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The Tjörnes Peninsula — a site of different vegetation patterns in the North of Iceland

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ABSTRACT: The benthic algal vegetation of the Tjörnes Peninsula, North Iceland, was investigated from Héðinshöfði in Skjálfandaflói to Lónsós in the Axarfjörður. Three different vegetation patterns were observed around the peninsula. Within Skjálfandaflói there is an enclave of Atlantic vegetation features, accentuated by the abundance of *Ceramium* species and *Cystoclonium purpureum* and the presence of *Mastocarpus stellatus* in the Fucacean undergrowth and within the *Devaleraea ramentacea* association. Atlantic vegetation features were also outstanding along the open coastline of the Máná section, although the vegetation was different from the one in Skjálfandaflói. Here *Corallina officinalis* dominated in tide pools and lagoons, locally also on low-eulittoral slopes. It was accompanied by warm water-floristic elements. *Asperococcus fistulosus,* which is common in the South Icelandic coastal area and absent elsewhere around Iceland, reappeared in this area of Tjörnes. To the contrast, the vegetation found within Axarfjörður, was devoid of most of the Atlantic floristic elements and their associations. This vegetation exhibited a cold-water character, with a pronounced dominance of brown algal belts.

Differences between the three areas were obvious also in the structure and composition of the *Devaleraea ramentacea* association, which was joined by *Mastocarpus stellatus* in Skjálfandaflói, by *Rhodomela lycopodioides* along the Máná section, and by *Antithamnionella floccosa* in the Axarfjörður.

Differences between the vegetation patterns of the three areas of the Tjörnes Peninsula were obvious also in the upper eulittoral, the sublittoral and in the tide pools.

The disjunction between the vegetation patterns found around this peninsula could be interpreted by the temperature factor, as well as by exposure conditions, the geological structure and shore configuration.

KEYWORDS: Vegetation patterns, algal associations, zonation, species distribution, North Iceland, Tjörnes Peninsula.

INTRODUCTION

The Tjörnes Peninsula is situated in the northeastern area of the Icelandic coast, between 66° 00´ and 66° 12´ N and 16° 57´ and 17° 22´ W. It separates Skjálfandaflói from Axarfjörður (Fig. 1).

This peninsula attracted for years the attention of geologists (BÁRÐARSON 1925, EINARSSON T. 1958, 1965, EINARSSON TH. et. al. 1967, STRAUCH 1963, 1966, EIRÍKSSON 1981a, b, 1985). It is formed by Tertiary flood basalts, covered by thick sediments and lavas of Pliocene and Quaternary age. The vertical distribution of strata reflects sedimentation during glacial and interglacial periods. Glacial horizons are interbedded by lava flows and fossiliferous marine sediments, which indicate marine transgressions.

The coastal rocks on the northwestern side of Tjörnes indicate alternating sedimentary rocks and lava flows in a distinct repetitive pattern (EIRÍKSSON 1985).

Beside its variegated geological structure, which reflects paleoenvironments, the Tjörnes Peninsula is interesting also as a site of widely different vegetation

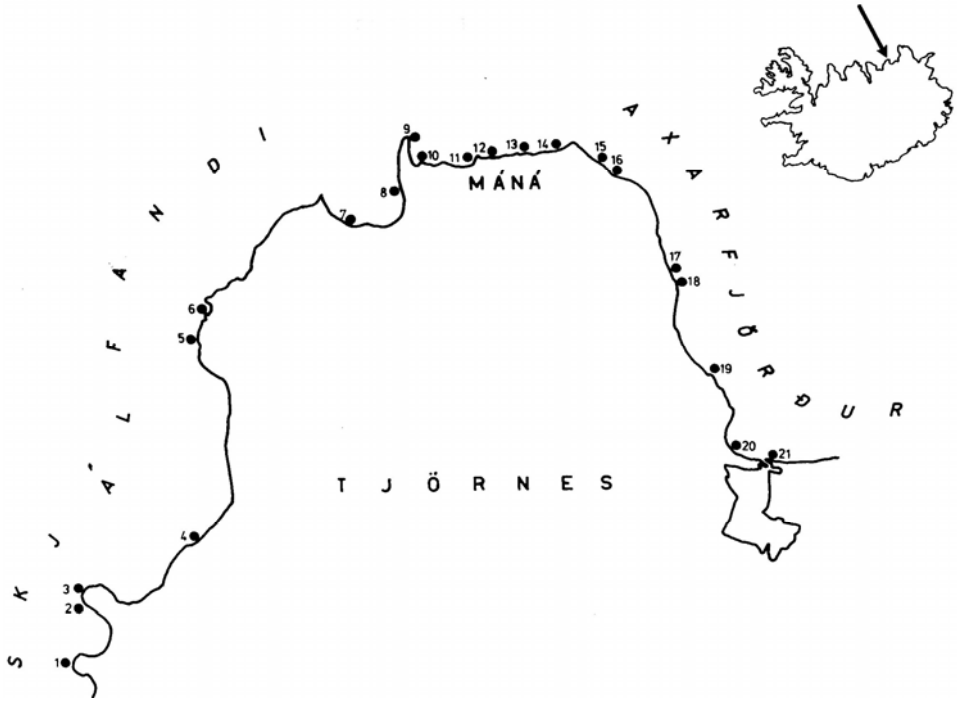


FIGURE 1. Map of Tjörnes. Skjálfandaflói: 1-Bakkahöfði, 2– Héðinsvík, 3–Héðinshöfði, 4–Barmur, 5-Hallbjarnarstaðir, 6-Hvalvík, 7–Breiðavík, 8-Breiðavík. Máná section: 9-Voladalstorfa, 10-Sandvík, 11-Árholt, 12-Mánárbakki, 13-Beitarvík, 14-Húsvík. Axarfjörður: 15-Selvík, 16-Selvík, 17-Bangastaðir, 18-Bangastaðir, 19-Háubrekkuhaus, 20-Fjallahöfn, 21-Lónsós.

patterns around its shores. These differences may be conditioned by the varying geological structure, the exposure conditions, the configuration of the littoral slopes and the average water temperatures.

Three different vegetation types of benthic algae were recorded around Tjörnes: that of Skjálfandaflói, of the Máná section, and of the inside of Axarfjörður. This peninsula was initially investigated in 1973 and later in 1977 and 1980, during late summer and autumn (August/September and October/November) along the coastline from Bakkahöfði and Héðinshöfði in Skjálfandaflói to Lónsós in Axarfjörður.

As pointed out in previous works dealing with the Icelandic benthic algal vegetation (MUNDA 1975, 1992a, b) the North Icelandic coast is a site of an intermediate North Icelandic vegetation type, created by the hydrographic conditions. There there is a mixing area of different primary and secondary water masses. The eastwards flowing branch of the Irminger Current is gradually cooled and diluted during its passage over the insular shelf (STEFÁNSSON 1962, 1969a, b, MALMBERG 1969, 1984). In the extreme Northwest there is a sharp hydrographic discontinuity due to the diminished influx of Atlantic water, intrusions of polar water from the East Greenland Current and occasionally also drift ice (SIGTRYGGSSON 1972). A pronounced floristic and vegetation limit was found in this area (MUNDA 1975, 1992a), separating the Atlantic from the North Icelandic vegetation. The latter is, however, formed gradually along the Hornstrandir coast (MUNDA 1992b). Further eastwards along the North Icelandic coast, changes of the North Icelandic vegetation were found, which obviously reflect the varying hydrographic conditions along this shelf area. Enclaves of Atlantic vegetation features were found in some protected sites along the Hornstrandir coast, at Skagaströnd, and again farther eastwards around the Tjörnes Peninsula.

Like the rest of the North Icelandic shelf, this peninsula is submitted to wide and irregular fluctuations of hydrographic parameters, both seasonally and annually. They are conditioned by a variety of factors, such as the magnitude of influx of Atlantic water, intrusions of polar water, the past meteorological conditions in neighbouring areas as well as the so-called "North ice" (MALMBERG 1984), which is driven by prolonged southwestern winds between Iceland and Greenland. There are, however, pronounced differences in the surface water temperatures during spring/summer between different sites along the North Icelandic coast, and enough uniformity during winter.

According to STEFÁNSSON (1969b) the Tjörnes Peninsula exhibits the highest average summer water temperatures in the entire North Icelandic coastal area.

This peninsula is, as mentioned, a site of widely different vegetation patterns of benthic algae. Pronounced Atlantic vegetation features were found within Skjálfandaflói, and a different *Corallina*-dominated type along the open Máná section, whereas the vegetation of the banks facing Axarfjörður was similar to the one found in the central area of the North Icelandic coast (e.g. Fljót outside

Skagafjörður, Siglunes, Ólafsfjörður) with affinities to the subarctic East-Icelandic vegetation type (MUNDA 1983, 1994).

Because of its heterogenity, the algal vegetation of this peninsula deserves a detailed description.

ECOLOGICAL CONDITIONS AND STUDY AREAS

Temperature conditions during algal samplings around Tjörnes are presented in Table 1. Lower surface water temperatures were obvious along the open Máná section, between Voladalstorfa and Selvík, than in Skjálfandi and Axarfjörður. There are no differences in the temperature conditions between the western and eastern shores of Tjörnes, according to own measurements. A tendency of temperature increase towards the inside of both Skjálfandi and Axarfjörður was indicated.

Station:	Temperature °C	
	Aug.	Sept./Oct.
Bakkahöfði	7.7	7.0
Héðinshöfði	7.8	7.1
Barmur	7.9	7.0
Hallbjarnarstaðir	7.2	6.8
Hvalvík	7.3	6.9
Furuvík	7.2	6.7
Breiðavík	7.0	6.5
Voladalstorfa	6.8	6.0
Sandvík	6.9	6.1
Árholt	6.8	6.0
Mánárbakki	6.9	6.2
Beitarvík	6.7	5.9
Húsvík	6.7	6.0
Selvík	6.9	6.2
Bangastaðir	7.2	6.5
Hábrekkuhaus	7.7	6.3
Gerðibrekkuhaus	7.9	6.3
Fjallahöfn	7.9	6.7
Lónsós	8.0	7.0

TABLE 1. Temperature conditions around Tjörnes.

There are, however, no previous data for the nearshore water temperatures around this peninsula. The only records for the Máná section (66°12´N and 17° 10'W) originate from 20 years temperature averages (1946 to 1966) for the surface water (STEFÁNSSON 1969 b).

According to these data the average surface water temperature at Tjörnes was higher than farther eastwards (Melrakkaslétta, Langanes) and westwards (Siglunes, Húnaflói, Horn) along the North Icelandic coast. A comparison of the monthly averages revealed lower winter temperatures than in Húnaflói and higher ones than in the rest of the North Icelandic coastal area. The average summer temperatures were notably elevated and, however, the highest in the entire area. The autumn water temperatures were again decreased and close to the average values found for Melrakkaslétta and Langanes. Nevertheless, the yearly average of 4.8° C was the highest for the entire North Icelandic coastal area (STEFÁNSSON 1969a, b).

The area investigated extends from the rocky promontories Bakkahöfði and Héðinshöfði within Skjálfandaflói over the Breiðavík area and the open Máná section to the inside of Axarfjörður (Fjallahöfn, Lónsós). The localities studied are signed on the map (Fig. 1).

The coastal slopes within Skjálfandaflói are mainly fine grained sedimentary rocks and conglomerates, locally rich in marine fossils (Breiðavík). Below the

rocky formations there are extenses covered by Alluvial sand, pebbles, gravel and some boulders. There are also big, rounded stones eulittorally (Figs. 17, 18, 19, 24c).

Around the long and narrow rocky formations of Bakkahöfði and Héðinshöfði there are flat, mostly sand-covered rocky platforms as well as extensive rocky and sandy lagoons. Farther northwards, in Barmur and around Hallbjarnarstaðir, the coastal rocks slope gently. There are also some steep, highly exposed isolated cliffs (e.g. Keltringar). Even farther north, within the bays of Furuvík and Breiðavík, there is a wide variety of substrata (cf. EIRÍKSSON 1981a, 1985) with conglomerates and sedimentary rocks, rich in marine fossils. The seaward cliffs in Furuvík reveal alternating sedimentary rocks and lava flows.

Around Voladalstorfa there are high fossilliferous sedimentary rocks. They touch rocky terraces in the upper and mid-eulittoral or slope steeply into the sublittoral. There are numerous rocky fissures and caves around Voladalstorfa, especially on its western side, where the rocks touch sandy slopes (Fig. 24c).

From Voladalstorfa to Sandvík and farther along the open and exposed Máná section, compact moderately sloping rocks prevail. The eulittoral slopes are interrupted by numerous tide pools (Figs. 14, 24a.) In the bays of Sandvík and Húsvík there are extensive sandy slopes, bare of vegetation, and the adjacent rocks are covered by a sandy layer. The rocky slopes are formed here by late Tertiary and Pleistocene basalts, andesite and hyaloclastite.

The littoral slopes within Axarfjörður are prevailingly formed by rounded stones and boulders (Fig. 20, 22a, b, 24b). Landwards there are locally high and steep slopes. Only in a few sites, e.g. Háubrekkuhaus, flat rocky formations were found.

The rocks within Axarfjörður are formed by interglacial and supraglacial lavas (Pleistocene). The inside of this open fjord is covered by Alluvial sand (Fig. 23).

Differences between the three areas around the Tjörnes Peninsula center to the configuration of the coastal slopes and exposure conditions, and less to hydrographic parameters, as far as own temperature measurements during the samplings can prove.

THE BENTHIC ALGAL VEGETATION

The benthic algal vegetation of the Tjörnes Peninsula belongs to the North Icelandic type (MUNDA 1975, 1992a,b) although with certain modifications. A wide variety of vegetation patterns was found around this peninsula regarding the zonation patterns, the main algal associations and floristic composition. Pronounced differences were in particular found between the vegetation of Skjálfandaflói and Axarfjörður. During field studies around Tjörnes three main vegetation types could be established for this rather small area: that of Skjálfandaflói, observed between Bakkahöfði and Breiðavík, the second along

the open and exposed Máná section, between Voladalstorfa and Selvík, and the third from Selvík to the inside of Axarfjörður.

The benthic algal vegetation of Skjálfandaflói exhibits several Atlantic characters, accentuated by the presence of *Mastocarpus stellatus* in the Fucacean undergrowth and in the *Devaleraea ramentacea* belt, as well as by the abundance of *Ceramium* species and *Cystoclonium purpureum* in tide pools and lagoons. Along the open and exposed Máná section *Corallina officinalis* was especially abundant, and a wide variety of low-eulittoral belts was observed. In Axarfjörður brown-algal belts dominated in the mid- and lower eulittoral. The admixture of *Antithamnionella floccosa* into the *Devaleraea ramentacea* association, was characteristic of this side of the Tjörnes Peninsula.

A – Skjálfandaflói

The benthic algal vegetation of Skjálfandaflói represents an enclave of Atlantic features regarding the abundance of *Mastocarpus stellatus*, *Ceramium* species and *Cystoclonium purpureum* in the tide pools and lagoons as well as on low-eulittoral slopes. Tide pools inhabited by *Corallina officinalis* were, on the other hand, rather rare. The flat rocky formations, which locally alternate with sandy slopes at the eulittoral level, allow the formation of wide Fucacean fields, with a complete sequence of *Fucus* species, from *F. spiralis* over *F. vesiculosus* to *F. distichus* ssp. *edentatus* or ssp. *evanescens. Ascophyllum nodosum* occurred only in single specimens and was not belt-forming. The rocks are mainly covered by a sandy layer and allow only a poor undergrowth of the Fucacean fields.

Further characteristics of this area are: An almost continuous belt of *Devaleraea ramentacea* in the lower eulittoral of rocky slopes, abundance of *Ulva lactuca* and *Enteromorpha linza,* dominance of *Laminaria saccharina* in the upper sublittoral, and extensive forests of *Laminaria hyperborea* in the lower sublittoral, totally covering the slopes of this shallow bay (Figs. 16 and 17).

In the inner area of Skjálfandaflói, several characteristic profiles were studied around the flat rocky promontories of Bakkahöfði and Héðinshöfði (Fig. 11). In the upper eulittoral belts of *Ulothrix* spp.—*Urospora penicilliformis, Blidingia minima* and *Enteromorpha intestinalis* with *E.compressa* were following each other in a vertical sequence. The fucoids were represented by *Fucus spiralis*, *F. vesiculosus* and *F. distichus* ssp. *edentatus*. They were followed downwards by a belt of *Devaleraea ramentacea,* mingled with *Mastocarpus stellatus* and *Palmaria palmata.* The upper sublittoral was dominated by *Laminaria saccharina.* At the level of *Fucus vesiculosus* tide pools were covered by *Enteromopha intestinalis* and *E. compressa.* Lower-lying pools, at the levels of *Fucus distichus* and of *Devaleraea ramentacea,* were colonized by *Acrosiphonia* species, by *Ulva lactuca* with *Enteromorpha linza* and by filamentous brown algae (*Chordaria flagelliformis* with epiphytic *Dictyosiphon* and *Ectocarpus* species).

On steep and rather exposed rocks high-level belts of *Blidingia*- and *Enteromorpha* were absent. At the level of the littoral fringe *Prasiola stipitata* and

Cyanobacteria *(Calothrix scopulorum, C. crustacea*) were locally found along with *Rhizoclonium riparium* in rocky fissures.

In between the rocky slopes there are extensive sandy and rocky lagoons, in which different algal associations were found. In shallow high-lying lagoons there was a prolific growth of *Ulva lactuca* and *Enteromopha linza*. Deep sand-covered lagoons were overgrown by *Chordaria flagelliformis,* which was heavily epiphytized by *Dictyosiphon foeniculaceus, D. ekmanii, Ectocarpus fasciculatus, E. siliculosus* and diverse microphytes. Rocky lagoons were occupied by dense stands of *Devaleraea ramentacea,* with *Cystoclonium purpureum* and *Ceramium* species as codominants. Companion species in such *Devaleraea* dominated rocky lagoons were *Palmaria palmata, (*epiphytized by *Ceramium nodulosum, Ectocarpus fasciculatus, Elachista fucicola, Dictyosiphon foeniculaceus, Chilionema foecundum, Hecatonema maculans), Ulva lactuca, Pylaiella littoralis, Acrosiphonia sonderi, Ectocarpus siliculosus, Chordaria flagelliformis, Enteromorpha linza* and *Dumontia contorta.* Single specimens of *Fucus distichus* ssp. *distichus* were likewise found in the rocky lagoons.

Lagoon specimens of *Devaleraea ramentacea* were usually heavily epiphytized by *Ceramium* species, dwarf *Ulva lactuca*, *Ectocarpus fasciculatus, E. siliculosus, Dictyosiphon foeniculaceus, Elachista fucicola, Chordaria flagelliformis* and *Porphyra miniata.*

Tide pools around Héðinshöfði were occupied by *Entheromorpha intestinalis* and *E. compressa* at the upper eulittoral level; and by *Acrosiphonia sonderi, Ulva lactuca* with *Enteromorpha linza, Devaleraea ramentacea, Palmaria palmata* and filamentous brown algae at the mid-eulittoral one. Pools occupied by *Ceramium* species and *Cystoclonium purpureum* were frequently found.

Locally steep rocky slopes covered by high-level belts of *Ulothrix* spp., *Blidingia minima,* dwarf *Pylaiella littoralis* and *Fucus distichus* ssp. *anceps, were* followed downwards by shallow lagoons, overgrown by *Ulva lactuca* and *Enteromorpha* species.

Farther north from Héðinshöfði, fucoids were absent on vertical slopes. Downwards followed rocky lagoons, dominated by *Devaleraea ramentacea.* In such extensive lagoons a certain vegetational gradient was observed. Farther seawards the density of the lagoon vegetation was decreased and crustose corallines along with juvenile specimens of *Laminaria saccharina* became dominant.

Within Skjálfandaflói, the vegetation in Barmur and around Hallbjarnarstaðir was also studied. In some spots there are big rounded stones and boulders embedded into the sandy ground (Fig. 19). On such stones juvenile *Fucus vesiculosus* specimens were found together with dwarf *Pylaiella littoralis* and *Acrosiphonia* sp. The steep surfaces of such rounded stones were covered by belts of *Petalonia* species (*P. fascia, P. zosterifolia)* and *Chordaria flagelliformis,* while the sublittoral vegetation was usually absent.

A normal zonation pattern was again found on moderately sloping rocky surfaces. The greater part of the area was occupied by an almost continuous *Ulothrix* spp.–*Urospora penicilliformis* belt, and by a prolific zone of *Enteromorpha intestinalis* and *E. compressa. Blidingia* spp. belts were rare and the same was true for *Porphyra umbilicalis*, which was subordinate in the upper eulittoral vegetation of this bay. In this part of Skjálfandaflói, *Fucus spiralis* was rare. *Fucus vesiculosus* predominated, and specimens with regenerated shoots were frequently found. In the tide pools, *Devaleraea ramentacea, Ulva lactuca, Acrosiphonia sonderi, Ceramium* species and *Chordaria flagelliformis* were common.

The pools were coated by crustose corallines (*Clathromorphum circumscriptum, Phymatolithon lenormandii, Lithothamnion* spp.) as well as *Ralfsia fungiformis* and *Hildenbrandia rubra.* In most of the rocky pools *Palmaria palmata, Rhodomela lycopodioides* and *Cystoclonium purpureum* were found as companion species.

Also in this area the rocks were covered by a sandy layer. Thus a poor understorey was found both in the *Fucus vesiculosus* and *Fucus dictichus* ssp. *edentatus* belts.

In the lower eulittoral the *Devaleraea ramentacea* belt had a continuous distributional pattern and proceeded downwards into the undergrowth of the *Laminaria saccharina* stands. Both *Laminaria digitata* and *Alaria esculenta* were subordinate in the upper sublittoral vegetation of Skjálfandaflói. In the understorey of *Laminaria saccharina,* crustose corallines, *Ralfsia fungiformis, Devaleraea ramentacea, Rhodomela lycopodioides, Palmaria palmata,* single *Corallina officinalis*, *Chaetomorpha melagonium, Chordaria flagelliformis* and *Cystoclonium purpureum* were observed.

In the bay of Breiðavík some changes in the vegetation pattern were noted. The upper eulittoral slopes are mostly formed by small, rounded pebbles, which are a suitable substratum for a continuous *Ulothrix* spp. belt. The *Blidinga minima* belt was discontinuous (Fig. 18). while *Porphyra umbilicalis* was absent. A complete sequence of *Fucus* species was again observed on moderate rocky slopes, with *Fucus spiralis*, *F. vesiculosus* and *F. distichus* ssp. *edentatus*. Below them a prolific *Devaleraea ramentacea* belt was usual. In the upper sublittoral *Laminaria saccharina* and *Alaria esculenta* occurred as codominants. A transition towards the vegetation pattern of the open Máná section was thus indicated. In the outer regions of this bay, on exposed rocks, *Porphyra umbilicalis* was again found in the upper eulittoral, above *Fucus distichus* ssp. *anceps*. In such highly exposed sites the zonation pattern was changed. Belts of *Petalonia fascia* with *Petalonia zosterifolia* and *Chordaria flagelliformis* dominated. This vegetational change in the outer area of Breiðavík might be due to the increased exposure of the slopes.

Prolific *Laminaria hyperborea* woods occupied the lower sublittoral also in this part of Skjálfandaflói. In the driftweed, which accumulates in Breiðavík the following Rhodophycean species were found attached to hapterae of *Laminaria hyperborea* or epilithic on small stones: *Odonthalia dentata, Ptilota gunneri, P. serrata, Phycodrys rubens, Delesseria sanguinea, Polysiphonia stricta, Coccotylus*

truncatus, Rhodomela lycopodioides, Palmaria palmata, Turnerella pennyi, Corallina officinalis, Porphyra miniata, Ceramium nodulosum, Callophylis cristata.

General characteristics of the algal vegetation of Skjálfandaflói:

Upper eulittoral – an almost continuous *Ulothrix* spp.—*Urospora penicilliformis* belt, widespread but discontinuous *Blidinga minima* belt, absence of *Porphyra umbilicalis* in the greater part of the area.

Mid-eulittoral – on moderately sloping rocky surfaces a complete sequence of Fucacean belts from *Fucus spiralis* over *F. vesiculosus* to *F. distichus* ssp. *edentatus*. The rather wide Fucacean fields exhibit a poor understorey on the sand-covered rocks. *F. distichus* ssp. *anceps* rare in the area.

Lower eulittoral – continuous belt of *Devaleraea ramentacea,* accompanied by *Cystoclonium purpureum* and *Ceramium* species, *Mastocarpus stellatus* locally codominant within this belt. *Chordaria flagelliformis* and *Petalonia* species only at a few extremely exposed spots.

Upper sublittoral – dominance of *Laminaria saccharina.*

Lower sublittoral – extensive forests of *Laminaria hyperborea.*

Tide pool and lagoons – for Skjálfandaflói characteristic wide rocky and sandy lagoons. In sandy lagoons dominance of *Chordaria flagelliformis,* in rocky ones *Devaleraea ramentacea* with *Cystoclonium purpureum* and *Ceramium* species. Tide pools dominated by *Acrosiphonia* species, *Ulva lactuca* with *Enteromorpha linza, Devaleraea ramentacea, Palmaria palmata, Ceramium* species and *Cystoclonium purpureum,* while *Corallina* dominated pools were rare.

B – Máná section

As the Máná section the coast-line between Voladalstorfa and Húsvík is considered. This area is highly exposed and exhibits a different vegetation type than that of Skjálfandaflói. Characteristic is the dominance of *Corallina officinalis* in tide pools and lagoons as well as locally on low-eulittoral slopes, as well as a broad and prolific *Porphyra umbilicalis* belt in the upper eulittoral (Figs. 14 and 15). A great variety of low- eulittoral belts was found along this area, while in the upper sublittoral mixed belts of *Laminaria saccharina* and *Alaria esculenta* were usual. The Atlantic character of the vegetation was accentuated by the

abundance of *Corallina officinalis* with companion warm-water floristic elements (*Asperoccucus fistulosus, Leathesia difformis)* and the dominance of *Cystoclonium purpureum* and *Ceramium* species in the tide pools.

Along the Máná section, moderately sloping rocky surfaces alternate with sandy extenses. The configuration of the emerged slopes creates numerous tide pools and lagoons. Locally, there are also bigger, rounded stones (figs. 13, 15, 24A).

Around Sandvík and Mánárbakki the upper eulittoral slopes were covered by a several meters broad *Porphyra umbilicalis* belt (cf. figs. 3, 4, 5), within which the dominant species exhibited high biomass values (2500 to 5000 g/m² fresh weight). Due to the configuration of the protruding coastal rocks different zonation types could be found on their landwards and seawards sides (cf. fig. 5). Landwards *Fucus spiralis* and *F. vesiculosus* followed below the *Porphyra* belt, limiting downwards to sandy or rocky pools, covered by *Acrosiphonia* spp., *Fucus distichus* ssp. *distichus,* and *Enteromorpha* species.

Seawards *Fucus distichus* ssp. *anceps* or *F. distichus* ssp. *edentatus* were usual, followed downwards by codominant *Rhodomela lycopodioides* and *Polysiphonia stricta,* undergrown by *Rhodochorton purpureum.* In the upper sublittoral *Laminaria saccharina* and *Alaria esculenta* formed a mixed belt. Along the entire Máná section prolific and wide low-sublittoral *Laminaria hyperborea* forests were usual.

In the upper eulittoral extensive rocky lagoons, covered by a sandy layer, were rather frequent. They were found just below the *Porphyra umbilicalis* level, and were fringed by *Fucus spiralis* and *Enteromorpha compressa.* In such lagoons *Acrosiphonia* species dominated, while the rest of the vegetation occurred in patches. *Fucus distichus* ssp. *distichus (*epiphytized by *Ceramium* species), *Cystoclonium purpureum, Palmaria palmata, Petalonia fascia, Eudesme virescens, Dictyosiphon foeniculaceus, Ulva lactuca, Cladophora rupestris, Chaetomorpha melagonium* and *Enteromorpha prolifera* were found in such mixed lagoon-populations. Due to a sandy layer, the understorey was poorly developed and only patches of crustose corallines and *Hildenbrandia rubra* were found.

Different tide pools were found along the eulittoral slopes. At the level of *Fucus spiralis* and *F. vesiculosus* they were dominated by *Enteromorpha* and *Acrosiphonia* species, first of all *A. sonderi.* Lower down the eulittoral, at the *Fucus distichus* ssp. *edentatus* level, pools dominated by *Corallina officinalis* were common, while pools dominated by *Devaleraea ramentacea* or by filamentous brown algae were rare. *Fucus distichus* ssp. *distichus* occurred as companion species in most of the tide pools, but was not association-forming in itself. It was frequently epiphytized by *Ceramium* species.

Different variants of the *Corallina officinalis* association were found in the tide pools. *Corallina* could occur in a pure growth on a ground of crustose corallines, with *Chaetomorpha melagonium* as the only companion species. In other pools it was found together with *Ceramium nodulosum, Cystoclonium purpureum,*

Polysiphonia stricta, Acrosiphonia species, *Palmaria palmata* and *Ulva lactuca.* The following species were found epiphytic on *Corallina* in the tide pools of this area: the warm-water floristic elements *Asperoccocus fistulosus* and *Leathesia difformis,* along with *Eudesme virescens, Petalonia fascia, Chordaria flagelliformis, Dictyosiphon foeniculaceus, Ectocarpus fasciculatus, E. siliculosus, Porphyra miniata,* dwarf *Ulva lactuca,* juvenile *Laminaria saccharina, Spongomorpha aeruginosa, Monostroma* sp. and *Acrosiphonia* sp. *Corallina* was heavily epiphytized in fully illuminated pools, while it was clean in low-lying, shadowed ones.

Corallina officinalis was, however, the leading and most frequent tide pool association along the Máná section. Next to it were *Ceramium* spp. and *Cystoclonium purpureum.* Further noteworthy tide pool associations were those of *Punctaria plantaginea* with *Asperoccocus fistulosus,* of diverse *Enteromorpha* species and of *Acrosiphonia sonderi. Acrosiphonia*-dominated pools were found, however, at different eulittoral levels. In the lower eulittoral they could be joined by filamentous brown algae, such as *Chordaria flagelliformis, Dictyosiphon foeniculaceus* and *Scytosiphon lomentaria.*

Some of the tide pools, especially in the bay of Sandvík, were covered by sand and thus the undergrowth was poorly developed or even absent. In clean rocky pools, on the other hand, *Hildenbrandia rubra,* crustose corallines (*Clathromorphum cicumscriptum, Lithothamnion* sp., *Phymatolithon lenormandii), Ralfsia verrucosa, R. fungiformis* and *Sphacelaria radicans* formed a continuous understorey.

Beside tide pools, extensive rocky and sand-covered lagoons were usual, especially in the bay of Sandvík. *Acrosiphonia* species, embedded in sand, were usual in shallow lagoons, situated between the Fucacean fields (Fig. 3). *Acrosiphonia* fields were found also on emerged, sand-covered rocks. Rocky lagoons were populated by *Chordaria flagelliformis,* which was heavily epiphytized. Juvenile *Laminaria saccharina* was found as companion species in such lagoons. Further companion species were: *Ulva lactuca, Palmaria palmata, Devaleraea ramentacea, Petalonia fascia, Acrosiphonia* sp., *Pylaiella littoralis, Dictyosiphon foeniculaceus*. There were likewise deeper, offshore lagoons, dominated by *Laminaria saccharina,* undergrown by crustose corallines and accompanied by single specimens of *Saccorhiza dermatodea.* Some shallow lagoons were populated by *Corallina officinalis* as dominant. In its undergrowth there was *Ralfsia fungiformis, Sphacelaria radicans, S. nana,* and crustose corallines. The epiphytic cover of *Corallina* was similar to the one, described for the tide pools, but the companion species were even more numerous (joined by *Rhodomela lycopodioides, Devaleraea ramentacea, Cladophora rupestris, Porphyra miniata, Enteromorpha linza, Punctaria plantaginea* and *Stictyosiphon tortilis).*

Like around Skjálfandaflói, also here *Fucus* species dominated the mid-eulittoral, while *Ascophyllum nodosum* occurred in single specimens and was not belt-forming

Characteristic of the Máná section is a great variety of low-eulittoral belts. In most sites, however, *Rhodomela lycopodioides* was outstanding as belt-former. In Sandvík and around Mánárbakki, up to Húsvík, it was found in mixed belts, either codominant with *Devaleraea ramentacea* and *Polysiphonia stricta* or only with the latter (Figs. 4 and 5). The undergrowth of this belt was frequently joined by *Rhodochorton purpureum.*

The *Devaleraea ramentacea* belt had a scattered distribution and was subordinate in the vegetation of this coast-line. It was found in a pure and prolific growth some places in Sandvík, where it was followed downwards by fields of crustose corallines (Fig. 3). Locally, as e.g. at some spots around Voladalstorfa, it protruded into the upper sublittoral. In the undergrowth *Clathromorphum circumscriptum, Lithothamnion* spp., *Ralfsia fungiformis* and *Sphacelaria radicans* were usual. *Devaleraea ramentacea* occurred exceptionally in a mixed belt with *Chordaria flagelliformis* in the bay of Húsvík, on the eastern side of the Máná section. Characteristic was also a low-eulittoral belt of *Corallina officinalis* (Fig. 2),

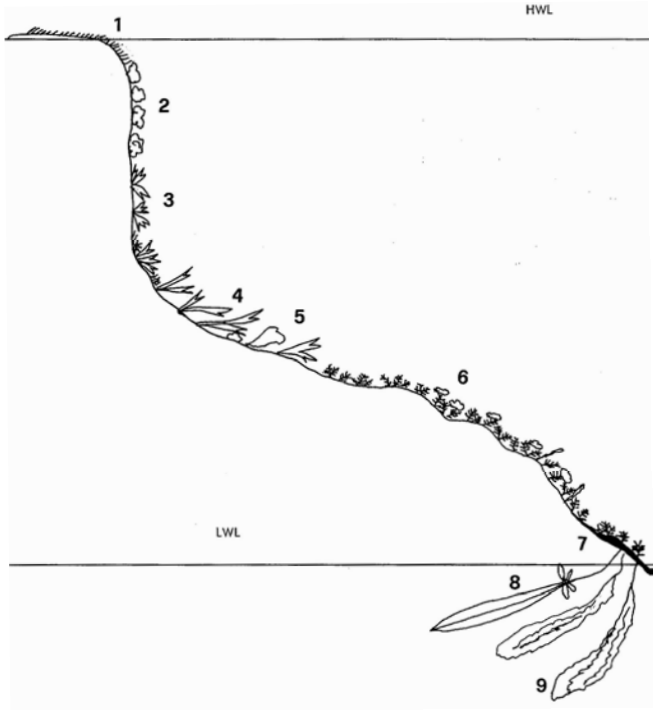


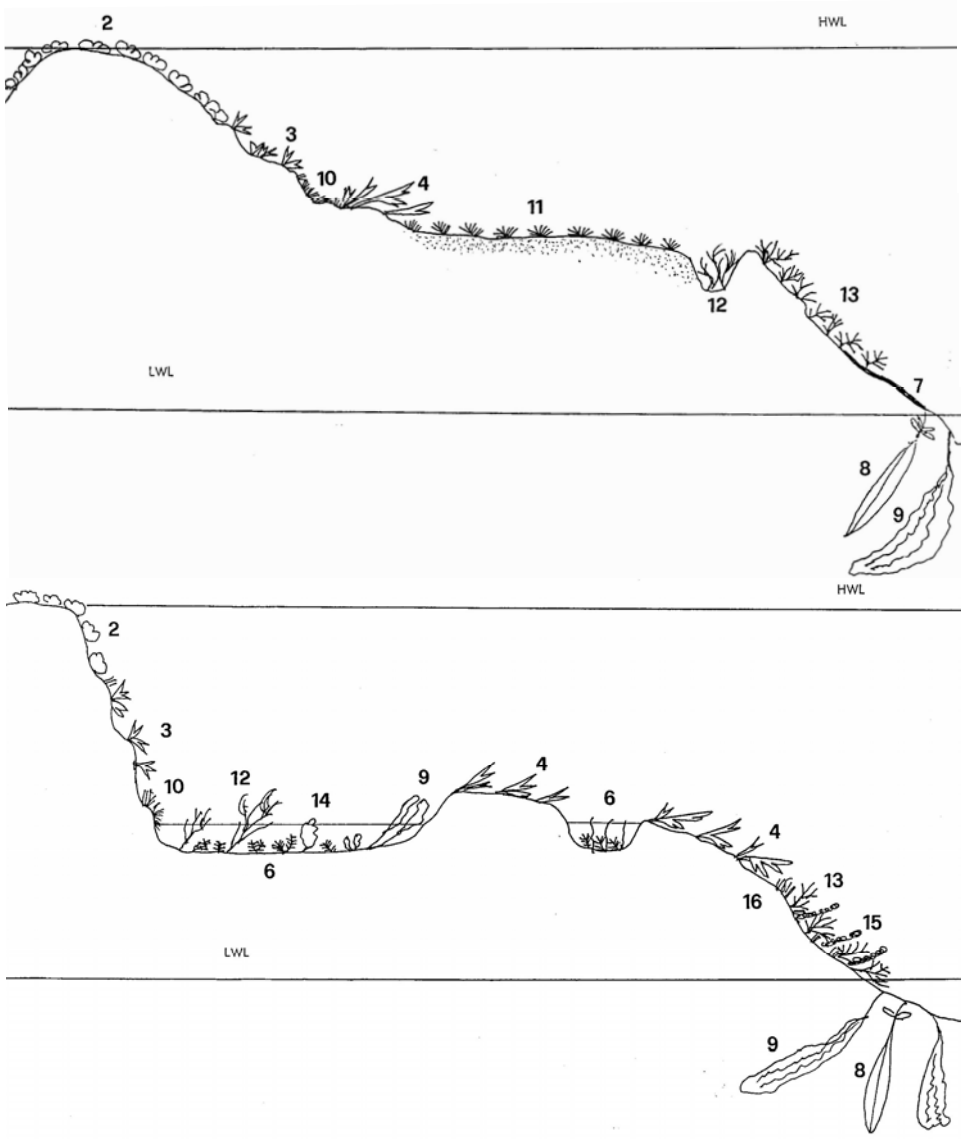
FIGURE 2. Schemes of zonation patterns around Tjörnes: Voladalstorfa.

Legend to numbers in figures 2—12:

1 *Ulothrix* spp.—*Urospora penicilliformis.* **2** *Porphyra umbilicalis.* **3** *Fucus distichus* ssp. *anceps.* **4** *Fucus distichus* ssp. *edentatus.* **5** *Palmaria palmata.* **6** *Corallina officinalis* with *Leathesia difformis*, *Asperococcus fistulosus* and *Chaetomorpha melagonium.* **7** Crustose corallines. **8** *Alaria esculenta.* **9** *Laminaria saccharina.* **10** *Pylaiella littoralis.* **11** *Acrosiphonia* spp. **12** *Cordaria flagelliformis.* **13** *Devaleraea ramentacea.* **14** *Ulva lactuca.* **15** *Rhodomela lycopodioides.* **16** *Polysiphonia stricta.* **17** *Fucus spiralis.* **18** *Fucus vesiculosus.* **19** *Ceramium* spp. **20** *Cystoclonium purpureum.* **21** *Fucus distichus* ssp. *distichus.* **22** *Enteromorpha intestinalis, E. compressa.* **23** *Blidingia minima.* **24** *Petalonia filiformis.* **25** *Porphyra abyssicola.* **26** *Petalonia* spp. (*P. fascia. P. zosterifolia*) and *Scytosiphon lomentaria.* **27** *Antithamnionella floccosa.* **28** Cyanobacteria (*Calothrix scopulorum, C. crustacea*). **29** *Prasiola stipitata.* **30** *Mastocarpus stellatus.*

which was especially well developed around Voladalstorfa on moderate rocky slopes. This *Corrallina* belt strongly accentuates the Atlantic character of the Máná vegetation.

In the upper sublittoral *Alaria esculenta* and *Laminaria saccharina* were found in mixed belts. *Laminaria digitata* was subordinate, as was also the case within Skjálfandaflói. As already mentioned, wide *Laminaria hyperborea* forests extend outside the open coast.



FIGURES 3 and 4. Schemes of zonation patterns around Tjörnes: Sandvík.

The Máná section is limited westwards by Voladalstorfa and eastwards by Húsvík. The vegetation of the two extreme spots exhibited some particular features which were described separately. Voladalstorfa is a long rocky promontory, formed by sedimentary rocks and basaltic lavas. The variegated configuration of the eulittoral rocky surfaces gives support to different algal belts. The uneven rocky surfaces may likewise cause a repetition of algal belts throughout the same transects. On vertical slopes the vegetation could start with an *Ulothrix* spp. - *Urospora penicilliformis* belt, which was mostly absent in Selvík and around Mánárbakki. Below it a rather narrow *Porphyra umbilicalis* belt was found, followed downwards by *Fucus distichus* ssp. *anceps* (Fig. 2). Below and in between *Fucus distichus*, *Pylaiella littoralis* and *Acrosiphonia* sp. were usual on vertical slopes, accompanied frequently by dwarf *Devaleraea ramentacea*. On moderate slopes, which follow below vertical rocks, the Fucacean growth was repeated by a belt of *Fucus distichus* ssp. *edentatus*. The horizontal slopes are locally populated by extensive *Corallina officinalis* meadows, undergrown by crustose corallines (Fig. 2). Such *Corallina* meadows were first of all found on horizontal rocky surfaces in the shelter of high walls.

On vertical slopes at Voladalstorfa *Devaleraea ramentacea* occupied the lower eulittoral and was followed downwards by fields of crustose corallines, like in Sandvík (cf. fig. 3). The *Devaleraea* belt had locally a wide vertical extension and reached into the sublittoral. *Rhodochorton purpureum* was found in the undergrowth, beside the usual crustose floristic elements. Companion species in the *Devaleraea* belt were *Palmaria palmata, Polysiphonia stricta* and *Rhodomela lycopodioides*.

Moderate rocky slopes, which follow below steep walls were occupied by *Fucus distichus* ssp. *edentatus.* The Fucacean fields were interrupted by meadows of *Acrosiphonia* species.

On steep, vertical slopes there was a reduction of the algal belts, and fucoids were locally absent. The following zonation was observed: *Ulothrix* spp. – *Porphyra umbilicalis* – *(Fucus distichus* ssp. *anceps)* – dwarf *Pylaiella littoralis* – juvenile *Laminaria saccharina* and lower down adult specimens of this species, mixed with *Alaria esculenta.* The intermediate red-algae belts were, however, absent.

Thus the configuration of the rocks caused a wide variety of zonation patterns around this promontory. Noteworthy are also deep rocky fissures and caves in the vertical walls, also on the side, turned towards Breiðavík (Fig. 24 c). In such shady habitats *Pilinia rimosa* together with *Rhodochorton purpureum* coated the rocky surfaces.

The vegetation was different in the bay of Húsvík and showed some similarities to the one found within Axarfjörður. Extensive sandy slopes in this bay are devoid of algal growth. A layer of sand covers the rocky slopes and prevents the development of an understorey both on the emerged slopes and in the tide pools. In this bay *Corallina officinalis* was absent. A further characteristic feature were notable amounts of *Ascophyllum nososum,* which occurred together

with *Fucus vesiculosus,* but was not belt-forming for itself. The upper eulittoral most usually coincided with sandy slopes and the zonation was as follows: *Fucus spiralis – F. vesiculosus* with *Ascophyllum nodosum – Fucus distichus* ssp. *edentatus – Devaleraea ramentacea – Laminaria saccharina* with *Alaria esculenta.* This refers to continuous rocky slopes. On boulders a different, broken zonation

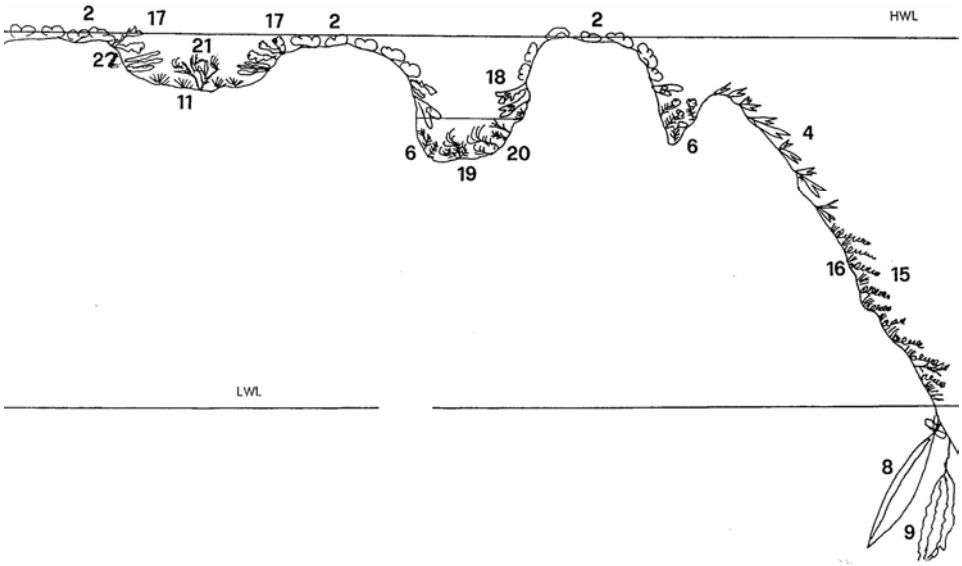


FIGURE 5. Schemes of zonation patterns around Tjörnes: Mánárbakki.

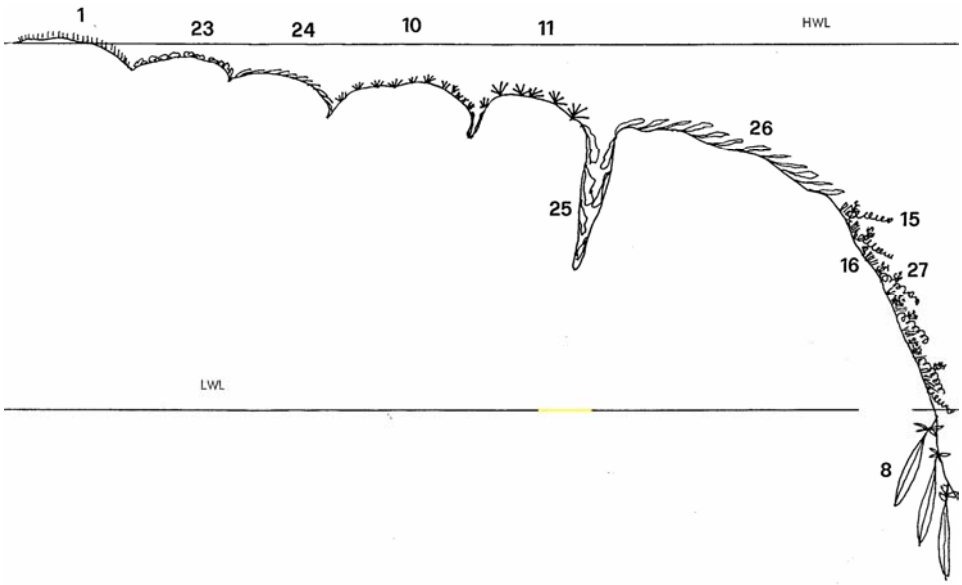


FIGURE 6. Schemes of zonation patterns around Tjörnes: Selvík.

pattern was found e.g. *Petalonia filiformis – Fucus distichus* ssp. *anceps – Pylaiella littoralis – Acrosiphonia* sp. *– Porphyra abyssicola – Petalonia fascia – Chordaria flagelliformis;* or: *Porphyra umbilicalis – Fucus distichus* ssp. *anceps – Pylaiella littoralis – Petalonia fascia* with *P. zosterifolia – Chordaria flagelliformis.*

Mostly, a broken zonation pattern was found in this area. A repetition of fucoid and other algal zones was usual on the boulders found throughout the eulittoral zone. Each boulder used to have its own zonation pattern, as dependent on the position along the eulittoral zone. The *Ulothrix- Urospora* belts were scattered and occurred only on small rounded stones in the uppermost eulittoral.

The algal vegetation of Húsvík exhibits low-eulittoral belts, common with Axarfjörður and absent in Skjálfandaflói, as well as along the rest of the Máná section.

The changed vegetation pattern found in Húsvík might be first of all due to the shore configuration, which is dominated by boulders, pebbles and sandy slopes. Tide pools were rare in this bay. They were mostly covered by sand and overgrown by *Acrosiphonia* species.

A great variety of algal associations and zonation patterns was thus characteristic of the Máná section. The abundance of *Corallina officinalis* in the tide pools and lagoons is one of the main characteristic features of this part of Tjörnes. In the upper eulittoral prolific and wide *Porphyra umbilicalis* belts were outstanding, while *Ulothrix – Urospora* and *Blidingia minima* belts were rare. Deviations from this pattern were found on the extreme eastern and western limits of the Máná section, viz. Voladalstorfa and Húsvík. In the latter *Petalonia filiformis* belts were frequent in the upper eulittoral. As contrast to the uniformity of the Fucacean fields, a great variety of low-eulittoral belts was observed, ranging from *Corallina officinalis* meadows on the western side of the area, over *Rhodomela lycopodioides* and *Devaleraea ramentacea* dominated belts along the central part of the Máná section, to brown algae belts in the eastern area *(Petalonia* spp., *Chordaria flagelliformis).*

C – Axarfjörður

The littoral slopes inside Axarfjörður are mainly formed by rounded, basaltic boulders which follow below steep slopes of the mainland. A broken and discontinuous zonation pattern was thus found within Axarfjörður as a whole (Figs. 20, 22a,b, 24 b).

The benthic algal vegetation of Axarfjörður was studied from the bay of Selvík to the innermost, sandy slopes at Lónsós (Fig. 23).

The main zonation patterns are presented in Figs. 6 to 10.

Characteristic of Axarfjörður was the absence of several warm-water floristic elements, such as *Corallina officinalis, Asperoccocus fistulosus, Leathesia difformis, Mesogloia vermiculata, Cladophora rupestris, Cystoclonium purpureum* and *Ceramium nodulosum.* As contrast to the vegetation of Skjálfandaflói and Máná, where

Atlantic vegetation features were outstanding, cold-water characters prevail in Axarfjörður. Its vegetation was similar to that found in the central area of the North Icelandic coast (Ólafsfjörður, Siglunes) .

Because of the configuration of the coastal slopes, dominated by rounded boulders, tide pools were rare in this fjord, and fucoid belts narrow or even absent. *Fucus distichus* ssp. *anceps* was the dominant fucoid. In the lower

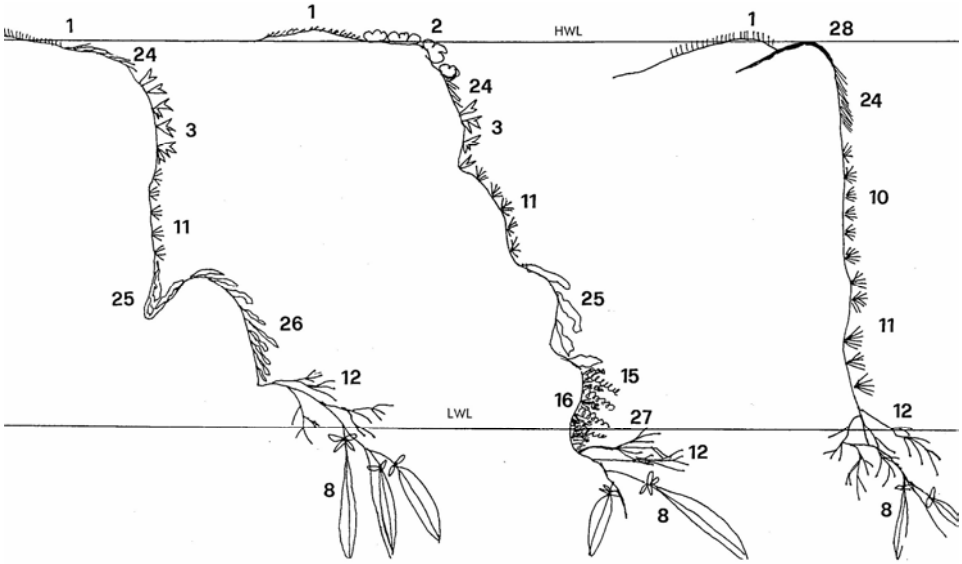


FIGURE 7. Schemes of zonation patterns around Tjörnes: Boulders in Selvík.

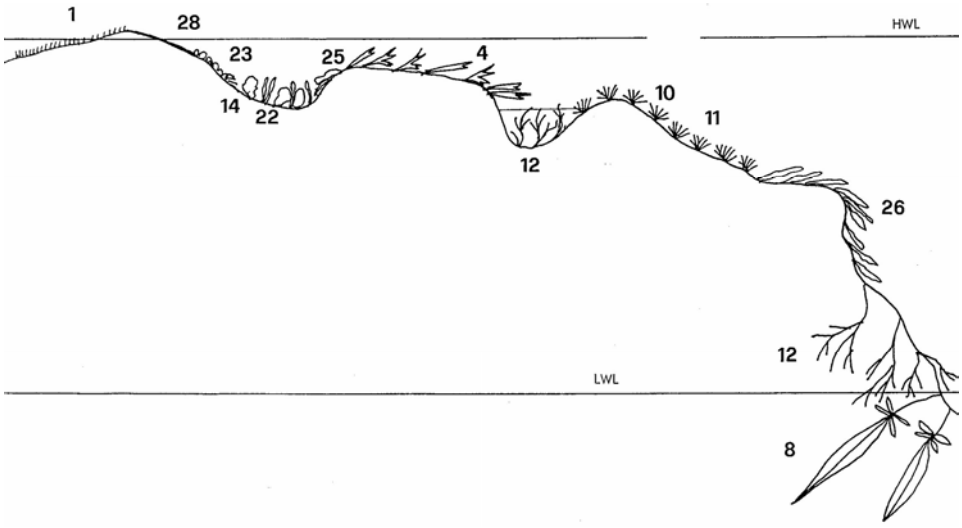


FIGURE 8: Schemes of zonation patterns around Tjörnes: Axarfjörður—Bangastaðir.

eulittoral brown algae belts were common on boulders, whereas the usual red algae belts, dominated by *Rhodomela lycopodioides* or *Devaleraea ramentacea* were found on continuous rocky surfaces.

In the bay of Selvík there are pebbles, rounded boulders and sandy slopes. Already in this bay the vegetation was different from the one observed along the Máná section. Due to uneven substrata, widely different zonation patterns were found. In the estuary of the river Selá the sandy slopes were occupied by belts of *Blidingia minima*, *Enteromorpha intestinalis* and *Pylaiella littoralis,* attached to pebbles. The *Ulothrix* spp. – *Urospora penicilliformis* belt had a discontinuous distribution and the same was true for that of *Blidinga minima.* The upper eulittoral was frequently occupied by Cyanobacteria (*Calothrix* species). This belt could protrude into the *Ulothrix* spp. zone or overlap with it (cf. Fig. 7). The *Porphyra umbilicalis* belt was narrow and discontinuous. A common high-level belt, situated lower down than *Ulothrix* spp. and *Porphyra umbilicalis,* was that of *Petalonia filiformis*. It was widespread all along the Axarfjörður coast.

In Selvík different zonation patterns were observed on boulders and on the gently sloping rocky surfaces (Figs. 6 and 7). The absence of *Fucus distichus* ssp. *anceps* and of *Porphyra umbilicalis* was characteristic of some highly exposed sites. Usual for the mid-eulittoral in Selvík, as well as for the entire coast of Axarfjörður, were belts of *Pylaiella littoralis* and *Acrosiphonia* spp. They occurred either in separate or in mixed belts on the boulders and on gently sloping rocky surfaces, and could occur even in paralelly running vertical zones. Lower down the eulittoral slopes, *Petalonia fascia,* frequently mixed with *P. zosterifolia,* formed broad and prolific belts. In the lower eulittoral and around the eulittoral/ sublittoral junction, *Chordaria flagelliformis* was usual on boulders - a vegetation feature shared with the mid- Nord and East of Iceland. On highly exposed, steep slopes the lower eulittoral was occupied by *Rhodomela lycopodioides,* accompanied by *Polysiphonia stricta* and *Antithamnionella floccosa,* the latter species being also present in the epiphytic cover of *Rhodomela*. Gently sloping rocky surfaces were, on the other hand, occupied by *Devaleraea ramentacea,* accompanied by *Antithamnionella floccosa.* The admixture of this species in the *Devaleraea* belt is, however, a characteristic feature of the Axarfjörður vegetation.

The upper sublittoral was occupied by belts of *Alaria esculenta* in its long and narrow growth form. In rocky fissures and crevices between the boulders *Porphyra abyssicola* was usual.

As already mentioned, a translocation and/or repetition of algal belts throughout the same transects was usual on the boulders. Each boulder exhibits, however, its own sequence of algal belts, (figs. 7, 10, 20, 22a, b).

A complete zonation pattern on the boulders could be as follows:

Ulothrix spp.- *Urospora penicilliformis*
Blidinga minima with *B.marginata*
Porphyra umbilicalis

Fucus distichus ssp. *anceps*
Acrosiphonia spp. with *Pylaiella littoralis*
Petalonia fascia with *P. zosterifolia* and *Scytosiphon lomentaria*
Chordaria flagelliformis
Alaria esculenta
Porphyra abyssicola in depressions between boulders.

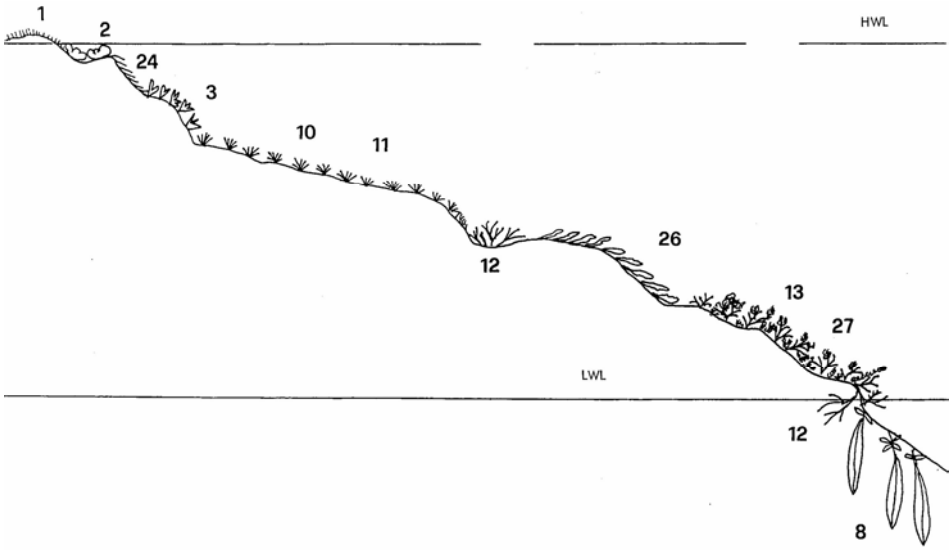


FIGURE 9. Schemes of zonation patterns around Tjörnes: Axarfjörður—Háubrekkuhaus.

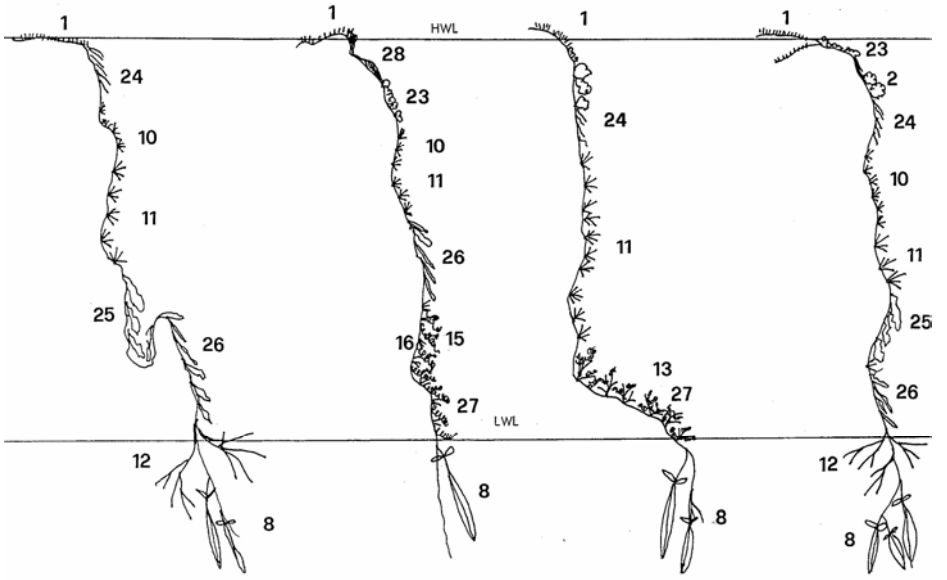


FIGURE 10. Schemes of zonation patterns around Tjörnes: Axarfjörður—boulders.

There are, however, variations in the sequence and extension of the individual algal belts, especially in the upper eulittoral, dependent on the height of the boulders and their distance from the shore. Belts of *Blidingia minima, Porphyra umbilicalis* and *Fucus distichus* ssp. *anceps* were frequently absent. The *Ulothrix* spp. belt appeared repeatedly on the tops of boulders throughout the eulittoral zone. Farther out from the mainland, the vegetation on boulders started with *Petalonia filiformis* or with *Acrosiphonia* spp. and *Pylaiella littoralis (*Fig. 22 a, b). Boulders situated distantly from the mainland could be totally coated by *Chordaria flagelliformis.*

It seems, however, difficult to present a clear-cut scheme of zonation patterns for a coast with discontinuous eulittoral slopes.

The vegetation features described above, and found in the bay of Selvík were, with small variations, common to the entire area of the Axarfjörður.

Its inside was studied in detail in several localities, such as e.g. Bangastaðir and Háubrekkuhaus. The innermost sandy area of Lónsós was vegetation free.

Within Axarfjörður *Fucus spiralis* was absent and *Fucus vesiculosus* rare. *Fucus distichus* ssp. *anceps* was the main fucoid in this fjord while *F. distichus* ssp. *edentatus* was found locally on continuous rocky surfaces. In many sites fucoids were absent (fig. 10).

On moderately sloping rocky surfaces, found only around Bangastaðir and Háubrekkuhaus (Figs. 8 and 9) fields of *Fucus distichus* ssp. *edentatus* were observed, followed lower down by zones of *Acrosiphonia* spp. and *Pylaiella littoralis.* Such slopes were interrupted by tide pools, overgrown by *Enteromopha* species and *Ulva lactuca* in the upper eulittoral, while in lower-lying pools filamentous brown algae were usual. In a few pools around Bangastaðir, *Ceramium areschougii* was also found. In the lower eulittoral *Petalonia* species were belt-forming and mingled with *Scytosiphon lomentaria.* Lowermost, however, *Chordaria flagelliformis, Devaleraea ramentacea* and *Rhodomela lycopodioides* belts alternated.

Devaleraea ramentacea with its codominant *Antithamnionella floccosa* was usual on moderately sloping surfaces lowermost in the eulittoral. *Antithamnionella* was found in the epiphytic cover of *Devaleraea* as well as epilithic in patches within the same belt. This association was usually floristically rich, with the following companion species*: Rhodomela lycopodioides, Palmaria palmata, Scytosiphon lomentaria, Polysiphonia stricta, Acrosiphonia arcta, A. grandis, Pylaiella littoralis, Ulva lactuca* and *Chordaria flagelliformis.* In the undergrowth the usual crustose floristic elements were found. *Ralfsia fungiformis* was more abundant here than along the Máná section and in Skjálfandaflói.

The *Rhodomela lycopodioides* belt, in which *Polysiphonia stricta* and *Antithamnionella floccosa* were codominant, was, on the other hand poor in companion species, but exhibited the usual undergrowth. This belt was common on steep, highly exposed slopes. Most usually, however, *Chordaria flagelliformis* was

found lowermost in the eulittoral and was situated between belts of *Petalonia* spp. and *Alaria esculenta* (Figs. 8 and 10).

In depressions between the boulders there were mats of *Porphyra abyssicola* as well as of *Ulva lactuca* and *Chordaria flagelliformis.*

Vegetation features which distinguish Axarfjörður from Máná and Skjálfandaflói were: high-level belts of *Petalonia filiformis,* extensive mid-eulittoral belts of *Acrosiphonia* spp. and *Pylaiella littoralis* and low-level belts of *Petalonia*

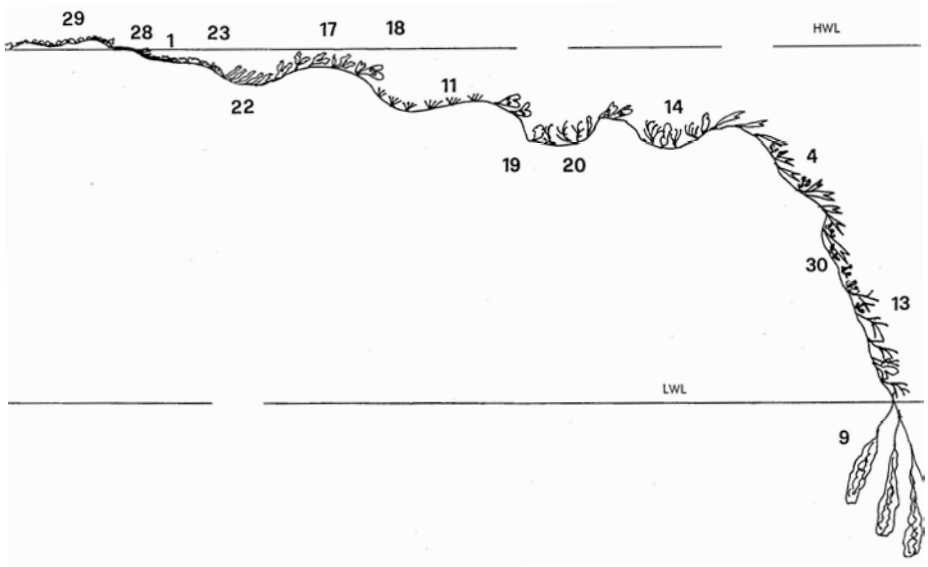


FIGURE 11. Schemes of zonation patterns around Tjörnes: Skjálfandi—Héðinshöfði.

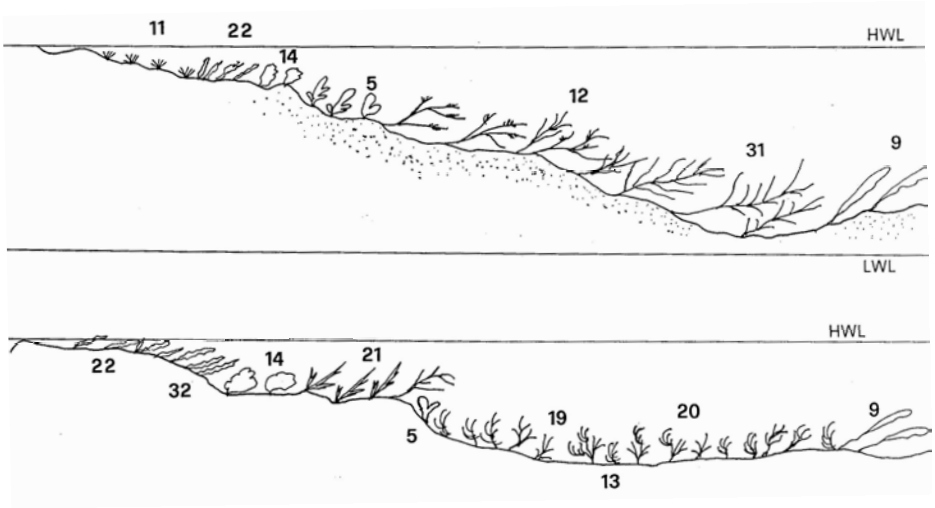


FIGURE 12: Schemes of zonation patterns around Tjörnes: Skjálfandi—Lagoons.

spp. and *Chordaria flagelliformis*. The admixture of *Antithamnionella floccosa* into the *Devaleraea ramentacea* and *Rhodomela lycopodioides* belts was a further characteristic feature of the Axarfjörður vegetation.

ALGAL ASSOCIATIONS AROUND TJÖRNES

The distribution of the main algal associations around this peninsula is presented in Table 2. The same criteria for the definition of vegetation units were used as in previous works (e.g. MUNDA 1978, 1979, 1983, 1987, 1992b, 1994, 1997).

Associations of the littoral fringe

Prasiola stipitata with its usual companion species *P. furfuracea* and *Rosenvingiella polyrhiza* was rather common in Skjálfandaflói, in particular on the rocky formations of Héðinshöfði. It had a scattered distribution along the Máná section and was rare in Axarfjörður. A similar, substrate-conditioned distributional pattern was found for

Rhizoclonium riparium which occupies rocky fissures.

Upper eulittoral associations

The distribution of the uppermost eulittoral associations was discontinuous, where there are sandy slopes at this level, as along the Máná section and locally also in Skjálfandaflói.

Ulothrix* spp. – *Urospora penicilliformis is the usual high-level association of northern Iceland. As found previously, its frequency and vertical extension increases eastwards along the North Icelandic coast (MUNDA 1975, 1992a). This association includes several *Ulothrix* species. It was continuous along the Skjálfandaflói coast, where there are rocky slopes, and subordinate along Máná, where it could be overgrown by *Porphyra umbilicalis*. In Axarfjörður it frequently overlapped with Cyanobacteria, and was found on the top of all the boulders.

Blidinga minima with *B. chadefaudii* and *B. marginata* was frequent in Skjálfandaflói, found also on pebbles. Along the Máná section it had a scattered distribution and was rare in Axarfjörður. There it was only prolific in local estuaries, as e.g. around the outlet of the river Selá.

Enteromopha intestinalis, accompanied with other *Enteromorpha* species occurred lower down the eulittoral than *Blidinga minima*. It was frequent in Skjálfandaflói and rare elsewhere around Tjörnes.

Enteromorpha compressa could be regarded as a separate association. It was found in prolific belts around tide pools of the Máná section and was also frequent in Skjálfandaflói.

Porphyra umbilicalis* f. *umbilicalis was the main high-level association of the Máná section, coating rocky surfaces in continuous, prolific belts (Figs. 14

TABLE 2. Main algal associations around Tjörnes. →

SKJÁLFANDAFLÓI	MÁNA SECTION	AXARFJÖRÐUR
LOWER EULITTORAL		
Devaleraea ramentacea	Devaleraea ramentacea	Devaleraea ramentacea - Antithamnionella floccosa
Devaleraea ramentacea - Mastocarpus stellatus	Devaleraea ramentacea - Rhodomela lycopodioides - Polysiphonia stricta	
	Rhodomela lycopodioides - Polysiphonia stricta	Rhodomela lycopodioides - Antithamnionella floccosa - Polysiphonia stricta
	Corallina officinalis	
Acrosiphonia spp.	Acrosiphonia spp.	Acrosiphonia spp.
		Pylaiella littoralis
		Porphyra abyssicola
		Petalonia spp.
	Chordaria flagelliformis	Chordaria flagelliformis
SUBLITTORAL		
Laminaria saccharina	Laminaria saccharina - Alaria esculenta	Alaria esculenta
TIDE POOLS		
Enteromorpha spp.	Enteromorpha spp.	Enteromorpha spp.
Ceramium spp. - Cystoclonium purpureum	Ceramium spp. - Cystoclonium purpureum	
Devaleraea ramentacea	Devaleraea ramentacea	
Enteromorpha linza - Ulva lactuca	Corallina officinalis	
Palmaria palmata	Palmaria palmata	
Acrosiphonia spp.	Acrosiphonia spp.	Acrosiphonia spp.
Dictyosiphon foeniculaceaus - Chordaria flagelliformis	Dictyosiphon foeniculaceaus - Chordaria flagelliformis	
	Punctaria plantaginea - Asperococcus fistulosus	
	Chordaria flagelliformis	Chordaria flagelliformis
LAGOONS		
Chordaria flagelliformis	Chordaria flagelliformis	
Ulva lactuca - Enteromorpha linza	Corallina officinalis	
Palmaria palmata	Palmaria palmata	
Acrosiphonia spp.	Acrosiphonia spp.	
Devaleraea ramentacea - Ceramium spp. - Cystoclonium purpureum	Fucus distichus ssp. distichus	
	Laminaria saccharina	

FIGURE 13. Rounded stones and boulders around Máná with Voladalstorfa and Sandvík in the background.

and 15). A high biomass was found within the *Porphyra* populations. It was rare in Skjálfandaflói and had a scattered distribution in Axarfjörður where it partly overlapped with the *Petalonia filiformis* belt.

Petalonia filiformis is an outstanding high-level association of northern Iceland. It was described for the island of Grímsey and for the Hornstrandir coast (MUNDA 1977a, 1992b), where its floristic composition was somewhat different, including dwarf *Chordaria flagelliformis*. This association was found all around Tjörnes, but was predominant in the high-level vegetation of Axarfjörður. It occurred usually lower down than the *Ulothrix* spp. – *Urospora penicilliformis* belt, limiting downwards to *Fucus distichus*- or *Acrosiphonia* spp. and *Pylaiella littoralis* belts. Dwarf *Pylaiella littoralis* and *Spongomorpha aeruginosa* were common companion species.

Fucacean associations

Fucus spiralis was a frequent Fucacean association within Skjálfandaflói and along the Máná section, occurring on the sheltered sides of rocky slopes. It was absent in Axarfjörður.

Fucus vesiculosus was usually found on flat rocky surfaces within Skjálfandaflói and along Máná, but was subordinate in the vegetation of Axarfjörður,

FIGURE 14. Rocky pools fringed by *Porphyra umbilicalis* and *Enteromorpha intestinalis* at Mánárbakki.

FIGURE 15. Prolific *Porphyra umbilicalis* belt in the Máná section.

where it was limited only to a few rather protected sites. Its floristic composition and zonal position was the same as along Hornstrandir (cf. MUNDA 1992b.)

Fucus distichus* ssp. *edentatus was the main Fucacean association around Tjörnes. It occupied moderately sloping rocks and was found lower down the eulittoral than *Fucus vesiculosus* or *Fucus distichus* ssp. *anceps.* The floristic composition of the association was also similar to the one described for the Hornstrandir coast. On sand-covered rocks, the understorey was impoverished and reduced to *Sphacelaria radicans, S. nana* and *Acrosiphonia* species. It was frequently interrupted by populations of either *Acrosiphonia grandis, Ulva lactuca* or *Pylaiella littoralis.* On the lower edges, floristic elements from the low-eulittoral belts joined this Fucacean association, such as *Palmaria palmata, Devaleraea ramentacea, Rhodomela lycopodioides, Chordaria flagelliformis* and *Petalonia* species. It is noteworthy, that within Skjálfandaflói *Mastocarpus stellatus* was found in its understorey, and that *Ceramium* species were outstanding in the epiphytic cover.

Fucus distichus* ssp. *anceps was a rare association in Skjálfandaflói, but the dominant one in Axarfjörður. There its zonal position was usually lower down than the *Petalonia filiformis* belt, limiting to *Acrosiphonia* spp. and *Pylaiella littoralis.* Around Máná, it occurred usually below *Porphyra umbilicalis.* Downwards the eulittoral zone, it could limit to *Fucus distichus* ssp. *edentatus* or directly to low-eulittoral belts, without *Acrosiphonia* spp. and *Pylaiella* littoralis belts interimposed.

It is noteworthy, however, that *Ascophyllum nodosum* did not form a separate association around the Tjörnes Peninsula.

Low-eulittoral associations

Distinctive characters between the three areas around the Tjörnes peninsula were most pronounced in the lower eulittoral. Low-eulittoral belts were rather uniform in Skjálfandaflói, whereas great variations were found along the Máná section and in Axarfjörður.

The ***Devaleraea ramentacea*** association was found in several variants around Tjörnes:

1—*Devaleraea ramentacea* in its usual form, without codominants and only a few companion species (cf. MUNDA 1976, 1983, 1992a, b).

In the undergrowth *Rhodochorton purpureum,* crustose corallines and *Ralfsia fungiformis* were common. The dominant species was usually present as f. *robusta* and was bare of epiphytes. This form of the *Devaleraea ramentacea* association was found along the Máná section, in particular at Voladalstorfa and in Sandvík. It occurred below *Acrosiphonia* spp. meadows or *Fucus distichus* belts, and was most usually followed downwards by fields of crustose corallines (*Clathomorphum circumscriptum, Lithothamnion* spp., Fig. 3).

2—*Devaleraea ramentacea* – *Mastocarpus stellatus.* This unusual association between an arctic, circumpolar species and a typical Atlantic one, was

common in Skjálfandaflói. *Ceramium* species were outstanding in the epiphytic cover of *Devaleraea.* Companion species were: *Ceramium nodulosum, C. areschougii, Cystoclonium purpureum, Palmaria palmata, Rhodomela lycopodioides, Ulva lactuca* and *Acrosiphonia grandis*. In the undergrowth *Hildenbrandia rubra,* crustose corallines, *Sphacelaria radicans, Rhodochorton purpureum, Ralfsia verrucosa* and dwarf *Acrosiphonia* sp. were found. This variant of the *Devaleraea* association exhibits a pronounced Atlantic character.

3—*Devaleraea ramentacea – Rhodomela lycopodioides – Polysiphonia stricta* was a common low-level association along the Máná section. Its usual zonal position was between *Fucus distichus* ssp. *edentatus* and *Alaria esculenta* with *Laminaria saccharina.* In the undergrowth *Ralfsia fungiformis* was well represented. *Palmaria palmata* and *Chordaria flagelliformis* were conspicuous companion species.

4—*Devaleraea ramentacea - Antithamnionella floccosa.* This variant of the *Devaleraea* association was characteristic of Axarfjörður and was absent elsewhere along the North Icelandic coast. *Antithamnionella* was found in patches in between *Devaleraea* and was richly represented in its epiphytic cover. This association occupied moderate rocky slopes and was fringed downwards by *Alaria esculenta. Rhodochorton purpureum* was common in the undergrowth beside the usual crustose floristic elements.

Rhodomela lycopodioides was an outstanding belt-former along the Máná section, and also in Axarfjörður. It occurred in mixed belts and thus different variants of its association were observed around Tjörnes:

1—*Rhodomela lycopodioides* with codominant ***Polysiphonia stricta*** was common along the Máná section.

2—*Rhodomela lycopodioides – Polysiphonia stricta – Antithamnionella floccosa.* This mixed association was found only in Axarfjörður, where it occupied steep rocky surfaces. Its floristic composition was similar to that of other variants of the *Rhodomela* association. It was most usually found between belts of *Petalonia* species and of *Alaria esculenta.*

Chordaria flagelliformis is an association characteristic of the subarctic East Icelandic vegetation pattern (MUNDA 1975, 1979, 1983, 1994,). It was dominant in the lower eulittoral and around the eulittoral/sublittoral junction in Axarfjörður, both on boulders and on rocky slopes. It had a patchy distribution along the Máná section and was found only at two spots in Skjálfandaflói. It was usually situated below the *Petalonia* spp. belts, or directly below *Acrosiphonia* spp. on boulders. Downwards it was followed by *Alaria esculenta.*

***Petalonia* spp.** This low-level association was widely distributed in Axarfjörður. It includes *Petalonia fascia* as the main floristic element, accompanied by *P. zosterifolia* and *Scytosiphon lomentaria.* This association was floristically poor, without epiphytes and companion species. It was usually situated lower down the eulittoral than the *Acrosiphonia* spp. association.

FIGURE 16. *Laminaria hyperborea* beds in Skjálfandi.

FIGURE 17. Sandy slopes in Breiðavík.

Porphyra abyssicola occupied rocky fissures and depressions between the boulders within Axarfjörður, and can also be regarded as a low-eulittoral association. *Rhodochorton purpureum* was common in its undergrowth together with crustose corallines and *Hildenbrandia rubra.*

Acrospihonia spp. This association includes several *Acrosiphonia* species (*A. sonderi, A. arcta, A. grandis, A. centralis)* and is characteristic of the North and East Icelandic coastal areas. *Acrosiphonia* species form usually extensive meadows on gently sloping rocky surfaces and can also interrupt Fucacean fields in the mid-eulittoral.

This association was rare in Skjálfandaflói and frequent elsewhere. *Acrosiphonia* meadows, with *A. sonderi* as dominant, were common along the Máná section, occurring on sand-covered rocks. In Axarfjörður, the physiognomy of the association was altered. It covered steep surfaces of basaltic boulders, which were frequently depleted of fucoids (figs. 10, 22a, b). In extreme cases, it could occupy the entire eulittoral slopes, between belts of *Ulothrix* spp. - *Urospora penicilliformis* and *Chordaria flagelliformis.*

Acrosiphonia populations on boulders were frequently overlapped by *Pylaiella littoralis.* They could occur in separate or in mixed belts. On some boulders they could even alternate in vertical zones. Nevertheless, a typical *Acrosiphonia* spp.—*Pylaiella littoralis* association, characteristic of moderately exposed slopes all around Iceland, was not observed around Tjörnes.

Pylaiella littoralis, occurring both in the mid- and lower eulittoral, was usually found on boulders within Axarfjörður, higher up the eulittoral than *Acrosiphonia* species.

Corallina officinalis. This typical Atlantic low-eulittoral association was a characteristic feature of the Máná vegetation. It was found in its western area, first of all around Voladalstorfa and in Sandvík, where it occupied moderately sloping rocky surfaces in the shelter of high rocky walls. It was similar to the *Corallina* association found in southern and western Iceland (cf. MUNDA 1977b, 1978) regarding its zonal position and floristic composition. Warm-water floristic elements were found in the epiphytic cover of *Corallina: Asperoccocus fistulosus, Leathesia difformis* and *Ceramium* species, beside *Eudesme virescens* and dwarf *Ulva lactuca.* This association was followed downwards the eulittoral by crustose corallines, like in the western fjords (Fig. 2).

Upper sublittoral associations

In the upper sublittoral, different belts were found in the three areas of the Tjörnes Peninsula.

Laminaria saccharina was dominant in Skjálfandaflói, occurring also in wide offshore lagoons. In its undergrowth there were crustose corallines, *Ralfsia verrucosa, Polysiphonia stricta, Rhodochorton purpureum, Sphacelaria radicans* and occasionally also *Ralfsia fungiformis.* In addition, *Rhodomela lycopodioides, Palmaria palmata, Chordaria flagelliformis* and *Devaleraea ramentacea* were found.

Laminaria saccharina – Alaria esculenta was the usual sublittoral association along the Máná section. The two codominants occurred in approximately

equal proportions, only in highly exposed sites *Alaria* dominated. *Laminaria digitata* was rarely represented within the same belt. The undergrowth of this association was the same as described for the pure *Laminaria saccharina* one.

Alaria esculenta was the main sublittoral association in Axarfjörður. The dominant species occurred in its long and narrow growth form. Notable quantities of *Chordaria flagelliformis* could be found within the same belt and the undergrowth was enriched by a continuous cover of *Ralfsia fungiformis*.

Low-sublittoral association

All around the Tjörnes Peninsula there are prolific, wide beds of ***Laminaria hyberborea***. This association covers the low-sublittoral surfaces of Skjálfandaflói (Fig. 16) as well as of the Máná section and Axarfjörður. The floristic composition of this association was obvious from the driftweed and has been mentioned in the text. In the Axarfjörður *Polysiphonia arctica* joined the sublittoral vegetation, while *Coccotylus truncatus* and *Turnerella pennyi* were not detected. *Desmarestia aculeata* was usual in the driftweed. The stipes and hapterae of *Laminaria hyperborea* were epiphytized by *Rhodochorton purpureum, Polysiphonia stricta, Phycodrys rubens, Delesseria sanguinea, Odonthalia dentata, Porphyra miniata, Ptilota gunneri, P. serrata, Callophyllis cristata, Rhodomela lycopodioides,* and *Haemescharia hennedyi*. It is noteworthy, that along the Máná section also single *Corallina officinalis* specimens were found on the hapterae.

Tide pool associations

Tide pools are frequent along the Skjálfandaflói and Máná sections (Figs. 4, 14, 24a) but absent along the greater part of the Axarfjörður coast. Tide pool associations are also a conspicuous distinguishing character between the different areas of the Tjörnes Peninsula.

Enteromorpha spp. with *E. intestinalis, E. prolifera* and *E. compressa* as the main floristic elements, was usual in pools of the upper eulittoral. It was frequent around Héðinshöfði, Bakkahöfði and along the Máná section (Sandvík).

Enteromorpha linza - Ulva lactuca was usual in mid-eulittoral pools and especially frequent within Skjálfandaflói.

Punctaria plantaginea, accompanied by *Asperoccocus fistulosus* was found in upper eulittoral pools around Sandvík and Mánárbakki. *Stictyosiphon tortilis* was usual as companion species.

***Acrosiphonia* spp** was a common tide pool association all around Tjörnes, found in pools of different eulittoral levels. In the upper- eulittoral ones, *A. sonderi* was dominant. *Acrosiphonia* species were common also in sand-covered pools, lacking undergrowth and companion species.

Corallina officinalis. This association was common and widespread along the Máná section, especially in its western area. It was rare in Skjálfandaflói and absent in Axarfjörður. In shadowed pools, lower down the eulittoral, *Chaetomorpha melagonium* was the only companion species. *Chlathromorphum circum-*

scriptum was usual in the undergrowth. In shallow, fully insolated pools the association was floristically rich and *Corallina* heavily epiphytized by *Asperococcus fistulosus, Laethesia difformis, Porphyra miniata, Ceramium* species, *Ulva lactuca, Ectocarpus fasciculatus* and *Eudesme virescens.* There were, however, numerous companion species in such *Corallina* pools, as mentioned in the text.

Ceramium* spp. – *Cystoclonium purpureum were codominant in numerous pools along the Skjálfandaflói and Máná sections. This typically Atlantic association was absent in Axarfjörður. Only in one spot pools occupied by *Ceramium areschougii* were found.

This association was absent in the central area of the North Icelandic coast, but was found on the island of Grímsey, along Hornstrandir as well as in Húnaflói (MUNDA 1977a, 1992a, b). In the named areas *Cystoclonium purpureum* was subordinate within this association.

Beside the two typically Atlantic tide-pool associations, others characteristic of the North Icelandic coastal area were found.

Devaleraea ramentacea was a common tide pools association along the Máná section. The dominant species was heavily epiphytized and the association similar to previous descriptions (MUNDA 1976, 1992a, b).. The abundance of *Ceramium* species within this association is noteworthy, both as companion species and in the epiphytic cover. *Cystoclonium purpureum* was likewise found within these *Devaleraea* pools. Thus the Atlantic character of the vegetation was accentuated even in the tide pools.

Palmaria palmata was likewise a common tide pool association all along the area, with the exception of Axarfjörður. The floristic composition was similar as along Hornstrandir, the dominant species being heavily epiphytized.

Dictyosiphon foeniculaceus — Chordaria flagelliformis. This association of filamentous brown algae was common in pools of the mid- and low-eulittoral. Several other brown algae were found as companion species, such as *Eudesme virescens, Ectocarpus siliculosus, Stictyosiphon tortilis,* and *Scytosiphon lomentaria*. This association was different from a pure ***Chordaria flagelliformis*** one, which was usual in low-lying pools, as well as in splash pools. It was found also in depressions between boulders in Axarfjörður, but was rare in Skjálfandaflói.

The tide pool associations described above, were similar to those found along the Hornstrandir coast and on the island of Grímsey. Characteristic is, however, their distributional pattern around this peninsula. During field studies around Tjörnes, *Monostroma* species were relatively rare and did not form a separate tide-pool association. The same was true for *Fucus distichus* ssp. *distichus* which was found only as companion species in most of the pools.

Lagoon associations

Beside tide pools, extensive rocky and sandy lagoons were found within Skjálfandaflói and along the Máná section. Only the most conspicuous lagoon associations will be mentioned.

Devaleraea ramentacea* – *Ceramium* spp. – *Cystoclonium purpureum was a common and characteristic association within Skjálfandaflói. The abundance of Atlantic floristic elements was outstanding. Other companion species were *Palmaria palmata, Rhodomela lycopodioides, Ulva lactuca, Enteromorpha linza* along with other *Enteromorpha* species, *Dumontia contorta* and *Fucus distichus* ssp. *distichus.*

Palmaria palmata was dominant in rocky lagoons around Skjálfandaflói and Máná, accompanied by the same floristic elements as the association named above. In addition the admixture of filamentous brown algae is noteworthy.

Fucus distichus* ssp. *distichus was a rare lagoon association, found first of all in the western area of Máná in nearshore rocky lagoons. The dominant species was heavily epiphytized by *Ceramium* species, beside other usual epiphytes.

Chordaria flagelliformis was a common association in both, sand-covered and rocky lagoons. It was frequently accompanied by juvenile *Laminaria saccharina,* as well as by other filamentous brown algae, first of all by *Desmarestia viridis.*

Laminaria saccharina was found in deeper, offshore rocky lagoons and was accompanied by *Sacchoriza dermatodea*. Such lagoons were found along the Máná section.

Ulva lactuca* – *Enteromorpha linza was, on the other hand, an association of near-shore, shallow lagoons and was usual in Skjálfandaflói. *Enteromorpha* species (*E. prolifera*, *E. clathrata*) were represented beside the two codominants.

FIGURE 18. Driftweed in Breiðavík.

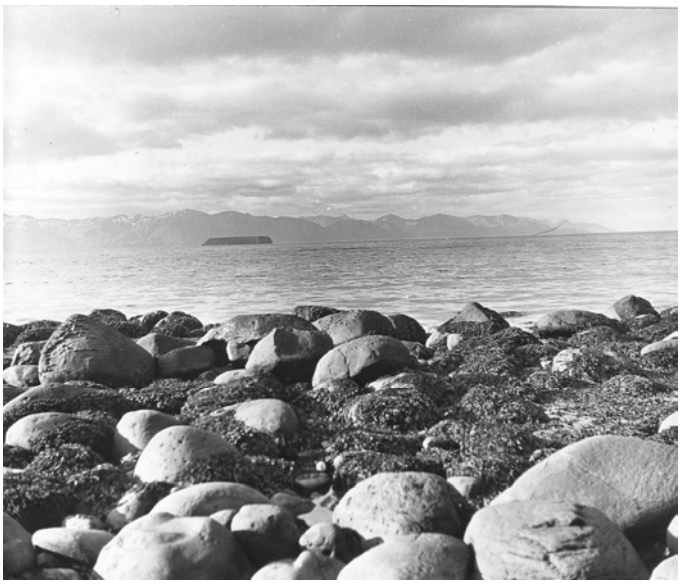


FIGURE 19. Rounded stones and gravel in the eulittoral in Skjálfandi

***Acrosiphonia* spp.** formed a conspicuous lagoon association in Skjálfandaflói and along Máná. Such lagoons were usually covered by sand and the dominants were devoid of undergrowth and companion species.

Corallina officinalis occupied shallow lagoons in the western area of the Máná section. It was usually heavily epiphytized, and the floristic composition was similar to that described for its tide pool association. Juvenile *Laminaria saccharina* plants were frequently found among the companion species.

DISCUSSION AND CONCLUSIONS

The benthic algal vegetation of the North Icelandic coast, which is an intermediate between the Atlantic vegetation of the South and West of Iceland, and the subarctic East Icelandic one, shows notable variations in the west- east direction. These variations are mainly due to the hydrographic conditions. As mentioned, the North Icelandic shelf is a mixing area of different primary and secondary water masses and a gradual cooling and dilution of the Irminger Current takes place in the eastwards direction (STEFÁNSSON 1962, 1969a, b, MALMBERG 1969). Within the entire Iceland Sea the strongest temperature and salinity gradients are found just above the North Icelandic submarine terrace.

The vegetation pattern found along the North Icelandic coast obviously reflects both, the hydrographic conditions and shore configuration. A detailed description was given for the Hornstrandir coast and Steingrímsfjörður in the Northwest, where this vegetation type is created gradually (MUNDA 1992b,

FIGURE 20. Boulders in Axarfjörður.

1997). Low-eulittoral belts of *Devaleraea ramentacea,* of diverse filamentous brown algae (*Petalonia* species*, Chordaria flagelliformis)* and extensive meadows of *Acrosiphonia* species are characteristic features of the North Icelandic vegetation type (MUNDA 1975). In the tide pools Atlantic and North Icelandic vegetation features mingle, since tide pool associations have a wider distributional patterns than low-level associations of the same species as e.g. of *Corallina officinalis* and of *Devaleraea ramentacea* (MUNDA 1981). A rather typical North Icelandic vegetation pattern was found in the central area of the North Icelandic coast (e.g. Skagafjörður, Ólafsfjörður, Siglunes) and was rather uniform. Notable variations were, on the other hand, found in the Northwest (Hornstrandir, Húnaflói) and around Tjörnes, close to the north-eastern area.

Enclaves of Atlantic vegetation features were characteristic of the Hornstrandir coast. They were found in sheltered bays and fjords (Ófeigsfjörður, Trékyllisvík) and are characterized by the presence of *Corallina officinalis* in tide pools and lagoons, and locally even on low-eulittoral slopes. Beside *Corallina,*

FIGURE 21. Belt of *Petalonia* spp. with *Scytosiphon lomentaria* at Bangastaðir in Axarfjörður.

notable amounts of *Ceramium* species and of *Cystoclonium purpureum* were found. These typically Atlantic floristic elements had a discontinuous distributional pattern already along Hornstrandir, and were absent in the central area of northern Iceland. They were still well represented along the eastern coast of the Húnaflói Bay, at Skagaströnd and on the island of Grímsey (MUNDA 1977a), and reappeared again at the Tjörnes Peninsula.

Devaleraea ramentacea, with its tide-pool and low eulittoral associations is, to the contrast, an indicator of cold-water and subarctic vegetation patterns. This species is regarded as endemic arctic by LÜNING (1985, 1990). Its low-level association is formed gradually along the Hornstrandir coast and follows almost continuously the low-eulittoral slopes of the North and East Icelandic coastal areas. The floristic composition and physiognomy of this low-level association varies, however, in different parts of the North Icelandic coast (MUNDA 1976).

In its typical form, the low-level association of *Devaleraea ramentacea* is floristically poor, and the dominant species clean of epiphytes. It was found as such already along Hornstrandir and farther south in the Húnaflói Bay. A variant of

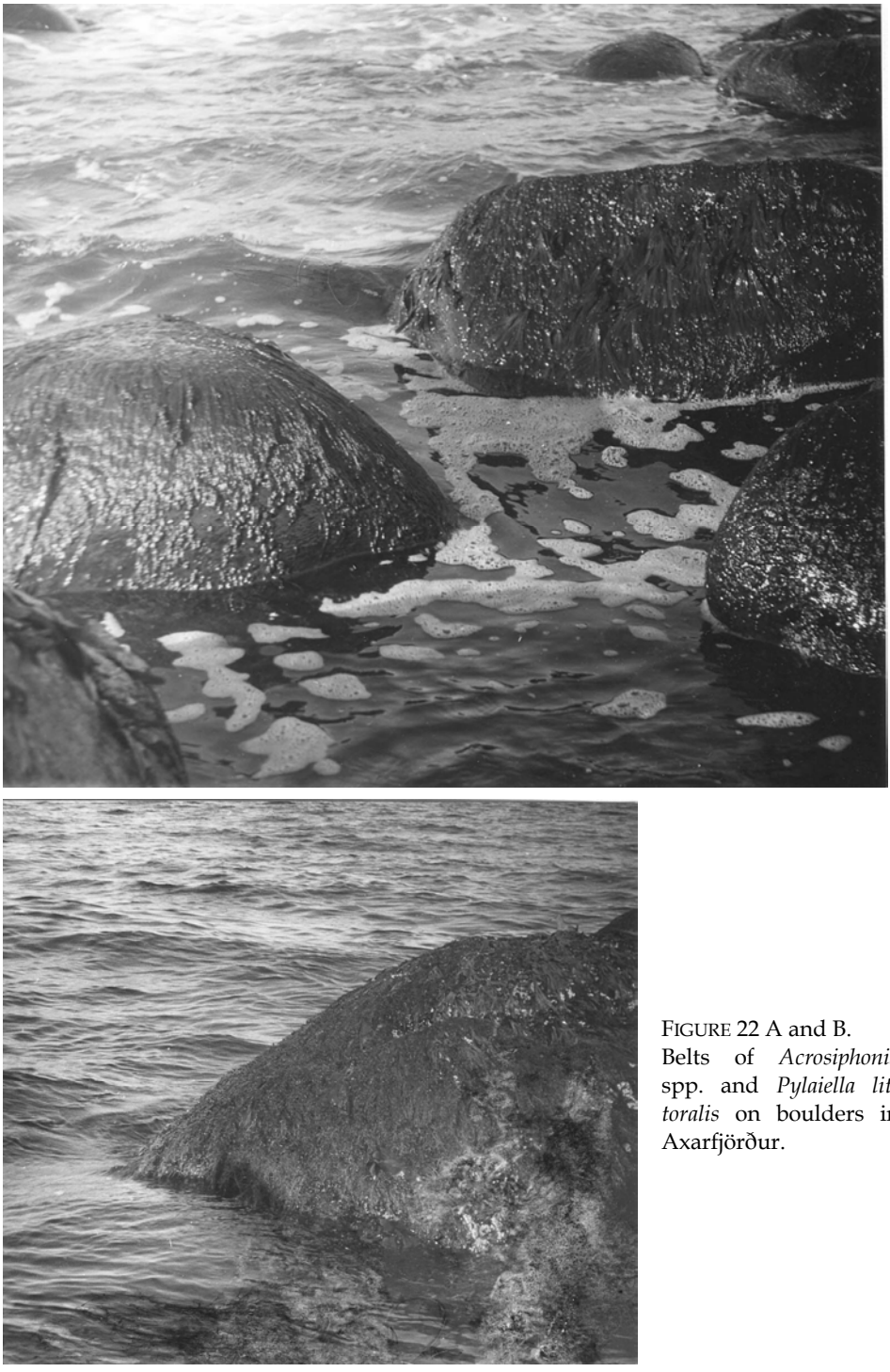


FIGURE 22 A and B. Belts of *Acrosiphonia* spp. and *Pylaiella littoralis* on boulders in Axarfjörður.

this association was usual along the eastern coast of Húnaflói, with *Ceramium* species and *Cystoclonium purpureum* as codominants.

Around the Tjörnes Peninsula the low-level association of *Devaleraea ramentacea* was found in several variants. In Skjálfandaflói *Devaleraea ramentacea* and the cold-boreal floristic element *Mastocarpus stellatus* occurred as associated codominants. The two species form, however, regionally separated low-level associations around the Icelandic coast (MUNDA 1976, 1977c), that of *Mastocarpus stellatus* extending as far north as to Hornbjarg.

It seems likely, however, that a local warming up of the surface waters within Skjálfandaflói is favourable for the development of this mixed association, in which also other Atlantic floristic elements were richly represented.

Along the open and highly exposed Máná section of Tjörnes *Devaleraea* was associated to *Rhodomela lycopodioides* and *Polysiphonia stricta,* whereas in Axarfjörður *Antithamnionella floccosa* occurred as codominant in the association, and was present also in the epiphytic cover of *Devaleraea.*

As obvious from the vegetation description of the Tjörnes Peninsula, three rather sharply delimited areas could be discerned. One of the distinguishing characters is also the structure and composition of the different *Devaleraea ramentacea* associations.

In Skjálfandaflói, the *Devaleraea ramentacea* belt follows the low-eulittoral slopes almost continuously. Along the open Máná section, to the contrast, different low-eulittoral belts alternated, among which that of *Corallina officinalis* was characteristic. *Rhodomela lycopodioides* was also an outstanding belt-former along this side of the Tjörnes Peninsula, alternating with *Devaleraea ramentacea,* which occurred either in pure or in mixed belts. Brown-algae belts dominated the low-eulittoral slopes within Axarfjörður (*Chordaria flagelliformis, Petalonia* species), where associations of *Devaleraea ramentacea* and of *Rhodomela lycopodioides* exhibited only a patchy distribution.

The three widely different vegetation types found around the Tjörnes Peninsula can be characterised also by their tide-pool and lagoon associations, as well as by the upper eulittoral and sublittoral algal belts.

In Skjálfandaflói the vegetation bears many Atlantic features, characterised by the abundance of *Ceramium* species, *Cystoclonium purpureum* and also *Dumontia contorta* in the tide pools and lagoons, although *Corallina officinalis* was rare. The presence of *Mastocarpus stellatus,* which was found also in the Fucacean undergrowth, however, accentuated the Atlantic character of the vegetation. In the sublittoral, *Laminaria saccharina* was dominant, whereas in the upper eulittoral *Blidinga minima* was rather common beside other usual high-level belts of *Ulothrix* spp. — *Urospora penicilliformis.*

The open Máná section of Tjörnes is characterised by the abundance of *Corallina officinalis* in the tide pools and lagoons as well as on low-eulittoral slopes. Atlantic-water vegetation features were obvious in the tide pools populated by *Ceramium* species and *Cystoclonium purpureum.* The upper eulit-

FIGURE 23. Sandy slopes at Lónsós.

toral along this coast-line was dominated by wide and prolific *Porphyra umbilicalis* belts. *Acrosiphonia* meadows were rather frequent along the Máná section. The Atlantic character of the vegetation was, however, less pronounced than within Skjálfandaflói, tentatively due to the rough conditions along this highly exposed area. It is noteworthy, that in the sublittoral *Alaria esculenta* and *Laminaria saccharina* occurred as associated codominants.

A rather sharp vegetation shift was observed on the eastern side of the Máná section, in Selvík. The vegetation of Axarfjörður was similar to that found in the central area of the North Icelandic coast, but devoid of most Atlantic floristic elements, with exception of *Ceramium areschougii*.. It was mainly limited to basaltic boulders. Thus a broken zonation pattern was found throughout the eulittoral zone in most sites. Brown algae belts (*Petalonia filiformis* in the upper eulittoral and *P. fascia*, *P. zosterifolia*, *Chordaria flagelliformis* and *Pylaiella littoralis* in the lower eulittoral) along with *Acrosiphonia* spp. mats dominated the eulittoral vegetation. *Alaria esculenta* occupied the upper sublittoral. It is also noteworthy, that the association between *Rhodomela lycopodioides*, *Polysiphonia stricta* and *Antithamnionella floccosa* was similar to the one found in the transitional area around Hornbjarg. This association is likely characteristic of boundary areas

between different vegetation types. JAASUND (1965), however, found a similar association in the north of Norway (Finmarken).

It seems likely, however, that the Tjörnes Peninsula separates widely different vegetation patterns.

Gently sloping surfaces with shallows and rocky or sandy lagoons favour the development of a prolific vegetation of filamentous red algae, as it is the case in Skjálfandaflói, while the exposed slopes of Máná favour the occurrence of *Corallina* populations. On the boulders and gravel of Axarfjörður, where also the exposure is high, conditions are suitable for the development of brown algae belts, with a discontinuous distribution throughout the eulittoral.

The absence of Atlantic floristic elements in Axarfjörður, found both in Skjálfandaflói and along Máná (e.g. *Mastocarpus stellatus*, *Dumontia contorta*, *Ceramium nodul*osum, *Cladophora rupestris*, *Cystoclonium purpureum*, *Corallina officinalis*, *Asperococcus fistulosus*, *Leathesia difformis*) cannot be explained only by the different substrate configuration (cf. Fig. 24a, b, c), geological structure of the coastal slopes and exposure conditions.

The overall distribution of individual species and of vegetation patterns in Icelandic coastal waters can be first of all attributed to different temperature regimes (STRÖMFELT 1886, MUNDA 1975). The distribution of benthic algae has been usually interpreted in terms of surface water temperatures (e.g. KAPRAUN 1980, van den HOEK 1982, 1984, BOLTON 1983, SEARLES 1984, LÜNING 1984, 1990, BREEMAN 1988, BREEMAN & PARKER 1994, YARISH et al. 1984, 1986.)

As mentioned, waters at the Tjörnes peninsula exhibited the highest average summer temperatures and the highest average yearly temperature of the entire North Icelandic coastal area (STEFÁNSSON 1969a, b). This local warming up of the surface waters, especially in the protected and shallow bay of Skjálfandaflói, could be due for the enclave of Atlantic vegetation features and the appearance of warm water floristic elements.

There is, however, a lack of nearshore water temperature measurements, which could elucidate the abrupt vegetational change between the Máná section and Axarfjörður. Own short-term measurements during algal samplings did not reveal notable differences in the surface water temperatures between the three areas of the peninsula. We could only tentatively assume a long-term temperature drop along the line of the Axarfjarðardjúp.

It is, however, difficult to present a plausible explanation. Nevertheless, the decisive influence of the water temperature with its seasonal and annual fluctuations cannot be excluded, if we try to find causative relationships for the occurrence of three widely different vegetation patterns around the Tjörnes Peninsula.

FLORISTIC LIST

The species distribution around Tjörnes is presented in Table 3. The numbers of the localities correspond to those signed on the map (Fig. 1).

FIGURE 24. Different shore configurations around Tjörnes. A: Moderate rocky slopes around the Mána section. B: Rounded stones and boulders in Axarfjörður. C: High sedimentary rocks with fissures in Breiðavík behind Voladalstorfa.

For the vertical distribution the same terms were used as in previous works e.g. (MUNDA 1992b): U—upper eulittoral, M—mid-eulittoral, L—lower eulittoral, S—sublittoral, TP—tide pools, F—rocky fissures.

The abundance of the individual species around Tjörnes is presented according to the usual scale: A—abundant, M—moderately abundant, R—rare, RR—very rare, D—dominant within the association, CD—codominant. Not all of the recorded species are named in the descriptions of the vegetation patterns of the three areas around Tjörnes.

Of the total of species recorded around Tjörnes 40% belong to the Phaeophyta, 34% to the Rhodophyta and 26% to the Chlorophyta, making a Rh/Ph ratio of 0.8, thus the same as found for the Hornstrandir coast.

In Axarfjörður several warm-water floristic elements were absent, such as *Corallina officinalis*, *Ceramium nodulosum*, *Cystoclonium purpureum, Mastocarpus*

TABLE 3. Species distribution around Tjörnes

RHODOPHYTA — BANGIOPHYCEAE	Skjálfandi							Mána section						Axarfjörður								Associ-Ation-forming
localities	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21,	Tidal level	
Bangia atropurpurea (Roth.)C.Ag.	-	-	-	-	-	-	-	M	M	-	-	-	-	-	-	-	-	-	-	-	U	D
Porphyra abyssicola Kjellm.	M	M	R	R	-	R	-	-	-	R	R	M	M	A	A	A	A	A	R	-	M, L, F	
P. miniata (C.Ag.) C.Ag.	-	-	-	R	R	R	R	R	-	R	R	-	R	R	R	RR	R	R	-	-	S, TP	
P. umbilicalis (L.) J. Ag.	-	-	-	M	M	R	R	M	M	A	A	A	A	M	M	R	R	RR	RR	-	U	D
RHODOPHYTA - FLORIDEOPHYCEAE																						
localities	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Audouinella parvula (Kylin) Dixon	-	RR	RR	-	RR	-	-	R	RR	RR	-	RR	-	RR	-	-	-	-	-	-	L, TP	
A. membranacea (Magnus) Papenf.	-	-	RR	RR	RR	-	-	-	RR	-	-	RR	RR	-	-	-	-	-	-	-	S, L	
A. virgatula (Harv.) Dixon	-	-	-	-	-	-	-	R	RR	R	R	RR	R	-	-	-	-	-	-	-	L, TP, F	
Antithamnion boreale (Gobi) Kjellm.	-	-	-	-	-	-	-	-	RR	-	RR	RR	-	RR	RR	R	R	-	-	-	S	
Antithamnionella floccosa (O.F. Müll.) Whittick	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	A	A	M	-	-	L, TP	CD
Callophylis cristata (C.Ag.) Kütz.	R	R	R	-	R	R	R	-	RR	-	R	R	R	R	R	R	R	R	R	-		
Dumontia contorta (Gmel.) Rupr.	-	R	M	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Ceramium areschougii Kylin	M	A	A	A	A	M	M	M	M	M	M	M	R	R	-	-	RR	-	-	-	TP	CD
C. nodulosum (Lightf.) Ducluz	A	A	A	A	A	M	M	M	M	M	M	M	M	-	-	-	-	-	-	-	M, L, TP	CD
Clathromorphum circumscriptum (Huds.) Batters	M	M	M	R	R	RR	R	M	M	M	R	R	R	R	RR	RR	-	-	-	-	S, L, TP	
Coccotylus truncatus (Pallas) Wynne et Heine	-	-	-	R	-	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	S	
Corallina officinalis L.	-	-	-	-	R	RR	-	A	A	A	A	A	M	-	-	-	-	-	-	-	L, M, TP	D
Cystoclonium purpureum (Huds.) Batters	A	A	A	A	A	A	M	M	M	M	M	M	M	-	-	-	-	-	-	-	M, TP	CD
Crouoria pellita (Lyngb.) Fries	-	-	R	-	-	-	R	RR	-	RR	R	R	-	R	R	-	-	-	-	-	S	
Delesseria sanguinea (Huds.) Lam.	M	M	M	-	-	-	M	R	R	M	R	R	R	R	R	R	RR	-	-	-	S	
Devaleraea ramentacea (L.) Guiry	A	A	A	A	A	-	A	R	M	M	M	R	M	A	A	M	A	M	R	RR	L, TP	D, CD
Fimbrifolium dichotomum (Lepech.) Gobi	-	-	R	R	R	-	R	-	-	RR	R	R	R	R	RR	R	R	-	-	-	S	
Haemescharia hennedyi (Harv.) Vinogradova et Jacov	-	R	R	R	R	-	-	-	R	R	-	RR	R	R	R	R	-	-	-	-	S	
Hildenbrandia rubra (Sommerf.) Menegh.	M	M	M	M	M	-	R	R	A	A	M	M	M	R	R	RR	R	R	R	-	M, L, TP	

Table 3 continued:

RHODOPHYTA - FLORIDEOPHYCEAE																						**Associ-ation-**
localities	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21,	**Tidal level**	**forming**
Leptophytum laeve (Strömf.) Adey	-	-	-	R	R	-	R	-	-	R	R	R	-	-	-	R	-	R	-	-	S	
Lithothamnion sp.	M	M	M	M	M	-	M	R	R	M	M	R	R	R	R	R	R	R	-	-	L, S, TP	
L. glaciale Kjellm.	-	-	-	RR	-	-	RR	-	RR	R	R	-	-	R	RR	R	R	-	-	-	S	
Mastocarpus stellatus (Stackh. in With.) Guiry	M	M	M	-	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	L	CD
Odonthalia dentata (L.) Lyngb.	R	R	R	R	R	-	R	-	-	R	R	R	R	R	-	R	R	R	-	-	S	
Palmaria palmata (L.) O. Kuntze	M	A	A	A	A	M	M	M	M	R	M	M	M	R	R	M	R	M	R	RR	L, TP	
Peyssonnelia rosenvingii Schm. in Rosenvinge	R	R	R	-	RR	-	-	-	RR	-	RR	RR	-	-	RR	-	-	-	-	-	S	
Phycodrys runbens (L.) Batt.	M	M	M	R	M	R	R	-	R	R	M	M	M	R	R	R	R	R	-	-	S	
Phymatolithon lenormandii (Aresch.) Adey	M	M	M	M	M	M	R	R	M	M	M	R	R	R	-	RR	R	R	R	-	S, L, M, TP	
P. laevigatum (Foslie) Foslie	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	L, S	
Polysiphonia arctica J. Ag.	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	R	-	-	S	
P. stricta (Dillwyn) Grev.	R	R	R	M	M	R	R	R	M	M	A	A	A	A	A	A	A	A	RR	-	S, L, M, F	CD
Pseudolithophyllum orbiculatum (Foslie) Lemoine	-	R	R	RR	R	-	RR	R	-	RR	-	RR	-	R	-	RR	-	RR	-	-	S	
Ptilota gunneri Silva, Maggs et Irvine	R	R	R	R	R	R	M	RR	R	R	R	R	R	R	R	R	R	R	-	-	S	
P. serrata Kütz.	M	M	M	R	R	R	R	R	R	M	M	R	R	R	R	R	R	-	-	-	S	
Rhodochorton. purpureum (Lightf.) Rosenvinge	M	M	R	-	R	-	-	R	R	R	M	M	M	M	M	A	A	A	-	-	S, L, TP, F	
Rhodomela lycopodioides (L.) C.Ag.	R	R	R	M	M	M	M	R	A	A	A	A	A	A	A	A	A	M	RR	-	S, L, TP	CD
Rhodophysema elegans (Crouan frat.) Dixon	-	-	R	R	-	RR	-	-	RR	-	RR	-	-	R	R	R	-	-	-	-	S	
Turnerella pennyi (Harv.) Schm.	-	-	-	R	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	S	
PHAEOPHYTA - PHAEOPHYCEAE																						
localities	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Alaria esculenta (L.) Grev.	R	R	M	R	R	R	M	M	M	M	M	M	M	A	A	A	A	A	RR	-	S, TP	D, CD
Ascophyllum nodosum (L.) Le Jol..	-	-	-	-	-	-	RR	-	R	M	M	R	R	-	-	-	-	RR	R	-	M	D
Asperococcus fistulosus (Harv.) Hook.	-	-	-	-	-	-	-	M	M	M	R	R	-	-	-	-	-	-	-	-	L, TP	
Chordaria flagelliformis (O. F. Müll.) J.Ag.	M	M	M	R	R	R	R	R	M	M	M	M	A	A	A	A	A	A	R	-	M, L, TP	D, CD
Chilionema foecundum (Strömf.) Fletcher	-	-	R	R	-	R	RR	-	-	R	R	RR	-	-	-	-	R	R		-	TP	
Ch.occelatum (Kütz.) Kuckuck	-	-	-	R	R	-	R	-	-	RR	-	-	-	-	-	-	-	-	-	-	L, TP	

Table 3 continued:

PHAEOPHYTA - PHAEOPHYCEAE localities	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21,	Tidal level	Associ-ation-forming
Dictyosiphon ekmani Aresch.	-	-	R	R	R	-	-	-	-	-	RR	-	-	-	-	-	-	-	-	-	TP	
D. foeniculaceus (Huds.) Grev.	M	M	M	M	M	M	M	R	R	R	M	R	R	R	R	R	RR	R	RR	-	TP	
Desmarestia aculeata (L.) Lam.	R	R	M	M	M	M	M	R	M	M	M	R	R	RR	R	R	R	R	-	-	S	
D. viridis (O.F. Müll.) Lam.	M	M	M	M	A	R	-	-	R	R	R	-	-	-	-	-	-	-	-	-	S, L, TP	
Ectocarpus fasciculatus Harv.	-	M	M	-	M	-	-	-	-	M	M	R	-	M	-	M	R	-	-	-	L, TP	
E. siliculosus (Dillw.) Lyngb.	M	M	M	M	M	-	-	R	R	M	M	R	R	R	RR	R	R	R	RR	-	M, TP	
Elachista fucicola (Well.) Aresch.	R	R	R	R	R	R	R	R	-	RR	R	R	R	RR	R	R	R	R	-	-	M, L, TP	
Eudesme virescens (Carm. ex Harv.) in Hook.	-	-	-	-	-	-	-	R	M	M	M	R	R	-	-	-	-	-	-	-	L, TP	
Fucus distichus L. emend. Powell																						
ssp. edentatus (de la Pyl) Powell	M	M	M	M	M	M	M	M	M	M	M	M	M	R	R	R	R	R	R	-	M, L	D
ssp. evanescens (C. Ag.) Powell	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M, L	
ssp. anceps (Harv.et Ward.ex Carruthers) Powell	-	R	R	-	-	R	R	A	A	A	M	M	A	A	A	A	A	A	-	-	U, M, L	
ssp. distichus Powell	A	A	A	A	M	R	-	-	-	A	A	A	-	-	-	-	-	-	-	-	TP	D
F. spiralis L.	M	M	R	R	R	R	R	-	M	M	M	M	R	-	-	-	-	-	-	-	U	D
F. vesiculosus L.	M	M	M	M	M	M	R	-	M	M	M	M	R	R	-	-	-	-	R	-	U, M	D
Hecatonema maculans (Collins) Sauv.	R	R	-	R	R	-	-	-	-	R	R	R	-	-	-	-	-	-	-	-	S, L, TP	
Isthmoplea sphaerophora (Harv.) Kjellm.	-	-	-	-	-	-	R	-	-	-	R	R	R	R	RR	RR	R	RR	-	-	U	
Laminaria digitata (Huds.) Lam.	-	R	R	R	R	-	R	R	R	R	RR	M	R	R	R	R	R	RR	-	-	S, TP	
L.hyperborea (Gunn.) Foslie	M	M	M	M	M	M	A	R	M	A	A	A	M	M	M	M	M	M	-	-	S	D
L. saccharina (L.) Lam.	A	A	A	A	A	A	M	M	M	M	A	A	M	M	R	R	R	R	R	-	S,TP	D, DC
Leathesia difformis (L.) Aresch.	-	-	-	-	-	-	-	M	M	M	R	M	R	-	-	-	-	-	-	-	L,TP	
Leptonematella fasciculata (Reinke) Silva	-	-	-	R	RR	-	R	-	R	R	R	-	-	-	-	-	-	-	-	-	L, TP	
Lithosiphon laminariae (Lyngb.) Harv.	-	-	RR	-	RR	-	R	-	RR	-	RR	-	R	R	RR	R	R	-	-	-	L,S	
Microspongium globosum Reinke	-	RR	R	-	R	-	-	-	R	R	RR	R	-	R	-	-	-	-	-	-	L,TP	
Mesogloia vermiculata (Schm.) S.F.Gray	-	-	-	-	-	-	-	-	R	R	R	-	-	-	-	-	-	-	-	-	L,TP	
Myrionema corunnae Sauv.	R	R	-	-	-	-	-	-	R	-	RR	R	-	RR	R	-	-	-	-	-	L,S	
M.strangulans Grev.	-	-	RR	-	-	RR	R	R	RR	RR	-	RR	-	-	-	-	-	-	-	-	L, S, TP	
Petalonia fascia (O.F.Müll.) Kuntze	-	R	R	-	-	R	-	R	R	R	M	M	A	A	A	A	A	A	A	-	L, TP	CD
P.filiformis (Batt.) Kuntze	-	-	-	RR	-	-	RR	-	-	R	M	M	M	A	A	M	A	A	RR	-	U	D
P. zosterifolia (Reinke) Rosenv.	-	-	R	R	RR	-	R	-	R	R	RR	-	RR	A	M	A	A	A	R	-	L	CD

Table 3 continued:

PHAEOPHYTA - PHAEOPHYCEAE **localities**	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21,	**Tidal level**	**Associ-ation-forming**
Petroderma maculiforme (Wollny) Kuckuck	R	R	-	R	R	R	-	R	-	RR	RR	R	-	R	-	R	R	-	-	-	L, TP	
Pilinia rimosa (Kütz)	-	-	-	-	-	-	R	M	RR	-	-	-	-	-	-	-	-	-	-	-	U	D
Pylaiella littoralis (L.) Kjellm.	M	M	M	M	M	R	R	R	-	M	M	A	A	A	A	A	A	A	R	-	U, M, TP	D, CD
Pseudolithoderma extensum (Crouan frat.) Lund	RR	-	R	-	R	-	-	R	R	R	R	-	-	R	R	-	-	-	-	-	L, S	
Punctaria plantaginea (Roth.) Grev.	-	-	RR	RR	-	R	-	-	-	R	R	R	R	-	-	-	-	-	-	-	TP	
Ralfsia fungiformis (Gunn.) Setch.et Gardn.	R	-	R	-	R	-	R	R	M	M	M	M	M	R	R	R	R	R	-	-	L, S, TP	
R. verrucosa (Aresch.) J.Ag.	M	M	M	M	M	M	M	R	R	R	M	M	M	R	R	R	R	R	RR	-	M, L, S, TP	
Sacchorhiza dermatodea (De la Pyl.) J.Ag.	-	-	M	M	M	-	-	-	-	M	R	R	-	-	-	-	-	-	-	-	TP	
Scytosiphon lomentaria (Lyngb.) Link.	R	R	R	M	R	R	R	R	M	M	A	A	A	A	A	A	A	A	R	-	L, TP	CD
Sphacelaria nana Näg. ex Kütz.	-	-	R	R	R	R	R	R	R	RR	R	R	R	M	M	M	R	R	-	-	L, TP, F	
S. plumosa Lyngb.	-	-	R	R	-	-	R	R	R	R	R	-	R	-	RR	RR	-	-	-	-	F	
S. radicans (Dillw.) C.Ag.	M	-	M	M	M	M	M	M	M	M	-	M	M	R	R	M	M	R	-	-	M, L, TP, F	
Spongonema tomentosum (Huds.) Kütz.	R	-	R	R	R	-	R	-	R	RR	R	R	R	R	R	R	R	R	RR	-	M, L, TP	
Stictyosiphon tortilis (Rupr.) Reinke	-	R	R	R	M	M	R	-	R	R	R	R	R	RR	-	RR	-	-	-	-	TP	
Streblonema cf. chordariae (Wollny) Cotton	-	-	R	R	-	-	-	-	RR	-	-	-	-	RR	RR	R	RR	-	-	-	L, TP	
CHLOROPHYTA - CHLOROPHYCEAE **localities**	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Acrosiphonia arcta (Dillw.) J. Ag.	R	R	R	M	R	R	R	M	M	M	M	R	R	A	A	A	A	A	-	-	M, L,	D
A. centralis (Lyngb.) KJellm.	R	R	R	R	M	R	M	M	M	M	M	M	M	M	A	A	A	A	-	-	M, L, TP	CD
A. grandis Kjellm.	M	M	R	R	R	M	M	M	M	M	M	M	M	A	A	A	A	M	-	-	U, M ,TP	CD
A. sonderi (Kütz.) Kornm.	M	M	M	R	R	R	R	M	M	M	M	M	R	A	A	A	A	A	RR	-	U, M, L, TP	CD
Blidingia chadefaudii (Feldm.) Bliding	-	-	-	-	-	R	R	-	-	RR	-	-	RR	R	R	R	R	R	R	-	U	
B. marginata (C. Ag.) Dang.	-	-	M	-	-	R	RR	-	-	R	-	-	R	M	R	M	M	M	-	-	U	CD
B. minima (Näg. exKütz.) Kylin	-	-	M	-	-	M	M	-	-	M	R	-	M	M	M	M	M	M	RR	-	U	D
Chaetomorpha capillaris (Kütz.) Börg.	-	-	R	RR	-	-	-	-	M	R	R	R	-	-	-	-	-	-	-	-	TP	
Ch. melagonium (Web.er Mohr.) Kütz.	-	R	RR	R	M	M	R	R	M	A	A	M	R	RR	-	RR	R	R	-	-		
Cladophora oblitterata Söderström	-	-	M	M	R	-	-	-	-	M	M	M	-	-	-	-	-	-	-	-	TP	
Cl. rupestris (L.) Kütz.	-	-	-	-	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-	U, M	

Table 3 continued:

CHLOROPHYTA - CHLOROPHYCEAE **localities**	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21,	**Tidal level**	**Associ-ation-forming**
Enteromorpha ahleriana Bliding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	RR	U, M	
E. clathrata (Roth.) Grev.	-	R	R	RR	-	-	-	-	RR	RR	R	RR	RR	-	-	-	-	-	-	-	TP	
Enteromorpha compressa (L.) Grev.	-	M	M	M	M	R	-	-	M	M	A	R	-	-	-	-	-	-	-	-	U,TP	
E. intestinalis (L.) Link.	M	M	M	M	A	-	-	-	M	M	M	M	R	RR	R	-	R	R	-	RR	U, TP	D
E. linza (L.) J. Ag.	M	M	M	A	A	M	R	-	-	R	RR	-	-	-	-	-	-	-	-	-	TP	D
E. prolifera(O.F. Müll.) J. Ag.	R	R	R	-	RR	-	-	RR	-	-	RR	-	RR	-	-	-	-	-	-	-	TP	
Monostroma grevillei (Thur.) Grev.	M	M	M	R	R	R	-	RR	M	A	M	R	-	-	-	-	-	-	-	-	TP, M	
M.undulatum Wittr.	-	-	-	-	R	R	R	M	M	M	A	M	-	-	-	-	-	-	-	-	TP	
Prasiola fufuracea (Mertens) Menegh.	R	R	R	R	-	R	-	R	R	-	-	R	R	RR	-	-	-	-	-	-	U	
P. stipitata Suhr. in Jessen	M	M	R	R	-	M	-	M	M	M	R	R	R	R	-	-	-	-	-	-	U	D
Rhizoclonium riparium (Roth) Harv.	R	R	R	-	-	R	R	RR	RR	-	-	RR	R	RR	-	-	-	RR	-	-	U, F,	
Rosenvingiella polyrhiza (Rosenv.) Silva	-	-	-	RR	-	RR	-	RR	-	-	-	-	-	RR	-	-	-	-	-	-		
Spongomorpha aeruginosa (L.) Hoek	-	-	-	R	-	R	R	M	M	M	R	R	-	RR	RR	-	-	RR	RR	-	U, TP	
Stichococcus marinus (Wille) Hazen	RR	-	RR	-	-	-	RR	R	-	-	-	-	RR	RR	-	-	-	-	-	-		
Ulothrix flacca (Dillw.) Thur	M	M	M	M	M	R	R	M	M	R	RR	M	M	M	M	M	M	R	RR	RR	U	D
U. pseudoflacca Wille	M	M	R	R	R	R	RR	R	R	M	M	M	RR	R	R	R	RR	RR	R	-	U	CD
U. subflaccida Wille	-	-	R	R	RR	RR	-	RR	R	RR	RR	RR	RR	R	R	R	R	R	R	-	U	CD
Ulva lactuca L.	M	M	M	M	M	A	-	R	R	M	M	M	R	RR	-	-	-	RR	RR	-	U, M, TP	
Urospora pennicilliformis (Roth) Aresch.	M	M	M	M	A	A	R	M	M	M	M	R	RR	R	-	RR	RR	RR	RR	-	U	CD
U.wormskioldii (Hornem.) Rosenvinge	-	-	R	-	R	R	R	-	-	RR	-	RR	-	RR	-	RR	RR	-	-	-	U	
CYANOBACTERIA **localities**	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Calothrix scopulorum (Web. et Mohr.) C. Ag.	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	RR	RR	R	R	-	U	
C. crustacea Schousb. in Thur.	-	-	-	-	-	-	-	-	-	-	-	-	-	RR	RR	-	RR	RR	RR	-	U	
LICHENES **localities**	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
Verrucaria maura Wahlenberg	-	-	-	-	-	-	R	-	-	-	-	-	-	R	R	R	R	-	R	-	U	
V. mucosa Wahlenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RR	RR	RR	-	-	-		

stellatus, Asperococcus fistulosus, Laethesia difformis, Cladophora rupestris, *Enteromorpha linza*, *Punctaria plantaginea*, *Coccotylus truncatus* as well as *Fucus spiralis*.

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