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Olgierd RÓŻYCKI

Academy of Agriculture in Szczecin  
Field Research Station  
72-020 Trzebież, POLAND

## Occurrence of Gastropoda and Bivalvia in Hornsund Fiord (West Spitsbergen, Svalbard)

**ABSTRACT:** The list of 29 gastropod species and 33 species of bivalves occurring in Hornsund Fiord as well as their zoogeographic status are presented. The occurrence and role of Mollusca in particular parts of the fiord are discussed.

**Key words:** Arctic, Svalbard, benthic fauna, Mollusca, zoogeography.

### Introduction

Molluscs are the important component of benthic communities in coastal waters of Svalbard, both in ecological (Stempniewicz 1990) and zoogeographic (Różycki 1990) aspects. The molluscan fauna of Svalbard is rather well recognized due to the papers by Mörch 1869, Sars 1878, Krause 1892, Knipowitsch 1901, Odhner 1915, Różycki 1984, 1987, 1989, 1991a and others). Polish studies on this animal group in this region began in 1977. Many hydrological and biological studies were undertaken in the Hornsund region during last 15 years (Urbański *et al.* 1980, Węśławski 1983, Węśławski and Kwaśniewski 1983, Swerpel 1985, Węśławski and Adamski 1987 and others). The results presented here are complementary to the previous works on the Hornsund ecosystem.

### Materials

From 1977 to 1985, at 151 stations situated in Hornsund Fiord area 162 samples of Mollusca were collected. The Hornsund Fiord area was divided into 4 smaller parts: open waters of the fiord and Isbjörnhamna, Brepollen and

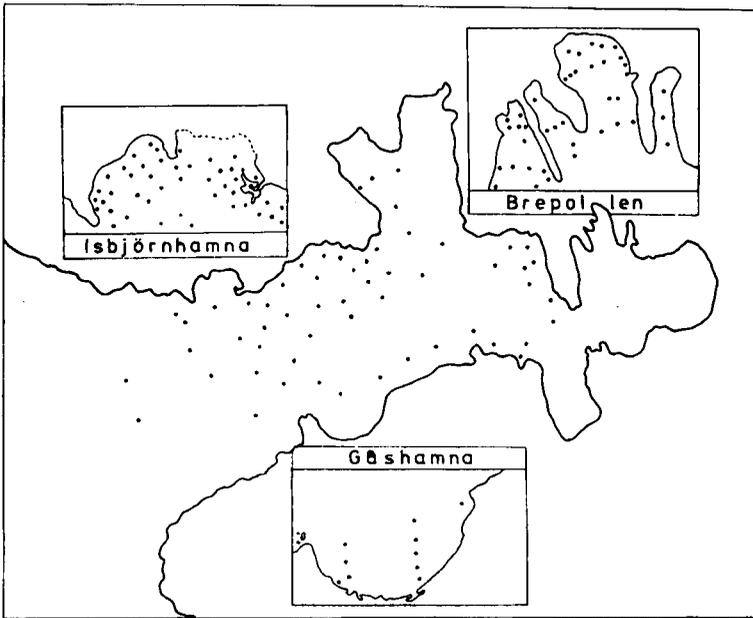


Fig. 1. The distribution of sampling stations in Hornsund Fjord

Gåshamna bays (Fig. 1). A total of 3854 specimens of molluscs were obtained (empty shells were not examined). Gastropods constituted 27.4% and bivalves – 72.6% of the total number of individuals. Basic data on the collected material are presented in Tab. 1.

Table 1

Mollusca collected in Hornsund Fjord

Areas	Year	No. of samples	No. of specimens	
			Gastropoda	Bivalvia
Hornsund (open waters)	1981	16	234	302
	1982	18	31	422
	1984	10	46	231
	1985	12	53	359
Isbjörnhamna	1977	11	152	13
	1981	27	141	183
	1982	17	165	306
	1985	1	—	25
Brepollen	1981	40	36	573
Gåshamna	1982	10	200	382
Total		162	1058	2796

Samples were collected at the depths from 1 to 240 m, from two types of bottom: hard (rocky, stony) and soft. Hard bottom was often covered with large algae and was most common at the depth down to 10–12 m. Soft bottom, mostly muddy with various contribution of gravel and sand, occurred below 10–20 m.

Samples were collected with various sampling devices such as Petersen, Van Veen and Ekman grabs; dredges were used occasionally.

## Investigated area

Hornsund is the most southern fiord of West Spitsbergen. Its coastal line is complicated forming numerous bays. Northern and southern coasts of the fiord area are covered with rocks and boulders, ranging down to the 20 m isobath. Gray mud covers deeper parts of the bottom in the northern part of Hornsund. Brown mud prevailed in sediments in the central part of the fiord (Moskal and Zajączkowski, *unpubl. data*). The maximal depth of the fiord is 280 m.

Hydrological conditions in the fiord depend on the inflow of the outer waters. Urbański *et al.* (1980), Swerpel (1985), and Moskal and Zajączkowski (*unpubl. data*) described physical and chemical properties of the Hornsund water masses. Warm water masses of Atlantic origin flow into the fiord (West-Spitsbergen Current). Their core is situated at the depth of 70–100 m and their temperature is 1.6–2.0°C. Cold waters of the South Cape Current also flow into the fiord, but below the Atlantic ones. The temperature of these waters is about 1°C and salinity varies from 34 to 35‰ (Swerpel 1985). In coastal parts of the fiord, where the influence of the land is strong, the temperature and salinity were more diversified being influenced by fresh water flow, sea-ice presence, tides and solar radiation. The influence of these factors quickly decreases towards deeper parts of the fiord.

In the Hornsund region in summer sea-ice and Arctic waters penetration was observed, with presumably 2–3 years oscillation period. This is probably related to the changes in sea current intensity at the southern coasts of West Spitsbergen Island.

## Results

29 gastropod taxa and 33 bivalve taxa were identified in the collected material (Tab. 2). Figure 2 presents maximal, minimal and average number of species per station in particular areas of Hornsund.

Table 2

## Check-list of Gastropoda and Bivalvia collected in the Hornsund Fiord

Explanations: H – Hornsund (open waters); I – Isbjørnhamna; B – Brepollen; G – Gášhamna

Taxa	Areas				Zoogeographical characteristics and probable origin <sup>1</sup>
	H	I	B	G	
1	2	3	4	5	6
<b>GASTROPODA</b>					
<i>Margarites costalis</i> (Gould, 1841)	+				low-Arctic, circumpolar
<i>Margarites groenlandicus</i> (Gmelin, 1791)	+	+	+	+	Arctic-boreal, circumpolar
<i>Margarites helicinus</i> (Phipps, 1774)			+		boreal-Arctic, Atlantic
<i>Margarites olivacea</i> (Brown, 1827)				+	Arctic-boreal, circumpolar
<i>Calliostoma formosa</i> (Mc Andrews et Forbes, 1847)	+			+	boreal-Arctic (?)
<i>Lacuna vincta</i> (Montagu, 1803)	+				boreal, amphiboreal
<i>Hydrobia ulvae</i> (Pennant, 1777)		+			boreal, Atlantic
<i>Onoba globulus</i> (Möller, 1842)	+	+		+	boreal, Arctic (?)
<i>Onoba mighelsi</i> (Stimpson, 1851)	+	+		+	boreal-Arctic, North-Atlantic
<i>Lunatia pallida</i> (Broderip et Sowerby, 1829)		+			boreal-Arctic, circumpolar
<i>Natica clausa</i> Broderip et Sowerby, 1829				+	boreal-Arctic, circumpolar
<i>Nucella lapillus</i> (Linné, 1758)				+	boreal, widely distributed in northern seas, Atlantic
<i>Trophonopsis truncatus</i> (Ström, 1767)				+	boreal-Arctic, circumpolar, Atlantic
<i>Astyris rosacea</i> (Gould, 1840)	+			+	Arctic-boreal
<i>Buccinum cyaneum</i> Brugière, 1792	+				low-Arctic, Atlantic
<i>Buccinum glaciale</i> Linné, 1761	+				low-Arctic, circumpolar
<i>Buccinum hydrophanum</i> Hancock, 1846		+			Arctic-boreal, Atlantic
<i>Buccinum scalariforme</i> Möller, 1842	+	+		+	Arctic, circumpolar
<i>Buccinum undatum</i> Linné, 1758	+				low-Arctic, Atlantic
<i>Buccinum undulatum</i> Möller, 1842	+	+	+		low-Arctic, Atlantic
<i>Colus latericeus</i> (Möller, 1842)	+				Arctic, Atlantic (?)
<i>Volutopsis norvegicus</i> (Gmelin, 1791)				+	low-Arctic, Atlantic
<i>Admete viridula</i> (Farbicius, 1780)	+				Arctic, circumpolar
<i>Oenopota harpularia</i> (Cauthouy, 1839)	+				boreal-Arctic, circumpolar
<i>Oenopota pyramidalis</i> (Ström, 1768)	+			+	low-Arctic, circumpolar
<i>Oenopota</i> spp.				+	
<i>Retusa obtusa</i> (Montagu, 1803)	+	+			low-Arctic, Atlantic
<i>Cylichna alba</i> (Brown, 1827)	+	+	+	+	boreal-Arctic, circumpolar
<i>Cylichna occulta</i> (Mighels et Adams, 1842)	+	+		+	low-Arctic, circumpolar
<b>BIVALVIA</b>					
<i>Nuculoma tenuis</i> (Montagu, 1808)	+			+	Arctic-boreal, widely distributed in northern seas
<i>Nuculoma corticata</i> (Möller, 1842)	+	+			boreal, Atlantic
<i>Yoldia hyperborea</i> Torell, 1859	+		+		Arctic, discontinuous distribu- tion, Pacific

Table 2 — continued

1	2	3	4	5	6
<i>Yoldia myalis</i> (Couthouy, 1838)	+			+	boreal-Arctic, circumpolar (?)
<i>Nuculana pernula</i> (Müller, 1779)	+		+	+	Arctic-boreal, circumpolar, Atlantic
<i>Portlandia arctica</i> (Gray, 1824)	+	+	+		high-Arctic, circumpolar, Atlantic
<i>Yoldiella intermedia</i> (M. Sars, 1865)		+			high-Arctic, circumpolar
<i>Yoldiella fraterna</i> Verrill et Bush, 1898	+	+			low-Arctic, circumpolar, Atlantic
<i>Yoldiella frigida</i> (Torell, 1859)	+				high-Arctic, Atlantic
<i>Yoldiella lenticula</i> (Möller, 1842)	+	+			Arctic, circumpolar, Atlantic
<i>Musculus niger</i> (Gray, 1842)	+				boreal-Arctic, circumpolar, Pacific
<i>Musculus corrugatus</i> Stimpson, 1851	+				high-Arctic, circumpolar, Pacific
<i>Musculus laevigatus</i> (Gray, 1824)	+			+	boreal-Arctic, circumpolar
<i>Chlamys islandica</i> (Müller, 1776)				+	Arctic, circumpolar, widely distributed
<i>Astarte borealis</i> Schumacher, 1817	+				boreal-Arctic, circumpolar, Atlantic
<i>Astarte montagui</i> (Dillwyn, 1817)	+				Arctic-boreal, circumpolar, Atlantic
<i>Astarte sulcata</i> (Da Costa, 1778)				+	Arctic-boreal, Atlantic (?)
<i>Thyasira flexuosa</i> (Montagu, 1803)	+				boreal-Arctic
<i>Thyasira ferruginea</i> (Forbes, 1851)	+	+		+	Arctic-boreal
<i>Thyasira sarsi</i> (Philippi, 1845)	+	+	+	+	boreal-Arctic, Atlantic (?)
<i>Axinopsida orbiculata</i> (G.O.Sars, 1878)	+	+			Arctic-boreal, Pacific
<i>Macoma calcarea</i> (Gmelin, 1790)	+	+			Arctic-boreal, Pacific
<i>Macoma moesta</i> (Deshayes, 1854)	+				low-Arctic, circumpolar, Pacific
<i>Macoma torelli</i> Jensen, 1904	+			+	low-Arctic, circumpolar, Atlantic
<i>Liocyma fluctuosa</i> (Gould, 1841)	+	+		+	Arctic, circumpolar, Pacific
<i>Serripes groenlandicus</i> (Bruguere, 1798)	+	+		+	Arctic, circumpolar, Pacific
<i>Ciliatocardium ciliatum</i> (Fabricius, 1780)	+			+	Arctic, circumpolar, Atlantic
<i>Mya truncata</i> Linné, 1758	+	+		+	boreal-Arctic, circumpolar, Atlantic
<i>Mya pseudoarenaria</i> Schlesch, 1931	+	+	+		boreal-Arctic, Atlantic (?)
<i>Hiatella arctica</i> (Linné, 1767)	+		+	+	cosmopolite, Pacific
<i>Pandora glacialis</i> Leach, 1819				+	low-Arctic, circumpolar (?), Atlantic
<i>Lyonsia arenosa</i> (Möller, 1842)	+			+	Arctic, circumpolar, Pacific
<i>Cuspidaria subtorta</i> (G.O.Sars, 1878)	+				Arctic, Atlantic

<sup>1)</sup> data of probable origin by Macpherson (1971) and Bernard (1979).

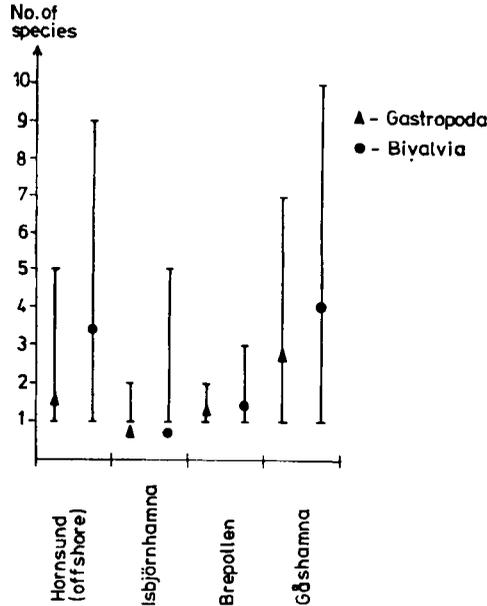


Fig. 2. The minimal, maximal and average number of gastropod and bivalve species per one station in particular subareas of Hornsund

### Open Hornsund waters

48 species of molluscs were found there: 19 gastropods and 29 bivalves (Tab. 2). 21% of the mollusc specimens collected in open Hornsund waters were gastropods, 79% — bivalves.

Gastropods and bivalves were not present at all stations. The frequency coefficient reached 48% for gastropods and 63% for bivalves. The average number of species occurring at one station was equal to 1.59 for gastropods and 3.41 for bivalves (Fig. 2). The most common gastropod species, *Margarites groenlandicus*, constituted 54.9% of the collected gastropod material, the contribution of other 18 species was not high. The frequency coefficient for Gastropoda was not high and varied from 2.2 to 10.8%. Four species of Bivalvia had more than 10% contribution in the samples: *Nuculoma tenuis* (15.1%), *Axinopsida orbiculata* (13.7%), *Portlandia arctica* (13.2%) and *Thyasira ferruginea* (12.4%); these numerous bivalve species gave together more than half of all collected bivalve specimens (54.4%). *Nuculoma tenuis* was the most common in the samples ( $F = 26.1\%$ ). The frequency coefficient for other bivalves varied from 2.2% to 17.4%.

Samples were collected at the depths from 4 to 240 m. Down to 20 m 80% of all gastropods were caught. Deeper than 20 m gastropods were rare; at greater depths mainly necrophagous *Buccinum* species were found. The presence of

gastropods was connected with hard, mostly rocky bottom overgrown with big brown algae. Bivalvia inhabited mainly greater depths of 50–200 m; 60% of all bivalves were caught there. Their presence was closely related to soft, muddy sediments.

Molluscan fauna of Hornsund was composed of boreal (6.3%), boreal-Arctic (27.1%), Arctic-boreal (16.6%) and Arctic (50.0%) forms. Among Arctic forms there were low-Arctic (28.8%), high-Arctic (22.9%) and Arctic with circumpolar distribution (22.9%). The contribution of species of Atlantic origin was 38% and that of Pacific origin – 23%. The origin of other 19 species (39%) is not known.

### Isbjörnhamna

In samples from this bay 11 species of Gastropoda and 13 of Bivalvia were identified (Tab. 2). In the collected material the contribution of Gastropoda was 38% and that of Bivalvia – 62%.

The frequency coefficient for gastropods reached 40% and for bivalves 44%. On the average 0.73 species of gastropods and 0.8 species of bivalves per one station were found (Fig. 2). The most abundant gastropods in the samples were *Margarites groenlandicus* (68.8%), *Cylichna alba* (12.7%) and *C. occulta* (10.5%). Other 8 gastropod species were represented by few individuals and constituted together 8.0% of all individuals. For *Margarites groenlandicus* the frequency coefficient was the highest ( $F = 39.0\%$ ); for other species it varied from 1.7 to 8.5%.

Among bivalves the most abundant were 2 species: *Thyasira ferruginea* (70.2%) and *T. sarsi* (16.9%). Other bivalves were represented by few individuals in the samples. The frequency coefficient only for *T. ferruginea* reached 27.1%. For other species varied from 1.7% to 11.9%.

Samples were collected at depths from 2 to 60 m. 75% of all gastropods were caught not deeper than 10 m (mainly *Margarites groenlandicus* living on thalli of algae: *Laminaria saccharina* and *L. digitata*), 22% of gastropod individuals were found at depths from 10 to 20 m, the remaining few gastropods were found deeper. Bivalves were collected mainly from 10 to 20 m (about 80% of all individuals). They were most numerous in muddy bottom, especially at stations near Hans glacier (eastern and central parts of the bay)

Molluscs inhabiting Isbjörnhamna were mainly Arctic species (41.9%), followed by boreal-Arctic (29.0%) and Arctic-boreal (20.8%), and the least numerous group of species were boreal forms (8.3%). According to their origin, Atlantic species were the most common (59%), Pacific species constituted 16.6% and the origin of 8 species (33.4%) was unknown.

## Brepollen

Samples were collected in the northern part of the fiord consisting of four small bays (Fig. 1) created after the regression of small glaciers. Four gastropod and 6 bivalve species were found there (Tab. 2). The contribution of gastropods in the collected material was low (5%); the remaining 95% were bivalve specimens.

Frequency coefficient for gastropods was 7.5% and for bivalves it was 97.5%. On the average, per one station 1.33 gastropod and 1.43 bivalve species were recorded (Fig. 2).

*Cylichna alba* was the most numerous gastropod there (27.8%), three remaining species were rare. The frequency coefficient, equal for all four species was very low (2.5%). *Portlandia arctica* was the most numerous (91.1%) among bivalves. Other 5 species were not abundant. Frequency coefficient over 25% was reached by two species: *Portlandia arctica* (87.5%) and *Thyasira sarsi* (25.0%). For other species it varied from 2.5% to 10.0%.

Samples were collected at the depths from 2 to 100 m, almost entirely from muddy bottom. Bivalvia were very rare in samples collected deeper than 15 m. Nearly 85% of all bivalves were collected at the depths from 2 to 15 m.

Main zoogeographic group in the collected material were boreal-Arctic forms (40%). The contribution of Arctic forms was 30%. Arctic-boreal molluscs constituted 20% and the remaining 10% were boreal forms. Species of Atlantic origin dominated (60%), 20% of species were of Pacific origin and for the remaining 20% the origin was not known.

## Gåshamna

In this bay 14 gastropod and 16 bivalve species were found (Tab. 2). The contribution of gastropods in the collected material was 34% and bivalves – 66% of individuals. Frequency coefficient for gastropods reached 80% and for bivalves 70%. On the average per one station 2.8 gastropods and 4 bivalves were found (Fig. 2).

*Margarites groenlandicus* was the most numerous among gastropod species (65.5%) and *Cylichna occulta* (10.5%) occupied the second place. These two species were the most frequent in the samples, their frequency coefficient was 40% and 30%, respectively. This coefficient for other gastropods was 10–20%. The most abundant bivalves were: *Liocyma fluctuosa* (63.6%), *Thyasira ferruginea* (11.8%) and *Serripes groenlandicus* (10.0%). Rather important species, because of the frequency of 30% were also *Thyasira sarsi* and *Hiatella arctica*, but they were not numerous.

Samples were collected from 2 to 50 m. Almost 90% of all gastropod and bivalve individuals came from 10 to 20 m. The occurrence of gastropods was

mostly related to algae covering rocky and stony bottom down to the depth of 12 m. Bivalves inhabited mainly soft, muddy sediments.

In Gåshamna the same number of Arctic and boreal-Arctic forms (33.5% each) was noticed. Contribution of Arctic-boreal forms was 26.4%; the least numerous were boreal molluscs (6.6%). Species of Atlantic origin dominated (33.3%). Pacific forms constituted 16.7% and the origin of 50% of species was unknown.

## Discussion

Taking into account the number of species of Gastropoda (29) and Bivalvia (33) found in Hornsund waters, this fiord, in comparison to other areas of Svalbard (Różycki 1984), can be considered to have a relatively rich molluscan fauna. About half of the total number of gastropod and bivalve species recently found in coastal waters of Svalbard archipelago (Różycki 1990) are herewith recorded from Hornsund.

In Hornsund, the average number of species of Mollusca found at one station amounted to 2.01 and was much lower than in other Svalbard areas. For example, this coefficient was 7.6 for Kongsfjorden (Różycki 1991a), for Isfjorden (only for littoral species) it was 6.9 (Różycki 1991b), for Gipsvika bay (Isfjorden) it was 7.4 (Różycki, *unpubl.*). The conclusion may be drawn that the conditions in the fiord are not favourable for Gastropoda and Bivalvia. Comparatively high frequency coefficient both for Gastropoda and Bivalvia as well as the highest average number of species of both classes of Mollusca show that the most favourable conditions for this animal group occur in Gashamna, the least favourable — in Isbjörnhamna, where these coefficients were lowest in the whole Hornsund area.

In Brepollen, the contribution of gastropods was low and the frequency of gastropods was exceptionally low ( $F = 7.5\%$ ). This might have been a result of lack of hard bottom covered with algae, which was the main habitat of gastropods in the shallow waters.

One can observe clearly big differences between the four distinguished Hornsund subareas in the number of species of Mollusca from 4 to 19 (gastropods) and from 6 to 29 (bivalves). Different assemblages of gastropods and bivalves occurred in different subareas. Results of similarity analysis (Sørensen coefficient) are as follows:

Hornsund/Isbjörnhamna	— 55.5%
Hornsund/Brepollen	— 31.0%
Hornsund/Gåshamna	— 56.4%
Isbjörnhamna/Brepollen	— 35.3%
Isbjörnhamna/Gåshamna	— 40.7%
Brepollen/Gåshamna	— 25.0%

The highest number of species in common for Hornsund open waters and Isbjörnhamna and also for Hornsund open waters and Gåshamna may be an evidence for significant hydrological similarity of these regions. The least similar molluscan assemblages occurred in Isbjörnhamna and Brepollen and in Gåshamna and Brepollen, reflecting significant hydrological differences between these subareas, observed by Urbański *et al.* (1981) and Swerpel (1985).

Occurrence of Gastropoda and Bivalvia in Hornsund as a function of depth and bottom sediment properties was the same as in other areas of Svalbard (Różycki 1984). Gastropods dominated at depths down to abt. 10–12 m, i.e. to the limit of brown algae occurrence. Typical inhabitant of this zone is *Margarites groenlandicus* dominating among gastropods.

Bivalves, in general, inhabited mainly deeper muddy bottom, (40–60 m). However, in open fiord waters, they were most abundant at the depths of 50–200 m; these depths were not sampled during previous research.

Molluscan fauna of Hornsund fiord is composed of boreal (6.5%), boreal-Arctic (27.5%), Arctic-boreal (17.8%) and Arctic forms (48.2%). Among the latter, low- and high-Arctic species can be distinguished. So, in terms of zoogeography, Hornsund fauna is a mixed one, with moderate dominance of Arctic species. Similar composition was found in all investigated regions. Therefore, Hornsund should be classified in the intermediate faunistic province (Svalbard province) belonging to the Arctic region, similarly to the whole area around south-western Svalbard.

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## Streszczenie

W latach 1977—1985 ze 151 stacji usytuowanych na obszarze Hornsundu (Rys. 1) zebrano 151 prób ślimaków i małży. Cały zbiór mięczaków liczył 3854 osobniki, z czego na ślimaki przypadło 27,4% a pozostałe 72,6% — na małże. Podstawowe dane charakteryzujące zebrany materiał przedstawiono w Tabeli 1. Próby pochodziły z głębokości od 1 do 240 m, z dna twardego (skaliste, kamieniste) oraz z dna miękkiego, utworzonego głównie przez muły lub muły z domieszką żwiru i piasku.

W zebranym materiale oznaczono 29 taksonów ślimaków oraz 33 taksony małży (Tab. 2). W wydzielonych na obszarze Hornsundu czterech akwenach występowało od 4 do 19 gatunków ślimaków i od 6 do 29 gatunków małży. Na jedną stację przypadało od 0,73 do 2,8 gatunków ślimaków oraz od 0,8 do 4,0 gatunków małży (Rys. 2). Średnio, na 1 stację przypadały w Hornsundzie 2 gatunki mięczaków. W wydzielonych akwenach wskaźnik frekwencji dla ślimaków wynosił od 7,5 do 80%, a dla małży od 44 do 97,5%. Najwięcej gatunków wspólnych miały otwarte wody fiordu i Isbjørnhamna oraz otwarte wody fiordu i Gåshamna (wskaźnik Sørensen = ok. 55%), natomiast między pozostałymi akwenami współczynnik podobieństwa między zasiedlającymi je zespołami ślimaków i małży nie przekraczał wartości 40,7%. Pod względem zoogeograficznym wody Hornsundu charakteryzował mieszany skład fauny; występowały tam gatunki borealne (6,5%), borealno-arktyczne (27,5%), arktyczno-borealne (17,8%) oraz arktyczne (48,2%).