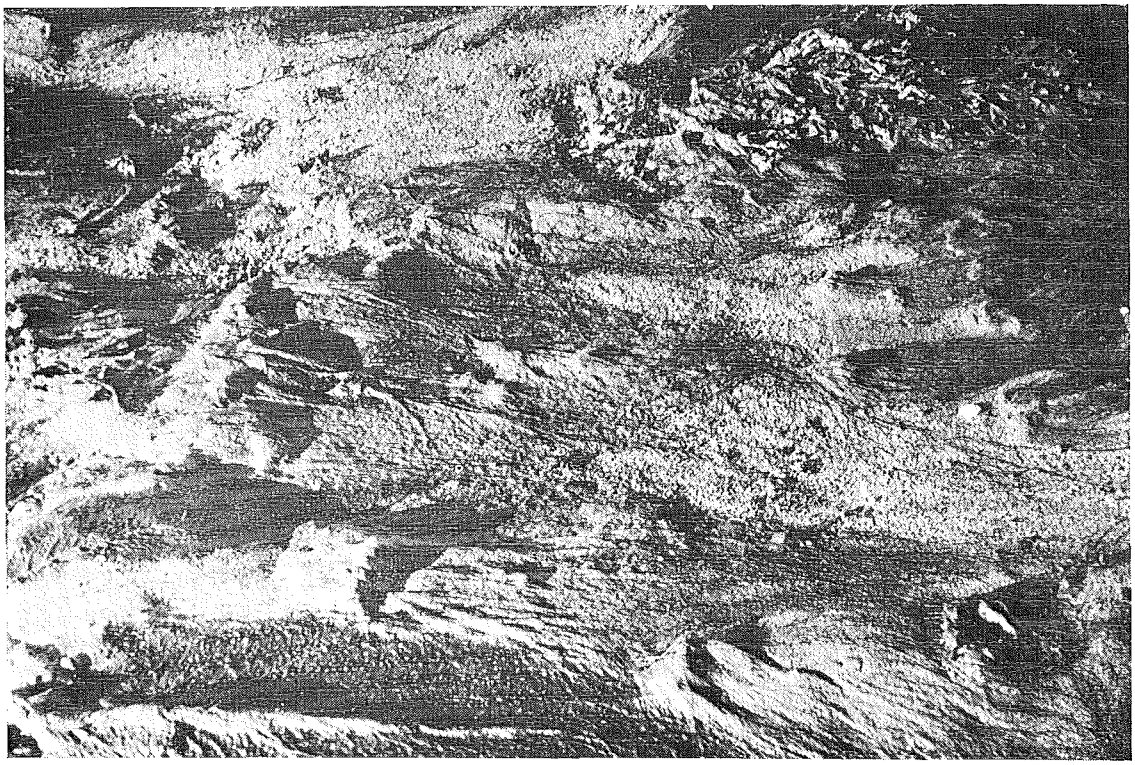


Fig. 7. Löngufjörur at Snæfellsnes. Filamentous algae (species of *Ectocarpus, Enteromorpha* and *Dictyosiphon)* with scattered *Fucus vesiculosus* on a sandy ground.

Fig. 8. Scattered *Fucacean* growth at Drangar in the inner part of Dýrafjördur (*Fucus vesiculosus, Fucus ceranoides, Ascophyllum nodosum).*

Fig. 9. Algal zonation at Reykjanes (Sandvík): *Fucus spiralis–F. vesiculosus–Ascophyllum nodosum–Gigartina stellata–Corallina offcinalis–Laminaria digitata* f. *stenophylla.*

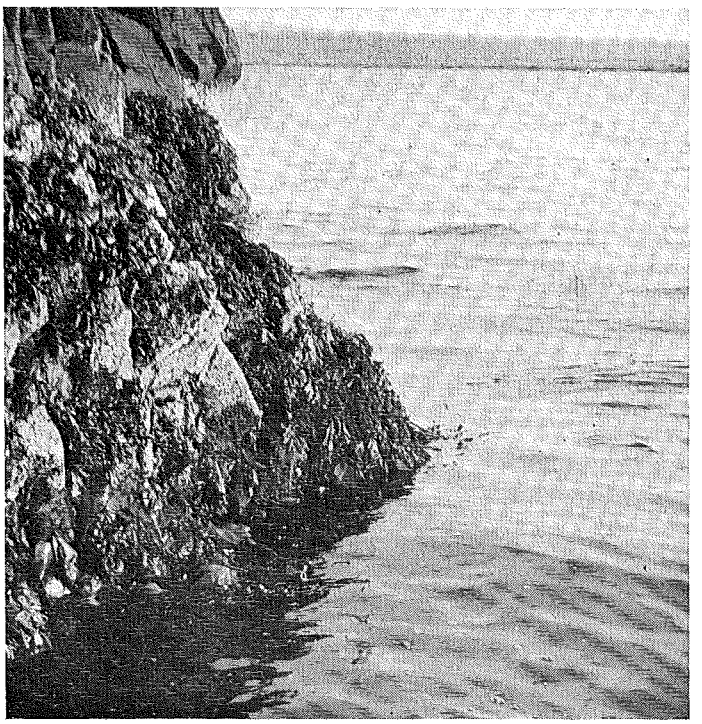


Fig. 10. Algal zonation in the outer part of Steingrímsfjördur: *Fucus distichus ssp. edentatus–Halosaccion ramentaceum* with accompanying species – *Laminaria digitata* f. *cucculata.*

Fig. 11. *Fucus distichus ssp. edentatus-Halosaccion ramentaceum-Laminaria digitata* belts from the same area as Fig. 10.

Fig. 12. *Laminaria hyperborea* in the outer part of Dýrafjördur.

Fig. 13. *Laminaria saccharina* f. *linearis* belt below *Gigartina stellata* at Reykjanes.

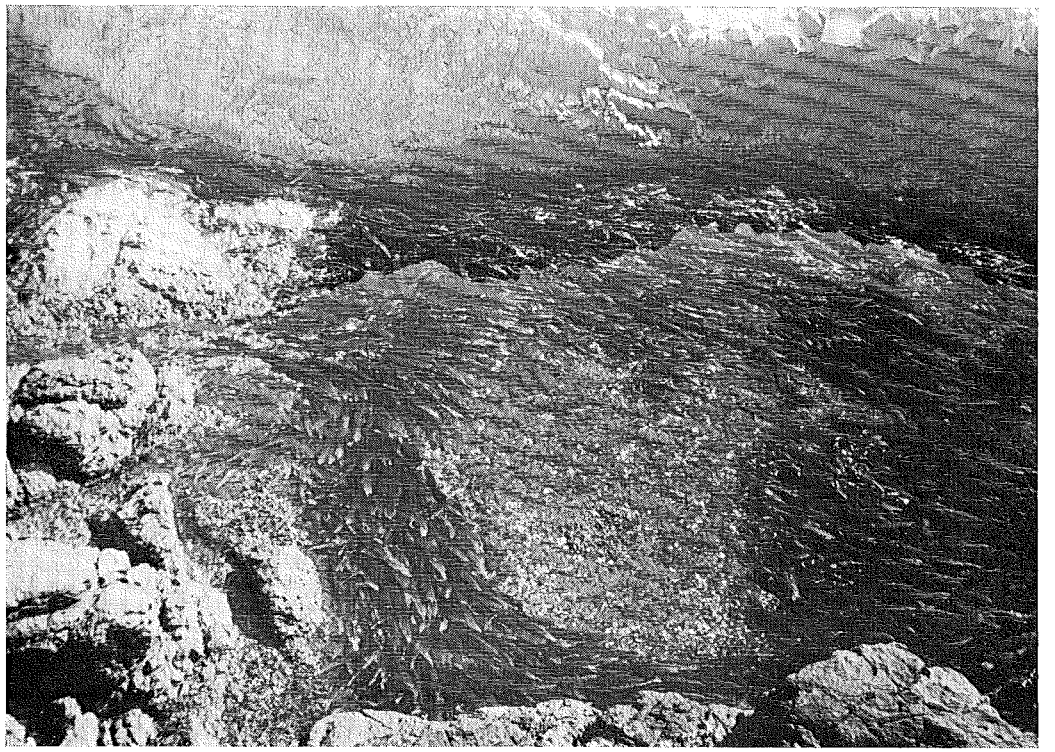


Fig. 14. *Alaria esculenta* belt (narrow form) at Vattarnes in Reydarfjördur.

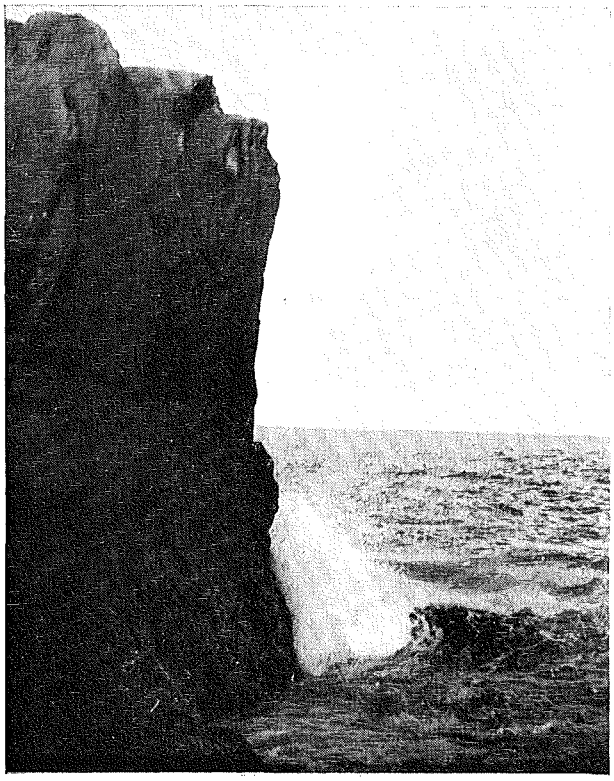


Fig. 15. Extremely exposed rocky formations between Vattarnes and Hafnarnes outside Reydarfjördur.

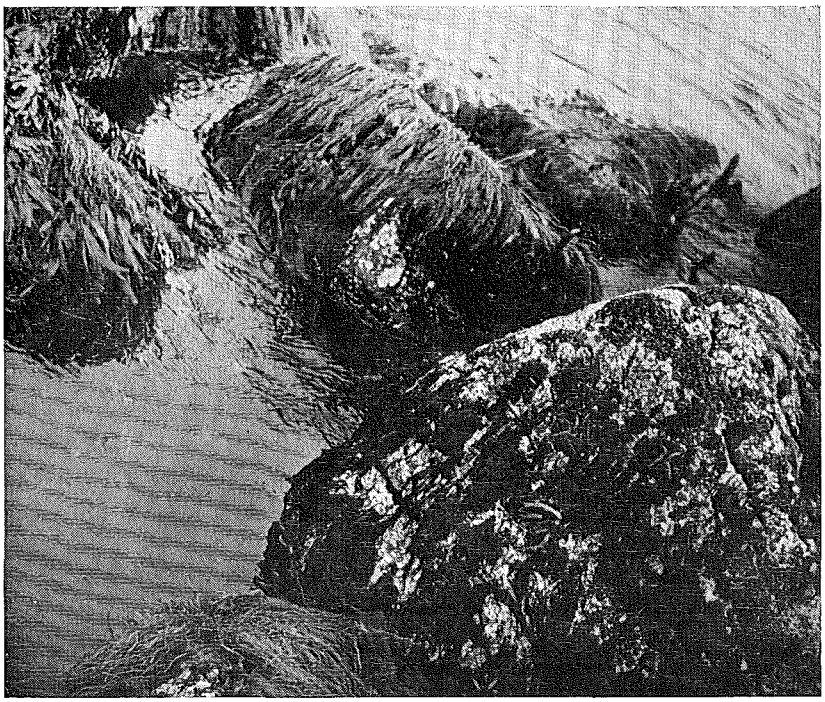


Fig. 16. *Acrosiphonia spp.* and lower down *Chordaria flagelliformis* in the outer part of Reydarfjördur.

ACTA NATURALIA ISLANDICA

PUBLICATIONS OF THE MUSEUM OF NATURAL HISTORY, REYKJAVÍK, ICELAND

Volume I:

1. Tr. Einarsson: Origin of the Basic Tuffs of Iceland. 75 pp. 1946.
2. J. Áskelsson: A Contribution to the Geology of the Kerlingarfjöll. A Preliminary report. 15 pp. 1946.
3. S. Steindórsson: Contribution to the Plant-Geography and Flora of Iceland IV. The Vegetation of Ísafjarðardjúp, North-west Iceland. 32 pp. 1946.
4. I. Davíðsson: Notes on the Vegetation of Árskógsströnd, North Iceland. 20 pp. 1946.
5. S. H. Pétursson: Die Herkunft der Milchsäurelangstäbchen des isländischen Speisequarks. 8 pp. 1946.
6. Ó. B. Bjarnason: The Component Acids of Icelandic Herring Oil. 9 pp. 1946.
7. H. Einarsson: The Post-larval Stages of Sand-eels (Ammodytidae) in Faroe, Iceland and W-Greenland Waters. 75 pp. 1951.
8. H. Lister, R. Jarvis, M. McDonald, I. W. Paterson and R. Walker: Sólheimajökull. Report of the Durham University Iceland Expedition 1948. With an Introduction by J. Eythórsson. 41 pp. 1953.
9. R. Dearnley: A Contribution to the Geology of Loðmundarfjörður. 22 pp. 1954.
10. T. Tryggvason: On the Stratigraphy of the Sog Valley in SW Iceland. 35 pp. 1955.

Volume II:

1. H. Einarsson: On the Post-larval Stages of Ammodytes Lancea Cuvier. 7 pp. 1955.
2. S. Thorarinsson: The Öræfajökll Eruption of 1362. 99 pp. 1958.
3. J. Áskelsson: Fossiliferous Xenoliths in the Móberg Formation of South-Iceland. 30 pp. 1960.
4. S. Steinthórsson: The Ankaramites of Hvammsmúli, Eyjafjöll, Southern Iceland. 32 pp. 1964.
5. E. Wenk, H. Schwander und H. R. Wenk: Laboradorit von Surtsey. 29 pp. 1965.
6. S. Jakobsson: The Grímsnes Lavas, SW-Iceland. 30 pp. 1966.
7. K. Saemundsson: Vulkanismus und Tektonik des Hengill-Gebietes in Südwest-Island. 105 pp. 1967.
8. K. Nakamura: En Echelon Features of Icelandic Ground Fissures. 15 pp. 1970.
9. G. Jónsson: Fasciation inflorescentielle et fasciation végétative. 15 pp. 1970.
10. N. Hald, A. Noe-Nygaard & A. K. Pedersen: The Króksfjörður Central Volcano in North-west Iceland. 29 pp. 1971.

No. 21. I. Munda: General Features of the Benthic Algal Zonation around the Icelandic Coast. 36 pp. 1972.

AVAILABLE FROM:

SNAEBJÖRN JONSSON & CO. H.F. — THE ENGLISH BOOKSHOP

Hafnarstraeti 4 & 9, Reykjavík — Iceland,
or through your bookseller.