Initial Settlement of Marine Benthic Algae on the Rocky Shore of Surtsey, the New Volcanic Island in the North Atlatnic

by

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The occurrence of barren rocky shore of Surtsey covering about the three-quarters of the 7-8 km long coastline makes it possible to study the process of colonization of benthic marine organisms along this coast.

This paper deals with the beginning of the algal settlement, the identification of the algae and their distribution. A survey has also been undertaken of driftweeds washed ashore for the purpose of estimating possible immigration routes of benthic algae to Surtsey.

1. Algal colonization

My first landing on Surtsey was made from a small inlet at the SE coast of the island, on August 29, 1964. The volcanic activity, characterized by intermittent lava streams which had been running into the sea for about 6 months, was then still going on. The SE coast was created by two lava flows of different ages. The more recent flow (fig. 1,1), situated SW of the landing point, offered a rocky shore apparently untouched by marine erosion. But the older flow (fig. 1,2), extending towards NE, was covered by boulders, gravel or sand interrupted by promontories. No macroscopic attached algae were observed on this coast, only fragments of drifted algae, such as Ascophyllum nodosum. Some stone pieces were detached in the upper littoral region from the solid rocky substrate of the two lava flows and preserved for further study in 5% formalin seawater.

Microscopic examination of slides obtained by scraping the surface of the stones revealed no algal vegetation on the recent lava flow. But on the older one, the age of which did not exceed 4-5 months, some very sparse marine benthic Diatoms and rod Bacteria were found. The identification of the Diatoms was made difficult because of the poor silicification of the valves and their inconspicuous striae. But the general feature of the cells and their dimensions, the morphology, the position of the plasts, and in some cases the number of carinal dots indicate that these Diatoms seem to belong to two species: Navicula (Schizonema) mollis (W.Sm.) Cl. and Nitzschia bilobata W. Sm. var. minor Grun., two cosmopolite species, known from the coasts of Iceland (1).

This first investigation seems to indicate that Diatoms, mixed with Bacteria, were the pioneers of the marine benthic vegetation of Surtsey and that their colonization takes place as soon as the rocky shore offers a suitable substrate.

Nine months later, when Surtsey was visited again, the coast had considerably increased due to new lava flows which marked the end of the volcanic activity of the island (fig. 1). The locality of Diatoms previously studied had now disappeared under a new lava flow and could not be followed any more. However, the rocky shore was already bordered by precipitous sea-cliffs, fringed by an abrasion platform. On the NW coast this platform, easily accessible at low tide, was mainly covered with sand and locally by boulders, rocky ridges and caps extending into the sea. These rocky localities (fig. 1, I,II,III,IV) were selected and explored thoroughly during the course of the summer 1965.

A survey, carried out on August 10, under a heavy tephra fall coming from a new sub-marine volcano near Surtsey, revealed, in one of these localities (fig. 1, III), the presence of algae growing directly on the rocks.

The profile of locality III shows a sea-cliff, about 20 m height, overhanging an irregular rocky terrace, which ends in the

sea by a very exposed promontory (fig. 2). The surface of the substrate was rough, fissured and alveolate and apparently suitable for algal anchorage. The occurrence of tephra covering the top of the promontory and the foot of the cliff indicated approximately the high tide level of the sea. In the Westmann archipelago this level reaches 2.62 m above the mean low water mark at springtide, with an average tidal amplitude of 2.52 m.

The vegetation seemed to be of two kinds: filamentous green algae and yellow-brownish gelatinous formations.

The green algae grew in isolated tufts or gregarously in scattered patches on the exposed side of the promontory, above and a little below the high water mark line (fig. 2). This level represents the lowest part of the supralittoral region and the uppermost part of the littoral region. These algae (fig. 3, A) are simple multicellular filaments, about 1-3 cm high, and 10μ-50μ broad. Each thread is attached to the substrate by extramatrical rhizoids. The cells, generally as long as broad, are provided with one perforated or fissured parietal chloroplast, containing many pyrenoids of polypyramidal structure. On fixed material, stained according to Feulgen's method, it appears that each cell is multinuclear. Some filaments were fertile, bearing tumid zoidocysts, either empty or full of spores of acuminate structure. These characteristics agree with H. JONSSON's (2) description of Icelandic specimens of Urospora mirabilis Aresch., which is very common along the coasts of Iceland.

Urospora mirabilis grew in pure population in Surtsey. However, three species of Diatoms were found as epiphytes on the filaments of Urospora: Thalassionema nitzschioides Hust., Synedra affinis Kütz. var. parva Kütz. and Licmophora gracilis (Ehr.) Grun. var. anglica (Kütz.) Per., which all occur on the coasts of Iceland (1).

The second type of vegetation encountered in this locality filled the cracks and the anfractuosities of the rock (fig. 3, B),

on the sheltered side of the promontory, around high water mark (fig. 2). Further study revealed luxuriant colonies of Diatoms, dominated by Synedra affinis var. parva, associated with a few Thalassionema nitzschioides and broken valves of Licmophora gracilis var. anglica. The rupicole form of Synedra affinis var. parva differs, however, from the epiphytic form by the deformation of the frustules, probably due to desiccation and poor silicification.

From this second investigation it is therefore clear that the first algal colonizers of the barren rocky substrate of Surtsey are Diatoms and filamentous green algae.

One month later, when we came back to Surtsey, the population of Urospora mirabilis had expanded considerably on the rocks and the Diatoms were still in place. New populations of Urospora had also developed in other rocky localities (II, and between III and IV), under similar environmental conditions. But no vegetation was to be found near the excrement of sea-birds, which had occupied the sea-cliffs for one month. This biotope, very common in Iceland, is characterized by nitrophilous algae as Prasiola and Enteromorpha. On the sandy beach, on the northern part of Surtsey and round the salt-water lagoon, situated in this part of the island, the substrate because of its mobility seems insuitable for the fixation of benthic marine algae. No attached algal vegetation was therefore to be found there. Dredgings carried out S and SE of Surtsey, on 15-20 meter's depth, revealed a sea-bottom covered with scoriae, completely devoid of algae.

The marine benthic vegetation found in Surtsey, about 21 month after the emergence of the island and about 15 months after the formation of the first rocky shore seems therefore only to be composed of Diatoms and filamentous green algae. No indigenous benthic animals, such as Barnacles, were met with on this coast.

2. Survey of driftweeds.

Macroscopic marine algae and various floating objects covered with algae are washed upon the shores of Surtsey, especially upon the large sandy beach in the northern part of the island. The following species were met with in the course of the summer 1965.

DIATOMEAE:

Licmophora paradoxa (Lyngb.) Ag., pure colony on Fucus vesiculosus, and mixed colonies on driftwood.

Fragilaria islandica Grun., many ribbon-liked colonies on driftwood with Licmophora paradoxa.

Thalassionema nitzschioides Hust., on driftwood, in company with Licmophora paradoxa.

Synedra affinis Kütz. var parva Kütz., on driftwood.

Nitzschia lanceolata W.Sm., on driftwood.

Amphora angusta (Greg.) Cl., on driftwood.

Navicula complanata Grun. var. hyperborea (Grun.) Cl. (?), on driftwood.

Navicula sp. (unidentifiable fragments), on driftwood.

Nitzschia sp. (unidentifiable fragments), on driftwood.

RHODOPHYCEAE:

Polysiphonia fastigiata (Roth) Grev., on Ascophyllum nodosum.

Rhodymenia palmata (L.) Grev., on driftwood.

PHEOPHYCEAE:

Ascophyllum nodosum (L.) Le Jollis, cast ashore.

Chordaria flagelliformis (Müll.) AG., on driftwood.

Chorda filum (L.) Stackh., on driftwood.

Fucus vesiculosus L., cast ashore.

Laminaria digitata (L.) Lam., on driftwood.

CHLOROPHYCEAE:

Ulothrix flacca (Dillw.) Thuret, on fishing net-float.

Urospora mirabilis Aresch., on fishing net-float.

Ulva lactuca L., on driftwood.

Acrosiphonia albescens Kjellm., on driftwood.

Among the species quoted above, which all occur along the coasts of Iceland, one finds those which have already colonized the rocky shore of the island, viz. Synedra affinis var. parva and Urospora mirabilis. This fact may explain how these species have immigrated into Surtsey. It should also be noticed that Ascophyllum nodosum is the most common algae cast ashore very probably because of its great abundance on adjacent coasts and also on account of its great floatability. The nearest locality known of this species is to be found at Heimaey, at 16.5 km from Surtsey.

Discussion

Until now Urospora mirabilis has been found only in pure population at Surtsey. However, it is known from H. JONSSON's work (3) that this species belongs to an algal community, generally composed, along the coasts of Iceland, by several associations where Ulothrix flacca, Bangia fuscopurpurea and Porphyra umbilicalis are predominating. None of these species have yet colonized Surtsey, but it can be assumed that they will do so in the near future. It therefore appears that Urospora mirabilis is the pioneer species of this community. It is also known (4) that the first vegetation

of the supralittoral region, to which this community is confined, does not develop, as do the pioneers of the sublittoral region, into different climax communities. It can therefore be added that Urospora mirabilis is definetively established on the shore of Surtsey. If so, it is probable that Codiolum gregarium, the corresponding unicellular sporophyt of Urospora, soon will appear on Surtsey. From unpublished personal data it is known that this type of heteromorphic life cycle occurs in Iceland.

A striking fact is the small number of algal species established until now at Surtsey. This is even more striking as the algal vegetation on the adjacent coasts, the nearest of which is just 4,4 km away, appears luxuriant, containing about 100 species (the marine Diatoms not included). This situation may, however, be due to two factors exercising their influence on the colonization patterns of algae in Surtsey: the relative isolation of the island and the severe environmental conditions encountered there. An attempt to demonstrate the first of these has been made by following the sequence of colonization on clean substrate transferred from Surtsey to Heimaey, in a well established floral area (see S.V. Hallsson, this report). Within a month and a half the surface of the rock had already been colonized by 8 species of algae. Young Barnacles and Sea-snails occurred also. The distance of Surtsey from adjacent algal vegetation seems therefore to act as an obstacle which delays the dispersal of the algae to the island. The second factor involved, even more important, is the mechanical action of the sea along the very exposed coasts of Surtsey, viz. by scouring the surface of the substrate by means of suspended particles and thus preventing the fixation of spores. This corrosive action is more intensive in the intertidal region than in the supralittoral region. This fact may explain why the first colonization is taking place in the supralittoral region and not in the lower region of the coast.

The marine algae represent the only vegetation actually established in Surtsey. One coastal species of higher plants,

Cakile probably edentula, was found last summer on the sandy beach by FRIDRIKSSON (5), but this first terrestrial growth succumbed soon later under a heavy shower of hot falling tephra from an adjacent submarine volcano. It is perhaps worth mentioning that these plants grew near some thalli of Ascophyllum nodosum cast ashore. It seems therefore likely that the driftweeds met on the shore, may, by means of their decomposition, give rise to organic matter, which enables the implantation of coastal growth. This may also be true for filamentous Fungi, insect pupae and living Acarida found last summer by S. HELGASON (personal communication) in rotted thalli of Ascophyllum, buried under the ash.

Our observations can hardly be compared with those carried out after the terrible eruption of Krakatau in 1883. Indeed, when visited for the first time by botanist, 3 years later, the island was already reoccupied by 11 species of Ferns, 15 species of higher plants and 6 species of blue-green algae, mixed with Bacteria and Diatoms. Nothing is therefore known about the beginning of the colonization (6, 7). Marine benthic algae are not mentioned, probably because of their absence on the coast, which seems to have been of sandy nature only. No comparison is either available with other recent submarine volcanic areas, for example the Isle of Faial, in the Azores, as no studies seem to have been devoted to this problem. On the other hand it is of interest to note that the initial phase of algal settlement of Surtsey shows a succession similar to that observed experimentally on artificial surfaces submerged by HUVÉ (8) in the Mediterranean Sea, although the species differ in the two areas.

Acknowledgements.

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Explanations to figures.

Fig. 1. Two superimposed sketch maps of Surtsey showing the outlines of the island, the nature of the coast and the rocky localities surveyed in 1964 (1,2) and in 1965 (I, II, III, IV). Note the extension of the rocky shore and the alteration of the sandy beach during this time.

(After aerial photos from the Icelandic Geodetic Institute).

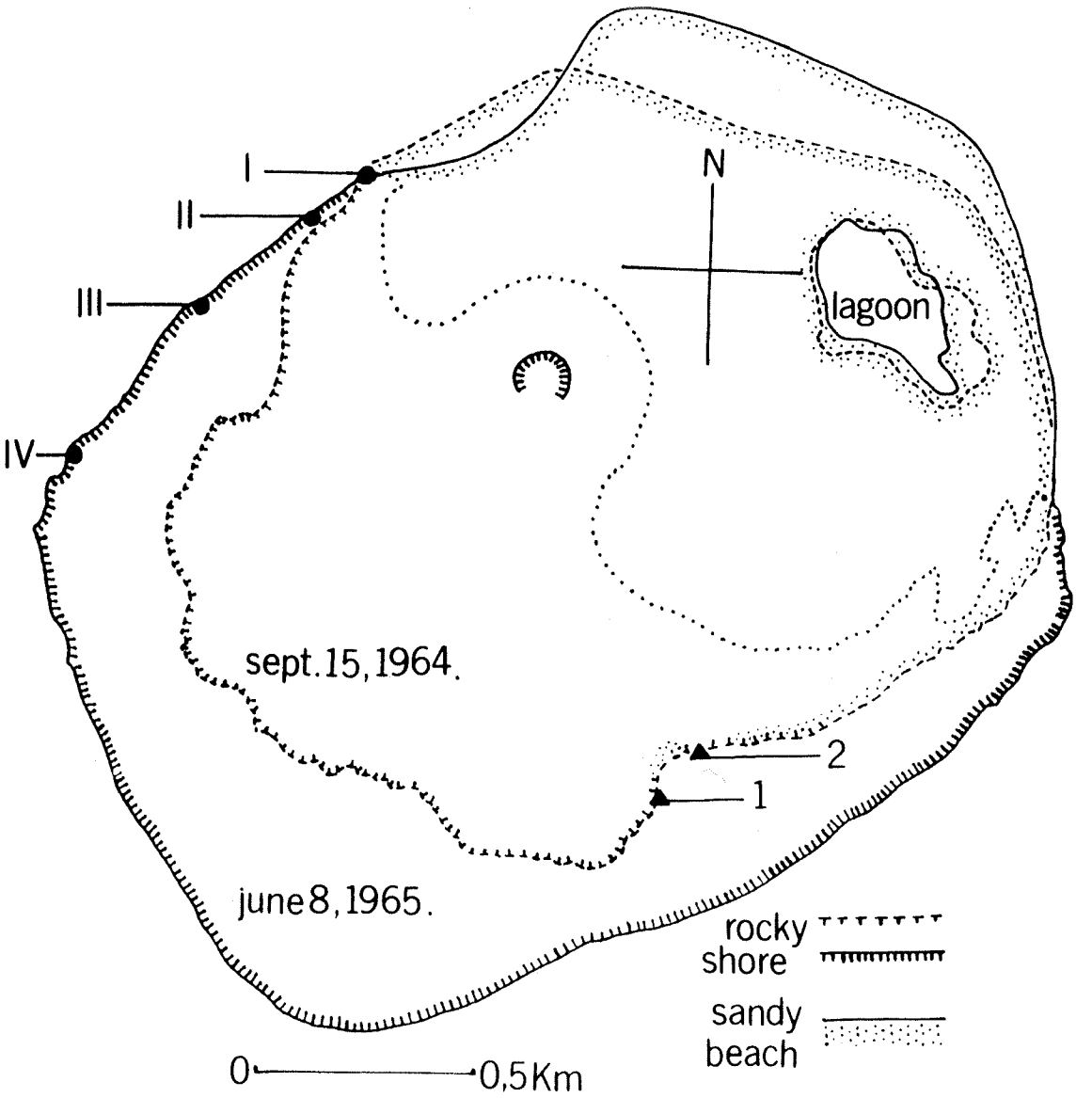
Fig. 2. Cross-section of locality III, showing the position of the vegetation around the high water mark line. MHHW: mean higher high water. MLLW: mean lower low water.

Fig. 3. The first macroscopic benthic vegetation found in Surtsey.

A. Green carpet of Urospora mirabilis (arrow)
B. Gelatinous formation of Diatoms (arrow).

Scale: match-stick: 4,5 cm.
(Photographer: H. Kristinsson)

Fig. 1


I
II
III
IV
N
lagoon
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2
1
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rocky shore
sandy beach
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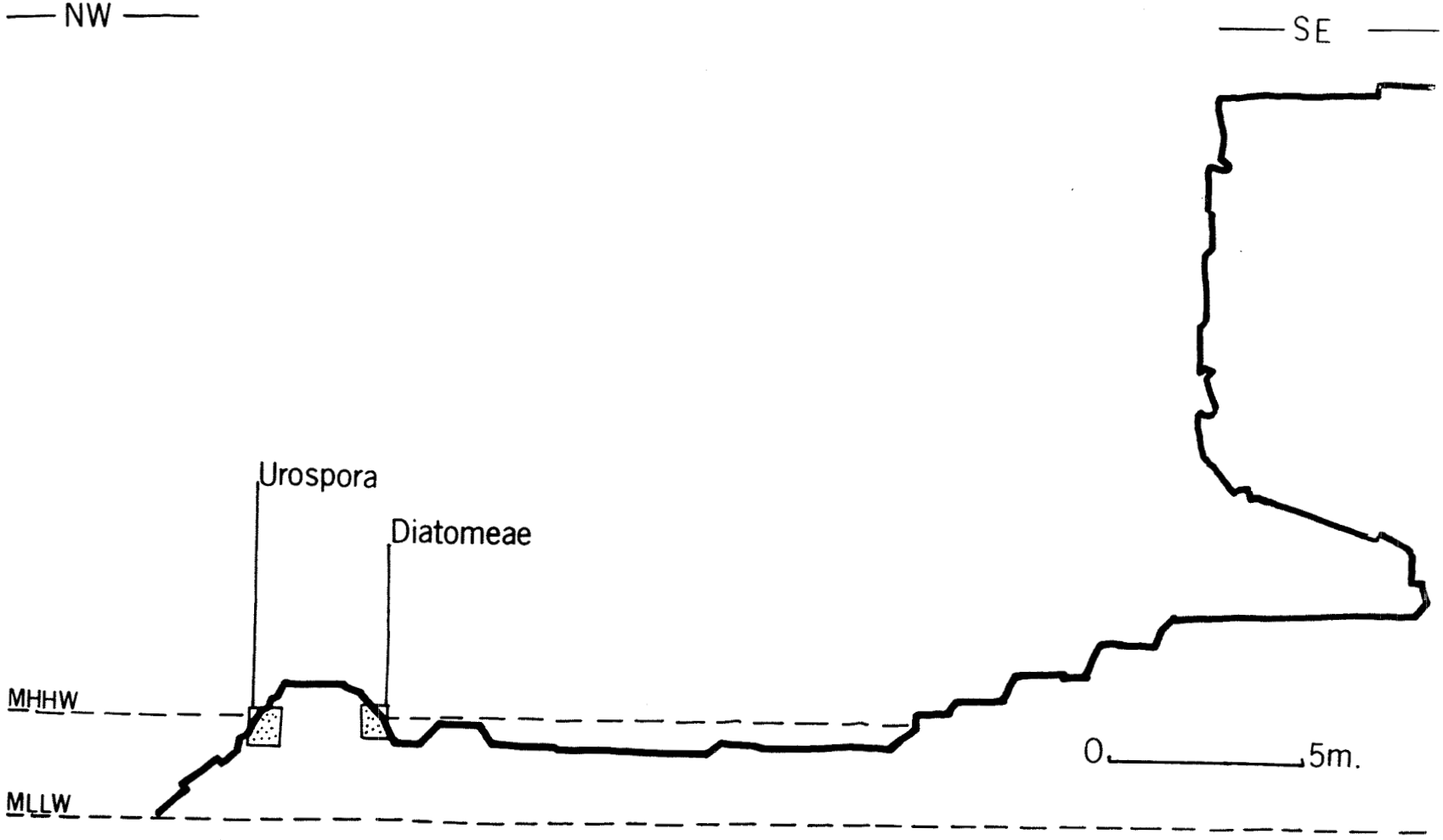

Fig. 2

Fig. 3