Benthic invertebrate fauna in the Disko West area with focus on Store Hellefiskebanke

J. L.S. Hansen, M. Sejr, A.B. Josefson, P. Patty, M. Hjorth & S. Rysgaard

Present knowledge concerning the benthic fauna in the Disko West assessment area has been very limited. In order to assess any potential impacts due to oil exploration or other activities, there is a strong need for establishing a baseline in regard to the occurrence and distribution of the benthic fauna in the Disko West area.

In May 2009, a ship based survey was carried out to document diversity and composition of the benthic macrofauna in the Disko West assessment area. A number of stations were sampled, including the soft bottom habitats on Store Hellefiskebanke (Figure 1). The benthic infauna was sampled using Haps and Van Veen grabs and photographs were taken to describe the epifauna. In addition sediment composition, sediment pigment content and sediment respiration was measured (results are not shown). The results of this study together with data from a previous investigation in 1976/1977 have been used to update our present knowledge concerning the benthic macrofaunal community in the assessment area.

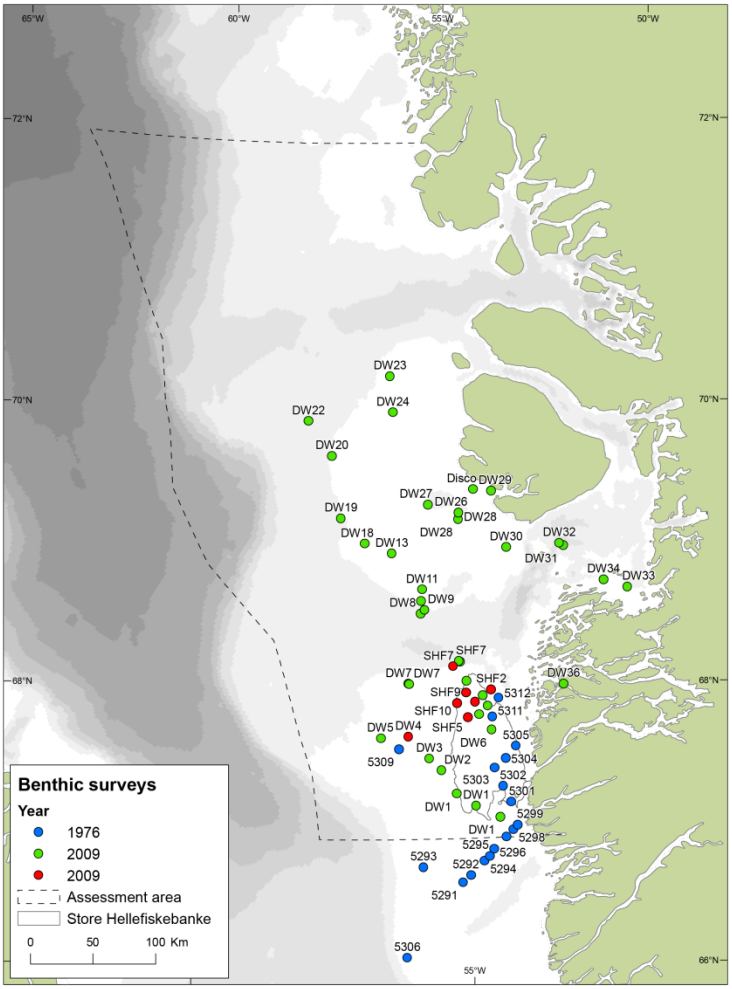

Figure 1. Stations sampled during the 2009 survey qualitatively and quantitatively (red and green symbols). Previous sampling (1976) is marked with blue symbols.

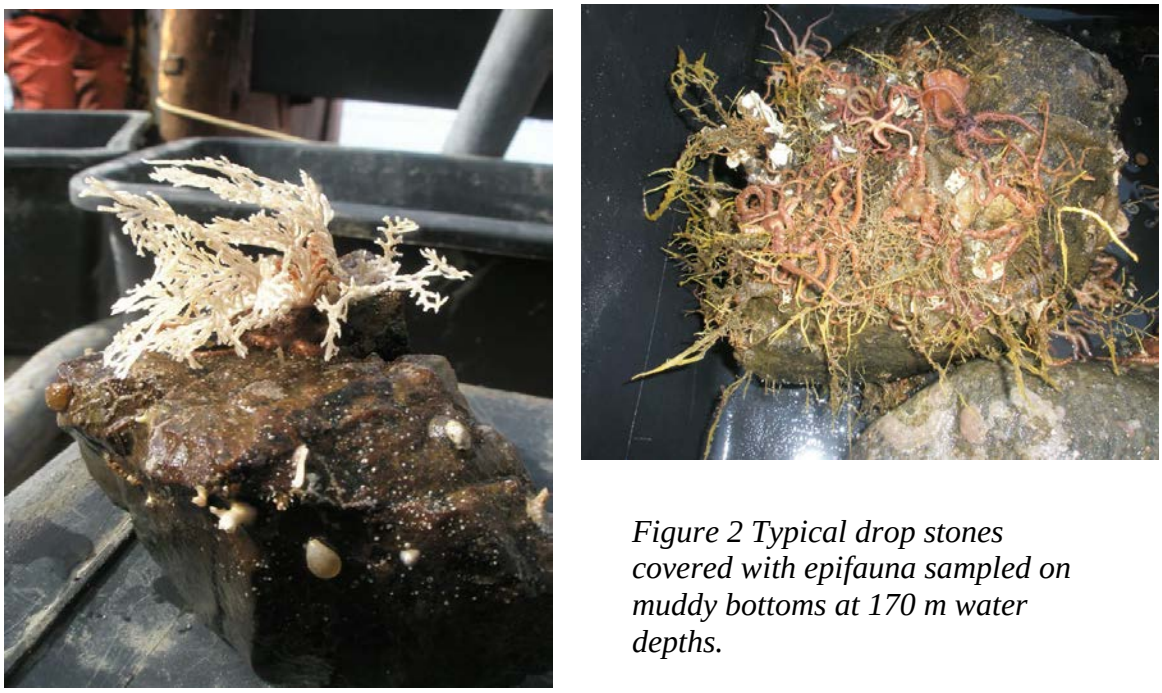

Figure 2 Typical drop stones covered with epifauna sampled on muddy bottoms at 170 m water depths.

The benthic habitats in the Disko West area

Major parts of the area covered by the survey can be characterised as hard bottom habitats especially in the shallow parts (water depths < 100 m). Such habitats include solid rocks and areas covered with boulders, gravel and shells, making a quantitative sampling sometimes impossible. Drop stones, i.e. stones originating from melting icebergs, are another typical feature, occurring on all sediment types at depth < 200 m. The surface of the drop stones was often covered with epifauna (Figure 2), indicating that the stone were on top of the sediment and exposed to epibiotic colonisation.

The sediment composition was related to water depth. The shallowest locations (< 30 m) were covered with well sorted sand whereas soft sediments (mud, silt and clay) were found at depths below 200 m. Depth between 150 and 200 represent a mixture of soft and hard bottoms.

Most of the shallow stations were located within or close to the Store Hellefiskebanke. Therefore the observations is not balanced in the assessment area and it is not possible to state if the distribution of soft/hard bottom is characteristically only for the Store Hellefiskebanke area or if in the relatively shallow areas (100-150 m) west of Disko Island the same mixture of sediment types occur.

The analyses of the sampled infauna and the photos of the epifauna document that the community composition followed the distribution of habitats along the depth gradient. The highest biomasses were found in the 50-100 m depth range with average values of ~500 g wet weight (ww) m^{-2} and about 300 g ww m^{-2} in the 100-150 depth range (Figure 3). In the shallow waters (< 50 m) and down to 150 m the total macrofaunal biomass was considerable lower, i.e. about one tenth or 30 - 50 g ww m^{-2}. The total abundance followed the same pattern, although less pronounced.

The average abundance in the samples between 50 - 100 m depth ranges was about 3000 indvs m^{-2} whereas the total abundance in the samples covering the other depth ranges varied between 1400-2200 indvs m^{-2}.

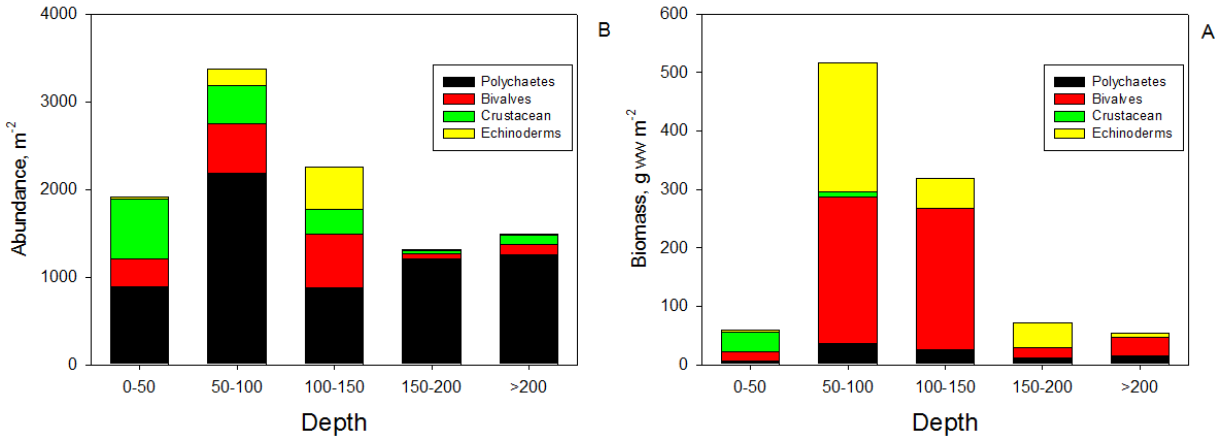

Figure 3. A) Distribution of benthic biomasses among major taxa in 50 m water depth intervals; B) Distribution of corresponding taxa in terms of abundance.

In most of the sampled area the biomass of the benthic fauna was only about one tenth of that found on the margins of the Store Hellefiskebanke. However, molluscs and echinoderms contain a relatively high amount of inorganic shell structures and as these two groups were most abundant on the Bank this biases the comparison somewhat. In terms of ash free dry weight (AFDW) the biomass was about 5-8 times higher in the 50-150 m depth range compared to the rest of the area. The abundance was more evenly distributed in the area due to a relatively higher abundance of small taxa (e.g. polychaetes, crustaceans) at the deep stations which were characterised by soft sediments.

Crustaceans were most abundant at the shallowest stations (< 50 m) with about 40 g ww m^{-2} (30 % of the total biomass). Echinoderms were most abundant in the 50-100 m range with average biomasses of 200 g ww m^{-2} corresponding to 20 % of the total biomass. However, in relative terms the echinoderms were most abundant in the 100-150 m depth range and their biomass contributed most significantly (40 %) to the total biomass in the 150-200 m depth range. Molluscs dominated the biomass (50-80 % of the total biomass) in the shallow waters (< 150 m), whereas at the deepest stations their share in the overall biomass was about 30 %.

Abundances and biomass of the polychaetes were more or less constant with depth. Thereby they contributed most significantly with 85 % to the total abundance and 45 % to the total biomass at the deepest stations (> 200 m; Figure 3). In the shallow waters (< 150 m) their contribution to the abundance was smaller at depth less than 150 m. At the deepest stations (> 200 m) the polychaetes contributed with 85 % of the total abundance and about 45 % of the biomass (Figure 3).

As stated before, the very shallow stations (< 50 m) were all located on the Store Hellefiskebanke and the total biomass of benthic macrofauna was in average only about 100 g wet weight m^{-2} (Figure 4.4.1.4). On the margins of the Bank, the biomass was about 500 g ww m^{-2} due to both

mollusc and echinoderms. The soft-shelled clam, *Mya* was also very abundant in this area. The taken photographs suggest a biomass of about 200 g ww m^{-2} of this clam. However, the clams were located too deep in the sediment to be collected during the sampling. When including this species into the calculation, it can be estimated that invertebrate faunal biomass might be about 700 g ww m^{-2} on the margins of Store Hellefiskebanke and maybe also in the 50-100 m depth range west of Disko Island which was not covered by the sampling.

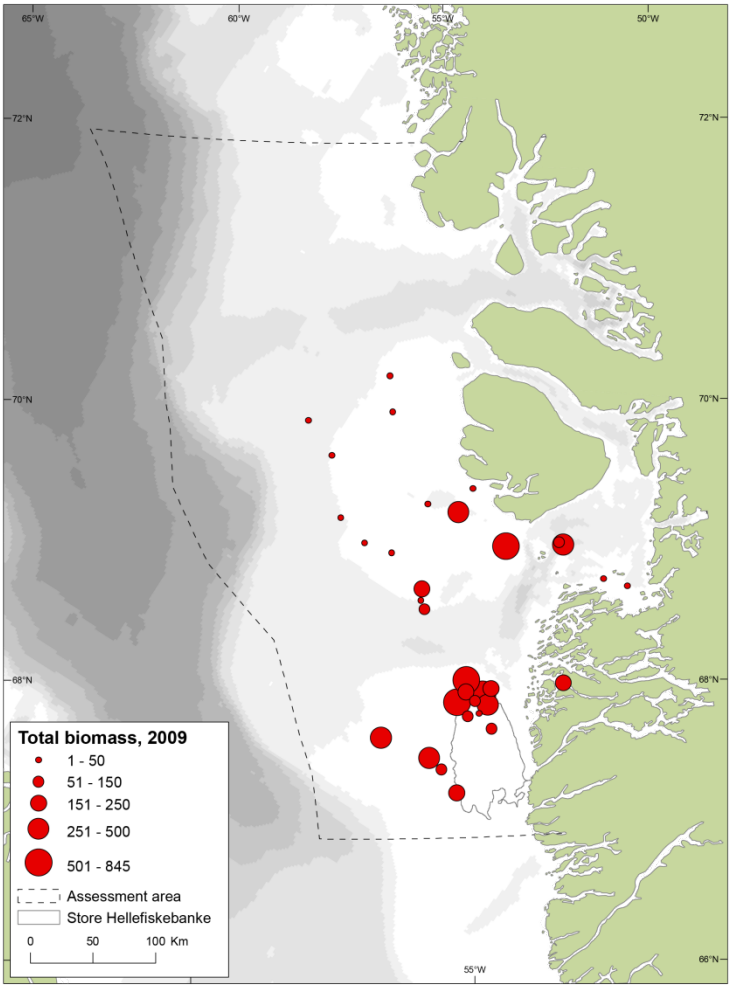

Figure 4. Distribution of benthic macrofauna biomass in the Disko West area May 2009.

Bathymetry, and in particular depth can be seen as a major factor for the distribution of the macrofauna communities in the Disko West area (Figure 5 and 6). The shallow community is characterised by high abundances of crustaceans (amphipods), large bivalves (such as the soft-shell clam *Mya*) and sea urchins and covered about 4100 km^2 of the central Store Hellefiskebanke. The biomass of the communities on the margins of the bank (50-150 m), covering about 11600 km^2 and smaller areas west of Disko, were dominated by the presence of sea urchins and *Mya*, which in particular covered the rest of the entire Bank area at greater depth (> 100 m). The area in the 150 to 200 m depth range is characterised by brittle stars (echinoderms) and bivalves which cover the outer margins west of the Bank (5300 km^2) and areas west of Disko and in Disko Bay. The deepest stations (> 200 m) constitute a major part of the sampled area with soft bottom sediment and a benthic community dominated by polychaetes, but relatively low biomasses. Some of these areas

should potentially be regarded as sedimentation basins with enhanced organic content in the sediment and higher macrofaunal biomass.

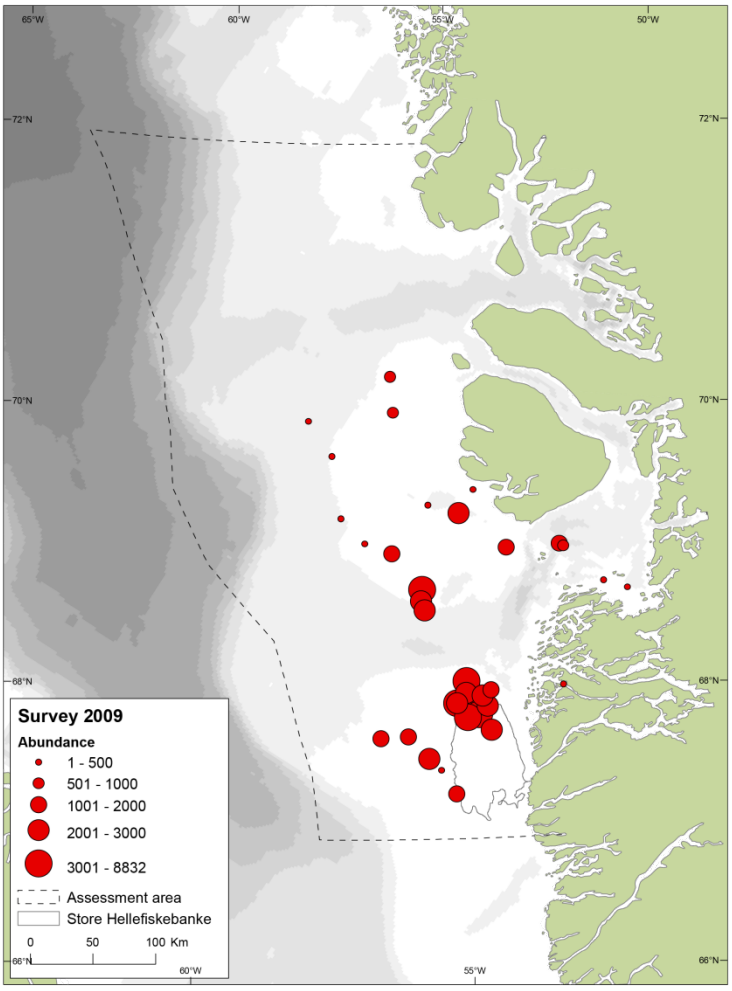

Figure 5. Abundance m^{-2} of benthic macrofauna in the Disko West area in May 2009.

Macrofaunal diversity and species richness

The diversity data include in principle only animals associated with soft sediments (e.g. sediment types where it was possible to retrieve quantitative samples). However, due to the presence of drop stones, some organisms that are normally associated with hard substrates occur frequently in the samples. Examination of the epifaunal communities on the drop stones showed that these differ markedly from the species composition of the surrounding bottoms and thereby contribute significantly to the total biodiversity of the bottoms.

This historical data from a previous study in 1976, consisting of observations from 16 stations and a total of 104 Van Veen grab samples is comparable to the 2009 survey. A total of about 630 species were recorded at the 16 stations, including bryozoans and polyps from scyphozoans that are not always included in macrofaunal surveys. The four major taxa present in 1976 were polychaetes, molluscs, echinoderms and crustaceans which contributed with about 360 species to the overall diversity. The polychaetes contributed with most species (145). Some of the stations in the 1976

survey were located more southerly than in the 2009 survey. Only 51 samples were taken in the same area as in 2009, and there the total species richness present was about 460 and about 279 within the four major taxa. The average number of species found in one 0.1 m^2 Van Veen sample was 61 in 1976 in the entire area. On average 34 species of the major taxa were found in the 51 samples taken directly on the Bank. In some samples a very high number of species, exceeding 100 species per 0.1 m^2 was found. There was no clear correlation between diversity and depth on the Bank. The distribution of species among samples in this restricted area was the same in 1976 as during the 2009 survey, showing almost identical species area curves (Figure 7).

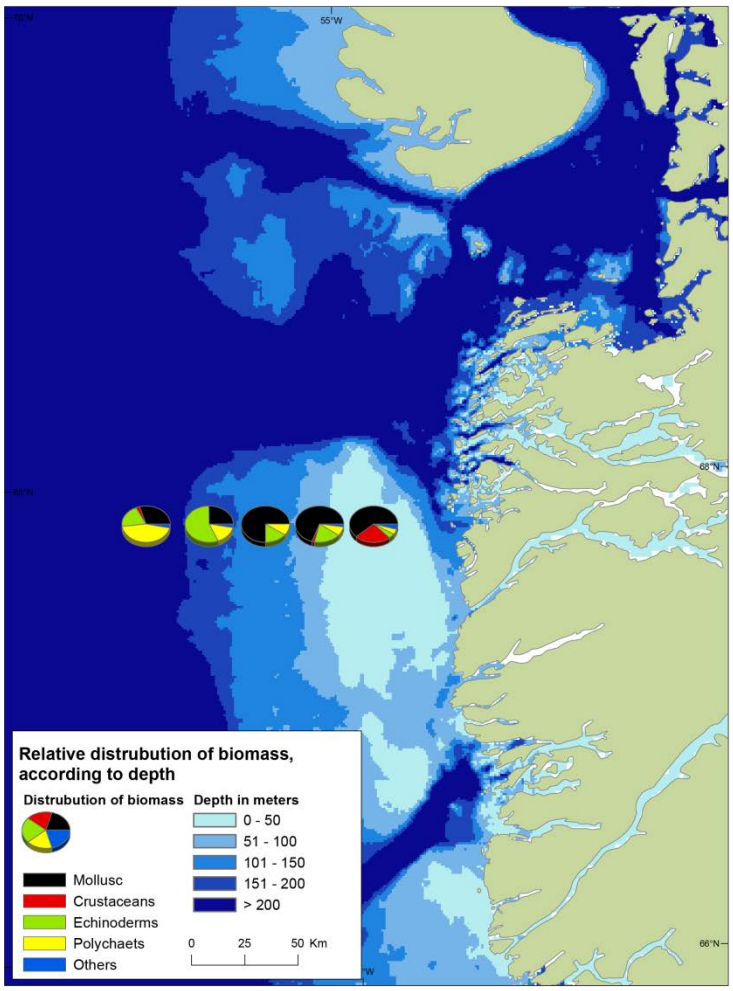

Figure 6. Distribution of benthic macrofauna communities during the survey in May 2009 in terms of biomass in different depth intervals <50 m, 50-100 m, 100-150 m, 150-200 m and depth > 200 m.

A comparison of the species richness during the 1976 and 2009 survey based on the four major taxa present in single 0.1 m^2 Van Veen samples showed that for a sampling effort of 41 samples the expected number of species was 291 in 1976 and 248 during the 2009 cruise.

However, by including only stations in the same part of the Bank the species area curves are almost identical. The estimate shows that sampling one more Van Veen sample (from 41 to 42) would increase the total species number by 2 and sampling of one more station would add 10 species. For a sampling effort of 104 samples covering a larger area (blue curve, Figure 8) it is expected to find 369 species of four major taxa. One more sample would add 1 more species to the list. If the same

kind of estimate is applied to all species identified in 1976 (635 in total) it could be expected to find 1-2 more species when taking one more sample. One more station would increase the number by 7-8 species. Considering the smaller area of the central Store Hellefiskebanke the species number will increase from 459 to 462 by sampling 55 instead of 54 samples.

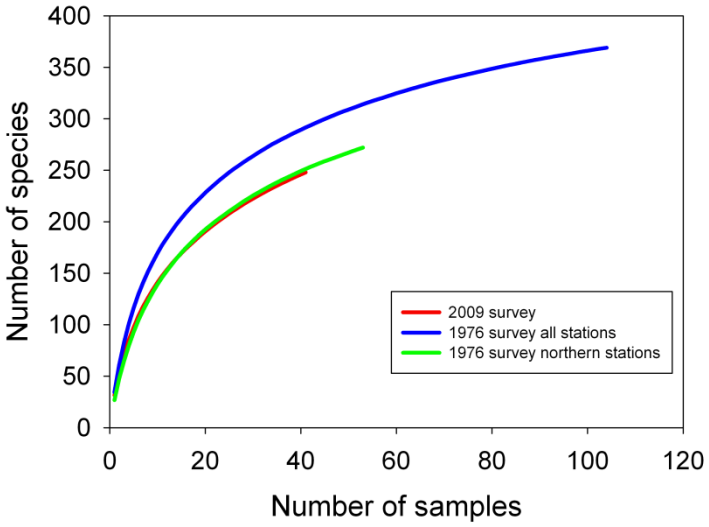

Figure 7. Randomised species accumulation curves showing cumulated number of species vs. number of Van Veen samples on the Store Hellefiskebanke in 1976 (blue line) and 2009 (red line). The green line shows the distribution of species at the stations in the northern part of the 1976 survey.

Opposed to the other three major groups (bivalves, echinoderms and crustaceans) the distribution of polychaete species richness did not differ much between Store Hellefiskebanke and the remaining Disko West area, since the bank is not in particular richer in polychaetes than the rest of the investigated area.

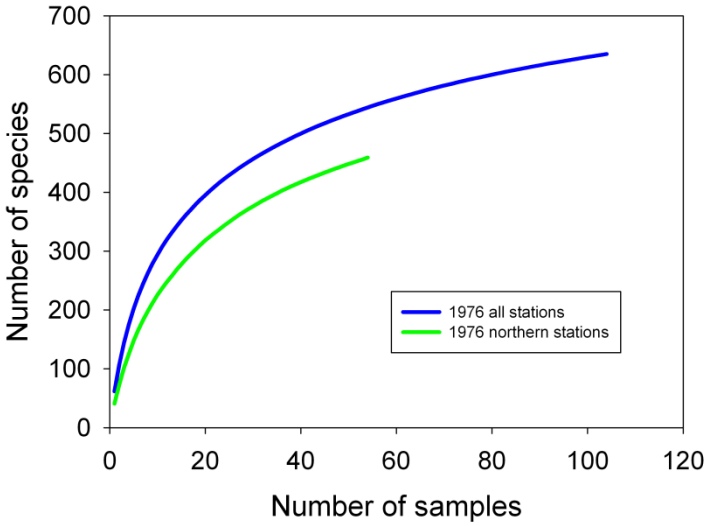

Figure 8 Distribution of species richness on the Store Hellefiskebanke in 1976 (data represents average number of species per 0.1 m^2 (Van Veen samples).

Habitat distribution

The benthic soft bottom habitats in the Disko West area are similar to what is found elsewhere at continental shelves at comparable depth; the softest sediment types (mud and clay) are distributed in the deepest parts where the finest organic and inorganic particles can settle. However, the presence of drop stones originating from the melting icebergs over centuries is a special feature that influences the benthic habitat by increasing the small-scale structural heterogeneity of the sediment surface leading to a high diversity (alpha and beta diversity) of the benthic communities. In addition to the presence of drop stones, a generally higher heterogeneity was found, except in water depth more than 300 m. It is unknown to what extend this heterogeneity relates to reworking of the sediment by iceberg scouring.

As found elsewhere the benthic ecosystem in the aphotic zone in the Disko West area fuelled by the sedimentary flux of organic particles from the productive surface layers. The organic particles are partly re-mineralised while sinking through the water column being exposed to pelagic heterotrophic processes. Therefore, the total input of organic material to the benthos not only depends on the local water column productivity but also on water depth. The deeper the water column the more material will be re-mineralised and the less is available for the benthic community. This pattern fits with the observation during the 2009 survey.

Diversity of benthic fauna in the Disko West area

The study in 2009 also documented the presence of a highly diverse macrofauna community at all locations visited. A total of about 270 species of the four major taxa has so far been identified in the samples, but further analysis will increase this number and some species are new to science. As indicated by the species-area curves (Figure 7 and 8), these numbers may only represents a fraction of the total diversity of the invertebrate fauna. During a previous investigation carried out at the Store Hellefiskebanke in 1976 about 700 species were documented in about 150 samples. The differences in community composition between individual samples were high and even higher among stations.

The distribution of polychaetes species among stations, for example, showed markedly differences in the communities although the stations were gathered in a relatively small area. The distribution of species among stations suggests that in sampling one more station the species list would increase by 5-6 new polychaete species alone and about 14 more species if all taxa are included. Data from 1976 showed almost exactly the same patterns and it is likely that the number of species in 2009 also would reach about 600-700 if all groups were included. Many species occur only in one of these two data sets, and although merging of the two data sets is not straight forward this suggests that the "real number" of species in the area could well be considerably higher maybe exceeding 1000.

Potentially there are several new species to science among the found specimens and so far one polychaete species is confirmed to be a new species belonging to the genus "*Asclerocheilus*".

Biodiversity "hotspot" Store Hellefiskebanke

From the studies performed in 2009 and 1976 it can be concluded that species diversity is very high on the Store Hellefiskebanke and the surrounding area. Despite the limited number of observations it is clear that the diversity is very high also when compared with other temperate regions, e.g. in Western Europe and other parts of the West Greenland Seas. In order to gain a more complete

picture of the species richness more studies are required including sea bottoms dominated by gravel and other types of mixed sediment which are difficult to sample.

Within the studied area, the Store Hellefiskebanke should probably be considered as a biodiversity "hotspot" and an area with a strong bentho-pelagic coupling. With more than 600 documented benthic species in total and a point diversity up to 100 species found in one single 0.1 m^2 sample, this emphasise the importance of the Store Hellefiskebanke for the total benthic diversity of West Greenland.

The biomass found on Store Hellefiskebanke (ca. 700-800 g m^{-2},) is about 10-fold higher on the banks margins (in the 50-150 depth range) compared to the rest of the investigated area. In particular, bivalves (e.g. *Mya*) and echinoderms contribute to these enhanced biomasses with up to 400-500 g ww m^{-2}. Another characteristic is the very high abundances of amphipods (crustaceans), a high quality food source for juvenile fish, in the shallowest part.

Secondary production is presumably high on the Store Hellefiskebanke and this may be due to the shallowness in combinations with the offshore location. The surface mixed layer probably extends all the way to the bottom of the bank. This means that the filter feeders have direct access to the primary production in the illuminated surface layer, resulting in a very efficient pelago-benthic coupling allowing sustaining enhanced biomasses of the benthic community. The shallow depth also suggests that wave energy can penetrate to the sea floor. The coarse and well oxygenated sediments on the top of the bank are probably also maintained by frequent sediment re-suspension thereby transporting the finer particles away from the area thus favouring species such as the sandeel (Box 4).

The benthos of the Store Hellefiskebanke is available for higher trophic levels, i.e. seabirds and marine mammals. Large Bivalves are valuable food items for king eiders as well as walruses. The shallowness of the bank makes these food resources easy accessible. Large aggregations of king eiders are seen in the area during winter (Box 5) and suggest an efficient utilization of the benthic macrofauna although any quantitative measurements of the significance of the predation are missing. The walruses occur in winter on the outer margins of the Store Hellefiskebanke (Section 4.8.5) where suitable size classes of bivalves have their highest densities. The benthic community in the area provides also a diverse food source to benthic foraging fish and predatory macrobenthos thereby sustaining their diversity.

The present data coverage is too sparse to determine whether similar productive benthic habitats exist in other parts of the Disko West area.

Conclusions

The quality of future baseline and effect studies performed in relation to oil exploration activities in Greenlandic waters depends to a large extent on availability of relevant taxonomic knowledge and reference material of the macrozoobenthic community. It is recommended to construct a reference collection based on this and other investigations for quality assurance of future investigations and for general documentation of the biodiversity.

It is recommended to develop equipment and techniques to sample gravel bottoms and bottoms with drop stones quantitatively.

Techniques for a more precise positioning of soft bottoms sampling in relation to small-scale properties of bottom surface morphology such as iceberg scours etc. will lead to a better understanding of small-scale habitat heterogeneity and thereby opening the possibility of developing better BACI-designed (**B**efore **A**fter **C**ontrol **I**mpact) macrofauna effect studies.

The Store Hellefiskebanke should be nominated as a highly vulnerable area due to the high diversity and ecosystem service. The uniqueness, however, depends on whether or not similar habitats exists in the Disko West area and whether or not such areas could serve as alternative foraging areas for key species like walruses, seals, eider ducks or sandeels.