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Occurrence of soft bottom macrofauna along the depth gradient in High Arctic, 79° N

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ABSTRACT: Soft bottom fauna have been sampled along the Spitsbergen fjord depression entering shelf, slope and Greenland Sea Ocean Basin at 200, 300, 500, 1500, 2000 and 3000 m depths. From 19 samples covering 1.9 m^2, 4295 individuals of 194 macrofauna species have been sorted. Density decreased markedly from over 6000 ind/m^2 in shelf stations to some 600 ind/m^2 below 1500 m depth. Only two taxa (*Chaetozone* group and *Lumbrineris* sp. A) occurred in more than 75% of samples, 55 taxa (28% of the total) were represented by single specimens only. The highest number of species per sample (65 taxa in 0.1 m^2) was noted at 525 depth. There were 14 eurybathic species and the same number of taxa were found exclusively below 2000 m depth, while 117 species were found only shallower than 300 m depth.

Key words: Arctic, biodiversity, macrobenthos, depth gradient.

Introduction

In recent years number of papers discussed the problem of large scale patterns in marine biodiversity (*e.g.* Gray 1997ab, 2000, 2001; Levin and Gage 1998, Flach and DeBruin 1999). The old paradigms of biodiversity dated from studies by Hessler and Sanders (1967), Sanders (1968) as well as the new ones presented by Grassle and Maciolek (1992) have been questioned and discussed. The main reason for that dispute is sparse knowledge on deep water fauna diversity, limited to only few localities sampled adequately (Gray *et al*. 1997). Second reason for controversies is lack of clear definition of diversity, treated freely as species richness, diversity of local fauna, eveeness of species distribution in community etc. (Gray *et al*. 1997, Flach and DeBruin 1999). The main paradigms disputed are:

- Increase of species diversity from the poles to the tropics (Hessler and Sanders 1967)

- Increase of species diversity from shelf to the ocean depth (Levin and Gage 1998)
- Top of diversity is to be found at mid- slope depths of some 2000 m (Rogers 2000)

Majority of above mentioned studied have been performed in mid- latitudes, southernmost in Australia at 35° S (Poore and Wilson 1993), northernmost in Norwegian Sea at 65° N (Gray 1994). There were studies in the High Arctic dealing with large scale biodiversity but either limited to meiofauna (Vanreusel *et al*. 2000) presenting single taxa like foraminiferans Culver and Buzas 2000) or completed with qualitative gear like epibenthic sledges (Brandt 1993, 1997; Brandt *et al*. 1996). Our study presents the account of the macrobenthos diversity collected quantitatively along the depth profile from the High Arctic.

The main goal of this work was to check if the three above mentioned paradigms are valid for the studied region. The present paper gives data on species occurrence and density along the depth profile. The follow up paper (Włodarska-Kowalczuk personal comm.) will present the community analyses and diversity indices from this material, while background information on sediment properties (pigments, granulometry) and meiofauna occurrence will be presented by Zajączkowski *et al*. (*in prep.*)

Material and methods

Quantitative samples of bottom sediments have been collected during three cruises on board r/v *Polarstern* and r/v *Oceania* in August 1999, 2000 and 2001. Sampling have been performed along 79° N parallel, from the outer basin of Kongsfjorden, through the shelf, continental slope down to the ocean basin (Fig. 1). Samples have been collected from 200 to 3000 m deep with the use of large box corer (*Polarstern* deep stations) and Van Veen grab (*Oceania* shallow stations). The basic characteristic of each sampling station and material collected is given in Table 1. Subsamples of an area of 0.1 m^2 have been cut from the large box corer sample, Van Veen grab was of 0.1m^2 area (33×33 cm) washed onboard in marine pre-filtered water on 0.5 mm screen. The washed macrofauna samples have been fixed in 4% buffered formaldehyde solution. The macrofauna has been sorted by major taxa and identified to the possibly lowest taxonomic level; where identification was not certain the A, B, C... categories have been applied. Data on sediments characteristics, pigments content, meiofauna and hydrology of sampling sites will be presented elsewhere in a separate paper (Zajączkowski *personal commun.*).

Meiofauna taxa (Nematoda, Harpacticoida) were excluded from analysis. Numerous pelagic organisms found in benthos samples (Copepoda) were also excluded as they are addressed in the paper by Zajączkowski (*personal commun.*).

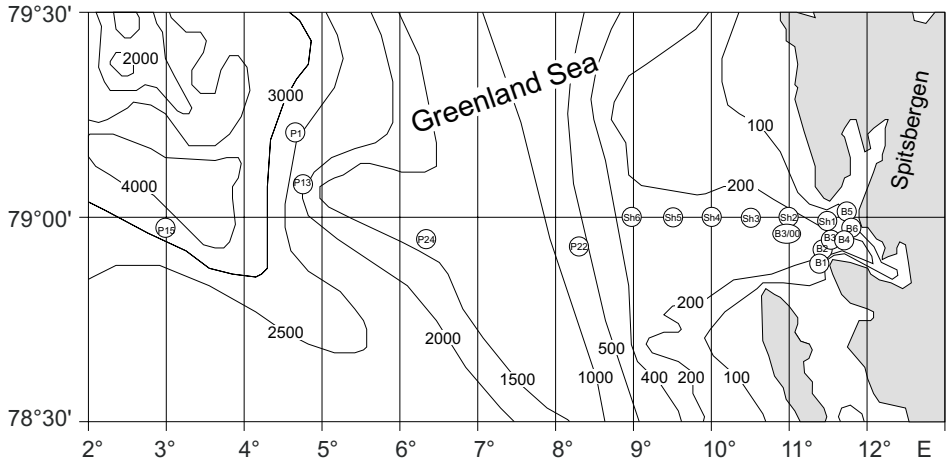

Fig. 1. Sampling stations, numbers refer to those in Table 1.

Table 1

Stations sampled during August 1999 and 2000.

station	latitude N	longitude E	depth (m)	organic matter %	sand and gravel fraction %	ship	sampler	number of species in 0.1m^2 sample	number of individuals per m^2
P15	79.00.00	03.00.00	2977	5.9	16.54	*Polarstern*	box corer	16	550
P16	79.00.00	03.00.00	2977	5.9	16.54	*Polarstern*	box corer	22	530
P1	79.18.00	04.19.00	2453	4.6	14.83	*Polarstern*	box corer	12	230
P2	79.18.00	04.19.00	2453		14.83	*Polarstern*	box corer	15	360
P13	79.09.00	04.14.00	2025	8.5	19.66	*Polarstern*	box corer	18	610
P14	79.09.00	04.14.00	2025		19.66	*Polarstern*	box corer	16	620
P24	78.54.00	06.46.00	1545	10.3	17.58	*Polarstern*	box corer	34	1640
P25	78.54.00	06.46.00	1545		17.58	*Polarstern*	box corer	29	1360
P23	78.55.00	08.28.00	525	2.5	93.45	*Polarstern*	box corer	65	2830
P22	78.55.00	08.28.00	525	2.5	93.45	*Polarstern*	box corer	57	2210
Shelf 6	79.00.15	09.00.13	212			*Oceania*	Van Veen	39	1930
Shelf 5	78.59.81	09.30.18	203	7.0		*Oceania*	Van Veen	55	2070
Shelf 4	78.59.99	09.59.43	260	7.0		*Oceania*	Van Veen	58	3790
Shelf 3	78.59.99	10.30.32	285	7.0		*Oceania*	Van Veen	38	7240
Shelf 2	79.00.10	11.00.53	288	7.0		*Oceania*	Van Veen	37	1350
Shelf 1	79.00.07	11.29.78	374	7.0		*Oceania*	Van Veen	31	7050
B3a	78.58.00	11.30.00	330	5.0	16.9	*Oceania*	Van Veen	22	1630

The numerous small buds of sponge *Thenea abyssorum* found in sample P16 were also exclude from the analyses.

The size of examined species was taken from the literature (maximum for species from Arctic region), hence the size frequency diagrams produce information on the potential size of species inhabiting given depth limit. These are not “average specimens” but rather information on percentage of large and small species from given sampling area.

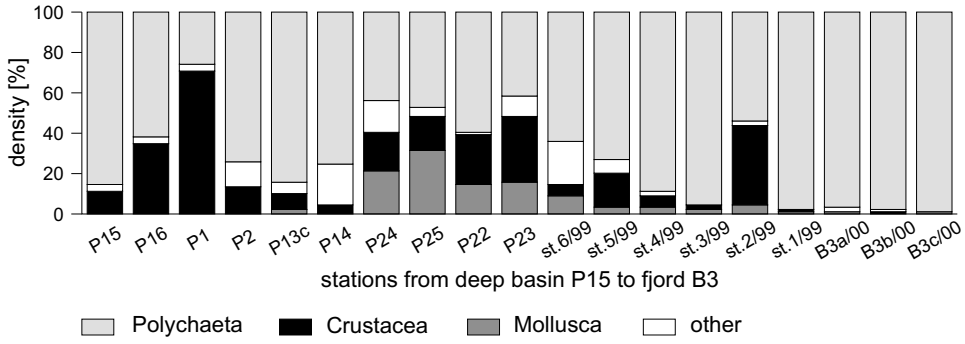

Fig. 2. Percent share of size classes represented in three depth zones.

Study area

Kongsfjorden is a medium-sized (26×12 km) west Spitsbergen fjord, without moraine sill at the entrance and deep depression (*renna*) which runs almost parallel to 79° N and is perpendicular to the isobaths on the shelf and ocean basin. The continental slope starts at a depth of 500 m about 100 km from the shore and extends to a depth of 3000 m at a distance of nearly 500 km offshore. The hydrology of Kongsfjorden is described in detail in Svendsen *et al*. (2002), while that of the neighboring open sea have been described, among others by Coachman and Aagard (1974), Aagard and Carmac (1994), Bonish *et al.* (1997). These papers indicate that the warm West Spitsbergen Current flows along shelf break at a water depth layer of 50–800 m (salinity 34.5 PSU and temperature above 2° C). The uppper water layer is formed by local coastal waters with lowered salinity (33–34 PSU) and variable temperature (in summer from –0.1 to 3° C). The near bottom waters, below 800 m are characterized by high salinity and low temperature (above 34.5 PSU, below –1.1° C). Ice pack occurs seasonally throughout the studied area (from November to June), and icebergs are common on the shelf. Bottom sediments consists of fine glacial mud with occasional dropstones (Zajączkowski *personal commun.*). A very high content of coarse sediment fraction (gravel and sand) was noted on station P22 only at a depth of 525 m.

Results

Taxa count

Our material contained 4295 specimens and yielded 194 taxa from 1.9 m^2 sampling area; this is an average of 104 species from each sampled m^2 and 22 individuals per species. The macrofauna was dominated by Polychaeta (101 taxa), Crustacea (57 taxa) and Mollusca (26 taxa) (Table 2). The three most abundant

species (*Prionospio cirrifera*, *Cossura longicirrata* and *Lumbrineris* sp. – all Polychaeta) constituted 41% of all the collected specimens and the ten most abundant species made up 65% of all the specimens collected. Among Mollusca the three most numerous species (*Thyasira dunbari, Yoldiella propinqua* and *Yoldiella lenticula*) made up 1.8% of macrofauna specimens. The three most numerous Crustacea species (*Harpinia propinqua*, *Tanaidacea* sp. A and *Leucon nathorsti*) made up less than 2% of the collected macrofauna specimens (Table 2). As many as 55 taxa were represented by single specimens only (28% of all taxa collected). The frequency of occurrence shows only two taxa, both polychaetes (*Chaetozone* group and *Lumbrineris*) that occurred in more than 75% of samples. The majority, 163 taxa (83% of the total) were represented in less than 25% of samples. The highest number of taxa per sample of 0.1 m^2 was found at shallow slope – 65 taxa on station P23 (525 m). The number of taxa decreased at greater depths to 22 taxa per sample at best below 2000 m depth (Table 1). There were 14 eurybatic taxa, which were found at the studied depths, and 14 species were found at depths greater than 2000 m only. Species found exclusively shallower than 300 m depth numbered 117.

Characteristics of taxa

The majority of species found in our samples were deposit feeders (45%) followed by filtrators (30%) and omnivores-carnivores (15%), this proportion changed very little over the depth gradient. Species marked as omnivores were more common on the shelf (23%) in comparison with deeper samples (2 to 3 % of species). The dominant zoogeographic group were arcto- boreal species (70%) followed by boreo-arctic (20%) and arctic taxa (10%). The shelf samples had the highest percentage of both boreal (17%) and arctic (13%) species compared to deeper samples which were dominated by arcto-boreal taxa (19%) Table 2. The size structure of macrobenthos shows a clear decrease in average specimen size, from the shelf (65 mm) to the slope samples (30.2 mm) and the deepest samples (27 mm). The distribution of species-specific size frequency of specimens collected on the shelf has two peaks – relatively large (70 mm) and very large animals (300 mm). Small species, below 30mm in length were the most common in deeper sampling (Fig. 2). The type of mobility of animals was similar along the depth transect, with more motile species in deep samples (62%) as compared to those from the shelf ones (55%) (Table 2).

Density

The density of macrozoobenthos was the highest at shallow shelf stations at more than 7000 ind/m^2 this figure decreased markedly to some 500 ind/m^2 in deepest stations (Table 1). Of the 50 most abundant species, only 7 were been found deeper than at shelf depth and none were observed below 525 m depth. There were only 7 species represented in the collection by more than 100 individ-

Table 2

List of individuals from identified taxa found in three groups of samples (shelf, slope and ocean depth) at 79° N. Symbols denote: A – Arctic, B – Boreal, AB – Arctic-boreal, K – cosmopolitic, u – unknown, c – carnivore, s – suspensions feeder, b – burrower, f – filtrator, o – omnivore, m – mobile, d – discretely mobile, s – sessile.

Taxa	size class mm	zoogeo. type	feeding type	mobility type	below 1500 m 6 samples	300 to 1500 m 4 samples	200 to 300 m 9 samples
PORIFERA							
Thenea abyssorum Koltun, 1959	5	AB	f	s	2		
NEMERTINI							
Nemertini indet.	10	u	u	m			3
Polychaeta							
Aglaophamus malmgreni (Theel, 1879)	100	B	c	m			2
Ampharete finmarchica (M. Sars, 1864)	50	AB	s	s			2
Ampharete goesi Malmgren, 1866	50	AB	s	s			1
Ampharete sp.	50	u	s	s			1
Ampharetinae indet.	50	u	s	s	11	1	
Amphicteis gunneri (M. Sars, 1835)	40	AB	s	s	1	3	4
Amphitritinae indet.	80	u	s	s	1	6	2
Aphelochaeta cf.*marioni* (Saint-Joseph, 1894)	B	s	m			12	
Aricidea cerrutii+A45 Laubier, 1967	B	s	m		5		
Aricidea spp.			s	m		50	
Aricidea suecica Eliason, 1920	B	s	m			1	
Artacama proboscidea Malmgren, 1866	80	B	s	s			1
Bathyone elegans (Theel, 1879)	100	AB	c	m		1	1
Capitella capitata s.l. (O. Fabricius, 1780)	80	AB	b	m			14
Capitellidae indet.	100	u	b	m		9	5
Caulleriella sp.		u	s	m			1
Chaetozone group	25	u	s	m	6	7	206
Chirimia biceps (M. Sars, 1861)	B	b	s		2	2	
Chone paucibranchiata (Kroyer, 1856)	80	B	f	s			2
Chone spp.	80	u	f	s		23	16
Clymenura polaris (Theel 1879)	A	b	s		5	36	
Cossura longocirrata Webster *et* Benedict, 1887	AB	b	m			635	
Diplocirrus longisetosus (von Marenzeller, 1890)	30	AB	s	d			4
Dorvilleidae indet.	30	u	o	m			2
Eteone spetsbergensis Malmgren, 1865	100	AB	c/b	m			1
Eteone spp.	100	u	c/b	m			16
Euchone sp.	30	u	f	s		3	2
Euchone sp./*Chone* sp.	30	u	f	s		2	
Exogone cf. *verugera* (Claparede, 1868)	5	AB	c	m		42	
Glycera cf. *capitata* Orsted, 1843	100	K	b	m		4	
Glycera lapidum de Quatrefages, 1866	80	B	b	m			2
Heteromastus filiformis (Claparede, 1864)	100	B	b	m		16	93
Lanassa nordenskioeldi Malmgren, 1866	70	A	s	s			3
Lanassa venusta (Malm, 1874)	70	AB	s	s			10
Laonice cirrata (M. Sars, 1850)	120	AB	s	d			5
Laonice sp. juv.	50	u	s	d			1
Laphania boecki Malmgren, 1866	50	AB	s	s		3	1

Table 2 *continued*.

Taxa	size class mm	zoogeo. type	feeding type	mobility type	below 1500 m 6 samples	300 to 1500 m 4 samples	200 to 300 m 9 samples
Leaena ebranchiata (M. Sars, 1865)	A	s	s			4	
Leitoscoloplos sp.	100	u	b	m			328
Levinsenia gracilis (Tauber, 1879)	B	s	m		5	131	
Lumbriclymene sp.		u	b	s		2	
Lumbrineris sp.	150	u	c	m	10	29	416
Lysippe labiata Malmgren, 1866	50	A	s	s			3
Maldane sarsi Malmgren, 1865	100	K	b	s		8	28
Mediomastus fragilis Rasmussen, 1973	B	b	m			1	
Melinna cristata (M. Sars, 1851)	50	AB	s	s		1	5
Myriochele danielsseni Hansen, 1882	30	B	b	m			8
Myriochele fragilis Nielsen *et* Holthe, 1985	30	B	b	m	34	11	
Myriochele heeri Malmgren, 1867	30	AB	b	m	35		3
*Galathowenia oculata (*Zaks, 1923) + A80	30	AB	b	m			56
Myriochele sp. A	30	u	b	m	20		
Myriochele sp. B	30	u	b	m	8		
Myriochele spp.	30	u	b	m	4	2	
Nephtys ciliata (O.F. Muller, 1776)	200	AB	c	m			4
Nephtys sp. juv.	100	u	c	m			1
Nereimyra punctata (O.F. Muller, 1776)	20	AB	c	m			1
Nereis sp.	100	u	o	m		1	1
Nicolea zostericola (Ortsed, 1844)	50	AB	s	s			1
Nicomache sp.	30	u	b	s		20	12
Nicomache trispinata Arwidsson, 1907	60	u	b	s		4	
Nothria conchylega (M. Sars, 1835)	100	AB	o	s		18	4
Notomastus sp.	150	u	b	m	10	1	
Ophelina abranchiata Stop-Bowitz,1948	60	B	b	m	3		
Ophelina acuminata Orsted, 1843	60	AB	b	m			8
Orbinia sp.	200	u	b	m		1	
Orbiniinae indet.		u	b	m			1
Owenia fusiformis delle Chiaje, 1841	50	*K*	f/s	d			4
Paraonidae indet.		u	s	m			31
Paraonis sp./*Paradoneis* sp.	u	s	m	74	16		
Pectinaria hyperborea (Malmgren, 1866)	50	AB	b	m			2
Petaloproctus borealis Arwidsson, 1907	B	b	s		7		
Pherusa plumosa (O.F. Muller, 1776)	50	AB	s	d			1
Pholoe minuta cf. (O. Fabricius, 1780)	20	B	c	m			11
Phyllodoce sp.	200	u	c	m		1	
Polydora sp.	25	u	f/s	d			1
Polyphysia crassa (Ortsed, 1843)	20	B	b	m			1
Praxillella gracilis (M. Sars, 1861)	100	AB	b	s			2
Praxillella praetermissa (Malmgren, 1865)	100	AB	b	s		11	1
Praxillura sp.	50	u	b	s			1
Prionospio cirrifera Wiren, 1883	30	B	s	d			733
Prionospio sp.	30	u	s	d		16	
Sabellides borealis M. Sars, 1856	50	A	s	s			3
Samythella neglecta Wollebaek, 1912	25	AB	s	s		3	6
Scalibregma inflatum Rathke, 1843	80	AB	b	m			1

Table 2 *continued*.

Taxa	size class mm	zoogeo. type	feeding type	mobility type	below 1500 m 6 samples	300 to 1500 m 4 samples	200 to 300 m 9 samples
Sphaerodoridae indet.	50	u	b	m		1	
Sphaerodoridium sp.	2	u	b	m		1	
Sphaerodorum flavum Orsted, 1843	30	B	b	m			1
Sphaerodoropsis philippi (Fauvel, 1911)	5	B	b	m			1
Spio filicornis (O.F. Muller, 1776)	30	AB	s	d			1
Spiochaetopterus tipicus M. Sars, 1856	30	AB	f/s	s	4	3	20
Spionidae indet.	20	u	s	d			5
Spiophanes kroyeri (Grube, 1860)	30	AB	s	d		10	5
Spirorbis sp.	20	u	f	s			2
Syllidae indet.	30	u	c	m		3	
Syllis cornuta Rathke, 1843	30	AB	c	m			7
Terebellidae indet.	60	u	s	s		10	1
Terebellides stroemi M. Sars, 1835	60	K	s	s		3	27
Terebellomorpha fragm.	60	u	s	s	2	1	
Trichobranchidae indet.	30	u	s	s		2	
Trichobranchus glacialis Malmgren, 1866	30	AB	s	s			1
SIPUNCULIDA							
Sipunculida indet.	5	u	u	u	23	9	7
Crustacea							
Ostracoda							
Ostracoda sp. A	5	u	s	d		1	
Ostracoda sp. B	5	u	s	d		7	
Cumacea							
Diastylis cf. *rathkei* (Kroyer, 1841)	20	BA	f/s	m		4	
Diastylis goodsiri (Bell, 1855)	30	A	f/s	m			6
Diastylis polaris Sars, 1871	15	A	f/s	m	1		
Diastylis scorpionides (Lepechin, 1780)	10	A	f/s	m			3
Diastylis sp. A	10	u	f/s	m		2	
Eudorella emarginata (Kroyer, 1846)	15	AB	f/s	m		1	14
Eudorella sp. A	10	u	f/s	m	1		
Leptostylis villosa Sars, 1869	10	AB	f/s	m			2
Leucon fulvus Sars, 1865	5	AB	f/s	m			6
Leucon nasica (Kroyer, 1841)	5	AB	f/s	m			2
Leucon nathorsti Ohlin, 1901	5	AB	f/s	m		25	
Leucon pallidus Sars, 1865	5	AB	f/s	m		1	
Leucon sp. A	5	u	f/s	m		8	
Tanaidacea							
Tanaidacea sp. A	5		s	d	1	26	
Tanaidacea sp. B	5		s	d		19	
Tanaidacea sp. C	5		s	d		1	
Tanaidacea sp. D	5		s	d			17
Spyraphus anomalus (G.O. Sars, 1869)	5	AB	s	d	11	1	
Isopoda							
Desmosomidia sp. A	5		s	m	5	7	10
Eurycope sp. A	5		s	m			1
Gnathia sp. A	5		s	s			3
Gnathia sp. B	5		s	s	3		

Table 2 *continued*.

Taxa	size class mm	zoogeo. type	feeding type	mobility type	below 1500 m 6 samples	300 to 1500 m 4 samples	200 to 300 m 9 samples
Gnathia sp. C	5		s	s	1		
Ilyarachnidae sp. A	5		s	m	2	8	
Ilyarachnidae sp. B	5		s	m	1	19	
Ilyarachnidae sp. C	5		s	m		1	
Munnidae sp. A	5		s	m			1
Amphipoda							
Acidostoma sp. A	15		c	m	2	2	
Ampeliscidae sp. A	15		f	d		5	
Ampeliscidae sp. B	15		f	d			2
Amphilochidae sp. A	5		s	m		1	4
Argissa sp. A	10		s	m	1	1	
Argissidae sp. A	10		s	m			1
Arrhis phyllonyx (M. Sars, 1858)	15	A	s	m			1
Bathymedon obtusifrons (Hansen 1887)	5	AB	s	m			1
Corophiidae sp. A	10		s	m			1
Harpinia propinqua G.O. Sars, 1895	5	AB	s	m	5	15	9
Hippomedon frigidus Stephensen, 1923	15	AB	s	m		2	
Idunella aequicornis (G.O. Sars 1876)	15	A	s	m			3
Ischyroceridae sp. A	5		s	m			2
Lysianassidae sp. C	5		s	m		2	
Melita quadrispinosa Vosseler 1889	10	A	s	m	1		
Monoculopsis longicornis (Boeck, 1876)	10	AB	s	m			4
Neohela monstrosa (Boeck 1861)	15	AB	f	d	1		
Neohela sp. A	15		f	d	3		
Oedicerotidae sp. A	5		s	m		17	
Oedicerotidae sp. B	5		s	m		2	
Paraphoxus oculatus G.O. Sars 1895	5	B	s	m			3
Stenopleustes latipes (M. Sars, 1858)	15	AB	s	m		1	
Stenopleustes sp. A	10		s	m	1		
Stenothoidae sp.	5		s	m		1	
Syrrhoe crenulata Goes, 1866	10	AB	f/s	m			1
Unciola leucopis (Kroyer, 1845)	15	A	s	m			10
Unciola petalocera (G.O. Sars 1885)	10	AB	s	m		4	
Mysidacea							
Boreomysis arctica (Kroyer, 1861)	30	AB	o	m		1	
Caudofoveata							
Chaetoderma sp.	10	u	u	u			5
Caudofoveata indet.	10	u	u	u			5
Polyplacophora							
Polyplacophora indet.	10	u	u	u		9	
Gastropoda							
Cylichna sp.	5	u	c	m			1
Frigidoalvania janmayeni (Friele, 1878)	5	A	u	u			4
Lepeta caeca (Muller, 1776)	5	AB	f	m			1
Lunatia pallida Broderip *et* G.B. Sowerby I, 1829	10	AB	c	m			2
Margarites groenlandica (Gmelin, 1791)	5	AB	s	m			1
Nudibranchia indet.	10	u	u	m			1

Table 2 *continued*.

Taxa	size class mm	zoogeg. type	feeding type	mobility type	below 1500 m 6 samples	300 to 1500 m 4 samples	200 to 300 m 9 samples
Oenopta decussata (Couthouy, 1839)	5	AB	c	m		1	
Prosobranchia indet.	5	u	u	u			3
Puncturella noachina (Linne, 1771)	5	AB	c	m			1
Bivalvia							
Nuculoma tenuis (Montagu, 1808)	5	AB	s	m		8	2
Nuculana pernula (Muller, 1779)	5	AB	s	m		3	2
Portlaindia arctica (J.E. Gray, 1824)	5	A	s	m			2
Yoldiella fraterna Verill *et* Bush, 1898	5	A	s	m			10
Yoldiella lenticula (Moller, 1842)	5	A	s	m		5	11
Yoldiella propinqua (Leche, 1878)	5	AB	s	m		48	14
Yoldiella lucida (Loven, 1846)	10	B	s	m			1
Dacrydium viteum (Holboll in Moller, 1842)	5	AB	f	s		4	1
Bathyarca glacialis (J.E. Gray, 1824)	10	A	f	s		7	
Thyasira dunbari Lubinsky, 1976	5	A	f/s	m	1	65	1
Thyasira sp.	5	u	f/s	m			1
Astarte crenata (J.E. Gray, 1824)	10	A	f	m		3	2
Cuspidaria subtorta (G.O. Sars, 1878)	5	AB	c	m			2
Bivalvia indet.	5	u	u	u		1	
Asteroidea							
Crossaster papposus (Linnaeus, 1767)	15	AB	s/c	m		1	1
Ophiuroidea							
Ophioscolex gracialis J. Muller *et* Troschel, 1842	10	AB	s/c	m			2
Ophiopholis aculeata (Linnaeus, 1767)	10	AB	s/c	m		12	6
Ophiacantha bidentata (Retzius, 1805)	10	AB	s/c	m		2	2
Ophiocten sericeum (Forbes, 1852)	10	AB	s/c	m			1
Ophiura robusta (Ayres, 1851)	10	AB	s/c	m		7	39
Ophiura sarsi Lutken, 1858	10	AB	s/c	m		3	9
Ophiura juv.	5	u	s/c	m		28	
Echinoidea							
Strongylocentrotus droebachiensis (O.F. Muller 1776)	30	AB	c	m			3
average idividuals/m^2				502	1970	3598	
together species in samples from given depth	40	98	138				

uals. The major taxa distribution along the depth profile shows the clear dominance of Polychaeta at shallower stations (98% in density), while the deepest stations show up to 60% dominance of Crustacea (Fig. 3). Below 1500 m depth the most abundant were polychaetes *Paraonis* sp. and *Myriochele* spp. followed by Sipunculida. The most numerous animals at depths between 500 and 1500 m were the bivalves (*Thyasira dunbari, Yoldiella propinqua*) and polychaetes (*Aricidea* sp., *Exogone* cf. *verugera*). The shelf samples were dominated by polychaetes *Prionospio cirrifera, Cossura longocirrata, Lumbrineris* sp., *Leitoscoloplos*, and these species were also the most abundant taxa in the all collected material (Table 2).

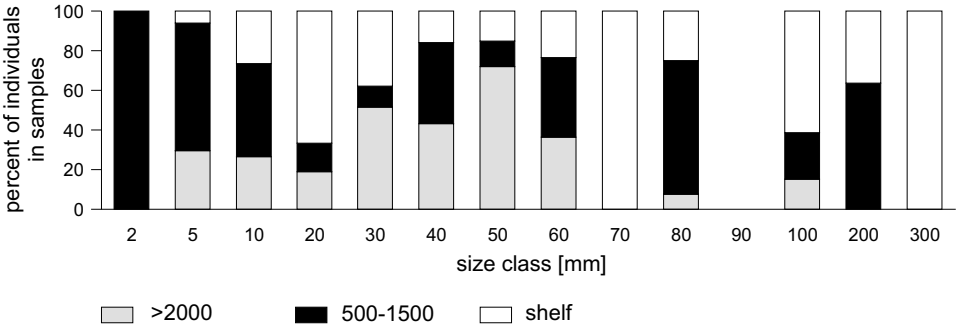

Fig. 3. Share of major macrofauna taxa (percent of density) from particular stations.

Discussion

Representativeness of collected material

The presented material does not encompass the full richness of the marine benthos from the investigated area. For example, we have omitted stones encrusting Bryozoa, found in abundance at station P22 on 525 m depth, where at least 40 species have been determined (Beate Bader *personal commun.*). There were over 140 Bryozoa species found on stones in the outer part of Kongsfjorden (Kuklinski *pers. commun.*). The reason why the encrusting Bryozoa were omitted was the inadequacy of the stones sampling gear. Since the typical plankton species found in sediment samples (*Calanus hyperboreus*, *C. glacialis*, *Themisto libellula*, *Thysanoessa inermis*) might be dead (Węsławski and Legeżyńska 1998) or occasionally visiting the near bottom water, they were not taken into account either. However benthopelagic and hyperbenthic species like *Boreomysis arctica* and number of Amphipoda were counted as "benthos" in our study. Large marine benthos like echinoderms, decapods (megafauna) as well as mobile crustaceans have been underrepresented in our collection due to the small sampling area (0.1 m^2) and type of the gear used. The good review of mobile epibenthos and megafauna richness of the area presents Piepenburg and Schmid (1996), Brandt (1993, 1997), Brandt *et al.* (1996).

Taxa characteristics

Three polychaetes (*Chaetozone* group, *Cossura longocirrata, Lumbrineris* sp.) are among species noted as the most typical and numerous in the Svalbard fjords and shelf soft sediments (Gulliksen *et al.* 1985, Kendall 1996, Holte and Gulliksen 1998, Wlodarska-Kowalczuk *et al.* 1998). Among ten most abundant species from our shelf samples six species were also reported as most abundant in North Norwegian and Svalbard fjords (Holte and Gulliksen 1998). Of the above mentioned, only *Chaetozone* species group were noted down to deepest stations in present study. The

Table 3

Ten most abundant taxa in each depth interval.

taxon	below 1500m ind/m^2
Paraonis sp./*Paradoneis* sp.	123
Myriochele heeri	58
Myriochele fragilis	57
Sipunculida indet.	38
Myriochele sp. I	33
Ampharetinae indet.	18
Spyraphus anomalus	18
Lumbrineris sp.	17
Notomastus sp.	17
Myriochele sp. II	13
taxon	300 to 1500m ind/m^2
Thyasira dunbari	163
Aricidea spp.	125
Yoldiella propinqua	120
Exogone cf.verugera	105
Lumbrineris sp.	73
Ophiura juv.	70
Tanaidacea A	65
Leucon nathorsti	63
Chone spp.	58
Nicomache sp.	50
taxon	200 to 300m ind/m^2
Prinospio cirrifera	814
Cossura longocirrata	706
Lumbrineris sp.	462
Leitoscoloplos sp.	364
Chaetozone group	229
Levinsenia gracilis	146
Heteromastus filiformis	103
Myriochele oculata	62
Ophiura robusta	43
Clymenura polaris	40

other two taxa were represented as single specimens in samples from shelf down to 525 m depth. Benthos from shelf samples was outnumbered by surface deposit feeders; this corresponds well with the gradient of transition from the very disturbed coastal area to stable, organically poor sediment which has been described by Włodarska-Kowalczuk (2000) for Kongsfjorden. The dominance of the taxa in the present material (10 species comprised 65% of the individuals) was very similar to that from Kongsfjorden soft bottom, where among 214 taxa 7 species comprised 50% of the collected individuals (Włodarska-Kowalczuk 2001). Of the four benthic assemblages described for Kongsfjorden (Włodarska-Kowalczuk 2001, Hop *et al.* 2002) the outermost one occupying the area at the entrance to the fjord overlaps with

Table 4

Number of macrobenthos species obtained in different geographic regions.

Number of stations	Sampled area	Length of the profile	Depth	Depth	Number of species	Number of individuals	Area of sampler	Species per 1 m^2	Individuals per 1 species	Sampling gear	Region	Latitude	Mesh size	Author
			min	max										
n	m2	km	m	m	n	n	m^2						mm	
14	21	176	1500	2500	798	90677	0.25	38	114	box corer	New Jersey, USA	40	0.3	Grassle and Maciolek 1992
	5.5	1200	250	4000	620	39582	0.1	113	65	Vann Veen	Norwegian Sea	56	1.0	Gray 1994
	12.5			305	163	5746	0.1	13	37	Vann Veen	Norwegian Sea	65	1.0	Gray 2000
38	10	50	11	51	803	60258	0.1	80	75	SmithMc Intyre Grab	SE Australia	35	0.5	Coleman et al. 1997
10	2.8	300	200	4000	300	11000	0.1	107	37	Vann Veen/box corer	Greenland Sea	79	0.5	present data
7	4.1		200	4500	696	8327	0.1	170	12	box corer	Goban Spur	55	0.5	Flach and De Bruin 1999
	12		9	111	323	13014	0.1	27	40		Loch Linnhe	57	0.5	Pearson 1970
30	8	30	50	300	218	30967	0.1	27	142	Vann Veen	Kongsfjorden	79	0.5	Włodarska-Kowalczuk 2001
	9.9		40	190	547	18858	0.1	55	34	Vann Veen	Aegean Sea	35	0.5	Karakasis and Eleftheriou 1997

present stations B1–B3. The characteristic species were ophiurid *Ophiura robusta,* gastropod *Lepeta caeca* and amphipod *Syrrhoe crenulata* which were all found in our samples collected in summer 2000, and in similar densities as reported by Włodarska-Kowalczuk 2000, from her samples collected in 1998. The size frequency diagrams of benthic animals in Svalbard area demonstrated distinct trough dividing the meiofaunal and macroorganisms (Kendal *et al.* 1997). Species sized from 1 to 5 mm, were equally rare in our samples, and this may suggest that the size separation between meio-and macrofauna is a universally observed phenomenon.

Species richness

The marine macrobenthic species pool of the neighbouring Svalbard shelf area numbers some 1871 taxa (Gulliksen *et al.* 1999). It is hardly possible to estimate the richness of local deep fauna, information collected by Dahl *et al.* (1976) and Brattegard (1993) name over 120 deep water (below 500 m depth) macrofauna species living in the Greenland Sea. Our small scale sampling below 500 m depth, revealed 72 species, all of which have been noted before from the area (Brattegard 1993, Gulliksen *et al*. 1999). It is not likely that the local deep water macrofauna of the area will be much more diverse, since Brandt (1997) notes only 10 malacostracan genera as exclusively deep water stenobathic from Greenland Sea. The soft bottom macrofauna in Kongsfjorden numbers at least 218 species (without encrusting Bryozoa, Ascidiacea and Hydrozoa) from depths of 50 to 300 m as reported by Wlodarska-Kowalczuk (2001). A few studies have been conducted on the macrofauna along an extensive depth profile, chiefly summarised in papers by Gray (1994, 2000), Coleman *et al.* (1997), Flach and DeBruin (1999). The results of species yield from the sampled area and species/individuals ratio from our study do not differ much from the low latitude sampling (Table 4). Patterns like ten-fold density drop from the shelf to the ocean basin and a species number increase in mid-slope area were common for our study and for the papers cited in Table 4. The coarse sediment found on station P22 at 525 m depth is probably the most important factor for the highest number of species since sediment heterogenity is commonly reported as key factor for benthos diversity.

In conclusion, we can state that the analysed material confirms the paradigm of increased species richness at mid-slope, the number of species (species richness) decreased from shelf to ocean depth, but there is no obvious species impoverishment when compared to low latitudes collection from similar depth limits.

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