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DISTRIBUTION AND ECOLOGY OF SOUTH SPITSBERGEN COASTAL MARINE AMPHIPODA (CRUSTACEA)

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ABSTRACT

The distribution within the area and preferences with regard to depth, salinity, temperature and habitat of 54 amphipod species found in South Spitsbergen coastal marine waters are described. The domination of eurytopic, euryhaline, shallow water benthic species in emphasized.

1. INTRODUCTION

Spitsbergen amphipods have been investigated extensively in the past with regard to their faunistics and taxonomy (Bruggen 1907, Oldevig 1917, Stephensen 1935, 1938, 1949, 1942).

Ecological studies on Amphipoda from this area have not been published except the paper by Lagardere (1968) on the Malacostraca communities. Preliminary information on coastal amphipod communities from Hornsund (SW Spitsbergen) and recent zoogeographical status of amphipod fauna of this region were presented by Węsławski (1983), Węsławski and Kwaśniewski (1983).

Well documented changes in hydrological and climatic conditions of the area (Blacker 1957) as well as descriptions of the new species and numerous taxonomic revisions within Amphipoda, make a good reason for new studies on present distribution of amphipods in Spitsbergen waters. Great importance of amphipods as a food for marine birds, fishes and seals in Spitsbergen marine waters was emphasized in old and recent studies (Hartley, Fisher 1936, Løvenskjold 1964, Ivašin et al. 1972, Mehlum, Gjertz 1984, Lydersen et al. 1985).

The purpose of this study is to present the recent distribution of Amphipoda in South Spitsbergen waters with some remarks on their ecology.

2. MATERIALS AND METHODS

Main part of presented material comes from collections made by the author during University of Gdańsk Spitsbergen Expeditions in 1977, 1979, 1981/82 and Polish Academy of Sciences Expedition in 1984/85. Additional data were collected by other expeditions from different institutes (see acknowledgments).

Table I. The collected materials from South Spitsbergen

Period	Number of samples containing amphipods	Type of samples
August/September 1975	15	light dredge
June/August 1977	130	different dredges, plankton, nets, baited traps, tidal collections, fish stomachs
June/September 1979	105	as above
July/September 1980	25	light dredge
August/December 1981	174	different dredges, baited and light traps, tidal collections, fish and bird stomachs, plankton nets
January/July 1982	166	as above
August 1984	170	as above plus seal stomachs and grab samples

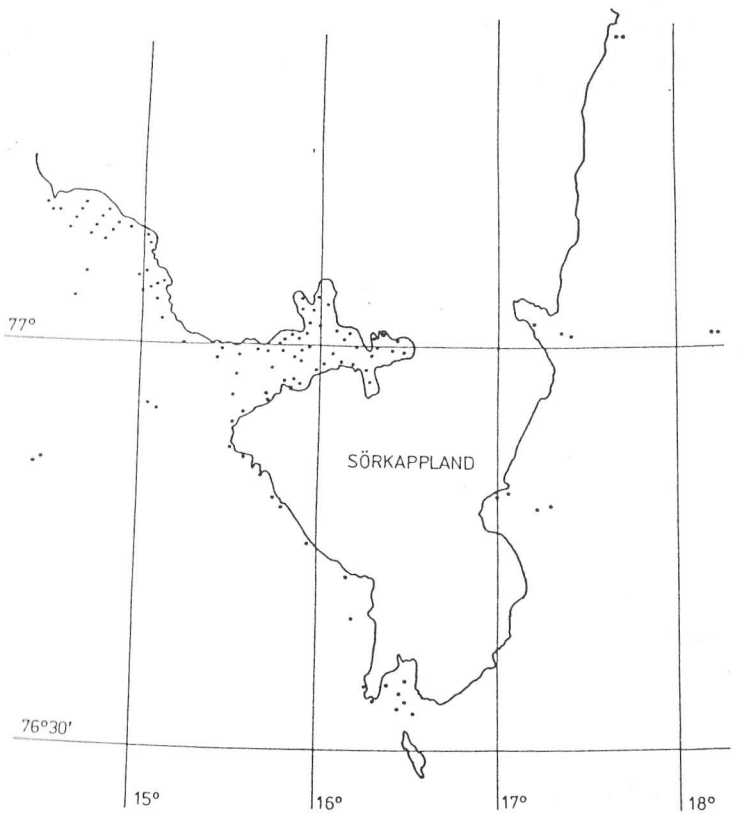

Fig. 1. Sampling stations and area investigated in 1975–1984

Table I presents the number of samples and kinds of gear used in particular years at sampling stations presented on Fig. 1. Samples were preserved in 4% formaline and sieved on 1 mm mesh size screen. Animals were determined with the help of the following keys: Stepehensen (1935–1942), Gurjanova (1951, 1957), Just (1970, 1978, 1980), Dunbar (1954), Vinogradov (1982), Stelle, Brunel (1968), Cvetkova (1975, 1976), Stelle (1982), Thurston (1980), Brjazgin (1974), Lagardere (1968) and Barnard (1968).

Measurements of temperature and salinity were carried out simultaneously with biological sampling. Detailed environmental data on South Spitsbergen waters can be found in papers by Urbański et al. (1980), Swerpel (1985), Swerpel, Zajączkowski (1990).

3. RESULTS

The collected material (785 samples containing amphipods) consists of over 30 000 specimens belonging to 54 species listed in Table II. In this number 8 species are new to Spitsbergen and 17 species are new to the South Spitsbergen region.

Four species observed earlier in the area (*Onisimus plautus*, *Harpinia plumosa*, *Proboloides glacialis*, *Aristias tumidus*) have not been found in present collection.

Table II. The list of amphipods collected from the localities shown on Fig. 1 in 1977–1984 + new to the area ++ new in Spitsbergen waters

Taxon	Number of samples	Number of individuals	Summer values		Biotop (habitat), preferred depth in Hornsund
			Salinity (‰)	Maximal temperature (°C)	
1	2	3	4	5	6
Gammaridea					
Lysianassidae					
+*Lepidepecreum umbo* (Goes 1866)	7	52	33.5–34.5	+0.5	mud, gravel-mud, 60–240 m
Orchomene minuta (Kroyer 1846)	54	420	5–30	+8	sand, mud, 0–2 m
Onisimus littoralis (Kroyer 1845)	117	over 10 000	5–30	+8	plants, sand, mud, 0–2 m
Onisimus edwardsi (Kroyer 1845)	54	2666	30–34	+3.5	gravel, plants, 2–20 m
Onisimus caricus Hansen 1866	2	29	33.5–34.5	−1.8	mud, 30–60 m
++*Onisimus brevicaudatus* Hansen 1866	1	1	33.5	−0.5	mud
Menigrates obtusifrons Boeck 1861	2	3	33–34.5	+2	stones, detritus, 2–20 m

cont.

1	2	3	4	5	6
Anonyx nugax Phipps 1774	120	over 1000	30–34.5	+4	mud. 30–60 m
+ *Anonyx sarsi* Steele, Brunel 1968	150	over 1500	15–34.5	+5	mud, sand, gravel, plants, 2–20 m
+ *Anonyx laticoxae* Gurjanova, 1962	6	26	34–35	+1	mud, 60–90 m
Stegocephalidae					
Stegocephalus inflatus Kroyer 1842	4	18	33.5–34.5	+0.1	mud, 30–60 m
Phoxocephalidae					
+ + *Harpinia serrata* G. O. Sars 1879	1	1	33.5	−0.5	mud, 60–120
Ampeliscidae					
+ *Byblis gaimardi* Kroyer 1846	6	6	34–34.5	+3.5	mud, 20–30 m
+ *Ampelisca eschrichtii* Kroyer 1842	7	12	34.5	+2	mud, 60–200 m
+ *Haploops tubicola* Lilljebrg 1855	5	9	34–35	+2.5	mud, 60–200 m
Haustoriidae					
Pontoporeia femorata Kroyer 1842	12	87	34–34.5	+3.5	mud, gravel-mud, 30–60 m
Dexaminidae					
Atylus carinatus Fabricius 1793	6	22	20–33.5	+6	mud, plants, 2–20 m
Gammaridae					
Weyprechtia pinguis Kroyer 1838	21	365	15–33	+6	plants, 0–2 m
Gammarellus homari Fabricius 1779	61	681	25–34	+4	plants, 2–20 m
+ *Melita formosa* Murdoch 1866	14	80	33–34	+3	mud-gravel, 20–30 m
Melita dentata Kroyer 1842	3	6	33–34.5	+3	mud, 20–30 m
Gammarus oceanicus Segerstrale 1947	82	1211	5–34	+8	mud, sand, gravel, stones, plants 0–2 m
Gammarus setosus Dementieva 1931	132	over 1600	5–34	+3	mud, sand, gravel, stones, plants, 0–2 m
Gammarus wilkitzikii Birul:	14	14	25–30	+1	surface waters, 0–2 m cryopelagial

Tab. II cont.

1	2	3	4	5	6
Melphidippidae					
Melphidippa goesi Stebbing 1899	1	1	34.5	−0.5	mud, 90–120 m
Eusiriidae					
Rhachotropis aculeata Lepechin 1780	3	4	32–34	+2	stones, detritus, plants, 20–30 m
Rozinante fragilis Goes 1866	3	3	28–30	+1	surface waters, cryopelagial, 0–2 m
Oedicerotidae					
Paroediceros lynceus M. Sars 1858	59	over 1500	30–34.5	+3	mud, gravel, 20–30 m
+ *Arrhis phyllonyx* M. Sars 1858	26	128	25–34	+1	mud, 20–30 m
+ *Acanthostepheia malmgreni* Goes 1866	3	9	33–34	0	mud, 30–60 m
+ *Monoculodes longirostris* Goes 1866	11	40	38–34.5	+3	mud, gravels, detritus 20–30 m
+ *Monoculodes borealis* Boeck 1871	16	121	30–34	+3.5	mud, gravels, plants, 2–20 m
+ + + *Monoculodes packardi* Boeck 1871	7	46	34.5	+2	mud, 60–120 m
Synopiidae					
Syrrhoe crenulata Goes 1866	1	1	34.5	+2.5	mud, 90–200 m
Calliopiidae					
Halirages fulvocinctus M. Sars 1858	7	31	30–34	+2	stones, detritus, plants, 20–30 m
Calliopius laeviusculus Kroyer 1838	35	933	20–34	+5	plants, 0–2 m
+ *Apherusa glacialis* Hansen 1887	12	60	28–30	+1	surface waters, 0–2 m cryopelagic
+ *Apherusa sarsi* Shoemaker 1930	2	45	33–34	+2	stones, detritus, 20–30 m
Pleustidae					
+ + *Neopleustes pulchellus euacanthus* G. Sars 1876	1	1	34.2	−0.3	mud, 2–20 m
Pleustomesus medius (Goes 1866)	2	2	33–34.5	+3.5	mud, gravel, 20–30 m
Pleustes panoplus Kroyer 1838	17	146	30–34.5	+3	mud, gravel stones, plants, 2–20 m
+ + *Pleusymtes glabroides* Dunbar 1954	12	37	32–34.5	+4	plants, 2–20 m

Tab. II cont.

1	2	3	4	5	6
++*Parapleustes monocus pis* G. O. Sars 1893	2	6	33–34.5	+3	stones, gravel, plants, 20–30 m
+*Parapleustes bicuspis* Kroyer 1838	3	5	33–34.5	+3	plants, 2–20 m
Ischyroceridae					
Ischyrocerus anguipes Kroyer 1838	106	over 5000	25–34.5	+8	plants, 2–20 m
++*Ischyrocerus* sp. T-1 Just 1980	±5	±20	25–34.5	+8	plants, 2–20 m
Corophiidae					
Unciola leucopis Kroyer 1845	7	10	34.5	+2	mud, 90–200 m
+*Neohela monstrosa* (Boeck 1861)	2	2	34.5	+2	mud, 90–200 m
++*Goesia depressa* Goes 1866	2	24	34.5	+2	mud, 60–200 m
Caprellidea					
Caprellidae					
Caprella septentrionalis Kroyer 1838	33	332	25–34.5	+6	plants, 2–20 m
Hyperiidea					
Hyperidae					
Parathemisto abyssorum Boeck 1871	7	38	34–35.5	+5	water layer 50–100 m
Parathemisto libellula Mandt 1822	49	367	28–34	+3	surface water 0–20 m
++*Parathemisto gaudichaudi* (Guerin 1825)	1	12	?	?	?
+*Hyperoche medusarum* (Kroyer 1838)	9	18	?	?	surface waters 0–10 m
+*Hyperia galba* (Montagu 1815)	3	5	?	?	surface waters 0–10 m

The occurrence of species observed is presented in Figs. 2–6. Only the Hornsund fjord area is shown on the distribution maps because of sufficient density of sampling points there.

Some peculiarities in species distribution may be observed. Regarding their horizontal zonation, the following distribution patterns were observed:

– amphipods distributed in the whole investigated area with no remarkable horizontal zonation. Represented by shallow water species inhabiting phytal zone through the whole area (Fig. 2) and deep water forms living on the muddy bottom (Fig. 3).

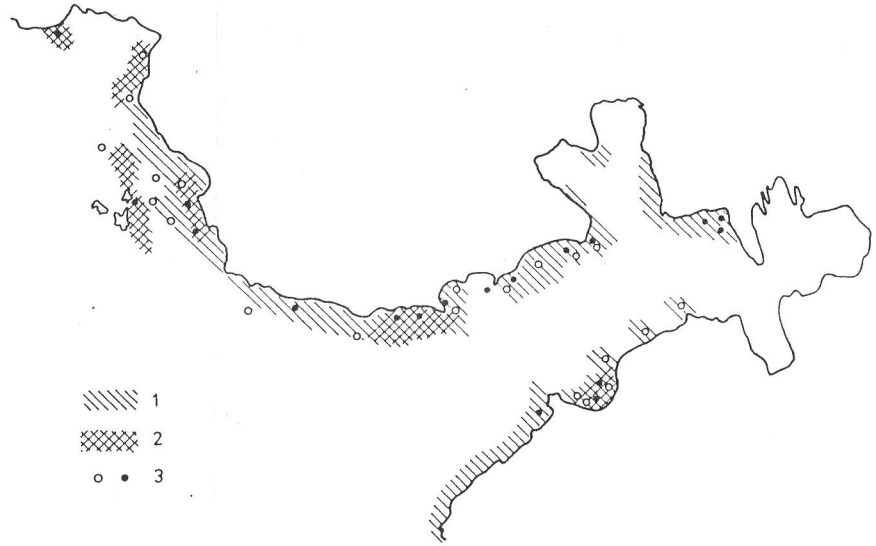

Fig. 2. Distribution of coastal water amphipods in Hornsund. 1 – area of occurrence of *Gammarellus homari*, *Ischyrocerus anguipes*, *Caprella septentrionalis*, *Weyprechtia pinguis*, *Pleustes panoplus*, *Onisimus edwardsi*; 2 – area of occurrence of *Pleusymtes glabroides*, *Parapleustes bicuspis*, *Atylus carinatus*, *Calliopius laeviusculus*; 3 – localities where above mentioned species were found

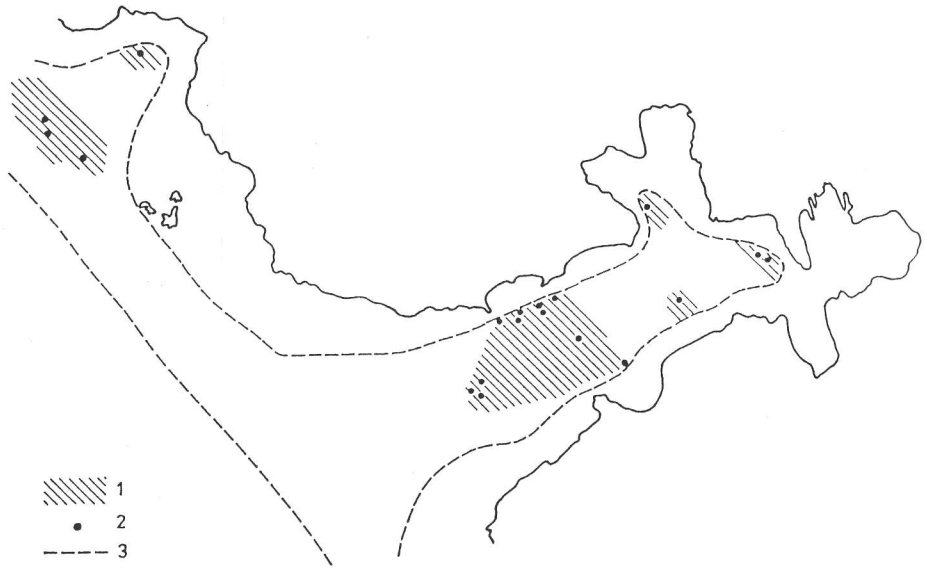

Fig. 3. Distribution of soft bottom, discretely motile amphipods in Hornsund fjord (*Ampelisca eschrichtii*, *Haploops tubicola*, *Unciola leucopis*, *Neohela monstrosa*, *Goessia depressa*). 1 – areas of occurrence; 2 – localities of samples; 3 – estimated limit of distribution

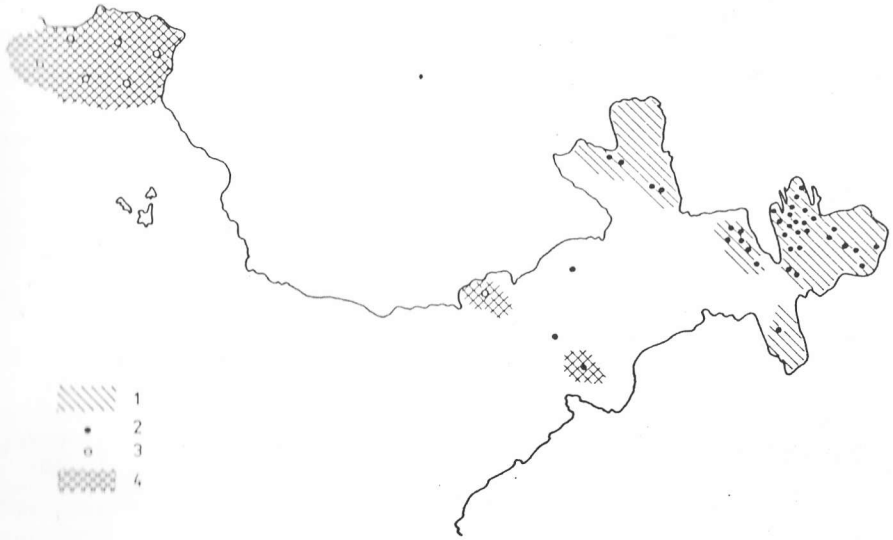

Fig. 4. Distribution of soft bottom amphipods in Hornsund. 1 — area of cold water species occurrence; 2 — localities of stations, where cold water species were found (*Arhis phyllonyx*, *Stegocephalus inflatus*, *Lepidepecreum umbo*, *Monoculodes packardi*, *Acanthostepheia malmgreni*); 3 — localities of stations where relatively warm water species were found (*Pontoporeia femorata*, *Byblis gaimardi*, *Melita formosa*); 4 — area of relatively warm water species occurrence

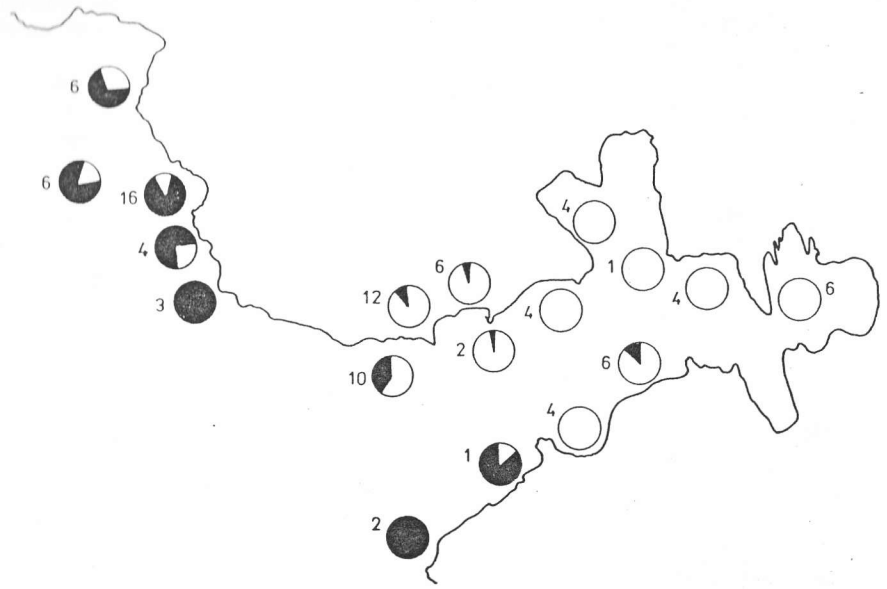

Fig. 5. Distribution of *Gammarus oceanicus* (black) and *G. setosus* (white) in Hornsund area. Numbers at circles denote number of samples collected on given locality

— amphipods distributed in the innermost part of fjord in partly isolated fjord basins (Fig. 4).

— amphipods distributed along the west coast of Sorkappland not entering the fjord basins (Fig. 4)

— amphipods which belong to closely related competitors prefering similar habitat and dividing area into separate zones of occurrence (Fig. 5)

— rare species, found in single localities only (Fig. 6)

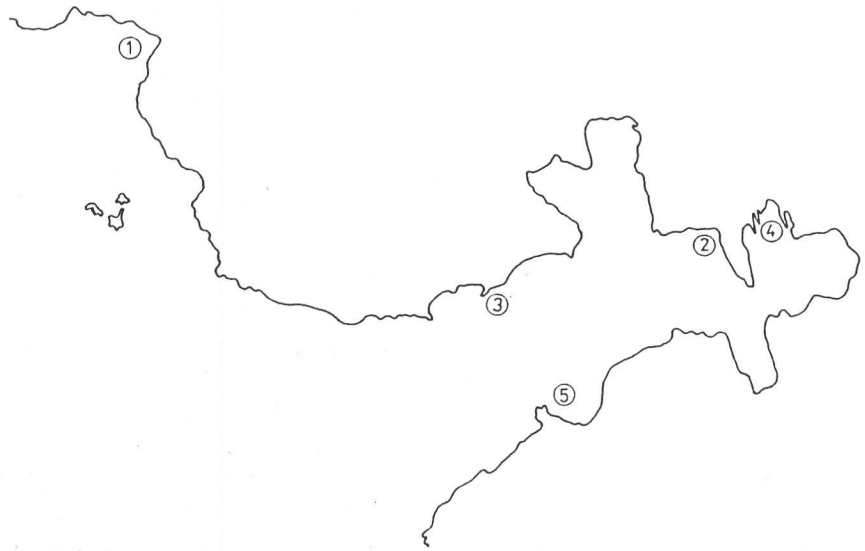

Fig. 6. Less common amphipod species, observed in single locality only. 1 — *Pleustes medius*, *Rozinante fragilis*, 2 — *Apherusa sarsi*, *Menigrates obtusifrons*, *Rhachotropis aculeata*, 3 — *Parapleustes monocuspis*, 4 — *Onisimus caricus*, 5 — *Syrrhoe crenulata*

Distribution of pelagic species is not presented on maps, since the investigated area was to small to search for the occurrence patterns of such wandering forms. Their occurrence reflects the variable water mass movements, so they can be found almost in each locality.

Some of the most common and abundant species belonging to benthic amphipods were not presented on the distribution maps since they may be found everywhere within the investigated area. To this group belong *Onisimus littoralis*, *Paroediceros lynceus*, *Anonyx sarsi*.

Habitat preferences shown in Table II permit us to say that most of the abundant and common species occupy phytal zone and are rather tolerant to the low salinity. Tidal zone amphipods belong to the eurytopic species observed within the whole noted range of temperature and salinity (*Gammarus setosus*, *G. oceanicus*, *Onisimus littoralis*).

Soft bottom forms can be separated into cold water species group (*Stegocephalus inflatus*, *Arrhis phyllonyx*, *Lepidepecreum umbo*) and relatively

warm water species group (*Pontoporeia femorata, Melita dentata, Byblis gaimardi*). Both groups occur at high salinity (34 – 34.5‰). An important difference between their habitats, except temperature is the type of bottom sediment. "Cold water" forms inhabiting basins of the inner part of Hornsund, live on gray, loose, glacial sediment. Whereas "warm water" species inhabiting outer fjord parts live on brown, compact sediment.

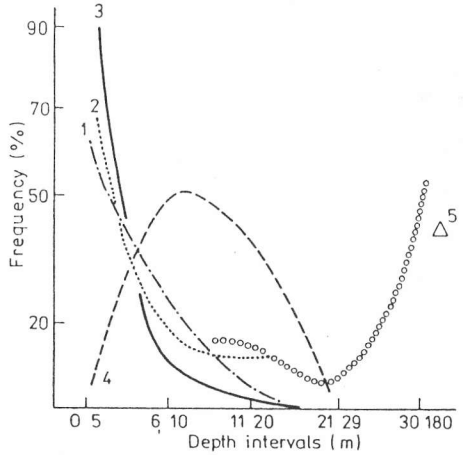

Fig. 7. The depth separated habitats of necrophagic Lysianassidae in Hornsund. 1 – *Anonyx sarsi*, 2 – *Orchomene minuta*, 3 – *Onisimus littoralis*, 4 – *Onisimus edwardsi*, 5 – *Anonyx nugax*, 6 – *Onisimus caricus*

The importance of depth as the segregating factor may be illustrated by depth preferences in five necrophagous lysianassids (Fig. 7), separation of sexes in *Gammarellus homari* population (Fig. 8), and separation of growth stages in some shallow water species like *Anonyx sarsi*, *Calliopius laeviusculus* and others shown in Table III.

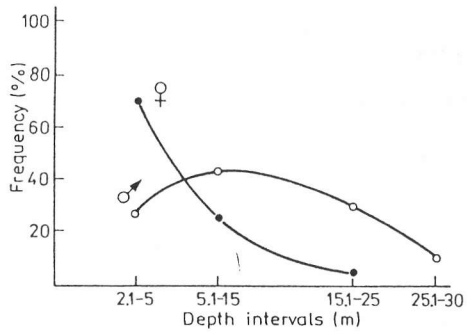

Fig. 8. The separation of sexes within population of *Gammarellus homari* in Hornsund, expresed as % of individuals of each sex collected at given depth interval

Table III. Distribution of growth stages among some amphipods observed in Hornsund

Species	Juveniles		Immatures		Adults	
	depth m	habitat	depth m	habitat	depth m	habitat
Gammarus oceanicus *Gammarus setosus*	0 – 0.5	algae on stones	0 – 1	detritus stones	0 – 5	detritus stones
Onisimus littoralis	0 – 0.5	mud	0 – 0.5	mud	0 – 20	sand, algae, detritus
Anonyx sarsi	0 – 1	detritus algae	1 – 15	laminarians mud	15 – 30	mud
Anonyx nugax	3 – 5	detritus algae	5 – 50	mud laminarians	50 – 200	mud
Calliopius laeviusculus	0 – 1	algae on stones	2 – 15	laminarians	2 – 15	laminarians

Table IV. Estimations of density for species observed in the investigated area and those from other regions

Species	n/m²	Region	Author and method
1	2	3	4
Onisimus littoralis	50 – 6000	Hornsund	present author tidal collection
	180	Franz Josef Land	Bušueva (1977) airlift sampler SCUBA
	3.1	Jan Mayen	Gulliksen et al. (1980) airlift sampler SCUBA
Anonyx sarsi	2 – 20	Middle Atlantic Bight	Dickinson et al. (1980) Van Veen sampler
	0.01 – 0.1	Franz Josef Land	Bušueva (1977) airlift sampler SCUBA
	0.6	Hornsund	shallow water dredgings, present author
Gammarellus homari	6	North Norway	Gulliksen (1980) airlift sampler SCUBA
	0.2 – 40	Franz Josef Land	Bušueva (1977) airlift sampler SCUBA
	1 – 2	Hornsund	present author, shallow water dredgings
Gammarus oceanicus	200 – 400	White Sea	Bek (1972) tidal collection
	300 – 400	Hornsund	present author, tidal collection
Gammarus setosus	0.2	Jan Mayen	Gulliksen et al. (1980) airlift sampler SCUBA

deep water species were not found in the investigated area. Most of the species collected belong to shallow water forms. Number of species occurring below 30 m depth decreases evidently, as was also observed in Canadian Arctic (Thompson 1982) and Franz Josef Land (Golikov, Averincev 1977).

The positive correlation between the diversity of sediments and number of amphipod species was reported by Biernbaum (1979) and Gurjanova (1951), although very rich amphipod fauna was observed also on very homogenous substrata like sand (39 species from Isle of Man, Jones 1948) or the deep sea soft sediment (more than 100 species found by Thurston 1980). In Arctic the evidently unfavourable conditions for amphipods create smooth, shallow water rocks, like those on Bjornoya, where at the depths from 2 to 30 m, only 9 species of Amphipoda were found (Christiansen 1965, Gulliksen 1979).

The number of species connected with phytal zone in the investigated area is similar to that found in European waters (Colman 1940, Makkaveeva 1979).

Resumming it is possible to say that out of 54 species observed in South Spitsbergen waters – 9 belong to the very abundant shallow euryhaline and eurytopic species. Over 50% of species are brackish water or euryhaline forms. Horizontal and vertical zonation is well developed among species observed. Temperature and salinity changes seem not to be of importance for species distribution pattern within the investigated area. Interspecies competition and different benthic substrata belong probably to the main segregating factors.

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Table IV cont.

1	2	3	4
	200–380	Franz Josef Land	Bušueva (1977) tidal collection
Ischyrocerus anguipes	4–370	Middle Atlantic Bight	Dickinson et al. (1980) Van Veen sampler
	6–22000	North Norway	Gulliksen (1977) airlift, SCUBA
	20–400	Hornsund	shallow water dredgings, present author
Goesia depressa	46	Hornsund	Petersen grab
Haploops tubicola	2–3	Hornsund	Petersen grab
Arrhis phyllonyx	6	Hornsund	Petersen grab
Unciola leucopis	2–3	Hornsund	Petersen grab
Ampelisca eschrichtii	1–2	Hornsund	Petersen grab

Only in some cases species density can be estimated quantitatively, such methods like collecting gammarids in tidal zone at low tide. Grab sampling on the soft bottom sediment containing ground burrowing Ampeliscidae and Corophidae give satisfactory results (Table IV). For orther species estimation of their abundance can be evaluated only from the results of dredge hauling along the known way.

4. DISCUSSION

In comparison to data from other Arctic and North Atlantic regions (Table V), South Spitsbergen amphipod fauna is moderately diversified. The Shannon–Wiener coefficient of species diversity calculated for all samples was H = 0.88. Such a low value is caused by the fact that 9 species were represented by more than 26000 specimens (90% of the whole collection). Most comparable to the investigated area with regard to the number of species and area (in km^2) are Port Valdez on Alaska (Feder, Kaiser 1981) and Jorgen Bronlund Fjord on North Greenland (Just 1970).

High population densities and mass occurrence of some species like *O. littoralis*, *Gammarus* spp. and *Ischyrocerus anguipes* were observed in other North Atlantic regions. Gulliksen (1977) found as much as 22000 ind./m^2 of *Ischyrocerus anguipes* in North Norwegia fjord. Bušueva (1977) and Gurjanova (1951) reported from Soviet Arctic the densities of *Gammarus* species of more than 3000 ind./m^2. All species abundant in the present collection (Table II) were observed in other Arctic regions also as numerous (Kuznecov 1964, Bek 1980, Cvetkova 1975). Most of species mentioned above as mass ones, occur in high densities in a patchy way. As a rule within

Table V. The areas and amphipod species number in different regions of Arctic and Subarctic

Region	Estimated area (km^2)	Number of amphipod species	Depths	Author
Thule (North West Greenland)	600	105	0–300	Just (1980)
Jørgen Brønlund Fjord (NE Greenland)	100	28	0–84	Just (1970)
White Sea	95000	98	0–300	Bulyčeva (1957)
Port Valdez (Alaska)	100	34	0–240	Feder et al. (1981)
Islandic Basin	500	120	3000	Thurston (1980)
Norwegian Basin	500	30	2000–3000	Dahl (1979)
South Spitsbergen investigated area	500	54	0–240	present work

the same small bay, during low tide *Gammarus* spp. aggregated only in some most convenient places; the same is true for *O. littoralis* found on tidal sandy bottom.

Small temperature amplitude throughout the year and winter isothermy of fjord waters (Węsławski et al. 1988) would suggest that the temperature changes are of minor importance for species distribution in the investigated area. Similar opinions were expressed by Gurjanova (1957) and Dunbar (1968) who have suggested that the temperature is a less important environmental factor for species distribution in the Arctic than other ones.

If above mentioned opinions are valid for the investigated area, the clear separation of Arctic species inhabiting inner fjord bays and boreal species occupying outer fjord parts is the result of competition between both groups of amphipod taxa.

The increasing influence of northward migration of boreal fauna into Spitsbergen area was reported by Blacker (1957) and Nesis (1959). This phenomenon may cause a shift of the Arctic species into inner fjord parts forming there the communities of a relict character (Węsławski 1983).

Almost 53% of South Spitsbergen amphipods can be considered brackish water species. In comparison with 36% of brackish water amphipod species of the North Sea (Kinne 1962) it confirms the opinions by Thorson (1936) and Gurjanova (1951) that coastal Arctic waters are especially rich in representatives of this physiological group. Diluted layer of surface water in Hornsund ranges from 1 to 20 m below the surface and is to be found miles away from the coast.

An example of Arctic submergence and shallow water occurrence of deep sea species is the distribution of *Arrhis phyllonyx*, *Anonyx nugax*, *Neohela monstrosa*, and *Stegocephalus inflatus*, which were found in Hornsund at 20–50 m depths. The same species were noted in North Atlantic from depths ranging to 2000 m (Stepehensen 1935–42, Gurjanova 1951, Dickinson et al. 1980). However species mentioned above are in fact eurybatic and strictly

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