Megabenthic communities of central Arctic in relation to sea ice margin: the results of image observation and trawl sampling

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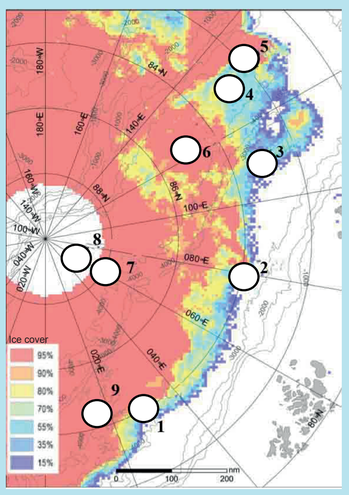
Material and methods

Fig.1 Location of stations



A photographic survey was carried out during the expedition of FS *Polarstern* ARK-XXVII/3 to the Central Arctic deep-sea basins in summer 2012 (2 August-29 September) when the minimum of sea ice cover in the Arctic Ocean was registered. Seafloor was photographed using a towed camera system (Ocean Floor Observation System, OFOS). Nine transects were performed in the Nansen and Amundsen Basins between 83-89N and 18-131E in the depth range 3468-4384m (Fig.1). The OFOS was towed at approximately 0.0-0.6 knots over 1.5-8 hours of bottom time and at a target altitude of 1.3m. In addition at seven transects Agassiz trawl samples were taken to verify taxonomical identifications of specimens on images.

Images were analyzed and stored using the image analysis program and database BIIGLE web-2.0 (Ontrup et al., 2009). In total, 5272 images were used for statistical analyses (Table 1). All overlapping images were excluded from the analysis. Other images were treated? a replicate samples of a transect.

Visible megafauna was counted and identified to the lowest possible taxonomic level. The mean biomass was calculated based on wet weight of preserved individuals sampled by trawl or was estimated using biomass data for congeneric taxa of similar body shape, or omitted if an appropriate analogue was not available.

Table 1. Details of transects.

Station, No	Corresponding trawl	Location (basin)	Survey time (min)	Water depth (m)		Total No. of images	No. of images analysed	Total area covered by images (m^2)	Total analysed area covered by images (m^2)	Transect length (м)
				Start	End					
1	+	Nansen	258	4010	4011	643	637	2361	2308	1550
2	+	Nansen	315	3477	3468	958	941	3721	3379	5500
3	+	Nansen	236	3571	3575	719	675	2989	2085	4380
4	+	Amundsen	270	4168	4172	790	739	2739	2259	1620
5	+	Amundsen	250	4041	4032	745	731	2170	1871	3150
6	+	Amundsen	472	4351	4354	1289	1131	3668	3122	3700
7	+	Amundsen	180	4384	4382	428	81	223	206	260
8	-	Amundsen	157	4375	4375	466	226	698	671	750
9	-	Nansen	74	4048	4066	225	111	296	289	210
Total			**2212**			**6263**	**5272**	**18865**	**16190**	**21120**

Possible effect on megabenthos communities of ice cover characteristics (ice thickness, age, percentage of cover) and sediment characteristics (Chl a, phaeopigment, chloroplast pigment equivalent (CPE), abundances of bacterial cells, total organic carbon, total carbon etc.) was analyzed.

Results

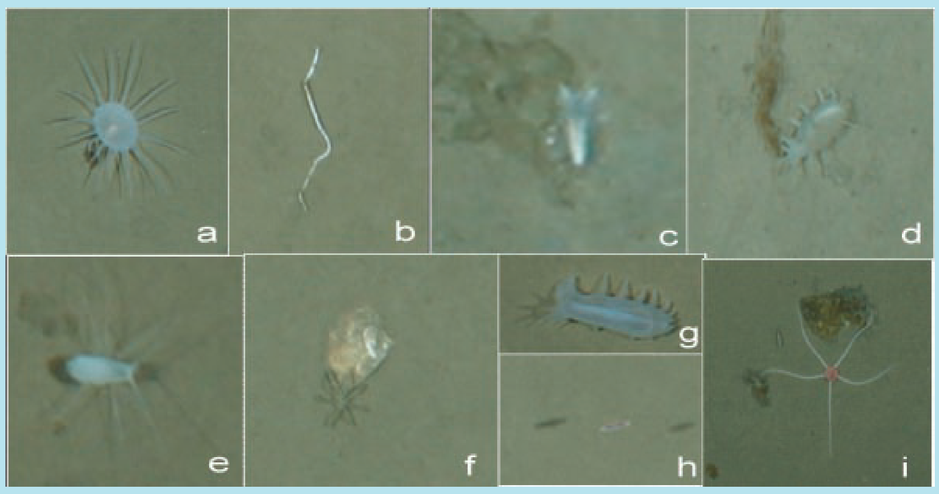
1. Taxa composition

At least 89 taxa were recognized in the study area in trawl samples and on images (73 taxa in the Amundsen Basin and 72 in the Nansen Basin):

- 23 taxa were found both in trawl samples and on images;
- 30 species were found only in trawl samples;
- 36 taxa were recorded only on images.

The total number of taxa per station varied from 20 to 56.

Fig. 2 Images of most abundant taxa



a-*Bathyphellia margaritacea* (Actiniaria), b- *Hyalopomatus claparedii* (Polychaeta), c- Macellicephalinae gen.sp. (Polychaeta), d- *Elpidia heckeri* (Holothuroidea),e – *Eurycope inermis* (Isopoda), f – *Ascorhynchus abyssi* (Pycnogonida), g – *Kolga hyalina* (Holothuroidea), h - *Onisimus leucopis* (Amphipoda), I – *Ophiostriatus striatus* (Ophiuroidea)

Correlation between images and trawl catches

Mobile organisms (amphipods, isopods, swimming polychaetes) were not caught by trawls or caught in very small numbers. Image analysis underestimated numbers of hydrozoans, bryozoans and sponges living on hard substrata (especially stalks of the sponge *Caulophacus*) and excluded infaunal polychaetes presented in trawls. Densities of epifaunal species numerous on images were undervalued based on trawl samples. As a result, the ratio of species estimated based on trawl samples does not match the one based on images.

2. Community structure

Fig.3 Density of most abundant taxa

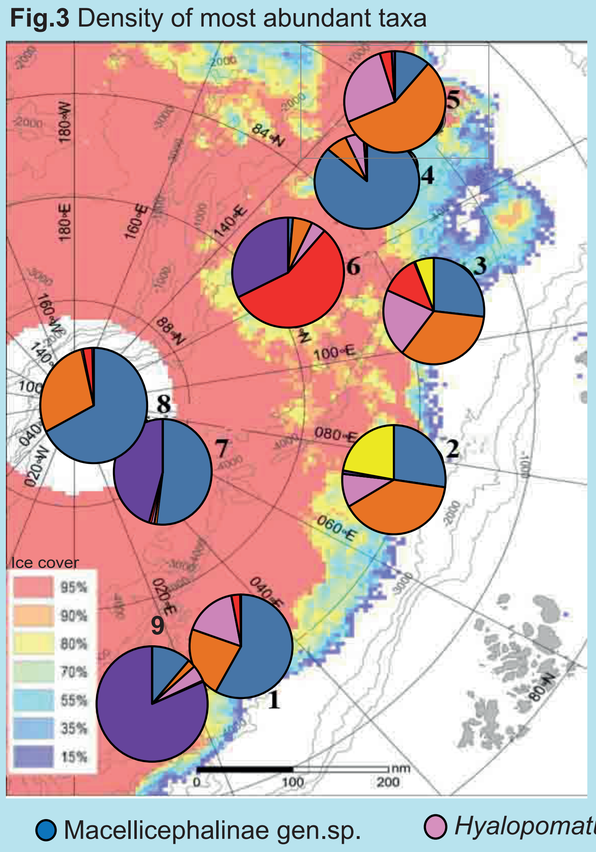
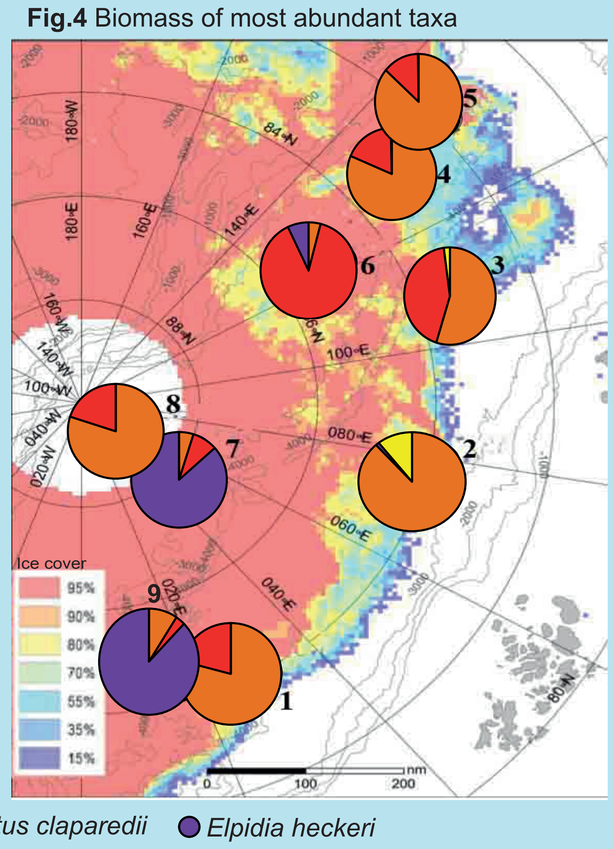


Fig.4 Biomass of most abundant taxa

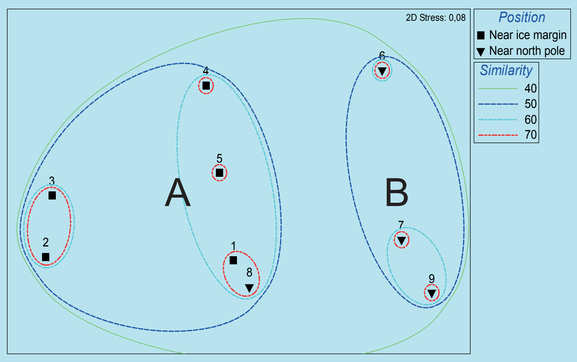


Macellicephalinae gen.sp. *Hyalopomatus claparedii* *Elpidia heckeri*

Bathyphellia margaritacea *Kolga hyalina* *Ophiostriatus striatus*

Differences between stations in abundance of dominant taxa revealed patchy structure of megafauna communities. Dominant species included the anemone *B. margaritacea*, the polychaete Macellicephalinae gen. sp. and holothurians *E. heckeri* and *K. hyalina* (Fig.3).

Fig.5 Multidimensional scaling plot for stations (Bray-Curtis similarity coefficients for the taxa abundance data)



Three types of megafauna communities were distinguished based on taxa dominating the biomass (Fig.4):

1) dominated by actiniarian *B. margaritacea*;
2) dominated by holothurian *E. heckeri;*
3) dominated by holothurian *K. hyalina*.

Multifactorial analyses showed two groups of communities based on the similarity index, with distance to the ice edge as the main structuring factor (Fig.5):

- ***group A:*** five stations located closer to the ice margin under the first-year ice with relatively high density and biomass of actiniarian *B. margaritacea* and high values for indicators of ocean productivity and export flux (Chl a, phaeopigment, CPE, Chl a/CPE ratio, total organic carbon, total carbon, abundance of bacterial cells, concentrations of nutrients); not taking into account the observed falls of sea-ice algal aggregates. The northern-most station (8), under the multi-year ice fell into the group.
- ***group B***: three stations located closer to the North Pole under the multi-year ice with relatively high density and biomass of holothurian *E. heckeri* and *K. hyalina* and lower indicators of productivity in the sediment.

3. Relationship between ice algae aggregations on the seafloor and megafauna

Using OFOS platform massive accumulations of live and degraded (Fig. 6) ice diatom algae *Melosira arctica* were observed in the abyssal zone of the Arctic Ocean at a depth of ~ 4000m for the first time during ARK-XXVII/3 (Boetius et al., 2013). The coverage of seafloor by algal patches varied from 0% to 10% (Fig.7). Patch sizes varied from 5 to 12cm. The contribution of ice algae to carbon export in 2012 in the ice-covered basins was estimated at least >85% of total carbon export. Ice algae can be a key food source for Arctic marine food webs including the benthic fauna.

Fig.6 Examples of ice algae aggregations at the seafloor

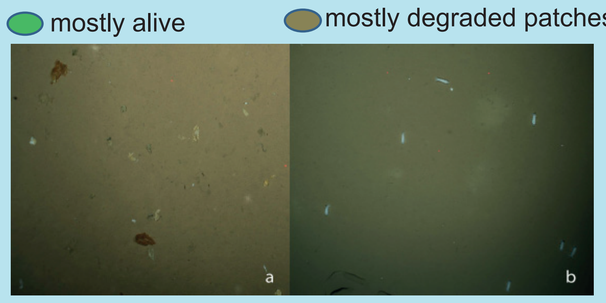


Image observations and investigation of the gut content showed that only some of the large mobile megafauna (ophiuroids and holothurians) accumulated on ice-algae depositions for feeding (Fig.8).

We couldn't find any direct relation of megafauna abundance and biomass with density of algal aggregations at the seafloor or with degree of their freshness. If extensive sea-ice algae (food) falls reoccur during the increasingly frequent sea-ice minima and years with rapid melt events, we expect that with time, ophiuroids and holothurians would increase their density significantly.

The high density of holothurian *K. hyalina* was found at station 6 with very old degraded algae deposits. Probably the high density of sea cucumbers at this station indicates that algal falls may have already occurred the year before and potentially provided energy for a higher population density.

Fig.7 The coverage of seafloor by algal patches

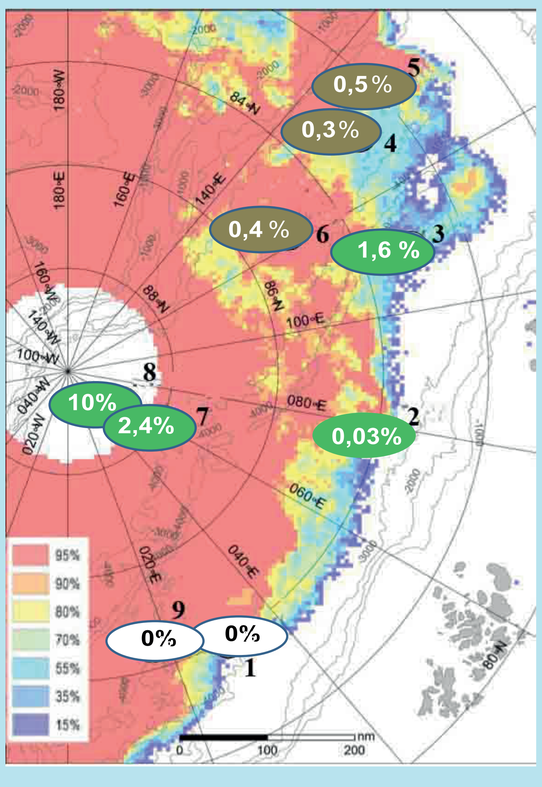
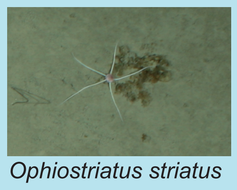


Fig.8 Megafaunal organisms feeding on algae

Elpidia hecheri



Ophiostriatus striatus

Kolga hyalina

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Acknowledgments

We thank captain and crew of Polarstern expedition PS ARK-XXVII/3 ICEARC. The project was funded by the Helmholtz program PACES and additional funds came from the ERC Adv Grant „Abyss" to Antje Boetius and RSF grant 14-50-00095 (ER, AK, AV, and AG: processing of the material).