Some observations of intertidal communities on Spitsbergen (79°N), Norwegian Arctic

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The zonation pattern of rocky shores on north-west Spitsbergen is described. Intertidal communities on protected sites have features remarkably similar to temperate areas. Black lichens dominate the littoral fringe, fucoids and gastropods the eulittoral zone, whereas upper sublittoral zone is occupied by kelp. The species composition seems to be typical for the Atlantic arctic areas.

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The Svalbard archipelago is situated in the north-eastern Atlantic, north of 75°N. The shore environment at this latitude is harsh. Sea ice covers almost the entire coast in the winter, and disappears in summer only from the west coast, due to the influence of warm Atlantic water (Coachman & Aagaard 1974). Thus, most shores are ice scoured, and are in addition influenced by melt water and sediments from spawning glaciers.

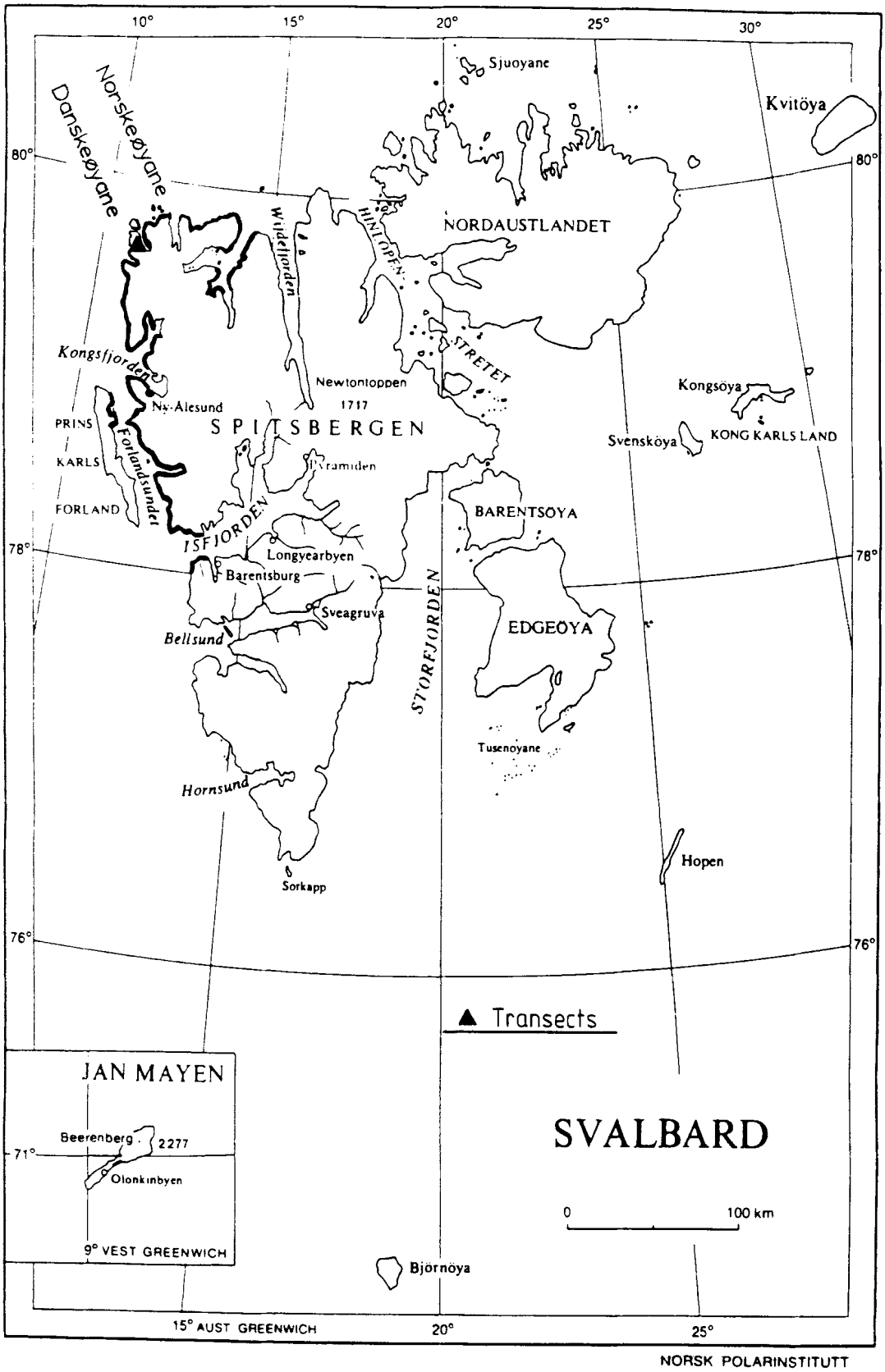
Studies on the marine intertidal flora in Svalbard are few. Some comments are given by Kjellman (1883), Walton (1922), Summerhayes & Elton (1923) and Zinova (1961), whereas Svendsen (1959) and Florczyk & Latała (1989) give a more detailed description from western Spitsbergen (Isfjorden, 78°N, 14°E) and Hornsund (77°N, 17°E), respectively. The information on the intertidal fauna is also limited. Observations on soft or rocky intertidal fauna on western Spitsbergen are given by Feyling-Hansen (1953), Radziejewska & Stankowska-Radzium (1979), Węsławski (1983) and Ambrose & Leinaas (1988). In addition, some notes can be found in Summerhayes & Elton (1923) and in different pollution reports (e.g. Schei et al. 1979; Gulliksen & Taasen 1982).

This paper is based on data collected on an expedition to Spitsbergen in August 1987. Rocky, intertidal communities on northwestern Spitsbergen are here described for the first time. Quantitative data are given on both flora and fauna with special weight on zonation patterns. The results are discussed in relation to intertidal studies in temperate regions.

Study area and methods

The survey was undertaken between Isfjorden (78°N, 14°E) and Woodfjorden (79°N, 14°E). Nearly the whole coast line was open, with low cliffs of granite and sandy or stony beaches (see Ødegaard et al. 1987; Hjelle & Lauritzen 1982). Numerous glaciers terminate in the sea, discharging fresh water along with masses of sediment. Inlets and skerries are mainly found around Danskeøyane and Norskøyane (79°40′–50′N).

The sea ice forms in fjords and shallow water in December and disappears in May. However, ice-masses in the East-Spitsbergen Current drift along parts of the west coast in spring and early summer (Vinje 1985). The north-west coast is free from ice about two to three months in the summer, but northerly winds often bring ice to the coast. The air temperature in Ny-Ålesund is highest in July (mean 4.5°C) and lowest in March (mean −12.1°C). The mean temperature is below the freezing point for 9 months, and the temperature sometimes falls below −30°C (Steffensen 1969). The mean sea temperature on the surface along the western outer coast is approximately 3–4°C in mid-summer, whereas the temperature in the fjords can be lower (see Svendsen 1959; Schei et al. 1979). Salinity measurements in mid-summer in the outer part of Isfjorden gave values between 29 to 34‰ (Svendsen 1959). At 78°N the sun does not set between 21 April and 22 August. It disappears on 26 October and is continuously below the horizon until 14 February. Thus, there is darkness for



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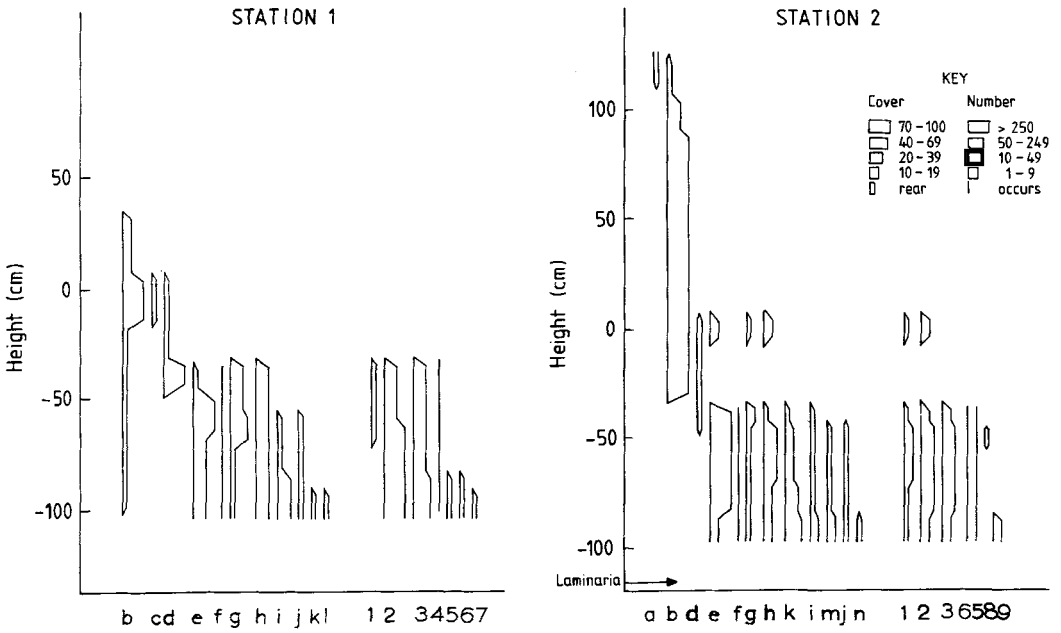

Fig. 2. Vertical distribution of organisms in the two transects from Danskeøyane (79°40'N), northwestern Spitsbergen. a: *Prasiola stipitata*; b: *Verrucaria maura*; c: *Rhizoclonium riparium*; d: *Fucus vesiculosus*; e: *F. distichus*; f: *Elachista fucicola*; g: *Verrucaria mucosa*; h: *Hildenbrandia rubra*; i: *Ralfsia* 2 spp.; j: *Spongomorpha* 2 spp.; k: *Pilayella littoralis*; l: *Sphacelaria* sp.; m: *Chordaria flagelliformis*; n: *Scytosiphon lomentaria*; 1: *Balanus balanoides*; 2: *Littorina saxatilis*; 3: *Gammarus oceanicus*; 4: *Oligochaeta* indet.; 5: *Bryozoa* indet.; 6: *Hydroidae* indet.; 7: *Fabricia sabella*; 8: *Margarites helicinius*; 9: *Caprella septemtrionalis*.

several months. The tidal amplitude in the area is low. Normal high and low water is 131 and 70 cm, respectively (Svendsen 1959).

Community analysis was performed in two quantitative transects at Danskeøyane. Three quadrates of 50 × 50 cm were positioned within each vertical interval of 50 cm on a transect running perpendicular to the shore (giving a total of 9 and 12 + 1 quadrates on Station 1 and 2, respectively). All plants and animals >1 mm were recorded. The percentage cover of the vegetation and sessile fauna inside each quadrate was estimated by use of 25 sub-quadrates, each covering 4%, whereas vagile animals were counted. The substrate in both transects consisted of large stones and rock, and the slope varied between 10 and 30°. The shore east and south of Danskeøyane and Norskøyane, which had a very poorly developed intertidal vegetation, was observed by boat, and no transect analysis was performed (see Fig. 1).

Results

As mentioned, the open rocky coast and the coast inside Krossfjorden and Kongsfjorden had a very poor vegetation consisting of a bright green filmy cover of the green algae *Ulothrix sp.* and *Urospora pencilliformis* (Roth) Aresch. In crevices and in protected inlets dwarf individuals of the brown algae *Fucus distichus* L. and *Pilayella littoralis* (L.) Kjellman were observed. No obvious zonation pattern arose.

Twenty-three taxa were recorded from the transects at Danskeøyane: 14 algae taxa and 9 animal taxa. Details from the transects are shown in Fig. 2.

The upper intertidal zone was dominated by lichens of the genus *Verrucaria*, probably mostly *V. maura* Wahlenb. The macro-algal vegetation consisted of the two green algae *Prasiola stipitata* Suhr in Jessen and *Rhizoclonium riparium* (Roth) Kuetz. ex Harvey, both with low cover. *R. ripa-*

Fig. 1. Map of the Norwegian Arctic with the observed areas (bold lined) and transect locations (marked).

rium was restricted to crevices and shadowy places where a filmy cover of blue-green algae was also found. On a plateau in the upper intertidal in Transect 2, influenced by bird droppings, a dense carpet of *P. stipitata* occurred along with the terrestrial species *Prasiola crispa* (Lightf.) Menegh.

Further down the brown canopy shaped alga *Fucus vesiculosus* L. formed a narrow but distinct zone, which was especially well developed in Transect 1. The canopy shaped *F. evanescens* was the predominant alga in both transects. It extended down into the sublittoral zone in Transect 1, but in Transect 2 its cover decreased noticeably in the lower part of the eulittoral zone. Both fucaceans were small, but nevertheless old plants. Fertile receptacles were observed on *F. evanescens*. The small brown alga *Elachista fucicola* (Velley) Aresch. grew as an epiphyte on *F. evanescens* in the lower eulittoral.

The undervegetation in the fucacean zone was poor, consisting of the lichens *V. maura*, *V. mucosa* Wahlenb. and the crustose red alga *Hildenbrandia rubra* (Sommerf.) Menegh. Further down two crustose species of the genus *Ralfsia*, two filamentous green algae species of the genus *Spongomorpha* and *P. littoralis* were found. *P. littoralis* occurred relatively abundantly in Transect 2 in areas where the cover of fucaceans was low. The brown algae *Scytosiphon lomentaria* (Lyngbye) Link, *Chordaria flagelliformis* (O. F. Muell) Agardh and a filamentous species in the genus *Sphacelaria* were found in small quantities.

The fauna consisted of 6 taxa groups designated as three species of Amphipoda, one Hydroida, two Gastropoda, one Bryozoa, one Polychaeta and some unidentified Oligochate species. The gastropod *Littorina saxatilis* (Olivi), the amphipod *Gammarus oceanicus* Segerstråle and the barnacle *B. balanoides* were the most common species. All three were only recorded from the fucacean zone. The abundance of the two former species was relatively high. More than 500 individuals of the gastropod were recorded per 0.25 m^2, and up to 100 of the amphipod. The barnacle population was low, consisting of older individuals. *G. oceanicus* consisted of two size groups: juveniles from this season, and individuals between one and three years old (A. Ingolfsson pers. comm.). Small quantities of Bryozoa, Hydroids and the polychaete *Fabricia sabella* (Ehr.) were observed on bare rock, under dense cover of fucaceans, together with two single findings of the amphipod *Amphithoe rubricata* (Montagu). Some sediments in Transect 1 were abundantly inhabited by oligochaetes.

Discussion

The intertidal zone of most of the west and north coast of Spitsbergen has a very poor intertidal flora and fauna, undoubtedly caused by a combination of factors such as heavy ice-scouring, wave action, melt water, sedimentation and possibly inadequate supply of nutrients (see Lee 1973). Areas where the intertidal zone is well developed were mainly found around Danskeøyane and Norskøyane in the northwest. This is in accordance with observations by Feyling-Hansen (1953), who observed luxuriant fucacean zones in only 6 of 32 localities between Isfjorden and Verlegenhuken (northeastern Spitsbergen), all around these islands.

The main zonation pattern on protected sites recorded here corresponds remarkably well to those described along the temperate coast in the North Atlantic (Lewis 1964). The upper zone of lichens represents the littoral fringe. No animals were recorded, not even *L. saxatilis* which is a very typical periwinkle in this zone in temperate regions. This periwinkle was only common in the *Fucus* zone. The difference in the width of the littoral fringe in the two transects was caused by different degrees of wave exposure. A barren pale strip observed in the lower part of this zone in the Canadian Arctic by Ellis & Wilce (1961) was not seen.

The upper limit of fucaceans serves to mark the boundary between the littoral fringe and eulittoral zone on Spitsbergen. In the temperate region the upper limit of the barnacle zone is often used to set the boundary (Lewis 1964), but on Spitsbergen the barnacle did not form a distinct zone. The main element in the eulittoral zone was *F. evanescens*, which is in agreement with observations from the Canadian Arctic (Ellis & Wilce 1961). The cover of *F. evanescens* in Transect 2 was markedly reduced in the lower eulittoral, corresponding to a high density of *P. littoralis*, possibly due to competition.

The upper limit of kelp is the boundary between the eulittoral and the sublittoral zone in Lewis' scheme. This demarcation was observed in Transect 2, although it was impossible to sample in the sublittoral zone. In Transect 1 we observed that *F. evanescens* was extending down into the sublit-

toral zone, and no Laminarian plants were observed.

F. evanescens, the dominant intertidal algae on the northwestern coast of Spitsbergen both in cover and biomass, is widespread in arctic regions of the North Atlantic. The species is chiefly found sublittorally in the extreme north (Rosenvinge 1926, 1910), but intertidal populations are reported from Ellesmere Island (Rosenvinge 1926) and Store Kolbeinsøy, East Greenland (75°50'N) (Rosenvinge 1910). It can grow under low irradiances, and it has a high response to increased photoperiod in early spring conditions, probably an adaptation to enable growth at low light levels in late autumn and early spring (Strømgren 1985). In North Norway the species is a dominant one on exposed coasts, but is scarce on protected sites, probably due to competition from *Ascophyllum nodosum* (L.) Le Jolis and *F. vesiculosus*. *Pilayella* and *Spongomorpha* seem to be well adapted to harsh intertidal conditions. These species can survive unfavourable periods as reduced fronds (Garbary 1976), and if they behave in the same manner as in temperate regions, they can reproduce throughout most of the year (South & Hooper 1980). *L. saxatilis* and *B. balanoides* are both known from arctic areas. The species are recorded in Agmagsalik (66°N) in East Greenland and in Upernavik (73°N) in West Greenland. Their distribution seems to follow closely the warm Atlantic water intruding into the arctic regions (Ellis & Wilce 1961). *G. oceanicus* is a common species in the intertidal of boreo-arctic regions (Steele & Steele 1974; Węsławski 1983).

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