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Olgierd RÓŻYCKI

Laboratory of Marine Biology, Maritime Academy,
Wały Chrobrego 1, 70-500 Szczecin, POLAND

Shallow-water bottom fauna of the Van Keulen fiord (Spitsbergen, Bellsund)

ABSTRACT: In the bottom fauna of the Van Keulen fiord 53 taxa of invertebrates (51 species) were recorded. Four different bottom types were sampled and the distribution of invertebrates in these bottom types is discussed. The most important components in the benthos of the fiord were Polychaeta, Crustacea, Bivalvia and Gastropoda (79.2%). From the zoogeographical point of view the Van Keulen fiord should be included into the transient zone, situated at the border of the boreal and arctic zones.

Key words: Arctic, Spitsbergen, bottom fauna, zoogeography.

1. Introduction

The contemporary faunistic and ecological publications concerning the bottom fauna of Spitsbergen are as yet rather scarce. They include the results of studies on the coastal rocky bottom fauna (Różycki and Gruszczyński 1981), the characteristics of the bottom fauna of the arctic estuary (Legeżyńska et al. in press) or bottom fauna groupings of the bays neighbouring the glaciers (Gromisz 1983). In two other recent works the soft bottom fauna of two Spitsbergen fiords (Gulliksen, Holte and Jakola 1985) and the fauna associated with laminarians (Różycki and Gruszczyński 1986) were studied. In several works the specific composition and ecology of important zoobenthos groups, such as Amphipoda (Węsławski 1983, unpubl. data) or Bivalvia (Różycki 1984, unpubl. data) were described. Polish oceanographic observations (Swerpel and Węsławski 1983, Węsławski and Kwaśniewski 1983, Swerpel 1985) supported the earlier records indicating that the waters off the Spitsbergen coasts constitute a very interesting water area from the hydrological point of view. This is due to mixing of warm Atlantic waters

flowing with the West-Spitsbergen Current with cold arctic waters of the East-Spitsbergen Current (Sørkaap Current) at the south-west coasts of this archipelago.

The main aim of the present work is to present the specific composition and certain ecological aspects of the distribution of the bottom fauna inhabiting the coastal waters of the Van Keulen fiord.

2. Study area

The Van Keulen fiord, situated in the western part of Spitsbergen (Fig. 1) is under the influence of warm waters of the West-Spitsbergen Current. This water body is partially isolated from the influence of the open sea (Greenland Sea, Bellsund) by a narrowing and shallows which occur at its inlet seriously diminishing the exchange of water masses between the open sea and the fiord.

In summer the hydrological conditions of the Van Keulen fiord are to a large extent determined by the inflow of glacial waters and by inflow of various streams fed by melting snow and ice. The above mentioned hydrological isolation makes winter ice stay in Van Keulen fiord much longer than in the neighbouring water bodies. In 1977 the presence of ice in almost the whole of the fiord area was recorded until June 25th, while at the southern coasts of the Bellsund (Malbukta, Recherchefjorden) no ice was recorded as early as on June 7th.

3. Material and methods

The material of the present paper was collected between June 26th and August 4th, 1977, at 7 stations situated at the southern coasts of the Van Keulen fiord (Fig. 1). At each station samples were collected 4 to 7 times and their total amounted to 40, 20 of which were from muddy bottom, 10 from the bottom of gravel and mud, 5 from stony and rocky bottom overgrown with algae and 5 from bottom of gravel. Samples were collected at the depth of 1—10 m (hard bottom) and 10—25 m (soft bottom). A triangular bottom dredge of a 50 cm edge length and 1 mm meshes was used for the sampling. This dredge was hauled for about 10—20 m along soft bottom and about 50 m along the hard bottom. In places where the samples were collected the depth and character of bottom sediments were determined. The collected material was sieved through the sieve with 1 mm meshes, and then preserved in a 4% formalin.

Gammarids of the length of less than 7 mm were determined as *Gammarus* sp. juv.

4. Results

In the investigated zone of the fiord, 4 habitats were distinguished which differed first of all in respect to their bottom sediments. The

Table 1

Faunistic comparison of four sampled habitats of the Van Keulen fiord

Bottom kind	Depth (m)	Number of species	Sörensen's index (%)
1 rock and stones overgrown with algae	1—10	20	1:2 — 9.0 1:3 — 43.5 1:4 — 33.3
2 gravel	15	2	2:3 — 14.3 2:4 — 5.5
3 mud and gravel	12—25	26	3:4 — 43.3
4 mud	15—18	34	

values of the coefficient of similarity of the fauna groupings inhabiting these habitats (Sörensen's index) never exceeded 50% (Tab. 1), justifying such a distinction.

4.1. Specific composition and distribution of the benthos

In the material collected in the Van Keulen fiord, 53 taxa were distinguished; 51 of them were determined to the specific level. The list of zoobenthos species and the character of their distribution at various bottom types are presented in Table 2.

Among the representatives of 11 animal classes, the most numerous in species were crustaceans (mostly Amphipoda) and bivalves (12 species each), gastropods comprising 10 species and polychaetes with 8 species. The representatives of the above mentioned classes constituted 79.2% of the total number of species of the bottom fauna collected.

22 species occurred only in one type of the bottom and these can be regarded as more or less stenotopic species. The remaining, occurring

Table 2.

The list of bottom fauna of the Van Keulen fiord and relative abundance of particular species

Species	Bottom kind				Zoogeographical characteristics
	rock and stones overgrown with algae	gravel	mud and gravel	mud	
1	2	3	4	5	6
POLYCHAETA					
1 *Antionëlla sarsi* (Kinberg)	+ + +		+ + +	+ + +	arct.-bor.
2 *Lumbriconereis impatiens* Claperede	+ +		+	+ +	bor.-arct.
3 *L. fragilis* (O. F. Müll.)	+		+ +	+ +	arct.-bor.
4 *Anaitides groenlandicus* Oersted			+	+	arct.-bor.
5 *Ammotrypane aulogaster* Rathke			+ +	+ +	arct.-bor.
6 *Brada granulata* Malmgren	+ +			+ +	arct.-bor.
7 *Pectinaria hyperborea* (Malmgren)				+	arct.-bor.
8 *Travisia forbesi* Johnston				+	arct.-bor.
PRIAPULIDA					
9 *Priapulus caudatus* Lamarck				+	arct.-bor.
CRUSTACEA					
10 *Balanus balanoides* Linnaeus	+ + + +				bor.
11 *Gammarus oceanicus* Segerstrale	+ + + +			+ + +	bor.-arct.
12 *G. setosus* Dementieva	+ + + +	+	+ + +		arct.
13 *G. wilkitzkii* Birula				+	arct.
14 *Gammarus* spp. juv.	+			+	bor.
15 *Gammarellus homari* (Fabricius)	+ +				bor.
16 *Atylus carinatus* (Fabricius)				+ +	arct.
17 *Anonyx sarsi* Steele et Brunel			+ +		arct.-bor.
18 *Ischyrocerus anguipes* (Kröyer)	+ + +				bor.
19 *Ischyrocerus* spp.	+				
20 *Byblis gaimardii* (Kröyer)				+	arct.-bor.

c.d. tab. 2.

1	2	3	4	5	6
21 *Pontoporeia femorata* Kröyer				+	arct.-bor.
22 *Caprella septentrionalis* Kröyer	+ + +		+	+ +	bor.
POLYPLACOPHORA					
23 *Ischnochiton albus* (Linnaeus)			+		arct.-bor.
24 *Hanleya hanleyi* (Bean)			+		arct.-bor.
GASTROPODA					
25 *Cylichna arctica* (Brown)			+ +	+ +	arct.-bor.
26 *C. alba* (Brown)				+ +	arct.-bor.
27 *C. scalpta*				+	arct.
28 *Margarites groenlandicus* (Gmelin)	+ + + +		+ + +		arct.-bor.
29 *M. olivacea* (Brown)			+		arct.
30 *Solariella obscura* Cauthouy	+				arct.-bor.
31 *Cingula castanea* (Möller)				+	arct.-bor.
32 *C. globulus* (Möller)			+		bor.-arct.
33 *Buccinum undatum* Linnaeus	+		+		bor.
34 *B. groenlandicum* Chemnitz			+		arct.
BIVALVIA					
35 *Astarte borealis* Schumacher		+	+ + +	+ + + +	arct.-bor.
36 *A. elliptica* (Brown)			+ +	+ + +	bor.-arct.
37 *A. montagui* (Dillwyn)			+ + +	+ +	bor.-arct.
38 *Musculus laevigatus* (Gray)			+		arct.-bor.
39 *Crenella decussata* (Montagu)				+ +	bor.-arct.
40 *Kelliella miliaris* Philippi			+	+	bor.-arct.
41 *Hiatella arctica* (Linnaeus)	+ + + +		+	+	bor.-arct.
42 *Mya truncata* Linnaeus			+	+	bor.-arct.
43 *Serripes groenlandicus* (Bruguiere)				+	arct.
44 *Ciliatocardium ciliatum* (Fabricius)				+	bor.-arct.
45 *Nuculoma tenuis* (Montagu)				+ +	bor.-arct.
46 *Chlamys nana* (Verrill et Bush)				+	bor.

c.d. tab. 2

1	2	3	4	5	6
BRYOZOA					
47 *Electra pilosa* (Linnaeus)	+ + + +		+ +		arct.-bor.
48 *Flustra foliacea* (Linnaeus)	+ + +				bor.
49 *Alcyonidium gelatinosum* (Linnaeus)	+ +		+ +		bor.-arct.
OPHIUROIDEA					
50 *Ophiura robusta* Ayres				+	arct.-bor.
ECHINOIDEA					
51 *Strongylocentrotus droebachiensis* O. F. Müller			+		arct.-bor.
HOLOTHURIOIDEA					
52 *Myriotrochus rinkii* Steenstrup				+	arct.
ASCIDIACEA					
53 *Ascidia prunum* O. F. Müller	+ +			+	arct.-bor.

\+ — scarce
\+ + — moderately abundant
\+ + + — abundant
\+ + + + — mass occurrence

in two or three different types of the bottom, were considered as more or less eurytopic ones. The most typical eurytopic species were *Lumbriconereis impatiens*, *Gammarus setosus*, *Caprella septentrionalis*, *Astarte borealis* and *Hiatella arctica*, that were found in three of four distinguished bottom types.

Hard bottom overgrown with brown algae

Hard bottom of stones and rocks was recorded at station I (Fig. 1), where samples were collected at depth of 1—10 m. This type of bottom was abundantly overgrown by a macrophytes association consisting of 8 species of brown algae (Tab. 3), occurring mainly at depths ranging

Table 3

Brown algae overgrowing the bottom of rock and stones in the Van Keulen fiord

Species	Relative frequency
FUCACEAE	
Fucus vesiculosus Linnaeus	+ +
F. serratus f. angustata Linnaeus	+ + +
Pelvetia canaliculata Dene et Thur	+ +
LAMINARIACEAE	
Laminaria saccharina Lamarck	+ + + +
CHORDARIACEAE	
Chordaria flagelliformis (Müller)	+ +
SCYTOSIPHOEAE	
Scytosiphon lomentarius (Lyngb.)	+
DESMARESTIACEAE	
Desmarestia aculeata Lamarck	+
Desmarestiaceae non ident.	+

\+ sporadic
\+ + rare
\+ + + common
\+ + + + very common

from 2 to 7 meters. Among these brown algae *Laminaria saccharina* was the most common and abundant species constituting about half of all algae.

In this type of bottom, 20 animal species occurred (Tab. 2), and crustaceans, which were most abundant in this place, constituted here 40% of the species of the macrofauna. The most abundant representive of this class was *Balanus balanoides* (mainly juveniles) overgrowing rocks and stones. Among the laminarians three amphipod species namely:

Gammarus oceanicus, *G. setosus* and *Ischyrocerus anguipes* were very abundant. Polychaeta were represented by 4 species, of which *Antinoëlla sarsi* was most characteristic for this habitat, and *Electra pilosa* was the most commonly recorded bryozoan species. Other animal classes were represented by single species, among which *Margarites groenlandicus* (Gastropoda) living on the algal thalli, and *Hiatella arctica* (Bivalvia) living among the algal rhizoids were the most abundant ones.

Species classified as occurring in masses or abundant constituted 50.0% of all animals associated with this habitat.

Bottom of gravel

The coarse gravel sediment was recorded at station V (Fig. 1), in the region where 12 seasonal fresh water streams carried water from melting snow and ice. The samples were collected there at a depth of about 15 m.

This habitat was inhabited by two invertebrate species: *Astarte borealis* (Bivalvia) and *Gammarus setosus* (Amphipoda), represented by single specimens only.

Bottom of gravel and mud

These sediments were recorded in the region of stations II and VII (Fig. 1), where samples were taken at the depths of 12—25 m.

This habitat was inhabited by 26 species of zoobenthos (Tab. 2). Bivalvia were here represented by 7 species and *Astarte borealis* and *A. montagui* were the most abundant bivalve species. Gastropods were represented by 6 species, *Margarites groenlandicus* being the most abundant species; among Polychaeta (5 species) *Antinoëlla sarsi* was the most abundant one. The representatives of the three above mentioned classes constituted 69.2% of the total number of benthic species, associated with this bottom type.

In this habitat, the majority of species (about 80%) were moderately abundant or scarce.

Muddy bottom

Fine muddy sediments, consisting mainly of glacial silt, were recorded in the regions of stations III, IV and VI (Fig. 1), where the material was collected at depths ranging between 15 and 18 m.

In this habitat the most diversified bottom fauna, consisting of 34 species

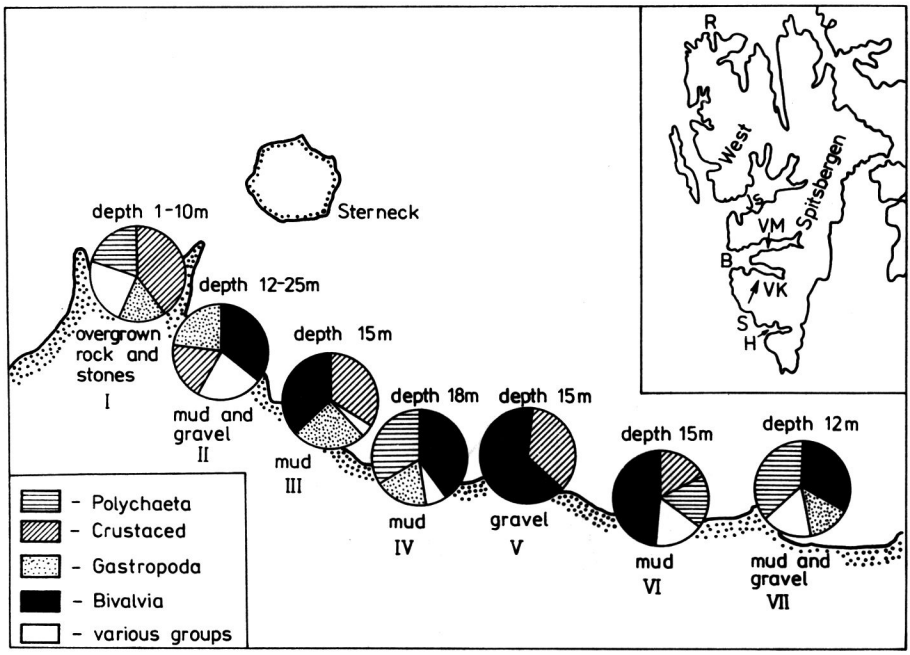

Fig. 1. Study area and sampling stations (I—VII) in the Van Keulen fiord

belonging to 8 classes (Table 2) was recorded. The bivalves (11 species), totalled 32.3% of all species of animals occurring in this type of sediment. Two species of the genus *Astarte*, *Astarte borealis* and somewhat less abundant, *A. elliptica*, were the two dominant bivalves. *Antinoëlla sarsi* was the most abundant among 8 polychaete species inhabiting this muddy sediment, and *Gammarus oceanicus* was the most abundant among 7 crustacean species. The benthic fauna associated with this habitat was characterized also by the presence of priapulids, holothurians and ophiuroids (one species each).

Out of 34 species of the macrofauna, only one (*Astarte borealis*) was classified as occurring in masses, 3 species (*Antinoëlla sarsi, Gammarus oceanicus* and *Astarte elliptica*) as abundant. Other 30 species were moderately abundant or scarce.

4.2. Zoogeographic characteristics of the bottom fauna of the fiord

The sublittoral at the southern coast of the Van Keulen fiord is inhabited by arctic, arctic-boreal, boreal-arctic and boreal forms (Tab. 2). The share of particular forms and mutual proportions among main animal

classes are presented in Fig. 2. In respect to the number of species arctic-boreal forms are the dominant ones; together with arctic forms they constitute almost 63% of all species. In the group of arctic species there are relatively few representatives of crustaceans, bivalves and gastropods. Noticeable is a high share of polychaetes among arctic-boreal forms.

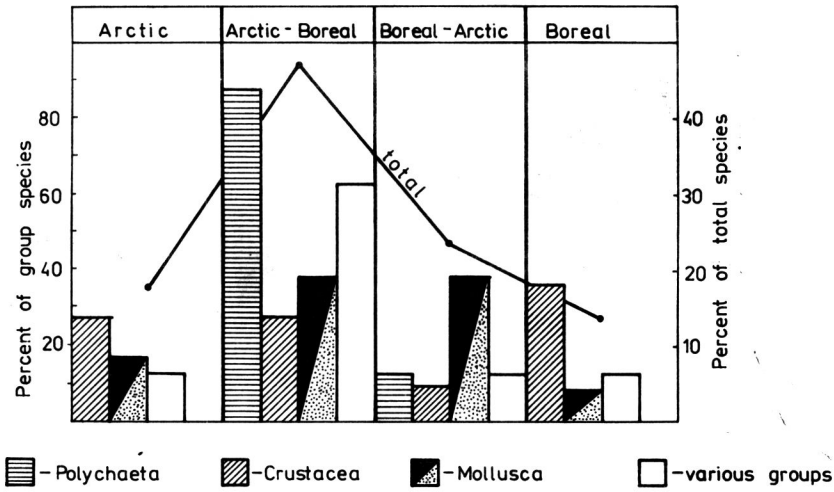

Fig. 2. Percentage share of various zoogeographical forms in the benthos of the Van Keulen fiord

The share of boreal species was the lowest. Among boreal forms noticeable was a very abundant barnacle, *Balanus balanoides*. Boreal gastropods, bivalves and bryozoans were represented only by single species.

5. Discussion

In the sublittoral of the Van Keulen fiord, in the depths of 1—25 m 53 taxa of the bottom macrofauna were found. In the coastal waters of Spitsbergen other authors recorded assemblages of the bottom fauna amounting to about 75 species in the arctic estuary (Nottinghambukta) of the depth of 0—7 m (Legeżyńska et al. in press), 101 species in the Hornsund waters of the depths from 1 to 130 m (Biała, unpubl. data) and 114 species in the waters of Skoddebukta of the depths from 1 to 140 m (Gromisz, unpubl. data). In the sublittoral of the Bear Island (1—50 m of depth), Gulliksen (1979) recorded about 75 taxa within the bottom fauna, whereas in the quantitative investigations of the fauna of soft bottom only conducted in the Raud and Van Mijen fiords

83 and 79 benthic species were found, respectively (Gulliksen, Holte and Jakola 1985). Thus the number of benthic species found in the Van Keulen fiord is much lower than that recorded earlier in other regions of Spitsbergen. The relative specific scarcity of the fauna may either reflect the considerable isolation of the waters of this fiord from the open sea, or is a result of sampling technique i.e. the penetration of the bottom by dredge only and to a limited depth of only 25 m.

The share of the most important animal classes constituting the bottom fauna of the Van Keulen fiord and some other water areas of Spitsbergen and the Bear Island are presented in Tab. 4. In all of them Polychaeta, Crustacea and Mollusca (Bivalvia and Gastropoda) were main dominants of bottom biocenoses.

The depths from which our samples were taken were low and similar at particular stations. Therefore it seems that the character of bottom sediments, was the most important factor differentiating the bottom fauna.

Various types of sediments were inhabited by invertebrates with different intensity (Tab. 2), and the occurrence of some species showed rather strong affinity to particular habitat. It was best expressed in the hard bottom overgrown with algae, where as much as half of all species were abundant and their presence was associated with large algae, mainly with *Laminaria saccharina*. At western coasts of Spitsbergen the fauna associated with large brown algae included 54 species (Różycki and Gruszczyński 1986) and composed of similar animal groups to those in the Van Keulen fiord. The composition of the assemblage inhabiting the hard bottom overgrown with algae in the arctic estuary was also similar (Legeżyńska et al., in press).

In the Van Keulen fiord the bottom of gravel was inhabited by only 2 species. Undoubtedly the reasons of this poverty were the mobile, unstable bottom composed of very coarse gravel as well as the influence of many fresh-water streams. In the habitat of the bottom of gravel and mud, 26 species of benthic animals were recorded. Similar bottom sediments in the arctic estuary were inhabited by 19 species of the macrobenthos (Legeżyńska et al., in press). In both studies the majority of species inhabiting this bottom type were not abundant.

The fauna associated with muddy bottom was the most diversified one (34 species). Moderately abundant and scarce species constituted there 83.3% of the whole fauna. Only one species occurred in masses (*Astarte borealis*) and 3 were abundant there. In the arctic estuary the muddy bottom was inhabited mostly by not abundant species (73.2%), and only 5 out of the total of 19 species were very abundant (Legeżyńska et al., in press).

A comparison of the fauna inhabiting the soft bottom of the Nottinghambukta (arctic estuary) and the fauna of this bottom type in

Table 4

The share of most important animal groups in the bottom fauna of the sublittoral of Spitsbergen and the Bear Island

Faunal groups	Nottinghambukta (Legeżyńska et al., in press)	Skoddebukta (Gromisz, unpubl. data)	Adriabukta and Brepollen (Biała, unpubl. data)	Van Keulen fiord Present paper	Bear Island (Gulliksen 1979)
Polychaeta	29.0%	29.6%	28.7%	15.1%	26.6%
Crustacea	28.0%	24.0%	40.6%	22.6%	14.6%
Mollusca	22.7%	36.6%	17.8%	45.3%	14.6%
others	20.3%	9.8%	12.9%	17.0%	44.2%
Total number of taxa	abt. 75	114	101	53	abt. 75

Van Keulen fiord indicates the presence of only 4 species in common, namely *Lumbriconereis fragilis*, *Anonyx sarsi*, *Gammarus oceanicus* and *Cylichna scalpta;* the abundance of these species were at the same time similar in both areas.

Out of the list of species dominating in the soft bottom fauna of the Van Mijen fiord, that is an area neighbouring the Van Keulen fiord, only one species — *Nuculoma tenuis* (Bivalvia) — was common for both fiords. In the full list of 79 species occurring in the soft bottom of the Van Mijen fiord only 9 (among them 5 species of Bivalvia) occurred also in the Van Keulen fiord. Such a dissimilarity of the soft bottom fauna of both fiords can be, however, a result of different sampling methods.

Zoogeographical composition of the bottom fauna reflects in the long run the influence of water masses affecting particular water body. The Van Keulen fiord, situated at the western coasts of Spitsbergen, is influenced both by warm atlantic-boreal waters and by cold arctic waters. Such situation causes that from the zoogeographical point of view the benthic community of this region should be considered as a mixed one. Van Keulen fiord may be classified as a transient area with a slight domination of acrtic-boreal forms. A similar zoogeographical composition of the fauna associated with laminarians was recorded in the waters of Western Spitsbergen by Różycki and Gruszczyński (1986). Such a zoogeographical picture of the fauna contradicts the scheme of Nesis (1959) according to which the coastal waters of Spitsbergen fiords and bays belong to the high Arctic region. Recent studies on the specific composition and distribution of Amphipoda (Węsławski, unpubl. data) and Bivalvia (Różycki, unpubl. data) in the waters of South-Western Spitsbergen indicate to the dominant share of boreal-arctic forms. Such a situation may be the result of the fact that the Arctic is growing warm since the beginning of the XX-th century, which was very convincingly reported among others by Blacker (1965) in relation to the bottom fauna of the western coasts of Spitsbergen.

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7. Streszczenie

W pracy przedstawiono skład gatunkowy fauny dennej litoralu fiordu Van Keulen oraz jej występowanie na 4 rodzajach osadów dennych. W bentosie fiordu stwierdzono 53 taksony (51 gatunków) zwierząt bezkręgowych (Tab. 2), przy czym 79.2% wszystkich gatunków to skorupiaki, małże, ślimaki i wieloszczety — zwierzęta typowe dla litoralu arktycznego (Tab. 4). W faunie dominują gatunki stenotopowe.

Dno twarde, o charakterze skalisto-kamienistym, porośnięte przez 8 gatunków glonów brunatnych (głównie przez *Laminaria saccharina*) (Tab. 3), było zasiedlone przez 20 gatunków zwierząt. Połowa bytujących tu gatunków to formy liczne i powszechne, a więc najbardziej związane z tym biotopem. Na dnie żwirowym, wyjątkowo niekorzystnym do osiedlania się zwierząt, występowały nielicznie reprezentowane 2 gatunki bezkręgowców (Tab. 2). Dno żwirowo-muliste zasiedlone było przez 26 gatunków zwierząt, z których żaden nie występował licznie. Miękkie osady muliste były zasiedlone przez 34 gatunki zwierząt, w tym aż 11 gatunków małży.

Fiord Van Keulen z zoogeograficznego punktu widzenia jest obszarem przejściowym, którego fauna składa się z mieszaniny form arktyczno-borealnych i atlantycko-borealnych (Fig. 2).