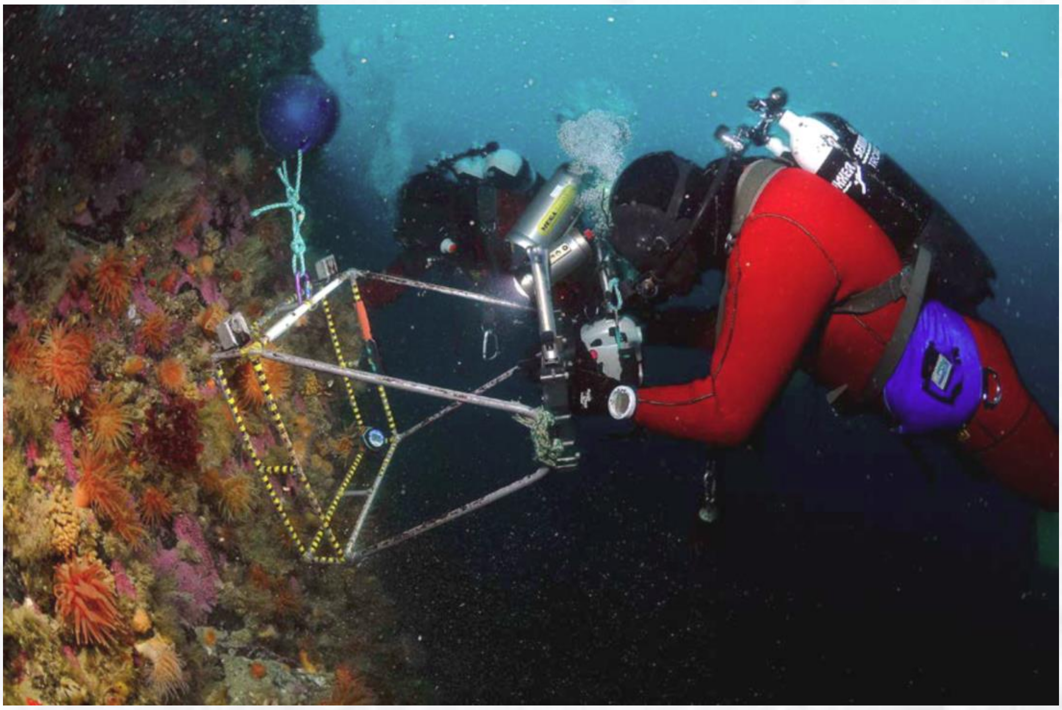
Rapport Report

Evaluation and monitoring of valuable marine benthic areas on Svalbard



SVALBARDS MILJØVERNFOND

Akvaplan-niva AS Report: 5613 - 1

Photograph on front cover: The picture shows the equipment used for the collection of the photographs on the new established permanent benthic monitoring station at Tommelpynten. (Foto: Bjørn Gulliksen)

Akvaplan-niva AS
Rådgivning og forskning innen miljø og akvakultur
Org.nr: NO 937 375 158 MVA
Framsenteret
9296 Tromsø
Tlf: 77 75 03 00, Fax: 77 75 03 01
www.akvaplan.niva.no

Evaluation and monitoring of valuable marine benthic areas on Svalbard

Forfatter(e) / Author(s)	Akvaplan-niva rapport nr / report no
Frank Beuchel Ida Dahl-Hansen Carl Ballantine Rune Palerud	5613 - 1
	Dato / Date 19.12.2014
	Antall sider / No. of pages 21
	Distribusjon / Distribution public
Oppdragsgiver / Client Svalbard Miljøvernfond	**Oppdragsg. referanse / Client's reference** 2013/00691-9 a-594-3

Sammendrag / Summary (Draft Report)

Results from UNIS cruises from 1995-2007 have been used to extract and evaluate valuable marine benthic areas on Svalbard. A rich benthic fauna with high biodiversity was found in areas of eastern Svalbard, especially in selected areas at Hinlopen strait, Storfjorden and Nordaustlandet. A new permanent benthic monitoring station at Tommelpynten at Hinlopen strait will generate data from pristine hard-bottom areas on eastern Svalbard as a supplement to the existing monitoring stations in two western fjords. Selected places in Hinlopen Strait, as well as areas in Storfjorden showed high biodiversity combined with high densities of amphipods, indicating enhanced vulnerability to human impacts such as oil spills. Fjords on the northern and northwestern coastline of Spitsbergen, areas in Storfjorden and narrow sounds at eastern Svalbard showed high densities of Tunicates, which have great potential for bio-prospecting. Management plans should pay attention to these valuable and vulnerable areas, because they are hotspots of biodiversity, important nursery and feeding habitats for many commercial fish species and invertebrates but have also links to larger protected animals like walrus, seals and seabirds.

Prosjektleder / Project manager	Kvalitetskontroll / Quality control
Beuchel	
Frank Beuchel	Paul Renaud

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Preface

In a study for the Norwegian Polar Institute, valuable benthic areas around Svalbard and benthic faunal oil-spill vulnerability were assessed based on existing knowledge from the Svalbard Marine Benthos Database, maintained by Akvaplan-niva. With additional funding from the Svalbard Environmental Fund, the database survey was extended to include more stations from UNIS cruises from 1995-2007. Furthermore, a new permanent benthic monitoring station was established in Hinlopen Strait, complementing the set of existing monitoring stations in Kongsfjorden and Smeerenburgfjorden. Results presented here are relevant for understanding the importance of protecting marine benthic habitats and for impacts of environmental management strategies in the region.

The data preparation has been performed by Akvaplan-niva with assistance from UNIS and UiT.

Tromsø 19.12.2014

Frank Beuchel

Akvaplan-niva

1 Introduction

The benthic community consists of a large number of animal groups, for example, sponges, cnidarians, nematodes, anthozoans, annelids, molluscs, echinoderms, sea spiders, bryozoans, brachiopods, crustaceans and tunicates. Some will live within the soft sediment (Infaunal), others will be found just above the sea bed (Hyperfaunal) while others live on the bottom of the sea bed (Epifaunal).

Most of the benthic fauna are relatively sessile or have little motility as adults. Many taxa have life spans of years to decades and communities thus reflect the local temperature, currents, primary production and depth conditions.These characteristics provide the potential for benthic fauna to integrate environmental influences over long time scales (Underwood 1996), and therefore the benthos is commonly regarded as a good indicator for long-term ecosystem change (Kröncke 1995).

Benthic communities have the potential to be affected by a range of human activities, like mining, oil and gas exploration, fishing activities and tourism. Today, the biologically rich western and central fjord areas of Svalbard are important fishery areas and popular cruise destinations, and they may become more important for exploitation of natural resources in the future. Many of these fjords offer sheltered environments and have a natural gradient in species diversity, with low benthic diversity in the innermost part due to freshwater runoff and a high sedimentation rate from glaciers, and higher diversity towards the mouth of the fjord. Benthic communities may indicate and be vulnerable to consequences of anthropogenic impacts like eutrophication and oil spills (Beuchel et al. 2011).

Benthic organisms can be affected by low oil-concentrations, and heavy, long-lived oil fractions can affect benthic communities over time (O'Clair et al. 1989). Behaviour, physiology, growth and reproduction in benthic animals are the processes most often being affected (Evenset and Christensen 2011).In addition, consequences of oil exposure can vary from nearly total decimation of communities, to marginal, sub-lethal effects at the individual level. On the ecological level, damage on one group of organisms can be transmitted to other groups through mortality in key- or prey organisms, or other ecological interactions (e.g. competition, breeding etc.) in the community. Abiotic factors (e.g. weather, temperature, waves, ice cover and currents) will influence the fate of spilled oil.

1.1 The Akvaplan-niva marine database

This report uses data from the Akvaplan-niva marine database, which consists of 1871 species of marine benthic macro-organisms and more than 30 000 records (Gulliksen et al. 1999). Data are available from 1002 stations from both literature and UNIS field surveys, and a further 428 UiT diving stations for which photographs and video are available. The database provides biological information about species occurrence as presence/ absence data, as well as species abundance data for some stations. In this report, we mainly focus on the available data from UNIS cruises from 1995-2007, as an extension of the work done in the PRIMOS project in 2011 (Beuchel et al. 2011). Due to the lack of abiotic information from these cruises, we concentrate our evaluation on the available biological data.

1.2 Long-term photographical benthic monitoring

Photography is an important tool allowing non-destructive or repeatable sampling where large amounts of data can quickly be retrieved (Rumohr 1995). It has been particularly useful in describing polar benthic assemblages (Jørgensen and Gulliksen 2001). Meaningful temporal variability in benthic communities of high-Arctic systems can only be detected if the studies are conducted over appropriately long time-scales, because life spans of conspicuous rocky bottom benthic species extend over several years (or even decades) and recruitment appears to be much slower compared to temperate systems (Piepenburg 2005).

Long-term photographic monitoring of Svalbard macrobenthos has been successful carried out on stations in some western fjords since 1980 (Beuchel and Gulliksen 2008, Kortsch et al. 2012). These data sets were used to document changes in benthic communities and suggest that benthic biota respond to fluctuations in regional climate patterns (Beuchel et al. 2006). In addition to long-term monitoring protocols, a network of benthic photographic inventory stations over the entire Svalbard archipelago exists, but so far no permanent monitoring station on the eastern part of Svalbard exists. This area is characterized by colder water masses, less particles, and light that penetrates deeper into the water column.

1.3 Objectives of this study

This study aims to further utilize the Akvaplan-niva marine database to give the management authorities an important tool for mapping and monitoring the Svalbard benthic marine environment. The network of UNIS stations in the database is used to evaluate which of the marine benthic areas of Svalbard are especially valuable and/or vulnerable to potential anthropogenic impacts, for example an oil spill. **(Workpackage 1)**

Addressing the need of improved long-term benthic monitoring on Svalbard, the second goal of this work is to establish a new permanent monitoring station at the eastern side of Svalbard. The aim is to collect benthic baseline data from a more pristine marine environment than we find in the western (more boreal influenced) fjords, because benthic communities in western and eastern fjords may respond differently to the same human pressures due to different species composition and functional traits. **(Workpackage 2)**

2 Materials and Methods

2.1 Work package 1

2.1.1 Use of database

Information on abiotic parameters were only available for the UiT diving stations (Beuchel et al. 2011). Therefore the evaluation of the UNIS field stations in this report is only based upon an analysis of the available biological information of the Akvaplan-niva marine database. Data from UNIS field stations were available from 1995 – 2007 (Figure 1). All species records are registered as presence/ absence data. The selection of UNIS stations was further limited to stations with ≥ 15 species. Stations with a lower number of species were not considered, because they mostly had no replicates resulting into an uncertain scientific value for those locations. Stations around Jan Mayen and offshore stations were also excluded. Species numbers (biodiversity), and species compositions (of amphipods and tunicates) from these stations was then extracted from the database. The sampling gear used during the UNIS field surveys were the Ockelmann sledge, the triangle scrape, the RP-sledge, the ordinary trawl, the shrimp- and Agassiz trawl, the Van-Veen Grab and samples derived from diving surveys. These gears collect epifauna, as well as hyperfauna and infauna, so a wide spectre of benthic fauna is considered in our survey.

2.1.2 Image analysis and processing

For both work package 1 & 2, all the images were initially processed using a script described in Beuchel et al. (2010), that was pre-made and could be loaded into '*Adobe Photoshop® CS6 (64 bit) extended'*. The latest version of Photoshop includes a measuring function tool allowing for area and count data to be taken. This allows for a faster approach to photographic analysis, which is an improvement on the methods described by Beuchel et al. (2010). The area-measurement tool measures the total area covered within the same species/family/group with count data being based upon the number of areas, which corresponds to the abundance. The count tool allows for many species groups to be counted simultaneously giving a running total of individuals as well as a running total of overall organism count per photo. Organisms were identified manually down to the lowest taxon possible and presence/ absence as well as count data was recorded.

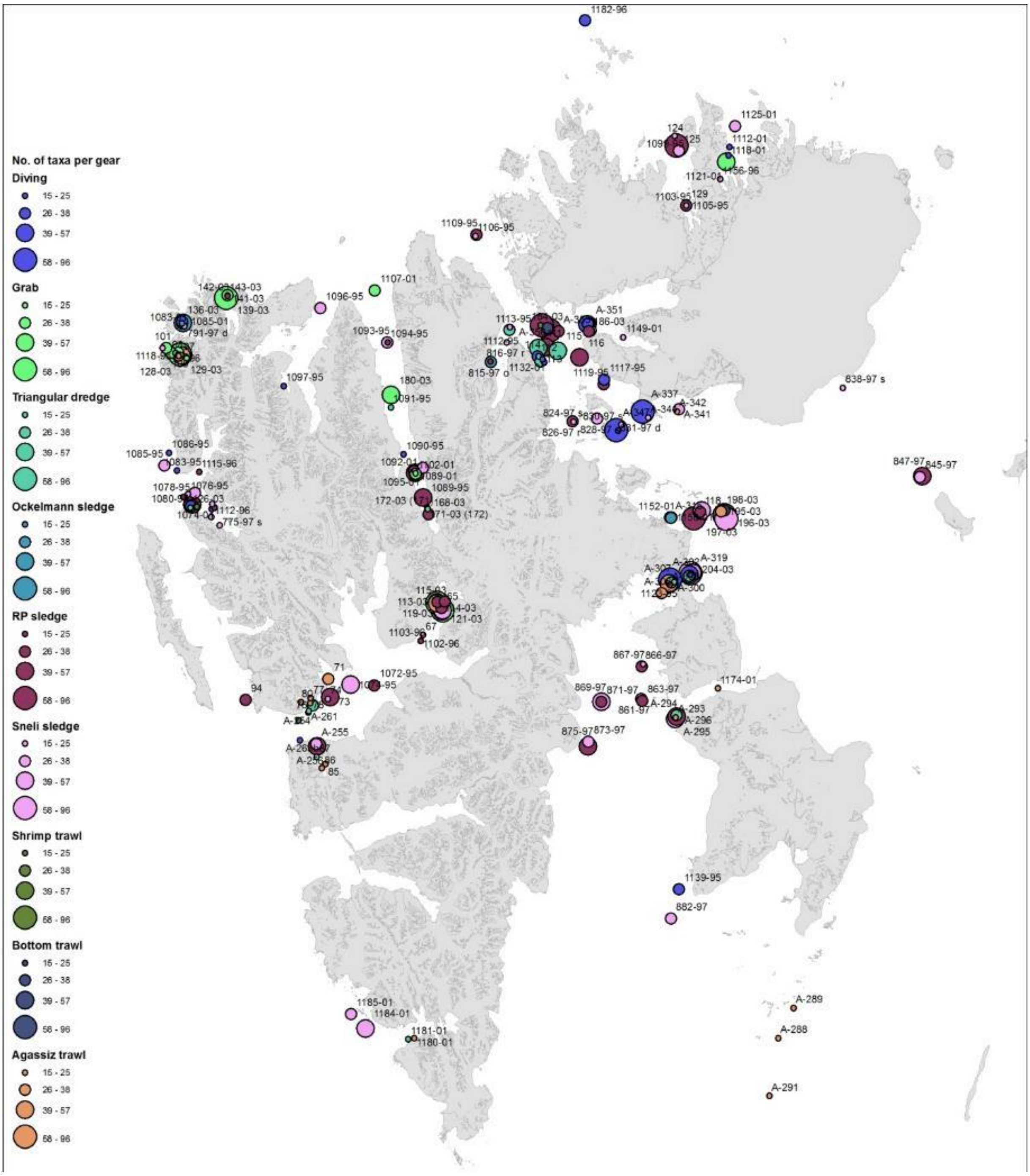


Figure 1. Map of Svalbard showing the selected UNIS field survey stations that contributed with data to this study. Different colours indicate the sample gear used, *while the bubble size refers to the number of species.*

2.1.3 Statistical analysis

Multi- dimensional scaling (MDS) and cluster analysis were carried out using the statistic package PRIMER v.6 (Clarke and Gorley 2006). The data were square-root transformed (MDS) and Log(x+1) transformed to down-weight abundances of dominant species. The MDS plot was calculated based on Bray-Curtis similarity matrices (Clarke et al. 2006). For direct ordination analysis, the program package CANOCO 4.5 (Ter Braak and Smilauer 2002) was used. The linear ordination model PCA and its canonical form RDA was applied, and significance tests were performed using Monte-Carlo restricted permutations (Ter Braak and Smilauer 2002, Leps and Smilauer 2003).

Specific groups of species for this study were selected from the database based on their known vulnerability to oil (Amphipods) or their potential for bio-prospecting (Tunicates, Mendola, 2000). Biodiversity data is based on presence/ absence (UNIS stations) and the total number of frames (UiT diving stations) from several replicates.

2.1.4 Analysis of pictures from a benthic inventory station at Gyldenøya

To increase the existing knowledge about hard-bottom benthic habitats with Arctic character, an existing time-series set of photographs from a location close to the island of Gyldenøya in the northern Hinlopen strait (Position: 79° 40,2' N, 19° 48' E) was analysed, as part of the evaluation of valuable areas. The locality has been annually re-visited since 2003 and shows a rich and characteristic rocky bottom fauna with typical depth zonation patterns for eastern Svalbard.

Several depth transects from 5 to 40 m depth were taken during each visit, with pictures taken in approximately 2m intervals. In total, presence/ absence data from 205 photographs across 16 transects were obtained from image analysis using Adobe Photoshop (Beuchel et al. 2010).

2.2 Work package 2

In August 2012, a permanent monitoring station was established north of Tommelpynten, Spitsbergen (Position 79° 33,550' N, 18° 37,005' E) (Figure 2). The location of the station is marked with red dots on the vertical rock just above the high water line (Figure 3).

The sampling method is based upon the non-destructive photographic technique developed by Lundälv (1971). Depth transects of photographs have been taken 26-27 September 2012 and 01 October 2013 using a digital Nikon D100 6mpx camera with a Nikkor 14mm lens, F/2.8 AF-D, and two external mounted strobe flashes. The diver-operated camera set-up (see picture on the front page of this report) was attached to a 50 x 50cm metal frame, which ensured accurate positioning of the camera over the area of the seabed giving a fixed focal distance and a known sampling area (0.25m^2), thus allowing quantitative analysis to be undertaken on the images (Lundälv 1971, Beuchel et al. 2010).

The diver took photographs approximately every meter whilst descending and ascending the vertical wall, with the deepest photograph being taken at ~45m.

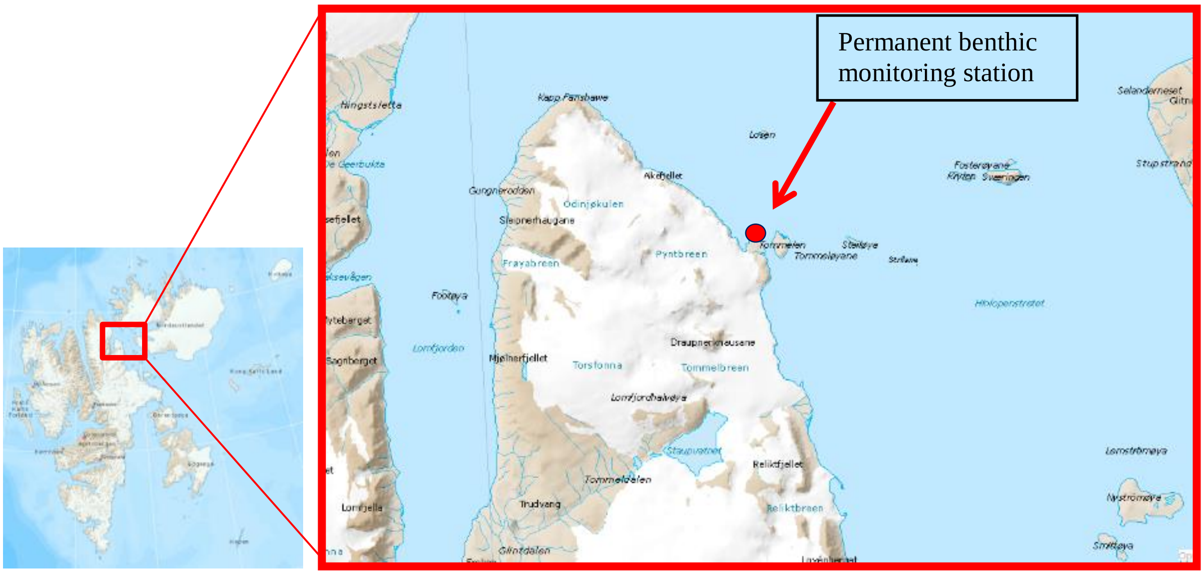


Figure 2. Map of Hinlopen Strait illustrating the location of the new permanent benthic hard-bottom station which was established 26./ 27.9. 2012.

Figure 3. The picture shows the locality of the permanent benthic monitoring station (north of Tommelpynten) with marks on the vertical rock just above the high water line. (Foto: Bjørn Gulliksen)

3 Results

3.1 Work package 1

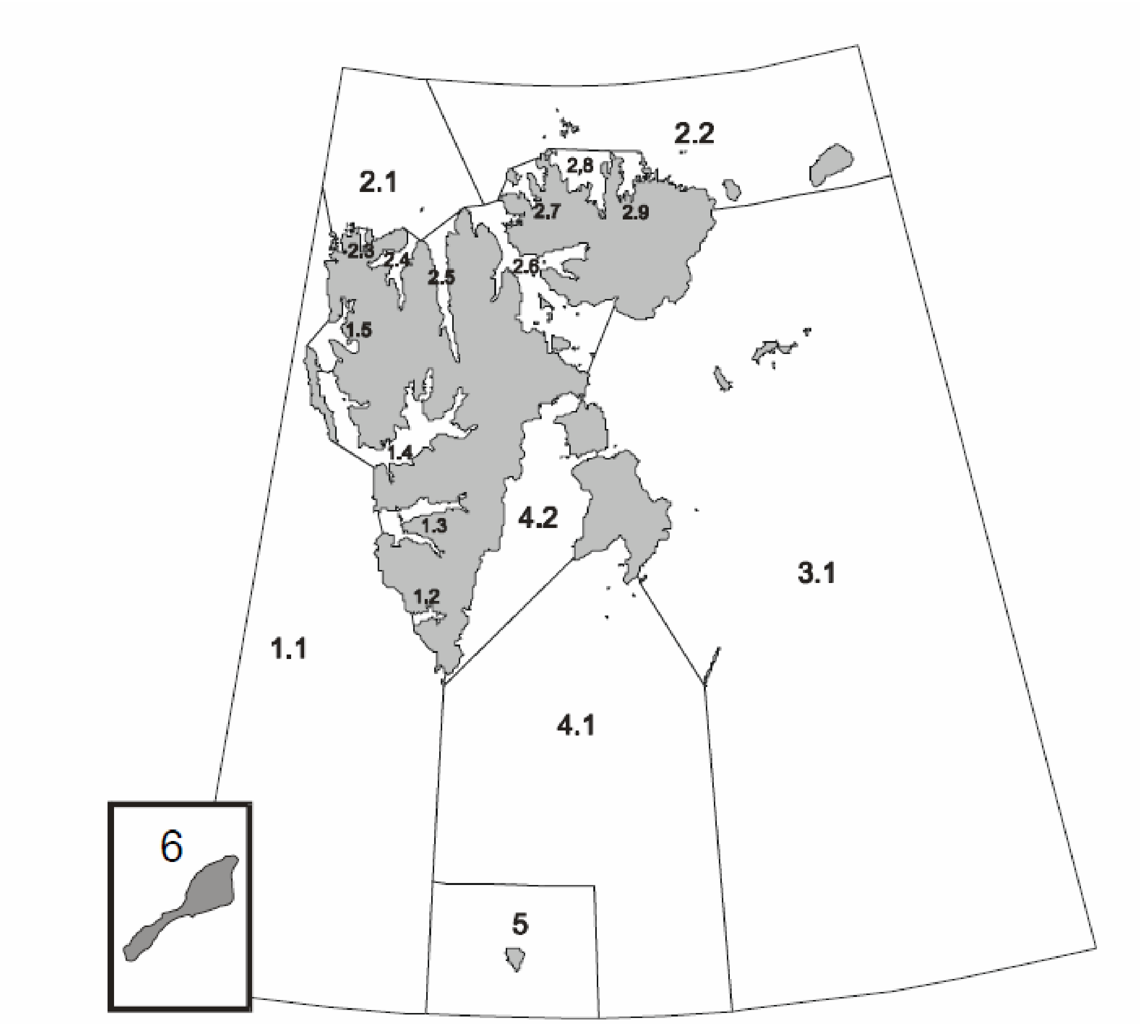
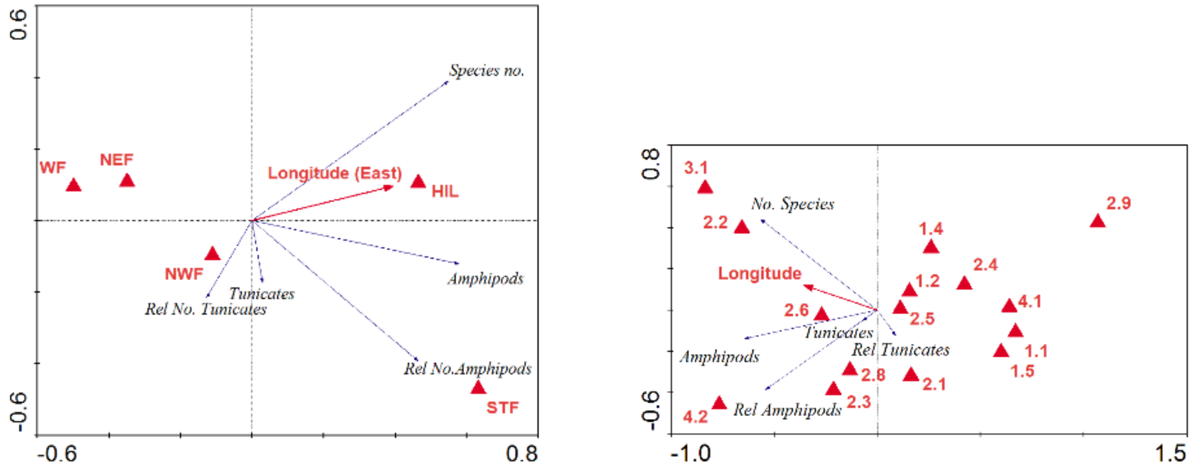


Figure 4. Classification of marine geographical zones for benthic fauna on Svalbard (Gulliksen et al. 1999)

Because of the large number of stations, and in order to simplify the statistical model, all sample locations were pooled into larger geographical areas. This is based on the classification of Gulliksen et al. (1999) (Figure 4).The benthic data used in this study were obtained using different sampling gear (Figure 1), on different depths and during different years. To extract valuable and vulnerable sites from the available set of stations, we tried to remove the effects related to those factors. This was approached by applying direct ordination methods (Ter Braak and Smilauer 2002), to separate effects related to gear (as well as depth and time) from effects that we were interested to explore, e.g. how the community and selected groups of species change among geographically distinct areas.

A preliminary significance test for all response variables showed that all geographical areas and longitude were significant predictors, while latitude was non-significant and therefore removed from the model. From the factors of which effects we wanted to remove, depth was found not to be significant and therefore removed from the model, while time and sampling gear (both significant variables) were added as covariables to the analysis.



A **B**

Figure 5. Ordination plot showing the selected groups of species in relation to their geographical distribution: A)in relation to larger geographical scales, WF= Western Fjords, NWF= North west Fjords, NEF= North East fjords, HIL= Hinlopen strait, STF= Storfjorden B)in relation to defined geographical zones according to Gulliksen et al. (1999). Rel. Amphipods= ratio of amphipods/total species number (the same for tunicates). Red arrows= gradients of explanatory variables, blue arrows= species gradients, red triangles= geographical areas

The analysis (Figure 5) indicates that the total number of species as well as the number of amphipods (and to a lesser degree relative number of amphipods) increases towards the eastern locations. Species number (one measure of biodiversity) seems to be higher in locations at Hinlopen strait and Storfjorden, and lower in Western fjords, Nordaustlandet and North-western fjords (Figure 6), which gives a more detailed view for the single stations, shows hot-spots of biodiversity in Billefjorden, Magdalenefjorden, the entrance of Raudfjorden, in central Hinlopen strait, around and south of the small islands of Kiepertøya in southern Hinlopen strait and in Heleysundet. The inner parts of Storfjorden and areas in Hinlopen strait are correlated to a high relative number of amphipods (Figure 5), presumably due to shallower and less exposed habitats. Hot-spots of amphipod density can be detected in the inner basins of Wijdefjorden, Magdalenefjorden and Billefjorden (Figure 6)- all fjords that have sills and therefore limited water exchange. A high abundance of tunicates is correlated to the North-western fjords, as well as Hinlopen Strait (Figure 5). Hot-spots of tunicate appearance is recorded in central parts of Hinlopen, areas in eastern sounds (especially Heleysundet), Magdalenefjorden and the entrance of Isfjorden (Figure 6).

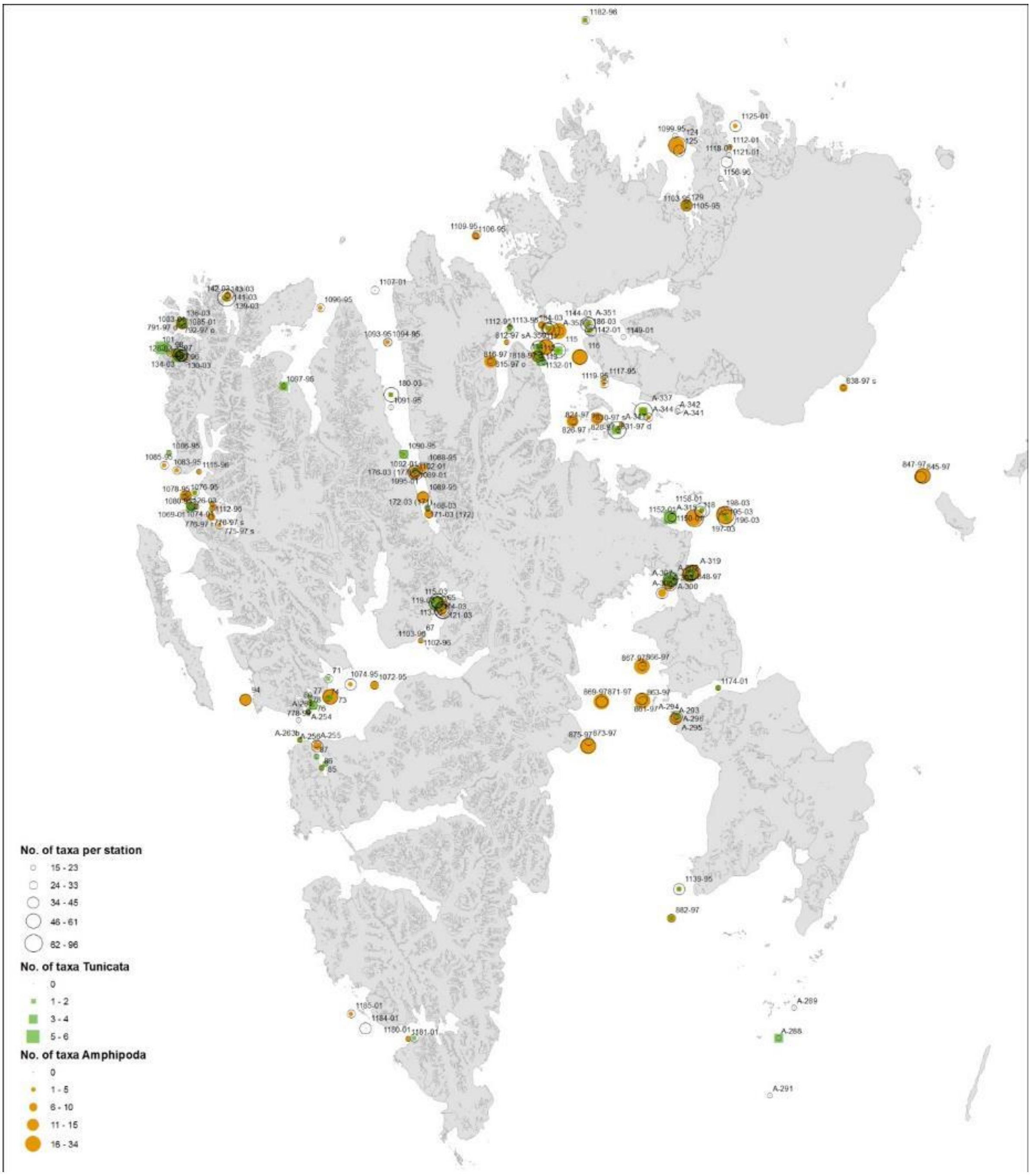


Figure 6. Map of sampling stations indicating total number of species per station (black circles), number of tunicates (green quadrats) and amphipods (orange bubbles).

3.1.1 Results from a photographic survey station at Gyldenøya/ Hinlopen

As a part of work package 1, photographs from stations that still lack data in our database where analysed. Hinlopen strait has been given high priority in the PRIMOS report (Beuchel et al. 2011). Gyldenøya in the northern Hinlopen strait is a site that has been revisited several times since 2003 and shows a rich and characteristic rocky bottom fauna.

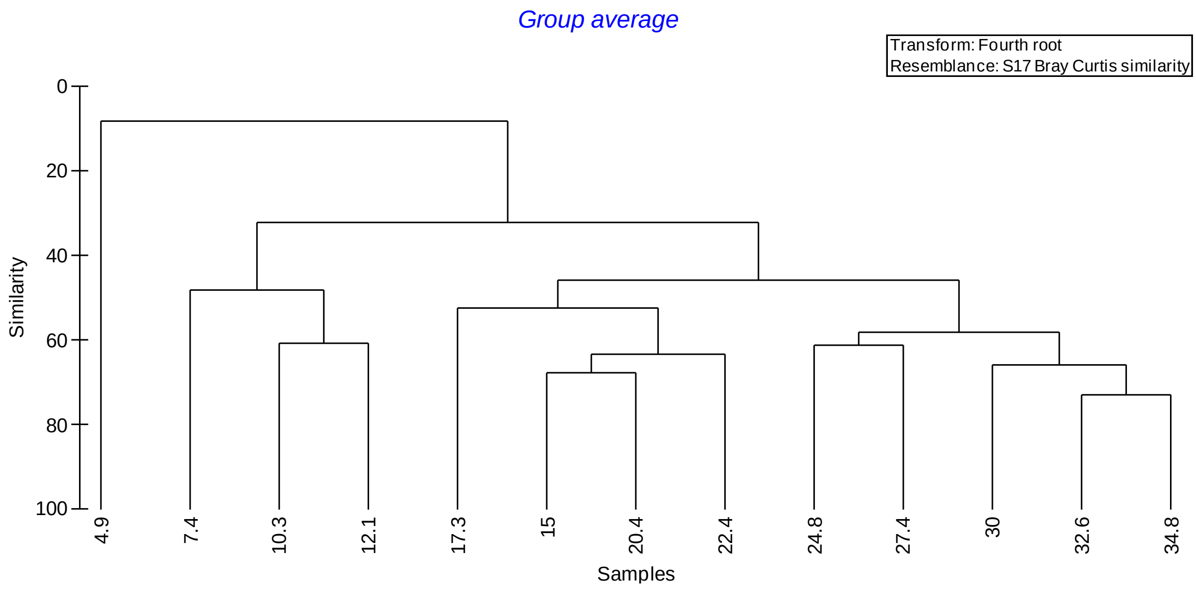


Figure 7. Cluster analysis illustrating similarity among benthic communities from different depths based on photographs (samples) from a rocky bottom locality near Gyldenøya.

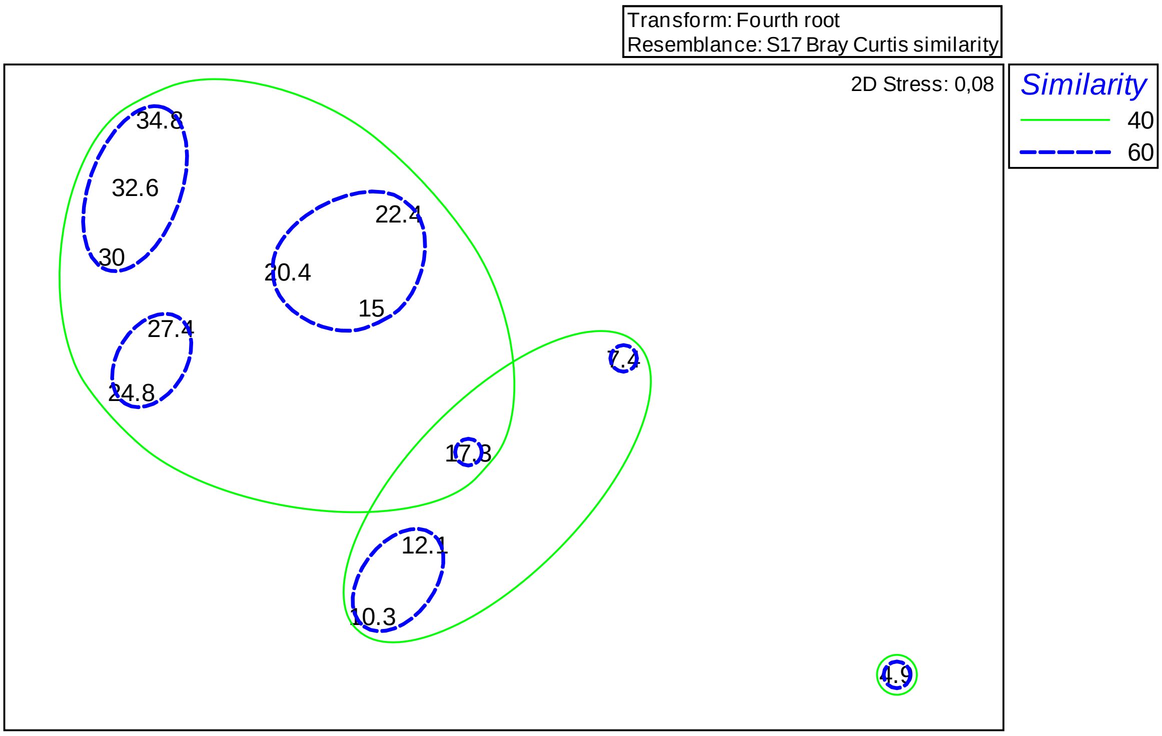


Figure 8. MDS plot of the same rocky bottom locality illustrating depth zonation patterns of the benthic community.

Based on the results from image analysis, we can distinguish between depth zones, but these zones are not as pronounced as they are from locations with vertical walls at the mainland. In the first zone until about 5m depth, kelps and large-bladed algae are characteristic. From 5 to approximately 12 meters depth, large leafy algae and red calcareous algae dominate, and there is a generally low abundance of other organisms. The next zone, down to about 24 m, is characterized by higher biodiversity, dominated by sea anemones, red calcareous algae and soft corals. In the deepest zone > 25m, different species of sponges, soft corals, sea anemones and bryozoans / hydrozoa dominate, resulting in a high biodiversity. There are still red calcareous algae at these depths (unlike stations on the mainland), because light penetrates deeper in Arctic waters due to smaller suspended particles and less stratification in the water column.

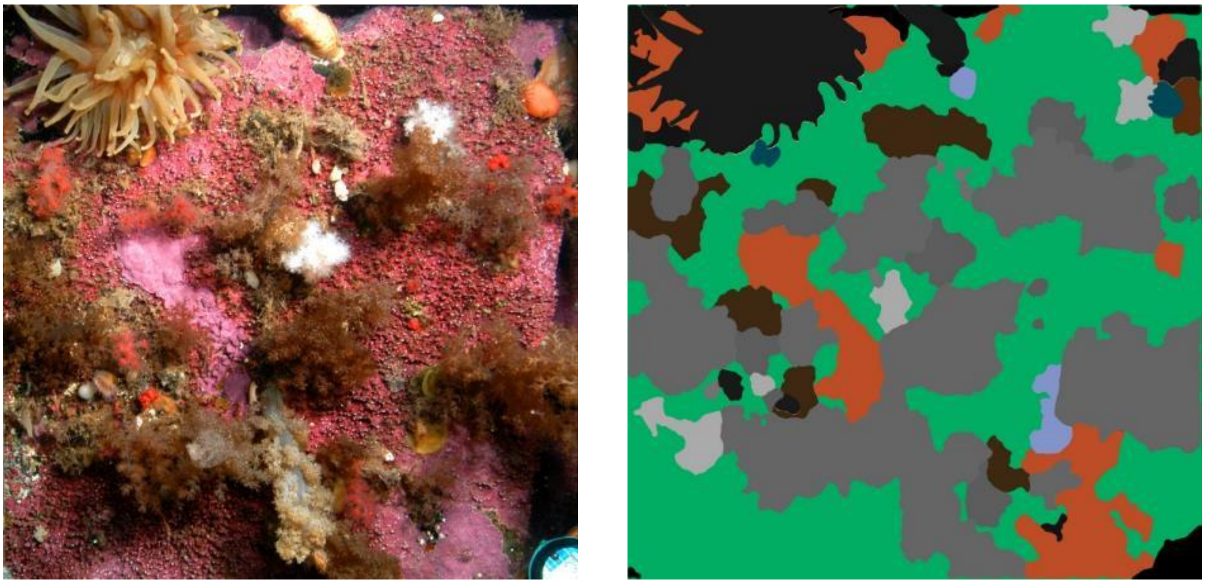


Figure 9. Example of image analyses of an underwater photograph from Gyldenøya. The analyses is carried out in Adobe Photoshop, following the method described by Beuchel et al. (2010)

There are only few known marine hard bottom areas on Svalbard with vertical walls that have such a rich marine settlement and biodiversity as we find on the sites in Hinlopen strait. They are unique marine habitats since they are characterized by strong currents and very clear water. Therefore, they deserve special administrative attention to protect them from activities that can increase the risk of contamination, such as marine traffic, tourism and exploitation of natural resources.

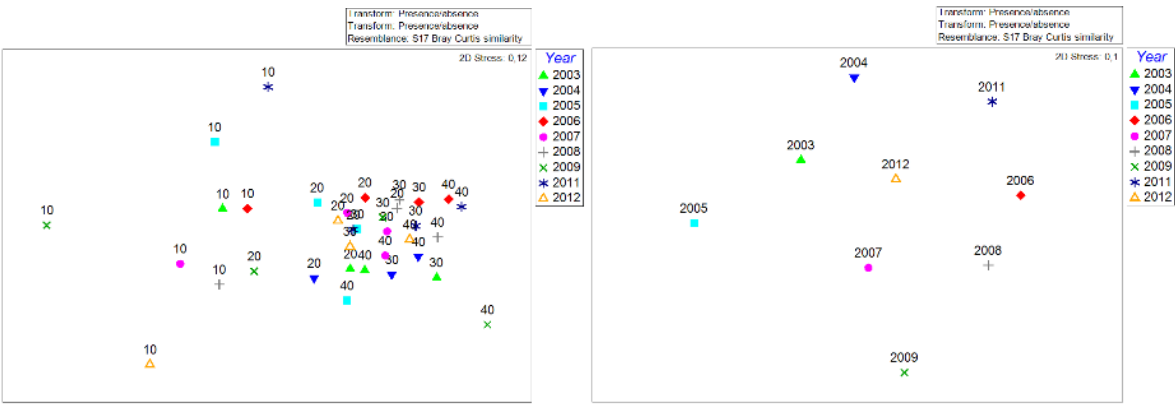


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Figure 10. MDS plot of benthic communities at a vertical site at Gyldenøya (a) for 10 m depth bins from 10- 40m and (b) for entire years.

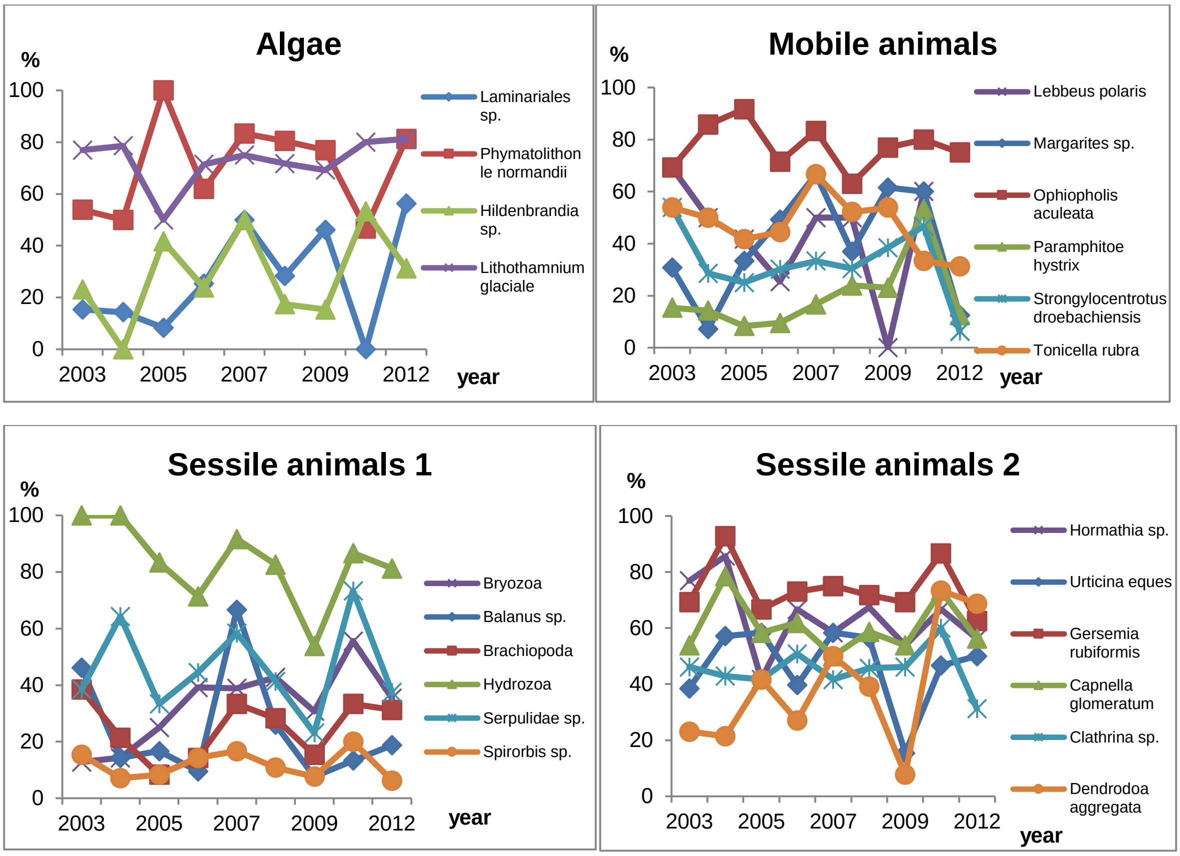


Figure 11. Occurrence (% of pictures present) of the most common groups of benthic organisms and algae at a photographic inventory station at Gyldenøya/ Hinlopen strait 2003- 2012

There are larger inter-annual differences in the upper water column (10-20m) than below (Figure 10A), indicating that external forces related to the surface (e.g. light, waves, ice scour) are mostly responsible for the changes in the benthic community. The changes from year to year (across the whole water column, Figure 10B) show relatively small differences, and the community in 2012 becomes again relatively similar to the one from 2003.

The analysis of distinct groups of species from 2003-2012 (Figure 11) generally shows a bit larger fluctuations from 2009 onwards. Many sessile animal groups show little variation until 2008, with a peak of maximum abundance in 2007. In 2009 there was a general decrease in abundance, followed by a rapid increase during the most recent years. Only macroalgae did not follow the same pattern. Laminariales sp. and *Phymatolithon* showed a drop in 2011, coincided with an increase in the crustose *Hildenbrandia* sp., which most likely benefited from the open space left from the leaf-like algae. The soft corals *Capnella glomeratum* and *Gersemia rubiformis* appear in almost same number of pictures during the investigated period. These two species were often found together in the pictures.

3.2 Work package 2

Hinlopen strait has a number of characteristic vertical walls with rich benthic hard bottom fauna. It is also referred to as a "Polar Front area" where warm Atlantic water from the north meets cold Arctic water from the south. There are existing photographical sampling locations in Hinlopen Strait (see WP1) that have been investigated several times since the middle of the 1990's. Some of these stations consist of vertical walls with nearly the same substrate from 0-50m depth, which offers the unique possibility to study vertical zonation of benthic fauna. Therefore, a permanent monitoring station was established in these area, in order to obtain continuous data from benthic rocky bottom fauna.

Figure 12. Some examples of underwater photography from the new established permanent monitoring station at Tommelpynten/ Hinlopen strait. The selection is taken from different depths to illustrate the depth zonation in benthic communities.

2012:

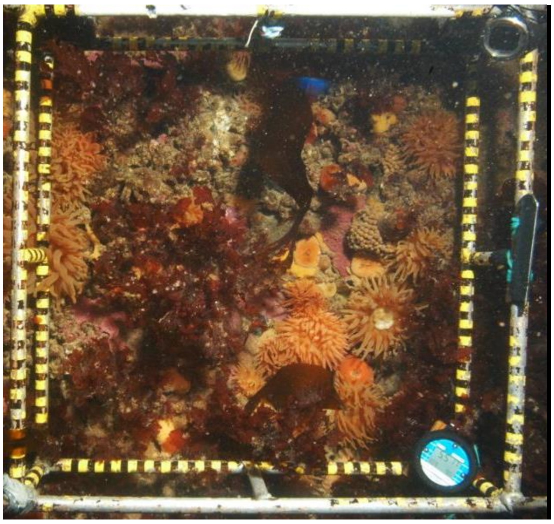
Tommelpynten 26.9.2012, at 16m depth

Tommelpynten 26.9.2012, at 27 m depth

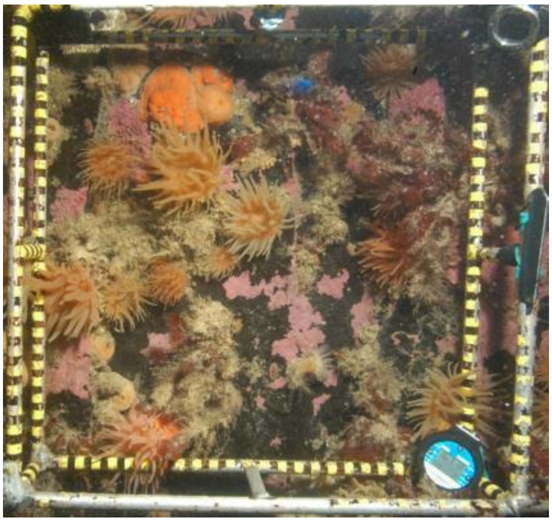
Tommelpynten 26.9.2012, at 33 m depth

Tommelpynten 26.9.2012, at 40 m depth

2013:

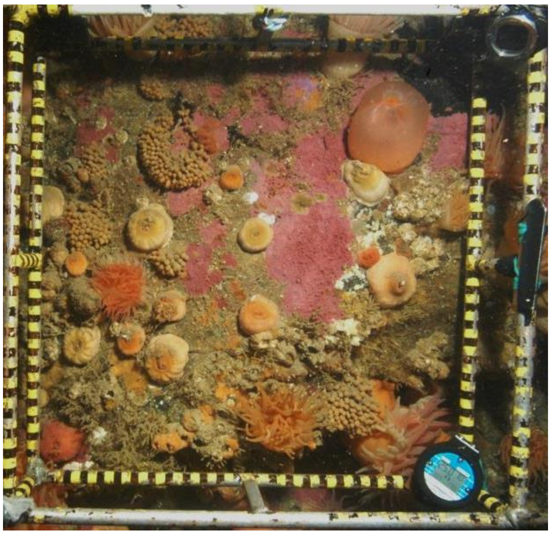


Tommelpynten 01.10.2013, at 7 m depth



Tommelpynten 01.10.2013, at 16 m depth

Tommelpynten 01.10.2013, at 25m depth



Tommelpynten 01.10.2013, at 30m depth

Table 1. Species records 2012-2013 from the newly established benthic monitoring station at Tommelpynten in Hinlopen Strait.

Urticina eques	*Bryozoa indet*	*Henricia sp.*
Hormathia nodosa	*Halocynthia pyriformis*	*Demosponge*
Strongylocentrotus sp.	*Phaephycea indet (bushy)*	*Pycnogonidae indet*
Tonicella sp.	*Cione intestinalis*	*Botryllus sp.*
Lithothamnium sp.	*Styela rustica*	*Bivalvia indet*
Hildenbrandia rubra	*Hyas sp.*	*Gastropoda sp.*
Synoicum turgens	*Paramphithoe hystrix*	*Chlamys islandica*
Laminaria sp.	*Crossaster papposus*	*Capnella glomeratum*
Gersemia rubiformis	*Stephanasterias albula.*	*Gorgonocephalus sp.*
Balanus sp.	*Dendrodea aggregata*	*Pagurus sp.*
Boltenia echinata	*Cheatognatha indet*	*Caprellidae sp.*
Phycudrys rubens	*Hiatella arctica*	*Triglops murrayi*
Lebbeus polaris	*Branchiomma sp.*	*Haliclystus auricola*
Hydrozoa indet.	*Margarites sp.*	*Polynoidae sp.*
Porifera indet	*Ophiopholis aculeata*	*Limacina sp.*
Serpulidae sp.	*Abietinaria abietina*	*Pteraster sp .*

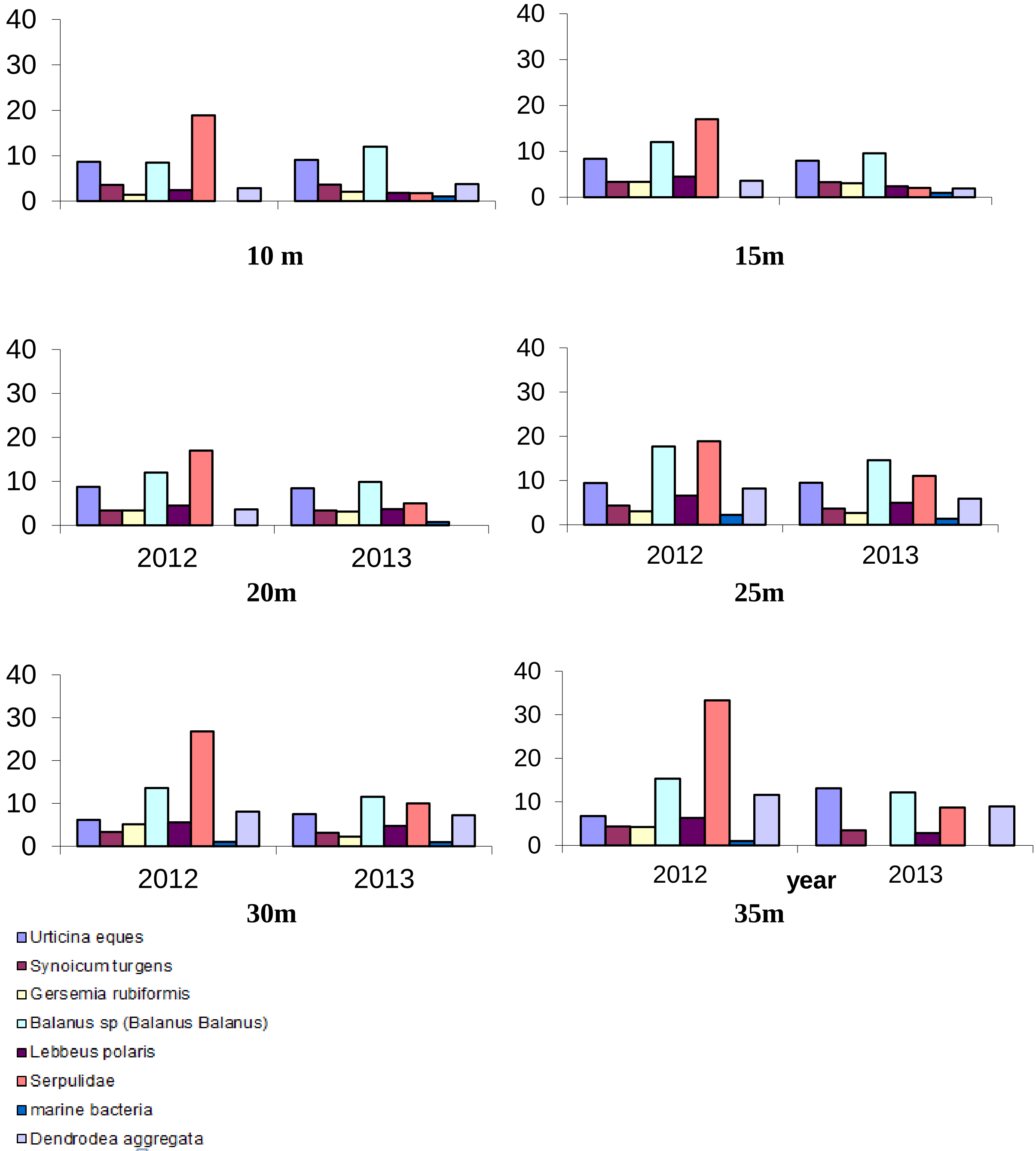


Figure 13. Abundance of the most common groups of organisms (individuals per m^2) at different depths at the permanent photographic monitoring station at Hinlopen strait 2012-2013

The results from 2 years of photographic surveys shows a rich benthic hard-bottom fauna, with no clear zonation pattern contrary to that known from comparable mainland stations. In general, a greater number of species was recorded in 2013 than in 2012 for depths shallower than 35m. Caprellid amphipods are present within all depth strata during 2013 but not in 2012. They were always found to be in connection with *U.eques/H.nodosa* presumably feeding on prey caught by the anemones. The colonial species showed a somewhat similar abundance between the two study years. The data suggest that *S.turgens* colonies decreased in abundance at most depths from 2012-2013. Marine bacteria increased in abundance from 2012-2013 at shallower depths but decreased in abundance at deeper depths.

3.3 Summary and management implications

High biodiversity (number of species) was observed in eastern fjords of Svalbard, especially in inner and outer Hinlopen strait, in Storfjorden and fjords on the northern part of Nordaustlandet. The analysis of samples from UNIS cruises indicates hotspots of biodiversity in the middle part of Hinlopen strait, west of the entrance of Walenbergfjorden and within the fjord itself. High biodiversity was also observed in the southern parts of Hinlopen.

Areas in Hinlopen strait and some areas in Storfjorden, Wijdefjorden, Magdalenefjorden and Billefjorden showed high densities of amphipods. This group of invertebrates is well known for its enhanced vulnerability to oil spills (Weslawski et al. 1997) and areas with high density therefore deserve special protection from potential treats.

Fjords on the northern and northwestern corner of Spitzbergen, areas in Storfjorden and narrow sounds on the east coast (Freemansundet, Heleysundet) showed high densities of Tunicates, which have great potential for bio prospecting.

Analysis of a hard-bottom locality at Gyldenøya revealed a rich benthic fauna with no clear zonation patterns and a euphotic zone reaching deeper than at comparable mainland sites. Similar results were obtained from the newly established monitoring station at Tommelpynten, on the opposite side of Hinlopen strait. Special administrative attention should be paid to these areas, because the benthic fauna is quite unique at some places, and dependent from low particles in the water column. The newly established monitoring station provides baseline data from a pristine area, located in an area with shifting water masses due to its localisation in the Polar front area. It is the only benthic monitoring site on the eastern part of Svalbard, and should therefore deserve special attention.

Our results help to increase the existing knowledge on valuable benthic areas on Svalbard. Management plans for these areas should pay attention to these benthic habitats, as they are important nursery and feeding areas for many commercial fish species and invertebrates but serve also as feeding places for larger protected animals like walrus, seals and seabirds. Many of these areas are hotspots of biodiversity with key functions for the entire marine ecosystem and therefore deserve special attention and protection.

4 Acknowledgements

We thank the officers and crew of the R/V Helmer Hanssen for their technical assistance during the fieldwork for the permanent monitoring station at Svalbard. We highly appreciated the advice and comments of Bjørn Gulliksen. In addition we are grateful for the work done by students and staff during many years of UNIS cruises, without whom the Marine benthic database would not exist. Akvaplan-niva, UiT the Arctic University of Norway, and the University Centre in Svalbard contributed additional funding to this study.

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