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Intertidal zone of Svalbard

3. Littoral of a subarctic, oceanic island: Bjornoya

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Abstract Twenty-two stations in the intertidal and shallow sublittoral of Bjornoya (74 °N, 19 °E) were studied in August 1994 revealing a large and diverse standing crop of macro-algae (16 species) and littoral macrofauna (at least 17 species). In most places the biomass of littoral macroorganisms exceeded 100 g ww/m^2. In the shallow sublittoral, between 2 and 20 m, 45 animal taxa and 23 algae species were collected. Littoral coarse sand meiofauna was dominated by Turbellaria, while, on algae, Halacaridae and Harpacticoida predominated. Meiofauna densities ranged from 0 to 169 ind./10 cm^2 and biomass from 0 to 0.4 g dw/m^2. The abundance of littoral species and their zoogeographic origin resemble that of Spitsbergen more than that of the northern Scandinavian coast, although both are of equal distance from Bjornoya. The first record of the boreal bivalve *Mytilus edulis* from the island is presented. Another striking feature was the presence of the arctic amphipod *Gammarus setosus* and the absence of its boreal sibling species *G.oceanicus*.

Introduction

This paper is the third in a series concerning the intertidal zone of the Svalbard archipelago. Previous reports have dealt with the intertidal macrofauna of Spitsbergen (Węsławski et al. 1993) and its meiofauna (Szymelfenig et al. 1995).

Bjornoya is the southernmost island of the Svalbard archipelago and is situated half-way between the Scandinavian Peninsula and Spitsbergen, about 500 km from the nearest land. For the European coastal fauna and flora it represents a potential stepping-stone for dispersion and migration to the Arctic. Its ecological and zoogeographical significance as a subarctic, oceanic island was noted in the classical work of Summerhayes and Elton (1923), who reported the Bjornoya littoral to be barren. Although the shelf waters surrounding Bjornoya are among the best known and studied fishing grounds in Europe (Robertson 1932; Lee 1952; Blacker 1957; Wiborg 1970; Dyer et al. 1984), surprisingly little information is available concerning its shallow sublittoral and intertidal waters, with only two workers (Christiansen 1965; Gulliksen 1979) having considered these areas. Additional information on individual species distribution can be found in the taxonomic and zoogeographical literature (South and Tittley 1986). In these works the littoral was considered more or less barren except for gammarid amphipods. The Gulliksen survey (1979) provides some quantitative information on the sublittoral, based on SCUBA-collected samples.

Present-day concerns over global climate change, as well as the potential threat of oil spills in the area (Bergsager 1984), provide a context for the new studies of Bjornoya coasts presented here. These aim to determine faunistic changes and provide data on marine biodiversity of the area.

Materials and methods

Study area

Bjornoya is situated at 74 °N and 17 °E. It is a rocky pear-shaped island of 20 km diameter, reaching elevations of no more than 400 m (Fig. 1). It lies on a large shallow extension of the Barents Sea shelf (Bjornoyabanken), and is boardered to the north by a 300-m-deep trough (Kveitehola) and to the south by the 500-m-deep Bjornoyarenna. For about 30 km around the island, depths do not exceed 100 m. Bjornoya is situated in the frontal zone of two major water masses; the warm West Spitsbergen Current (summer surface sea temperatures +4 to +8 °C) and the cold Barents Current (or Bjornoya Current with waters of summer surface temperature 0–1 °C). Tidal waters in July 1994 were very well mixed, being +4 to +5 °C temperature and 34 ppt salinity all around the island. This pattern was repeated in the shallow sublittoral. Tides are of M2 type, with an amplitude of up to 1 m. Ice

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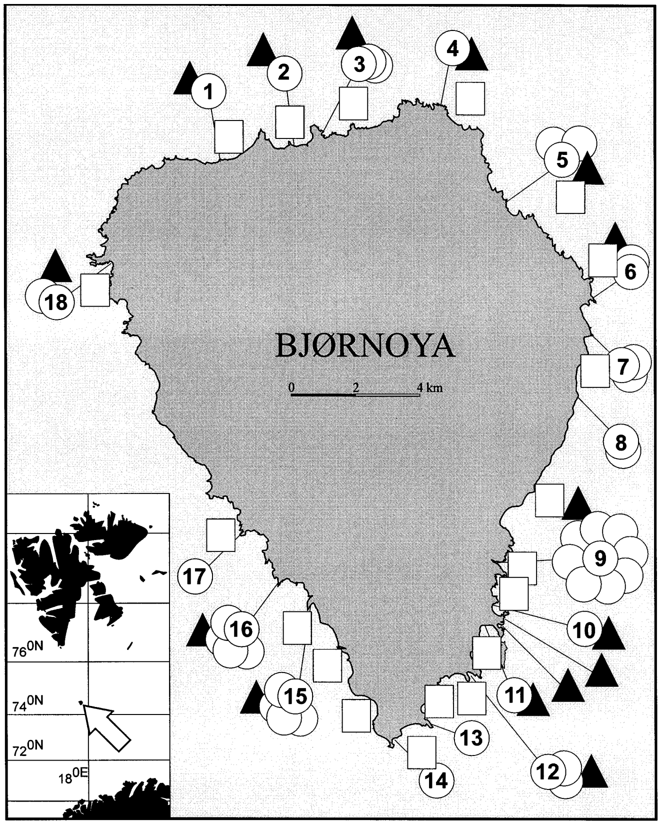

Fig. 1 Sampling stations in the littoral of Bjornoya, July 1994. *Circles* denote macrofauna samples, *squares* meiofauna sampling and *triangles* sublittoral dredgings

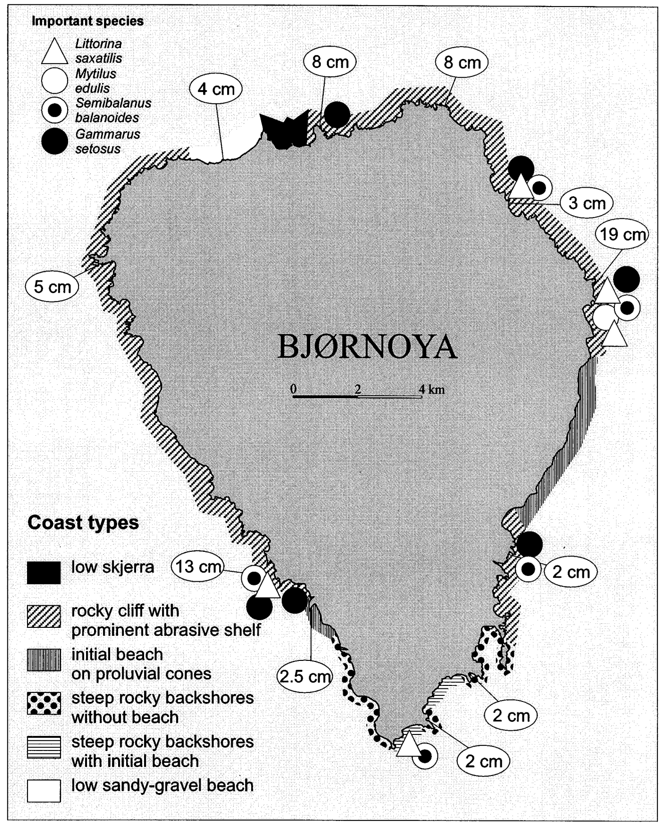

Fig. 2 Types of coast and important littoral species occurrence at Bjornoya. Number of centimeters indicates maximal length of *Fucus distychus* fronds

was not present in July 1994, but reports claim the usual drift-ice cover disappears in late May and returns again in February (Vinje 1977; Den Norske Los 1988). Tidal currents around Bjornoya are very strong, and in coastal narrows may reach 3–5 knots. All coasts of the island are greatly exposed to wave action.

According to the classification used in our previous studies, five types of coast have been determined on Bjornoya (Fig. 2). The dominant features are high rocky cliffs with a beach at their foot but small pocket beaches of coarse sand and large gravel are found in many localities. One longer stretch of sandy beach (Kobbebukta) lies on the north coast. Low and flat skjerra occur in many localities (Horn and Orvin 1928).

Bjornoya hosts one of the biggest seabird colonies in the Northern Atlantic area (Isaksen and Bakken 1995): wading birds, however, are not common. Eiders have been observed close to the shore but never in great numbers. No sea mammals were observed within 1 nautical mile to the shore during our survey. Litter (mainly plastic objects) was found on all pocket beaches, but never in very high amounts (below 2 objects/100 m beach). Stranded kelp was found in a few localities, but never in large quantities.

Samples were collected in the intertidal and shallow sublittoral (between 2 and 30 m depth). Littoral stations were chosen to be representative of common biotopes. The distribution of sampling stations reflected coastal topography, sites being closest together in the most complex areas. Sampling was conducted at low tide. Records of salinity and temperature, coastal geomorphology, the width of the intertidal zone, and type of substratum were made at each point in additon to notes on stranded objects and photographs. Besides collections made at sampling stations, the whole coastline was inspected from a rubber boat. Forty-two samples were collected at 18 littoral sampling stations (Fig. 1). Macroorganisms were collected quantitatively from three randomly selected squares (625 cm^2 each), at mid-water line. Samples were mixed together and preserved in 4% formaldehyde solution. On hard substrata organisms were removed by scraping with a knife while on soft sediments the upper 5 cm was collected. A handnet was used to collect mobile organisms at 0.5-m depth nearby. Each sample was sieved on 0.5-mm-mesh screen, sorted and identified to the lowest taxonomic level. Biomass was measured as wet weight (plus/minus 0.2 mg) after the organisms had been gently blotted on filter paper. In this paper, the wet weight is presented unless otherwise stated. Dry weight and calorific equivalents were taken from previous studies (Węsławski et al. 1993).

Fucus fronds were measured in most localities, and the longest recorded at any given locality was presented as "maximal *Fucus* length".

The meiofauna was sampled with a core tube of 2-cm diameter, inserted into sediment to 5-cm depth, at low-, mean- and high-water marks. Samples were stained with Rose Bengal and extracted on a stack of sieves of 1 mm, 0.5 mm, 0.2 mm, 0.1 mm and 0.57 mm. Meiofauna was sorted to major taxa, counted, and measured to calculate the biomass, using the methods outlined by Szymelfenig et al. 1995.

Shallow sublittoral macrofauna was collected using a light triangular dredge of 30 × 30 × 30 cm opening and 1-mm mesh size. Samples were washed on a 0.5-mm screen and preserved in 4% formaldehyde. Dredging was completed at 15 stations, and in most of them on approximatively 3-, 7- and 15-m depths by towing parallel to the shore line (Fig. 1).

Results concerning species occurrence are presented in terms of their frequency (F%), which relates to the number of times a species occurred in all samples taken by the method under consideration. Numerical dominance (D%) relates to the number of individuals of a species compared to all individuals of all species collected.

Results

Macroorganisms abundance

Forty-two invertebrates taxa, 3 fish species and 23 macroalgae species were found in 42 littoral and 35 shallow sublittoral samples (Table 1). In the littoral samples, only 6 macrofauna taxa and 12 macrophytes were frequent with the crustacean *Gammarus setosus* and the algae *Pilayella littoralis* and *Fucus distychus*. In the sublittoral samples, the crustacean *Ischyrocerus* spp. (mostly *I. anguipes*) was most abundant, and was accompanied by a number of gastropods and crustaceans, typical of kelp meadows, dominated by *Laminaria sachcharina*. *Littorina saxatilis*, *Semibalanus balanoides* and *Gammarus setosus* occurred on all island coasts (Fig. 2). *Fucus* length did not exceeded 3 cm in most localities, with the exception of a single, very sheltered, place (Fig. 2).

Biomass

The biomass of littoral macroorganisms ranged from neglible on exposed gravel beaches to nearly 2000 g wet weight/m^2 on sheltered skjerra. The biomass- rich areas were patchily distributed all along the island coast. The main biomass component of the fauna was represented by gammarid amphipods, while filamentous algae were generally most important among plants exceeding 500 kJ/m^2 (Table 2, Fig. 3). We collected no quantitative data from the sublittoral, which is mostly barren bottom covered with shell fragments.

Communities in the littoral

Gammarus community

This was found among loose stones on sheltered beaches and consisted of *Gammarus setosus* (subarctic-arctic species) with an admixture of large oligochaetes and occasionally, in soft- sediment pockets, polychaetes (*Flabelligera* sp.). The density of macrofauna ranged from 20 to 800 ind./m^2 with a biomass of 1–12 g/m^2 (Table 2).

Fucus- Semibalanus community

This was dominated by *Fucus distychus* with attached peryphyton, *Semibalanus balanoides* and *Littorina saxatilis ag*. The density of macrofauna ranged from 10 to 800 ind./m^2, and biomass was 120–2000 g/m^2.

Oligotrophic community

This community type had neither macrofauna nor macrophytes and was found on sandy and gravel beaches. It was dominated by Turbellaria with a biomass of less than 1 g/m^2.

Chlorophyta or green algae community

This community consisted of dense cover of filamentous *Acrosiphonia*, *Enteromorpha*, *Ulothrix*, and *Urospora* with a low number of amphipods: biomass 10–400 g/m^2, density 12–400 animals /m^2. This was the most commonly dispersed assemblage in the littoral along the coasts of Bjornoya (Fig. 3).

Communities in sublittoral

Laminaria - Margarites - Caprella community

This is also typical of the Spitsbergen coast, with numerous gastropods (*Margarites groenlandica*) and small amphipods (*Ischyrocerus anguipes, Caprella septentrionalis*). This community was restricted to rocky outcrops. Two fish species were commonly observed here (*Myoxocephalus scorpius, Liparis* spp.).

Mysis oculata - amphipods community

This community occurred on coarse shell sands. It contained nine actively motile crustacean species represented by large numbers of individuals. Both sublittoral assemblages mentioned above occurred randomly in samples collected from 3-, 7- and 15-m depths.

Meiofauna

Collections from soft sediment – mainly pocket beaches – were made around the island (Fig. 1). The density of the meiofauna ranged from 0 to 167 ind./10 cm^2 (mean 39.8, SD 43), and biomass from 0 to 0.4 g dry weight/m^2. Individual weights of the most important taxa are given in Table 3. Turbellaria were numerically dominant in most of the samples. Nematoda and Harpacticoida were next in abundance and frequency of occurrence. The meiofauna was also sorted from the littoral samples of algae, but here only a rough estimate of biomass was possible – it ranged from 0.1 to 0.5 g dw/m^2. At station 10, a series of similar pocket beaches was selected to represent the small-scale variability. Meiofauna density in 18 such samples ranged from 0 to 167 ind./10 cm^2, (mean 22.5, SD 40). Respective biomass values ranged from 0 to 0.29 g dw/m^2 (mean 0.254, SD 0.388).

Discussion

The species list presented in this study gives 45 faunal taxa, while Gulliksen (1979) noted 85 taxa from the same area. Comparison of the two studies is difficult as Gulliksen's work was performed over a larger depth range (0–50 m) and employed different methods of sample collection. In particular, Gulliksen used diving to collect samples from sublittoral hard substrata and this material contributed significantly to the difference

Table 1 Check list of species found in present study. In 1994 samples, asterix indicates presence of dead or fragmented individuals. For Gulliksen (1979) samples, asterix indicates species presence

Taxon	1994, 0–2 m (42 quant. sample) Frequency %	1994, 2–25 m (36 dredgings) Frequency %	1977–1978 (0–50 m) Gulliksen (1979) Presence
Zoobenthos			
Porifera			
Leucosolenia sp.			*
Grantia sp.			*
Clathria sp.			*
Sycon sp.			*
Halichondria panicea (Pallas)			*
Spongiae indet.		2.9	*
Coelenterata			
Actiniaria indet.		*	*
Coryne sp.			*
Electra sp.			*
Haliclystus octoradiatus H.J. Clark		*	
Hydrozoa indet.	2.4	2.9	*
Lafoe sp.			*
Sertularia tenera G.O. Sars			*
Sertulariidae indet.			*
Nemertina indet.			*
Turbellaria	7		
Nematoda indet.		*	*
Bryozoa			
Alcyonidium gelatinosum (L.)		17.1	
Bryozoa indet.	2.4	5.7	
Crisia sp.			*
Eucratea loricata (L.)			*
Flustra sp.			*
Lichenophora sp.			*
Scrupocellaria scrupea Bsk.			*
Tricellaria ternata (Ellis & Solander)			*
Valkeria uva (L.)			*
Halacaridae indet.	31	*	
Pantopoda indet.		5.7	*
Crustacea			
Anonyx sarsi Steele & Brunel		20	*
Semibalanus balanoides (L.)	12	5.7	
Balanus balanus (L.)		*	*
B. crenatus Brugiere			*
B. hammeri (Ascanius)			*
Caprella septentrionalis Kroyer		42.9	*
Dajus mysidis Kroyer	*	*	
Eupagurus pubescens (Kroyer)		5.7	*
Gammarellus homari (Fabricius)	10	54.3	*
Gammarus setosus Dementieva	21	5.7	
Harpacticoida indet.	67	*	
Hyas araneus (L.)		5.7	*
Ischyrocerus anguipes Kroyer	2.4	80	*
Metopa bruzelii Goes			*
Metopa sp.			*
Mysis oculata (Fabricius)		65.7	
Onisimus edwardsi Kroyer		22.9	*
O. littoralis (Kroyer)		31.4	
Parapleustes assimilis (G.O. Sars)			*
Pleusymtes glabroides (Dunbar)		5.7	
Oligochaeta indet.	62	*	*
Polychaeta			
Amphitrite cirrata O.F. Muller			*
Anaitides sp.			*
Capitella capitata (Fabricius)			*
Cirratulus cirratus (O.F. Muller)			*
Fabricia sabella (Ehrenberg)	12		
Harmothoe sp.		28.6	*
Nainereis quadricuspida (Fabricius)			*
Nereis pelagica L.			*

Table 1 (Continued)

Taxon	1994, 0–2 m (42 quant. sample) Frequency %	1994, 2–25 m (36 dredgings) Frequency %	1977–1978 (0–50 m) Gulliksen (1979) Presence
Nereis sp.			*
Nicolea zostericola (Oersted)			*
Pholoe minuta (Fabricius)			*
Phyllodicidae indet.			*
Polynoidae indet.			*
Pygospio elegans Claparede			*
Spio filicornis (Muller)		2.9	*
Spionidae indet.		2.9	*
Spirorbis spiryllum (L.)		8.6	
Spirorbis indet.			*
Syllidae indet.			*
Terebellidae indet.		8.6	*
Thelepus cincinnatus (Fabricius)			*
Typosyllis sp.			*
Mollusca			
Alvania castanea (Muller)			*
Buccinum undatum (L.)		47	*
Chlamys islandica (Muller)			*
Dendronotus frondosa (Ascanius)			*
Hiatella arctica (L.)		*	*
Lacuna divaricata (Fabricius)			*
Littorina saxatilis (Olivi)	14.3		
Margarites groenlandicus (Gmelin)	2.4	57.1	*
M. helicinus (Fabricius)		*	
Musculus discors (L.)			*
M. laevigatus (Gray)		5.7	
M. niger (Gray)			*
Mytilus edulis L.	2.4		
Onchidopsis camea Bergh			*
Velutina velutina (Muller)			*
Ascidiacea			
Aplidium glabrum (Verill)			*
A. mutabile (Sars)			*
A. pallidum (Verill)			*
Ascidia prunum Muller?		8.6	
Dendrodoa aggregata (Rathke)	2.4	5.7	*
Didemnum albidum (Verill)			*
Molgula griffithsii (MacLeay)			*
M. siphonalis M. Sars			*
Sidnyum turbinatum Savigny			*
Styela rustica (L.)			*
Synoicium incrustatum (M. Sars)			*
S. pulmonaria (Ellis & Solander)			*
Synoicium sp.		*	*
Synoicium turgens Phipps			*
Tridemnum tenerum (*Verill*)			*
Echinodermata			
Asterias sp.			*
Cucumaria frondosa (Gunnerus)		2.9	*
Ophiopholis aculeata (L.)			*
Strongylocentrotus sp.		*	*
Pisces			
Boreogadus saida (Lepechin)		11.4	
Liparis sp.		*	
Myoxocephalus scorpius (L.)		8.6	
Phytobenthos			
Acrosiphonia flagellata Kjellman	4.8	7.6	
A. incurva Kjellman	7.1	2.9	
A. sonderi (Kutzing) Kornmann	33.3	17	
Alaria esculenta (L.) Greville	4.8	21.4	
Chorda tomentosa Lyngbye		5.7	
Chordaria flagelliformis (Muller) Agardh	19.1	8.6	
Cladophora sp.	2.4		
Delamarea attenuata (Kjellman) Rosenvinge		2.9	
Dictyosiphon foeniculaceus (Hudson) Greville		2.9	

Table 1 (Continued)

Taxon	1994, 0–2 m (42 quant. sample) Frequency %	1994, 2–25 m (36 dredgings) Frequency %	1977–1978 (0–50 m) Gulliksen (1979) Presence
Dilsea integra (Kjellman) Rosenvinge		2.9	
Enteromorpha prolifera (Muller) Agardh	16.7		
Fucus distichus L.	38.1		
Halosaccion arcticum L.	4.8		
H. ramentaceum (L.) Agardh	16.7	17.1	
Laminaria cf. agardhi		5.7	
Laminaria saccharina (L.) Lamouroux	4.8	11.4	
Laminaria sp.		5.7	
Palmaria palmata (L.) Kuntze	2.4	5.7	
P. pulmonaria	2.4		
Phycodrys rubens (L.) Batters	2.4	8.6	
Phyllophora truncata (Pallas) Zinova		2.9	
Pilayella littoralis (L.) Kjellman	42.9	2.9	
P. varia		2.9	
Scytosiphon lomentarius (Lyngbye) Agardh	2.4		
Sphacelaria arctica Harvey		2.9	
Urospora penicilliformis (Roth) Areschoug	2.4	5.7	

Table 2 The characteristics of littoral assemblages

Bjornoya littoral assemblages	*Fucus* (n = 16) Ind./m^2	F%	*Gammarus* (n = 9) Ind./m^2	F%	Chlorophyta (n = 18) Ind./m^2	F%	Oligotrophic (n = 13) Ind./m^2	F%
Acrosiphonia flagellata						11.1		
A. incurva		19						
A. sonderii		38		33		27.8		
Alaria esculenta		6				5.6		
Ascidia nd.			3	11				
Balanus balanoides	75.0	13	58	11	102.8	11.1		
Bryozoa n.d.	1.6	6						
Chordaria flagelliformis		19		11		22.2		
Cladophora sp.						5.6		
Cypris balanus	9.4	6						
Enteromorpha prolifera		13				27.8		
Fabricia sabella	882.8	25			1388.9	5.6		
Fucus distichus		100						
Gammarellus homari	3.1	13	3	11	1.4	5.6		
Gammarus setosus	3.1	6	750	100				
Halacaridae	734.4	25			519.4	33.3		
Halosaccion arcticum						11.1		
H. ramentaceum		25				16.7		
Harpacticoida	2615.6	63			2888.9	77.8		
Hydrozoa nd.			3	11				
Ischyrocerus sp.	3.1	6						
Laminaria saccharina						11.1		
Littorina saxatilis	48.4	25	14	22				
Margarites groenlandicus	4.7	6						
Mytilus edulis	1.6	6						
Oligochaeta	1789.1	81			583.3	50.0		
Palmaria palmata		6						
Urospora cf. *penicilliformis*						5.6		
Phycodrys rubens		6						
Pilayella littoralis		56				50.0		
Polychaeta n.d.	309.4	44	278	33	794.4	27.8		
Scytosiphon lomentarius						5.6		
Turbellaria	31.3	6	139	11	1.4	5.6	20000	100
Biomass ww g/m^2								
Biomass min.	95		60		1			
Biomass max.	958		1953		1468			
Biomass mean	630		583		597			
Biomass SD	287		686		375		< 1	
Energy value kJ/m^2	2236		1560		1539		< 1	

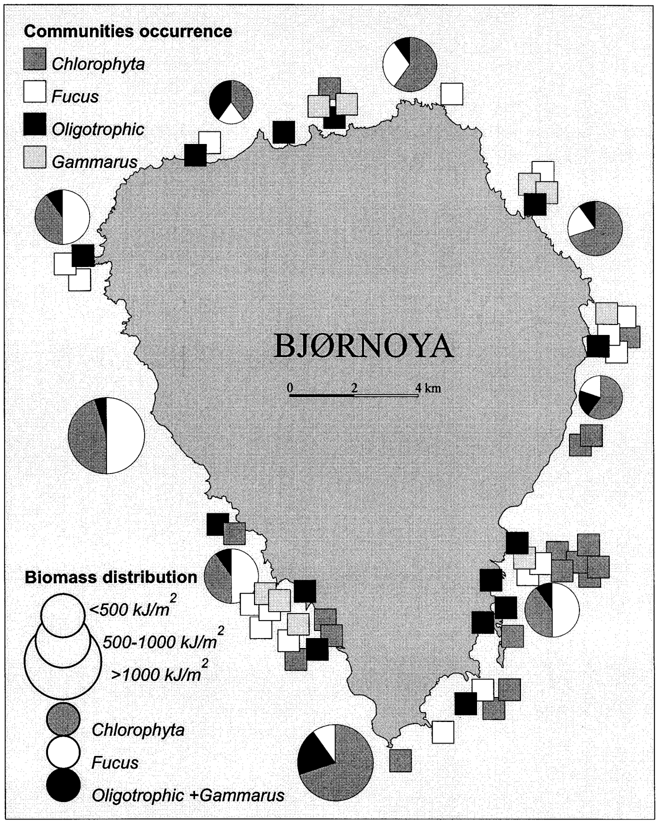

Fig. 3 Intertidal biomass distribution and littoral assemblages occurrence along Bjornoya coast

Table 3 Meiofauna individual biomass (dry weight), frequency of occurrence (%) and maximal density (ind./10 cm^2) of principal meiofaunal taxa collected from sandy beaches

Taxon	Ind.dw (μg)	Mesh size	F% (n = 49)	Max. dens. Ind./10 cm^2
Turbellaria	0.5	50		
	1.0	100		
	3.1	200		
	7.5	500		
			67	147
Nematoda	0.1	50		
	0.1	100		
	2.4	200		
			29	78
Harpacticoida	0.1	100		
	0.5	500		
			6	17.5
Oligochaeta	2.0	100		
	6.7	200		
	12.1	500		
			6	10
Cyclopoida	3.6	500	4	2.5
Polychaeta			2	2.5
Halacaridae			2	2.5
Ostracoda	30.0	500	2	5
Tardigrada			2	2.5
Gastrotricha			2	2.5
Foraminifera	2.5–6.5		2	2.5

between the faunal collections. This is clearly shown by the predomination of Ascidiacea and other sessile organisms in Gulliksen's samples while our samples contain more hyperbenthic and actively moving animals.

The biomass found on sublittoral hard substrata by Gulliksen ranged from 200 to 6000 g/m^2, and was 90% dominated by Ascidiacea. He also noted the barren character of shell-gravel beds around the island inhabited by *Onisimus edwardsi* (Gulliksen 1979). Nineteen animal taxa found in our samples were not reported by Gulliksen (1979). Most of this difference is attributed to the sampling method, particularly as some species not present in Gulliksen's samples were probably too shallow-living (e.g. *Littorina saxatilis*, *Semibalanus balanoides*, *Onisimus littoralis*) to have been collected by him.

The intertidal fauna and flora of Bjornoya are very similar to those of Spitsbergen where 37 species of intertidal fauna and 22 of intertidal flora were recorded (Węsławski et al. 1993). Elsewhere in the Arctic, 34 intertidal species were reported from Baffin Island (Ellis 1955) while 43 were listed from West Greenland 65 °N (Steven 1938). Compared to Spitsbergen, the Bjornoya intertidal is impoverished (17 macrofauna and 16 macrophyte species found in this study); however, all littoral species found on Bjornoya were noted also on Spitsbergen (Florczyk and Latała 1989, Węsławski et al. 1993). The exception is *Mytilus edulis*.

Mytilus edulis was present on Spitsbergen during the postglacial climatic optimum and its remains are commonly reported from raised coastlines 7,000–9,000 years old (Madsen 1936; Hjort 1995). It is common at relatively high latitudes, on Alaska at 70 °N, Pond Inlet at 70 °N in Arctic Canada, and south west Greenland (Ellis and Wilce 1961; Feder and Kaiser 1980). It is common on relatively warm northern Scandinavian coasts at 72 °N. Bjornoya lies about 600 nautical miles from the mainland, the distance considered by Mileikovskij (1968a) as the range of the successful bivalve's larval drift.

When compared to northern Scandinavia, the Bjornoya littoral is much poorer in species and biomass. The average intertidal biomass in Finmark ranged from 500 to 5,000 g ww g/m^2 and the species list may easily exceed 100 macrofaunal taxa there (J. M. Węsławski unpublished work). The species reduction in the Arctic intertidal has commonly been attributed to ice scouring (Ellis 1955) or a combination of tidal height and ice thickness (Ellis and Wilce 1961). However, Høpner Petersen (1962, 1966) proved that the ice foot does not necessarily remove barnacles and periwinkles from the Arctic littoral. Given its low tidal amplitude and the short annual period for which ice is present, one may reach the conclusion that the heavy wave action on the exposed beaches of Bjornoya is the principal physical force reducing animal diversity.

This is certainly not the case for small algae, since Metzelin and Witkowski (1996) found over 240 species of diatoms in our samples from pocket sandy beaches. The meiofauna found at Bjornoya littoral was less abundant, when compared to Spitsbergen where it often exceeds 900 ind./10 cm^2 (Szymelfenig et al. 1995). However, the biomass range was similar to that from Spitsbergen, because the meiofauna was dominated by large Turbellaria on Bjornoya, while at Spitsbergen localities small Nematoda dominated (Szymelfenig et al. 1995).

Of particular interest is the abundance around the island of the littoral amphipod *Gammarus setosus*, a species generally restricted to the cool innermost fjord basins of western Spitsbergen and the cold eastern part of the Svalbard archipelago (Węsławski 1994).In warmer waters it is usually replaced by the closely related boreal species *Gammarus oceanicus*, which is distributed from the Baltic to North Spitsbergen on shores bathed by the Norwegian Coastal Current or North Atlantic water masses (Steele and Steele 1974; Tzvetkova 1975; Węsławski 1994). Its absence at Bjornoya may suggest that *Gammarus oceanicus* has successfully colonised Spitsbergen in the past and is not transported from the mainland at present time. This substitution is paradoxical in that the new finding of *Mytilus edulis* gives us a clear indication of the transportation of propagules from mainland Scandinavia to Bjornoya. However, unlike *Mytilus edulis*, amphipods have direct benthic development and hence transportation would require the rafting of a brooding female.. It is quite possible that this has not occurred frequently and that *Gammarus setosus* is a relic of earlier cooler times on Bjornoya, while *Gammarus oceanicus* is a relic of a warmer period on Spitsbergen. Littoral and shallow-water benthic fauna from Scandinavia may be rafted on kelps and floating litter from the south, while ice provides substratum for the migrants from the north. The problem of animals drifted from the Scandinavian mainland was presented by Thorson (1950) and Milejkovskij (1968a, 1968b). The presence of periwinkles, barnacles and mussels confirms the subarctic character of the Bjornoya intertidal while *Gammarus setosus* is an example of its arctic linkages.

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