UNIS

SVALBARDS MILJØVERNFOND

COASTAL MARINE HABITATS ON SVALBARD
AN EVALUATION OF HISTORICAL AND NEW DATASETS

REPORT ON PROJECT NO.: 13/24 - KYSTSONEDATA

KYSTSONEDATA - EN EVALUERING AV EKSISTERENDE DATASETT

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This report is partly based on new data collected during a five day cruise. The quality of the data and the underwater pictures they are extracted from are thanks to the skipper and the highly qualified diving team consisting of Carl Ballantine, Ida Helene Kalvik and Peter Leopold and Lars Frode Stangeland.

The historical dataset we have used in this study has been collected by prof. Bjørn Gulliksen and his diving teams, and is stored and made available by Akvaplan-niva.

SAMMENDRAG

Mer enn 400 steder av Svalbards grunne marine områder er undersøkt ved dykking og dokumentert ved fotografering fra 1977 og fram til idag. Dette arbeidet har i hele perioden vært ledet av tidligere professor Bjørn Gulliksen ved Universitetet i Tromsø, Norges Arktiske Universitet. Denne primære hensikten har vært å lokalisere egnede områder økologiske undersøkelser og for langtidsovervåking. Fem lokaliteter overvåkes idag.

Som et biprodukt av dette arbeidet finnes det en mengde lokaliteter som er grundig dokumentert med høyoppløselige bilder. Dette er et unikt materiale som på lik linje med flyfotografier over land dokumenterer tilstanden til landskapet og det biologiske miljøet på et gitt tidspunkt.

I 2013 bevilget Svalbard Miljøfond midler til at et lite utvalg av disse lokalitetene kunne refotograferes.
Hovedhensikten var å undersøke bildematerialets verdi som:

- bidrag til fremtidig kystsonekartlegging
- dokumentasjon av biologiske endringer som følge av klimaendringer
- grunnlag for valg av egnede lokalilteter til undersøkelser med spesielle krav til habitatstruktur.

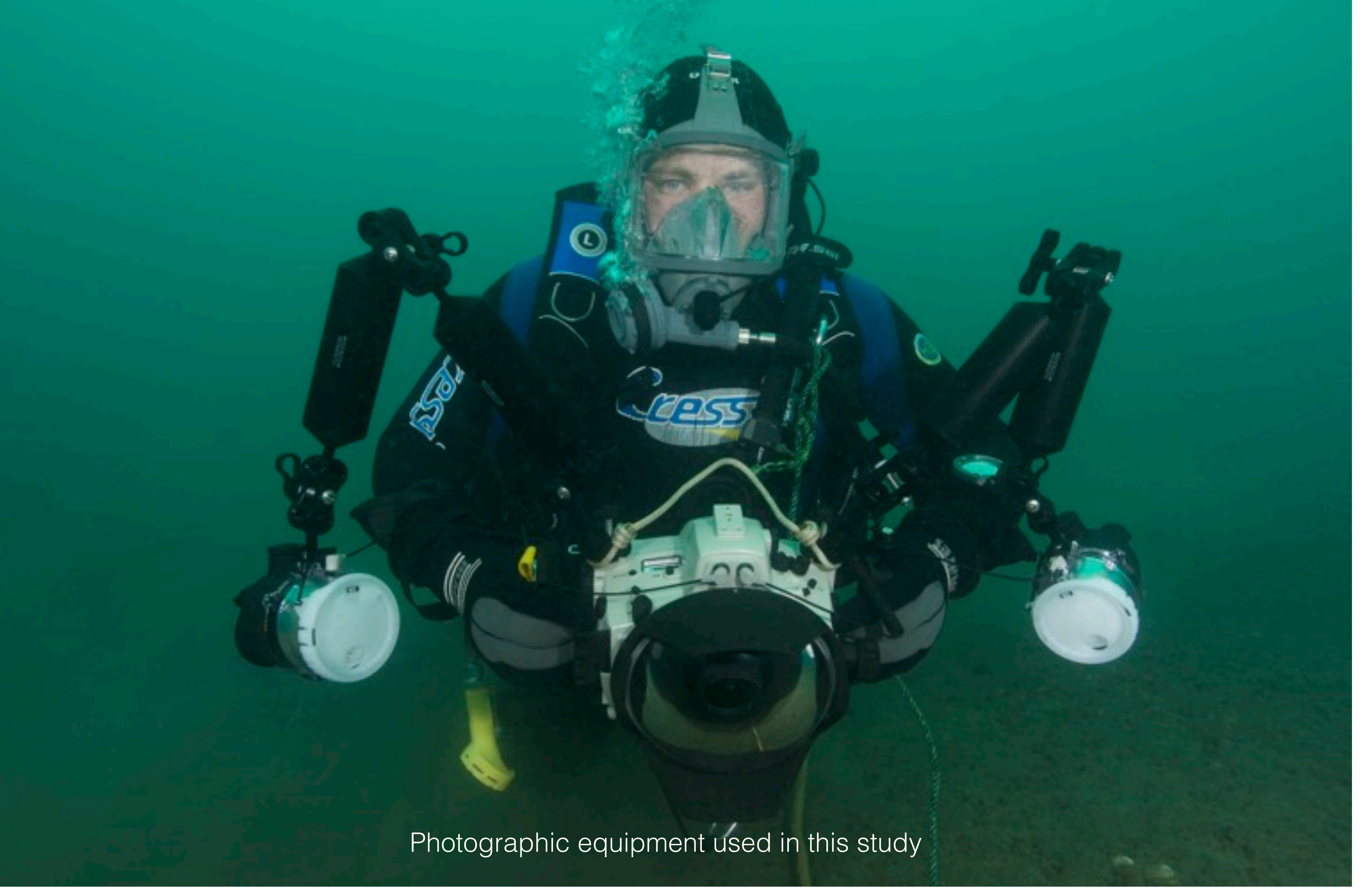
Til sammen ble åtte lokaliteter ble undersøkt i 2013. To av disse overvåkes årlig. Undersøkelsen avdekker at datamaterialet inneholder viktig og anvendbar informasjon om substrat og diversitet for disse lokalitetene.

Endringer i diversitet og annen samfunnstruktur er mulig å detektere. Om disse endringene er forårsaket av klimaendringer krever en gjennomtenkt innsamlingsstrategi. Endringer forårsaket av klima må kunne skilles fra variasjon i substrat eller eksponering på ulike tidspunkt. I denne undersøkelsen er trolig noen av de dokumenterte endringene forårsaket av tildels unøyaktige posisjonsangivelser gjort før GPS var tilgjengelig. Det har igjen ført til at før og nå bildene ikke er helt sammenlignbare.

Bildesamlingen er en rik kilde til beskrivelser av lokaliteter av ulik type (bunnforhold, artsammensetning, dyp, eksponering etc.). Dette er av stor verdi for forskere og andre som er på utkikk etter lokaliteter med spesielle karaktertrekk.

Idag er dette bildearkivet og ikke minst de dataene som er ekstrahert fra bildene og andre kilder vanskelig tilgjengelig. Særlig er ekstraherte data spredt i ulike vitenskapelige publikasjoner og rapporter. Kostnadene og tidsbruken som er gått med for å hente ut denne informasjonen tilsier at den burde vært samlet systematisert og tilgjengeliggjort for ny bruk.

Det nyateblerte SIOS (Svalbard Arctic Integrated Observing System) Senteret i Longyearbyen er en mulig kanal for en slik tilgjengeliggjøring, i samarbeid med institusjonene som idag sitter på materialet.


Photographic equipment used in this study

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INTRODUCTION

The benthic communities are rather complex and include a wide range of organisms from bacteria to plants (phytobenthos) and animals (zoobenthos). Zoobenthos cover a wide variety of groups such as sponges, cnidarians, annelids, molluscs, echinoderms, bryozoans, brachiopods, crustaceans and tunicates. The position in which they can be located in relation to the substrate leads to their differentiation:

- Infauna – organisms that live in the substrate.
- Epifauna – organisms that live on the surface of the substrate.
- Hyperfauna (=hyperbenthos) – organisms that live just above and in association with the substrate.

When fully matured the majority of zoobenthic organisms have reduced motility or are sessile. Many taxa are long lived with some individuals spanning years to decades, thus allowing benthic communities to reflect changes within the abiotic environmental conditions. These characteristics allow the benthos to integrate environmental influences over long time scales (Underwood 1996), thus making these organisms good indicators for long-term ecosystem change (Kröncke 1995). Benthic communities have the potential to not only be affected by anthropogenic activity but are also susceptible to long term environmental shifts.

During 1980 long term permanent underwater photographic monitoring stations were set up around the west coast of Svalbard by Gulliksen and collaborators. These monitoring sites have indicated that high arctic benthic communities which have been destroyed (e.g. by pollution, environmental change, mechanical disturbance etc.) take considerably longer to re-establish than when compared to lower latitude benthic communities (Beuchel and Gulliksen 2008). Analysis from these stations have also indicated significant ecosystem changes as a result of climatic variability (Beuchel et al. 2006).

Berge et al. (2005) documented the return of the blue mussel Mytilus edulis after a 1000-year absence in the waters surrounding the coast of Svalbard. Although this is a large time scale, by biological standards, due to the recent changes in global climate, over the past decades, species have been extending their ranges poleward (Bradshaw and Holzapfel 2006). In light of this there is reason to believe that other benthic organisms may have established themselves within Svalbard waters over the past 35 years. There is also reason to believe that changes have taken place, both in the species composition and density of the different species within the benthic communities the last decades.

Gulliksen and colleagues, prior to the setup of the permanent monitoring sites in 1980, undertook many pioneering inventory dives around the west coast of Svalbard in order to map the shallow areas by means of underwater photography, and to find the most suitable and relevant localities for mounting of permanently marked monitoring areas. Inventories were also carried out after 1980, and between the period of 1977 and 2008 over 400 localities were photographed, organisms were sampled for verification of species composition and the composition of benthic communities were documented at different localities with different types of substrate. This potentially unique dataset spans this era of climatic change as well as the documented reoccurrence of previously absent species, thus it can be used to manage and monitor Svalbard's marine environment.

The aim for this project is to evaluate the material and its possible future use as background material for

a) future coastal zone mapping
b) analysis of the effects of climate change
c) applications where the choice of locality is based on habitat descriptions are essential.


RV Viking Explorer

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MATERIAL AND METHODS

INVENTORIES PRIOR TO 2013

The inventories at Svalbard prior started in 1977 at Bear Island, and continued in 1978 at Spitsbergen. The first years of the inventories took place from R.V. Johan Ruud (30,5 m) and then from mid-90'ties with the larger R.V. Jan Mayen (later R-V. Helmer Hansen) (63,8 m). The inventories were carried out using different sampling tools (benthic sledges, trawls, diving-observations, underwater photography, diver operated suction samplers and collection of organisms by hand while diving). Which tool and method selected were in the first years based on information from maps available and depth from the ships echo-sounder. The landscape above water did quite often also give information about conditions below the water surface. Sampling positions before GPS was available was determined based on the sea charts. However, some localities where sampled without reliable information from charts due to lack of details and the presences of 'blank' areas in the available sea charts from Svalbard.

Theis study is primarily based on information collected from diving operations. The diving was usually carried out from small Zodiacs. Rough descriptions of the diving-stations are based on visual observations while diving, underwater photography, and collections of conspicuous organisms. Underwater photographs were taken using either a Hasselblad SWC with correction lens set or Calypso Nikkor II, usually equipped with an 80 mm lens and “Close-up equipment”. The latter camera was usually used to obtain “close-up” pictures of single animals for species identification while the wide-angle Hasselblad camera primarily was used for habitat descriptions.

Quantitative information has been collected at some localities by taking photographs of frames enclosing known areas (usually ¼ m^2). Solitary species were counted and cover of organisms was calculated by placing a transparency on which 100 random points were plotted upon paper copies of underwater photographs and recording the presence or absence of the different organisms under these points. Quantitative samples for biomass determinations have also been taken along vertical depth transects at some locations.

Combined there is a substantial amount of information collected about habitats and biological composition from more than 400 shallow area locations around Svalbard.

The information used in this report is primarily based on visual observations and underwater photographs taken from the descriptions of a small number of selected localities. The historical data is taken 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). This dataset was made available to us by our partner Akvaplan-niva. In addition to information of presence and abundance of species, this data base consists of abiotic site-information such as substrate composition, angle of substrate, wave exposure, water current and silt on rock. The data and descriptions collected in 2013 were incorporated in this data base to make it available for later studies.

2013

Based on the numerous known diving localities undertaken by Gulliksen and collaborators in 1979, a select of eight localities were chosen to be revisited as part of this report. These localities were mainly within the Isfjord catchment, yet two were located within the Kongsfjord catchment. They were chosen due to their easy accessibility via RV Viking Explorer in which the highest number of sites could be revisited with the allocated funding and boat time available. A ninth station "Müllerneset" was intended to re-visit as well, but diving was terminated because of strong currents at this location when diving took place.

The substrate at all localities, apart from two, was solid bedrock or mixed bottom with a high fraction of bedrock and boulders. Between 30 and 266 photos were taken at each locality, yet a maximum of 25 photos were analysed for a single station. This was due to the quality, duplication and interest of the taken photos (e.g. photos of divers, macro photos, photos of only kelp lamina etc.). Photos were randomly taken by divers at depths between 5 and 30 m at six of the chosen localities. The final two localities, Kvadehuken and Sagaskjæret, were used as photographic time series monitoring for years. The stations were for practical reasons included in our

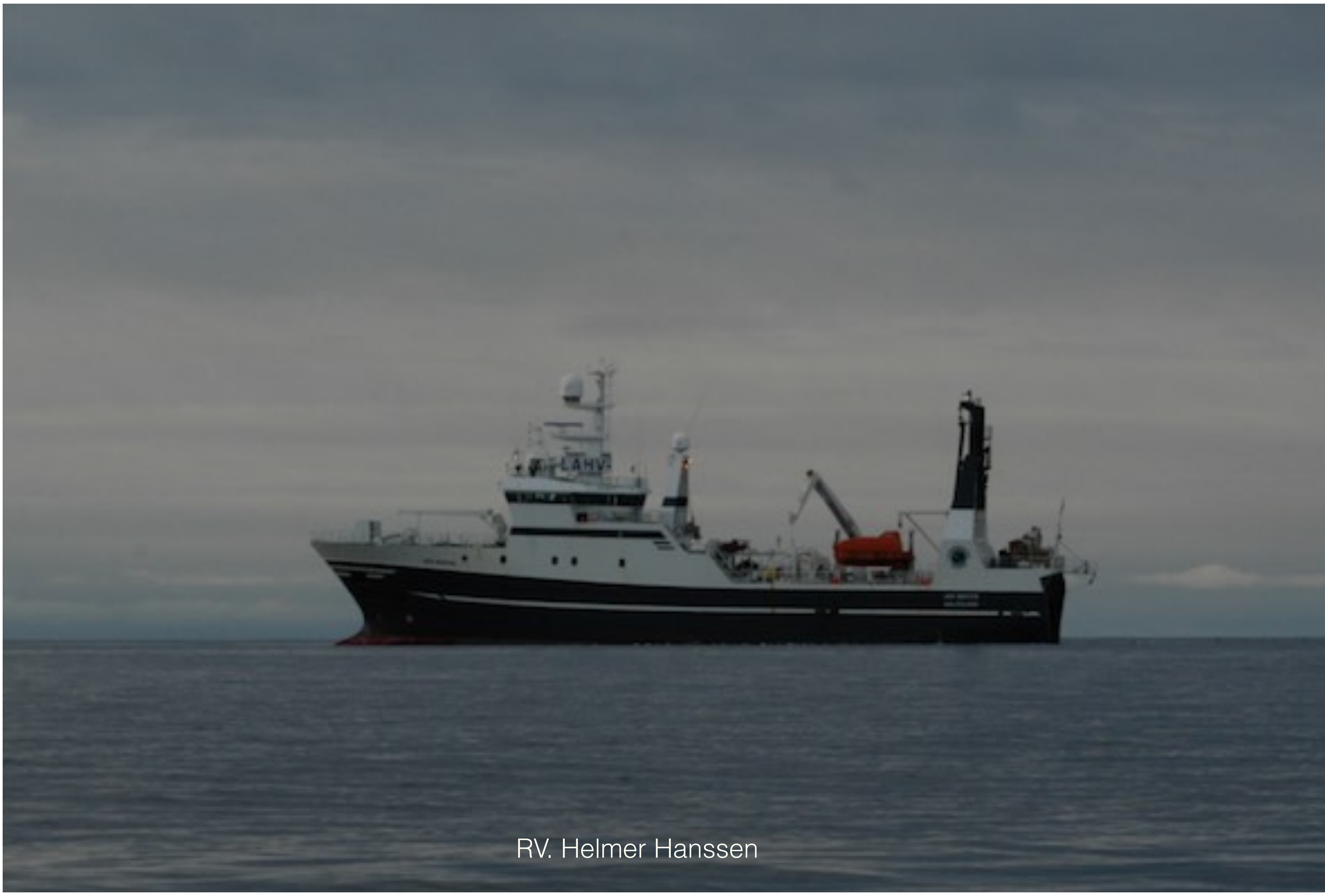
survey and the most recent data from 2013 were incorporated in this project.
The photos were taken using a NIKON D800E or a NIKON D7000 camera camera with an AF Nikkor ED 14mm lens or similar in a SUBAL underwater housing and SUBAL dome port.

PHOTO ANALYSIS

For the analysis of underwater pictures, a modified protocol described by Beuchel et al. (2010) was applied using the commercial software package Adobe Photoshop Cs5 extended. All the analysed photos were corrected for colour, brightness, clarity, and saturation. The photos from Kvadehuken and Sagaskjæret were also cropped because they are part of a time series and being taken within a frame. Once corrected, the count tool was used to identify individuals as well as species. The data were then manually transferred to Microsoft excel as a database both for presence/absence and count data.

STATISTICAL ANALYSIS

For the evaluation of similarity within samples and between the localities, Multi-dimensional scaling (MDS) and Cluster analyses was applied, using commercial software package of Primer v.7.0.10 (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).



RV. Helmer Hanssen

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RESULTS

The selected revisited locations are described individually, comparing both the original description and the description obtained in 2013. This gives a first impression of changes since the first visit or alternatively a clue wether the diver have actually hit the same spot on their revisit.

The 2013 pictures is analyzed to give an impression how well the number of species reflects the true number of species present at the site (species accumulation curves).

The same dataset is used to compare the visited locations. This gives us an impression on their uniqueness and the diversity they represents.

Finally the 2013 dataset is compared with the originally obtained data to evaluate if a change in community structure can be detected.

2013 to the left. 1979 to the right. Observe the variation in substrate.

BOURENESSET

Position 1979:
N 79° 10.00'
E 11° 41.00'

Position 2013
Same

HABITAT DESCRIPTION

1979: The dive site is an area that is semi exposed to wave activity with a slight current speed of 0-0.5m/s in Krossfjorden. The studied area has a varied substrate ranging from bedrock with a thin layer of mud, to boulders with gaps infilled by mud, via a muddy gravel. Most of the areas where bedrock is exposed are relatively steep, whereas areas with boulders and gravel are somewhat more horizontal.

2013: The substrate from the shoreline down to about 5m was made up of small to medium sized “clean” pebbles, with one or two scattered larger stones. Some of the larger pebbles were overgrown by tufts of green and brown algae. As moving deeper the gaps between the pebbles become infilled by coarse sediment, and the pebbles gradually increase in size. The deeper stones are covered in a kelp forest which blocked all sight of the substrate below.

Two pictures from 2013. The one to the right showing an area graced by sea urchins

DAUMANNS-ODDEN

Position 1979:
N 78°12.00'N
E 12°58.00'E

Position 2013
N 78°11.95'
E 12° 58.27'

HABITAT DESCRIPTION

1979: Located on the wave exposed northern shoreline of outer Isfjorden. The substrate consists of shallow gradual sloping uneven bedrock from the shoreline to deeper water, with a weak current (0-0.5m/s) flowing over it. The bedrock is without sediment which is due to high wave exposure.

2013: Due to its location this area is known to be rather exposed to the full force of the waves as they enter from the Fram-strait. The substrate consists of hard bedrock encrusted with red coralline algae. There are some clean un-colonised patches, however these are scattered few and far between. The bottom is very uneven with crags, cracks, and outcrops. Between these outcrops the larger cracks are filled with medium - large rocks, whereas the smaller cracks are filled with fragments of deceased mollus-can shells. The majority of the bedrock is overgrown by the leafy red algae (*Phycodrys rubens).*

Typical substrate. Picture from 2013.

FUGLEFJELLA

Position 1979
N 78° 12.00'
E 15° 10.00'

Position 2013
Same

HABITAT DESCRIPTION

1979: An exposed area with high wave activity and a weak current of 0-0.5m/s. The substrate of soft mud is scattered with relatively large boulders (15–50cm) and smaller pebbles, and gently slopes from the shoreline towards deeper water. Some rocks between 0-15 m depth had a height of 2-3 m. The high deposition from the meltwater river is probably the main reason why the mud persists on the floor despite being in an area of high wave activity. The bottom was softer with increasing depth, and the bottom was quite soft and muddy with few rocks and pebbles deeper than about 15 m depth.

2013: The substrate consists of very fine soft sticky sediment deposited as a mound with gentle sloping sides, more than likely brought and deposited by river outflow during the summer months. The sediment itself is covered in polychaete casts and living tubes along with siphons of molluscs mainly *Mya truncata*. Small islands in the form of drop stones, mollusc shells and echinoderm tests can be seen scattered across the otherwise soft sediment.

KAPP STAROSTIN

Position 1979:
N 78°06.00'
E 13°50.00'

Position 2013:
N 78° 05.78'
N 13° 49.32'

HABITAT DESCRIPTION

2013: Located on the southern side of Isfjord near the fjord entrance. The diving locality is a formation of scars and gullies jutting out into the fjord from the land going from about 5m to a depth of 20m. Above there are clearly signs of ice scour leaving blank rocks without any colonisation. The locality has a dense kelp forest. The substrate found here on the scars is predominantly bedrock covered in encrusting calcareous red algae, although not much bedrock is visible due to algal and sessile organism colonisation. Very small scattered patches of clean uncolonised bedrock can be seen. On the top of the scars and within the gullies the bedrock itself is broken up by cracks and indentations which are filled with a mixture of sediment (sand and silt), broken mollusc shells, and small to medium sized stones. The presence of soft bottom fauna indicates that this soft sediment is permanent feature of the indentations and cracks.



Examples from 1984 left, and 2013 to the right

SALPYNTEN

Position 1984:
N 78°12.80'
E 12°11.40'E

Position 2013:
N 78° 12.45'
E 12° 09.70

HABITAT DESCRIPTION

1984: Located on the southern tip of Prins Karls Forland. The locality is very exposed to the full force of the wave energy from the Fram Strait. The current running in the area is rather weak being 0-0.5m/s. Although the wave exposure at the area is strong the dive location was pretty sheltered which is indicated by the muddy bottom. The muddy bottom is covered with small pebbles and in some areas the bedrock can be seen. From the shoreline the substrate has a gentle slope of about 30 degrees with less bedrock, pebbles and gravel with increasing depth down to 30 m.

2013: The shallower areas are solid bedrock covered with sessile organisms and algae. The bare rock that is visible is covered in encrusting red algae. Very small patches of “clean” un-colonised bedrock can be seen, but this is a very rare occurrence. The solid bedrock is not smooth being covered in many outcrops with indentations which are filled with coarse sediment. As you go deeper the bedrock is replaced by 100% coverage of coarse sediment scattered with broken mollusc shells and small – medium sized stones.

2013. Observe the similarity to the substrate found near Fuglefjella.

VARDEBUKTA

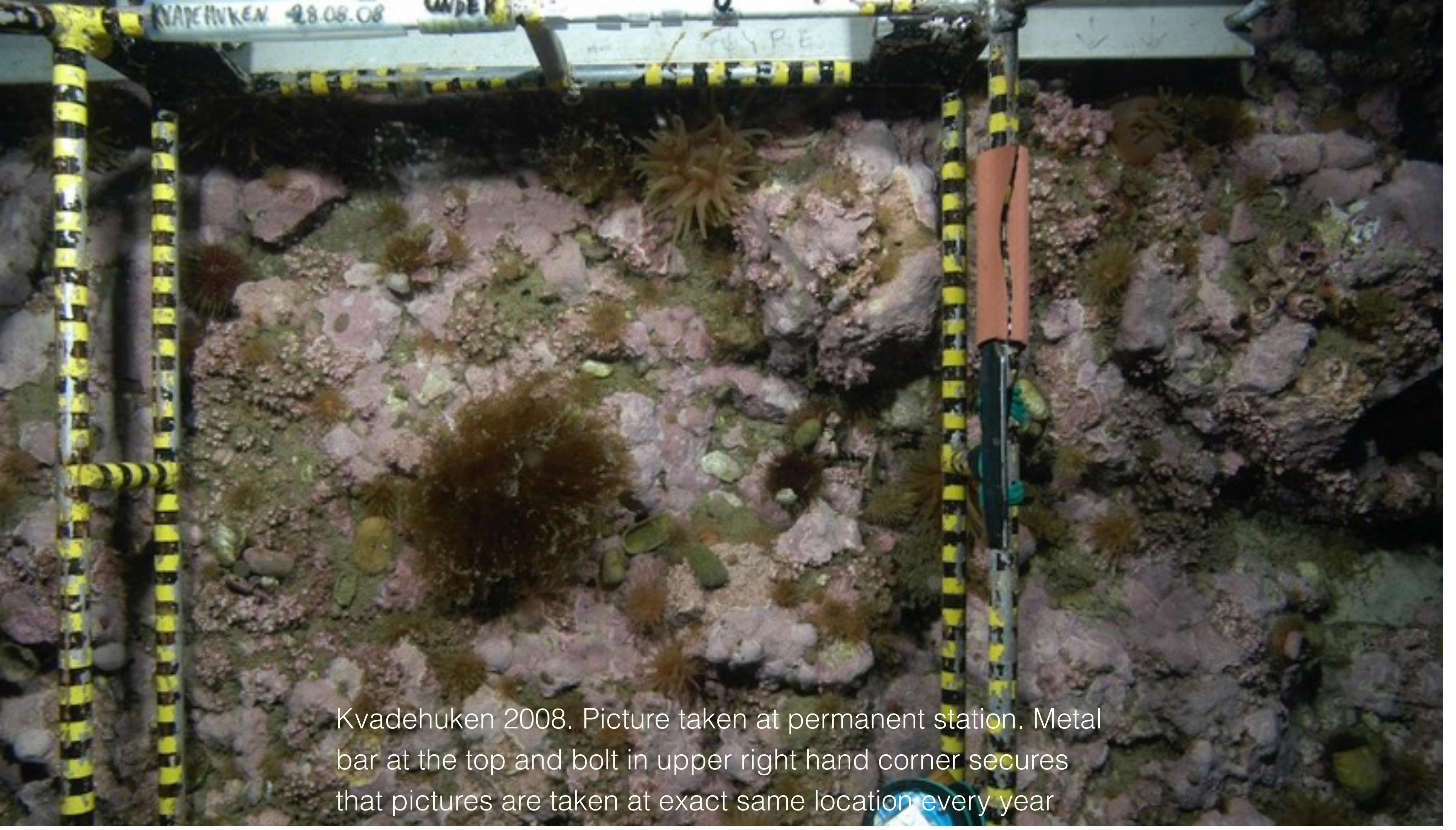
Position 2013:
N 78° 05.77'
N 13° 50.28'

New station

HABITAT DESCRIPTION

2013: A small bay located on the outer southern side of Isfjord just east of Kapp Starostin. The substrate consists of very fine soft sticky sediment almost entirely covered in polychaete tubes. Small patches of “clean” sediment can be seen scattered around the area. These are areas where larger organisms have been burrowing. Scattered across the sediment are islands formed from relatively large drop stones all of which have kelp attached to them. In the background of many photos there seems to be a wall of kelp forming.

This location was first visited in 2013.



Kvadehuken 2008. Picture taken at permanent station. Metal bar at the top and bolt in upper right hand corner secures that pictures are taken at exact same location every year

KVADEHUKEN

Position 2013:
N 78° 58.63'
E 11° 29.89'

Position 1980:
Permanently marked photo station. Exact same location

HABITAT DESCRIPTION

1980: The location was established as a permanent station, and re-photographed annually since then. There is no original description of the site, but but described in several scientific publications

2013: Located on the outer southwestern side of the Kongsfjorden outlet. The diving locality is an uneven horizontal rocky bottom characterized by bare bedrock covered with a mix of small, medium and large stones. The majority of the substrate is covered by encrusting red algae, although newly deposited rocks have yet to be colonised giving very small "clean" patches. The small indentations within the solid bedrock as well as the gaps between the stones are often infilled with sediment. The bottom changes from being near horizontal bedrock to uneven bedrock with an angle of 30 – 90 degrees at about 15 m depth. The bottom morphology then resembles steps in a stair, and there are even some small caves where the bedrock is vertical. The relatively steep bedrock with a few scattered rocks and pebbles seems to continue to even greater depths which is also indicated by studies with an echo-sounder.

Sagaskjæret permanent station in 2006

SAGASKJÆRET

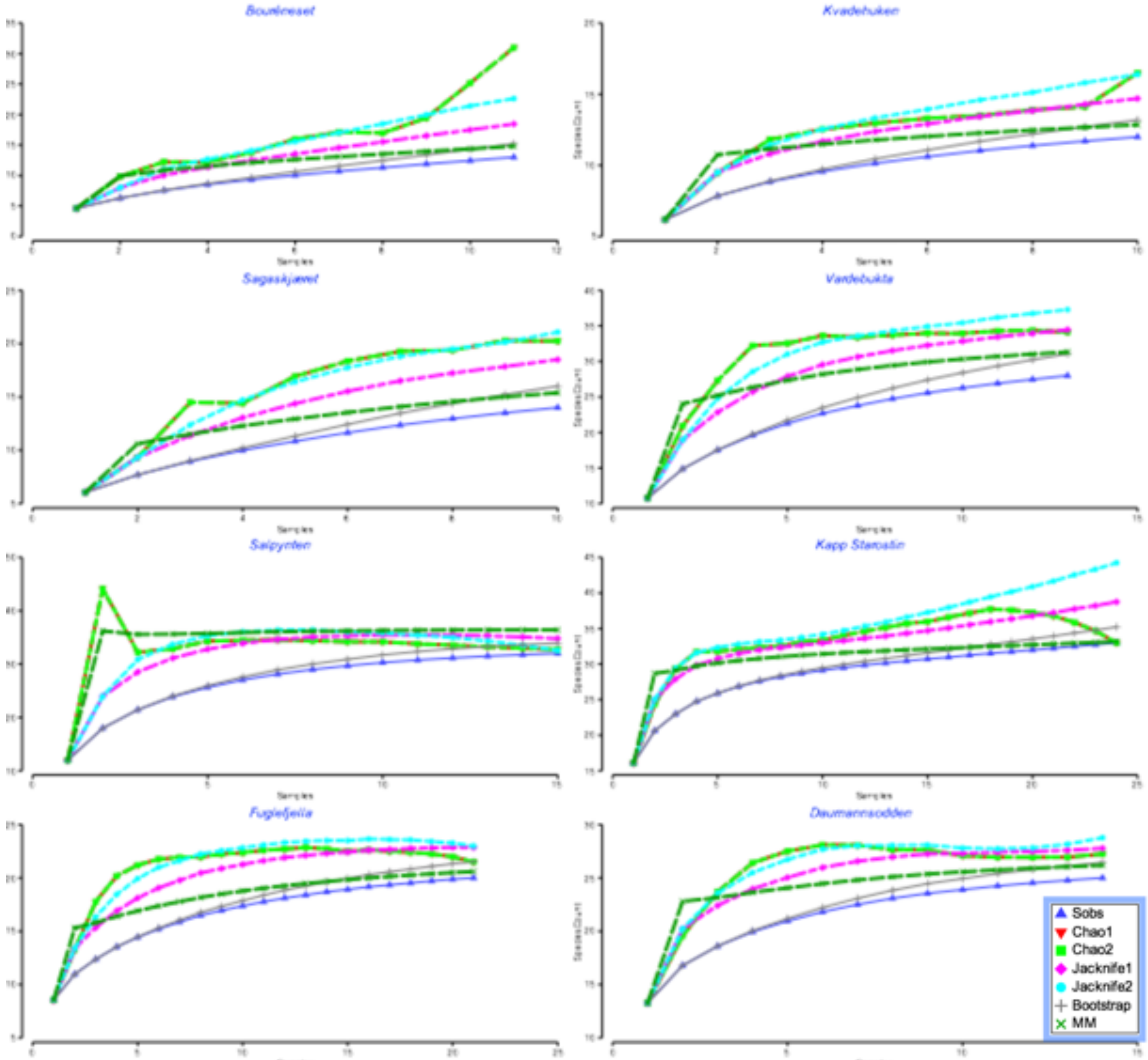
Position 2013
N 78° 12.46'
E 13° 56.37'

Position 2003:
Permanently marked photostation. Exact same location

HABITAT DESCRIPTION

1984: A small islet on the northern shoreline of Isfjorden that is very exposed to wave action. The current flow is weak with the main movement caused by wave activity. The substrate consists of mainly bedrock yet in areas there are boulders ranging from 15 cms upwards exceeding well over 50cms in diameter. The gentle slope of the islet makes it perfect for the crashing waves to roll up with great force.

2013: The diving location is on the outer exposed side of the small islet. The substrate consists of bare uneven bedrock covered completely in red calcareous algae. At depths between 7 and 9 meters, a kelp forest is located; here kelp holdfasts and bryozoans obscure the bedrock. Below 9 meters, the uneven bedrock can be viewed with cracks, indentations and small outcrops. The cracks and areas next to overhangs on the bare bedrock have very few shells or stones, and only a small amount of sediment is deposited. Within the kelp forest, bryozoans and holdfasts trap sediment.



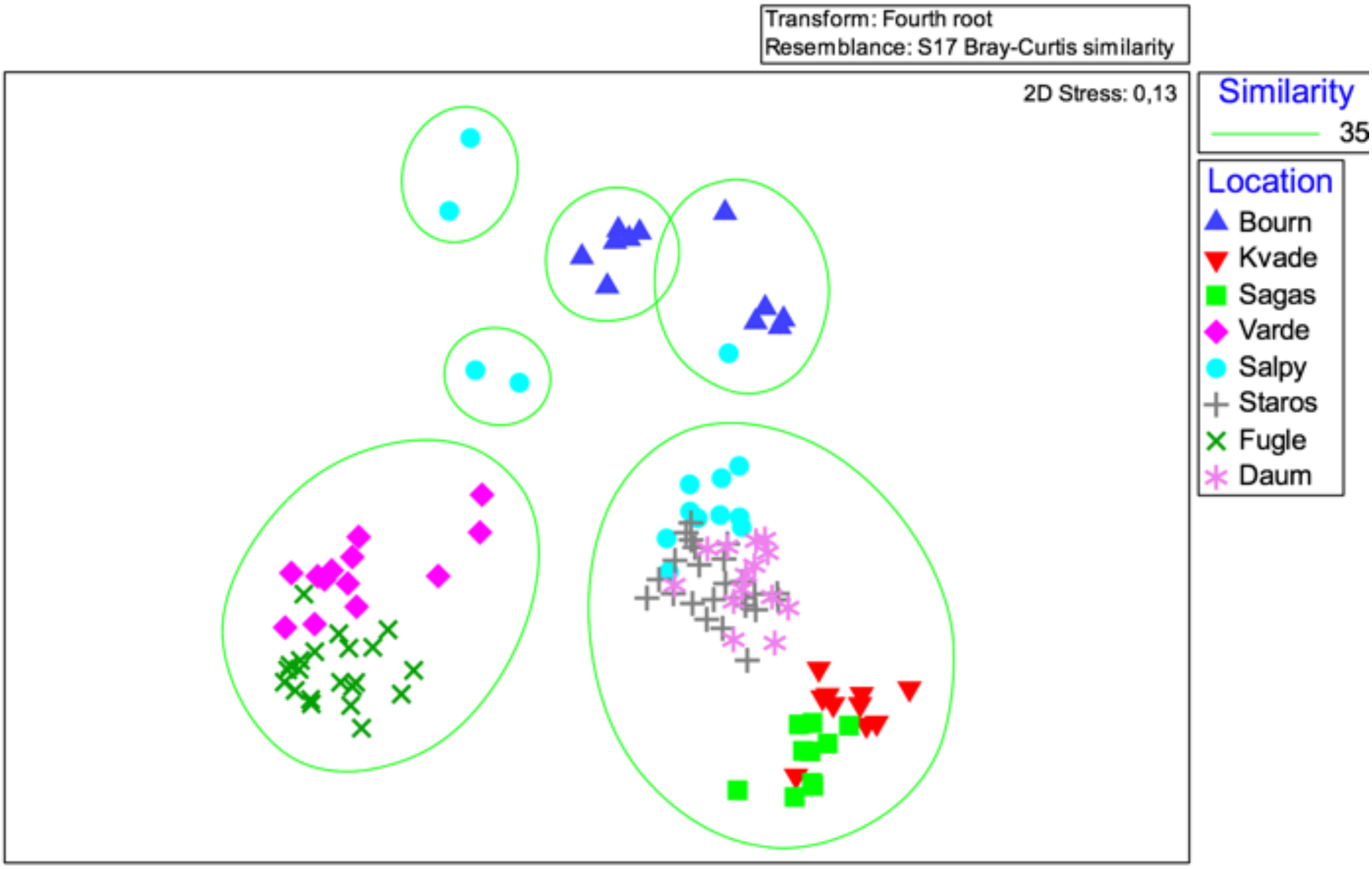
THE NUMBER OF SPECIES IN A LOCATION

The species accumulation plot above shows the observed number of species (blue line) as the number of samples (Photographs) increases. The remaining lines estimates how many species theoretically can be expected when the number of samples (photographs) reach an infinite number.

This analysis helps us to evaluate our sampling method whether the number of pictures taken is enough to cover the biodiversity at the different locations. The selection of functions is restricted to the content of the primer package v.7 (Clarke and Gorley 2006).

The differences between observed and expected number of species are relatively low at Daumannsodden, Fuglefjella and Salpynten.

Bouréeneset, Sagaskjæret and Kapp Starostin show highest deviations, while moderate deviations are observed for Kongsfjorden and Vardebukta.



SIMILARITIES BETWEEN LOCATIONS

In the figure above (MDS plot) the similarity between samples (photographs) are compared along two dimensions. Each location is represented by several photographs. There is a clear separation of the localities based on the species composition that to a large extent reflects the habitat type.

The two softbottom habitats Vardebukta and Fuglefjella are well separated from the other localities.

The hardbottom localities (Kapp Starostin, Daumansodden, including the two permanent photostations) are more similar to each other than to the other localities.

Bouréeneset is different from the other localities.

Salpynten shows the most diversely separated picture composition. This probably reflects the habitat diversity in this location. The shallower hard-bottom component is clearly similar to the other hard bottom localities, while the deeper transitional zone and soft-bottom components are more closely to other soft bottom stations and to Bouréenset.

Location	Year							
	79/80	84	97	2013 (including algae)	2013 (without algae)	Found in both old and 2013 pictures	Only found in 2013	Not found in 2013
Bouréeneset	15			13	7	4	3	9
Daumannsodden	9			25	18	5	13	4
Fuglefjella	15		9	20	16	6	10	13
Kvadehuken*	17	16	17	12	*	7	3	9
Sagaskjæret		36	33	14	13	10	3	29
Salpynten		27		32	24	15	9	10
Starostin	10		19	33	27	16	11	6
Vardebukta				28	20			

SIMILARITIES BETWEEN OLD AND NEW DATA

Some locations have been visited more than once in the past. In the table above are the number of species recorded in the 2013 compared with the historical records. It also shows how many species that were found for the first time in 2013, how may that occurred both in 2013 and in the older samples, and how many that had been recorded before, but not in 2013. In this comparison, algae are left out since this group has not been recorded in historical data, apart from at the Kvadehuken site where algae are included in the comparison.

At Sagaskjæret, less species were recorded in 2013 compared to 1979, but the number of pictures taken was also much lower. This is reflected in the relatively high difference between the observed and the theoretically estimated number of species for Sagaskjæret in the previous figure.

The same pattern can also be seen at Bouréeneset, with less species in 2013, but that is also suggesting a much higher infinite number.

At Daumannsodden, considerable more species were observed in the pictures in 2013 (even without macroalgae), while the number of analysed pictures was actually much less. It looks like that the site that we visited in 2013 was more heterogeneous having more cracks and furrows thus allowing a higher biodiversity. This points out that in areas with larger heterogeneity, it is vital to compare samples taken on similar substrate..

At Kapp Starostin the number of recorded species increased considerable from 10 in 1980 to 19 in 1997 to 27 in 2013, with almost identical number of pictures taken.

In the majority of the re-visited locations the species diversity remained rather stable (Fuglefjella, Kvadehuken, Salpynten) or or showed an increase in the number of species (Daumannsodden, Starostin). This may be an indication that new species has entered these areas.

The number of species missing in the 2013 samples are relative high at some stations, may indicate a high species-turnover for many of the visited places.

Vadebukta (new station) showed a relative high number of taxa considering that it is one of the few soft-bottom locations, were many more species might be hidden in the sediments and therefore are not recordable in the photos.

The potential of the material from old diving stations (and other historical data that are archived in marine databases for Svalbard) has already been demonstrated to be of great value for coastal zone mapping and in evaluating of valuable marine coastal habitats (Beuchel et al. 2011, Beuchel et al. 2014, Kortsch et al. 2012). Together with the long-term existing permanent photographic monitoring stations (Beuchel and Gulliksen 2008), the network of these inventory stations can be supplement which can give valuable information in a more fine-scale resolution. It may have a great potential in for decision makers on a local scale, when these stations could be re-visited frequently for evaluation of ongoing change since valuable base-line data (back to late 70s and beginning of 80s) exist.

The results of this report help to fill some gaps in the existing knowledge on valuable benthic areas on the western fjords of Svalbard. Management plans for these areas should pay attention to these and other predominantly hard-bottom 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 for future management plans.

Effects of climate change have already been documented for two long-term monitoring stations on the west coast of Svalbard (Beuchel et al. 2006, Kortsch et al. 2012). Due to the lack of good quantitative data it is difficult to assess changes due to climate variations based on the existing dataset. Another limitation of the study is the fact that we look at only two points in time with > 30yrs in between, thus we presumably missing a lot of variability in between. With frequent (not annual) re-sampling of a selection of these stations, these shortcomings could be improved and the quality of data would be better. Another problem is the lack of physical data in the 70s and 80s. Only frequent CTD data exist, these measurements became more common towards the end of the 90s and 2000 years (Mankettikkara 2013), in addition to that permanent mooring stations (Cottier et al. 2007) became established with continuous measurements of a range of physical data that gave a new quality in explaining changes in the biological environment.

New digital camera systems- many more pictures and good positioning system allows documentation of area in much better way.

RV Viking Explorer from a divers view

EVALUATION

In this study eight of more than 400 locations have been revisited to establish their potential in

1) future coastal zone mapping
2) evaluate the effects of climate change biological community composition
3) as a tool for selecting localities is based on habitat descriptions.

It is clear that data from the already visited sites may play a role as validations sites for community structure maps based on physical models.

The comparison has in several instances indicated that changes in community structure changes are detectable. It is also obvious that differences in community structure may arise from other sources in addition to climate change. In this study it is evident that it may be difficult to revisit locations where information on position is taken from nautical charts og other positioning than highly accurate GPS's. It is also likely that the position on some occasions reflects the position of the ship and not the exact diving sites. With a modern hand held and accurate GPS positioned at the diving site it will be more likely to revisit a diving location and then have samples taken at a location with a similar physical habitat. That said, older photographs may prove to be valuable for comparisons studies, if a sampling strategy is developed that take into consideration that random samples are taken at same depth and same substrat category, rather than just random samples at the same location.

Effects of climate change have been documented for two long-term monitoring stations on the west coast of Svalbard (Beuchel et al. 2006, Kortsch et al. 2012), showing that changes i community structure due to climate change is detectable when other sources for variation is under control.

For investigations that rely on a defined type of habitat, wind- and wave- exposure, depth etc., the information contained in these inventories will be a highly valuable and cost effective starting point.

In 2013 we used digital cameras with a resolution, and focus range that makes it possible to identify organisms in size down to a few mm. In most cases this is impossible to do with photographs taken from an analog camera. The collection of photographs that make up the Svalbard inventories are however to a large extent taken with a Hasselblad SWC camera. The quality of the pictures, and the information that is possible to extract from them makes them and the data they represent quite unique, and a valuable reference point for future studies.

The potential of the material from old diving stations (and other historical data that are archived in marine databases for Svalbard) has already been demonstrated to be of great value for coastal zone mapping and in evaluating of valuable marine coastal habitats (Beuchel et al. 2011, Beuchel et al. 2014, Kortsch et al. 2012).

The results of this report help to fill some gaps in the existing knowledge on valuable benthic areas on the western fjords of Svalbard. Management plans for these areas should pay attention to these and other predominantly hard-bottom 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 for future management plans.

Sagaskjæret in Isfjorden seen from the south

4

APPENDICES

This report is based upon data collected during a during a 5 day cruise in outher Isfjorden, Kongsfjorden and Krossfjorden.

The first table in the appendix summarizes the species identification based on the pictures taken.

The second table compares the number of pictures in 2013 with pictures taken earlier and used in this study

The last appendix lists the brief description of the habitats as it is seen in individual pictures. This list gives an impression of the heterogeneity in the different locations.

List of species and taxa found during the survey in 2013. The numbers indicate in how many pictures the species was found. Total number of pictures for each station in brackets.

Location Species name	Bouréeneset (11)	Daumannsodden (14)	Fuglefjella (21)	Kvadehuken (10)	Sagaskjæret (10)	Salpynten (15)	Starostin (24)	Vardebukta (13)
Algae								
Laminaria spp.	11	6	1			13	14	1
Green algae	6							
Filamentous brown algae	6	8	5			9	21	7
Filamentous green algae	1						3	2
Fluffy brown algae	2					5		5
Ulvophyceae		1				2	1	4
Phymatolithon lenormandii		14	5	1	1	13	24	
Fluffy green algae		1				2		7
Filimentous red algae	1						1	1
Phycodrys rubens		14		1		8	23	1
Plumaria plumosa		14	2			12	21	
Mollusca								
Margarites sp.	11	1	2	9	3	4	19	1
Coryphella verrucosa	1		4					
Tonicella sp.		13		7	3	3	2	
Hiatella arctica		9			1	6	8	
Mya truncata			2					4
Bivalvia indet.								2
Buccinum			17			2	9	11
Euspira pallida			8					1
Chlamys iclandica							1	
Arthropoda								
Caprellida sp.	4					2	1	2
Hyas sp.	1		4			5	4	4
Balanus balanus		11	2	4	9	1	19	2
Pagurus sp.		3	2		1	4	9	13
Lebbeus polaris		3		5		1	8	
Natantia indet.								1
Gammarid amphipods		2				9	6	3
Crangonidae			1					1
Mysidae						1		1
Pyconogonida						3		

Species list continued.

Location Species name	Bouréeneset (11)	Daumannsodden (14)	Fuglefjella (21)	Kvadehuken (10)	Sagaskjæret (10)	Salpynten (15)	Starostin (24)	Vardebukta (13)
Nemertea								
Lineus spp.			1				1	
Annelida								
Serpulidae	4	14		1	1	11	23	3
Branchiomma		3	15			4	8	11
Chone infundibuliformis			21					13
Cnidaria								
Urticina eques		12		1	1	5	24	
Hormathia nodosa							9	
Hydrozoa indet.	1					9	1	
Halcampa arctica			18					12
Urticina felina						2	5	
Gersimia rubiformis				3	1			
Porifera								
Yellow porifera		4				9	5	
Grey porifera						4		
Orange porifera		3				2	7	
Bryozoa								
Bryozoa	1	1			2	7	23	
Echinodermata								
Strongylocentrotus droebachiensis		14	3	9	1	8	21	
Ophiuroid		4	2			3	14	11
Henricia sp.		2	1	1		1	1	
Asteroidea indet					1			4
Asterias rubens					7			
Chordata								
Synocium turgens		11					24	
Ascidacea indet				2	2			3
Halocynthia pyriformis		1						

The table below shows the number of pictures, from each location, that has been included in the analysis. Some of the locations have been visited more than once (1979/80, 1984 and 1997). Data extracted from the combined number of old pictures have been used to compare with data taken from pictures taken in 2013.

The bottom type column indicate the dominating type of substrate found in the different location

Location	**Bottom type**	**Year**			
		79/80	**84**	**97**	**2013**
Bouréeneset	Mixed	28			11
Daumannsodden	Mixed	18			14
Fuglefjella	Soft	22			21
Kvadehuken	Hard	10	10	10	10
Sagaskjæret	Hard		20	41	10
Salpynten	Mixed/Soft		15		15
Starostin	Mixed/Soft	22		24	24
Vardebukta	Soft				13

Below are short characterization of the habitat based upon the pictures taken at each location.

BOURÉENESSET

DSC_1011

Laminaria spp. dominates the entire frame with a very fine dusting of sediment on the lower fronds.

DSC_1012

Laminaria spp. dominates the entire frame with a very fine dusting of sediment on the fronds. Only one laminarian individual was counted due to only one stipe being visible

DSC_1015

Laminaria spp. dominates the entire frame with a very fine dusting of sediment on the lower fronds. Top fronds relatively clean but may be due to diver action. Only one laminarian individual was counted due to only one stipe being visible.

DSC_1016

Laminaria spp. dominates the entire frame with a very fine dusting of sediment on the lower fronds with the top fronds being relatively clean. Only one laminarian individual was counted due to only one stipe being visible.

DSC_1019

Laminaria spp. dominates the entire frame with a very fine dusting of sediment. Only added one laminarian individual due to no stipes being visable.

DSC_1021

Laminaria spp. found on the edge of the photo. A large clear patch in the centre dominated by pebbles covered by a layer of fine sediment. Green algae is growing in the patch where there is no laminarian.

DSC_1023

Laminaria spp. found on the edge of the photo, fine dusting of sediments on the fronds. Clear patch in the middle of the photo that is made up of pebbles covered with fine material, lots of green algae growing in the patch on the pebbles.

DSC_1024

Very open small pebbles no fresh sediment. Green algae and brown filamentous algae dominate. A patch of kelp in the bottom corner but only one individual counted due to only one stipe being visable.

DSC_1025

Very open area with lots of small pebbles, some sedimentation amongst them but seems that they have been washed away. Green algae and filamentous brown algae dominate. Only one laminarian spp individual with fresh sedimentation on top.

DSC_1026

Entire photo dominated by filamentous and "fluffy" brown algae, some green algae breaking it up. Small patch of pebbles that is clean of fresh sediment.

DSC_1029

Mix of medium and small pebbles making up most of the frame, scattered with one or two larger rocks. Larger rocks are covered in algae. A few laminarian individuals along the fringes of the photo.

DAUMANNSODDEN

DSC_0856

The photo was taken over solid bedrock with encrusting red algae covering the rock where it could be seen. The rest of the rock was dominated by red algae with some individual laminarians scattered in between. Looks to be a slope of about 30 degrees but this may be down to camera angle.

DSC_0860

Clean bedrock on either side of the photo covered in encrusting red algae. Centre of the photo looks like a small fissure in the rock that has been filled by relatively large stones.

DSC_0865

Bedrock making up the substrate. One huge Synocium turgens in the centre, the rock itself is scattered with read algae clumps.

DSC_0866

Solid bedrock covered in encrusting red algae. Most of the frame is covered by red algae clumps and filamentous brown algae.

DSC_0868

Solid bedrock patches covered with encrusting algae. Most of the frame is covered by two red algae species, almost 100% coverage. Only a few individuals counted due to unsure if they are single individuals or if they are one large individual.

DSC_0871

Mainly bedrock, one crack in it is filled with a mix of dead bivalve shells and small rocks. One boulder is on the bottom right hand side of the photo. Very clean rock covered in encrusting red algae with a few sparse tufts of leafy red algae.

DSC_0875

Bedrock covered completely with encrusting red algae. Small cracks are filled up with a mix of sediment, small stones, and broken shells. A couple of small patches of red algae are seen but mostly looks like a grazed barren landscape which fits with the high number of sea urchins.

DSC_0877

Bedrock covered completely with encrusting red algae. A few small cracks that are filled with sediment, small rocks and broken shells. A few tufts of red algae break up the otherwise bare bedrock.

DSC_0880
Bedrock covered completely with encrusting red algae. Seems to be a slope with a few small ridges. Sparsely covered in red leafy algae.
DSC_0882
Bedrock covered in encrusting algae. Looking along a ridge on a slope of bedrock which is where most of the organisms are located. Small amount of fine sediment located in the cracks.
DSC_0883
Clean bedrock covered in encrusting red algae. A couple of boulders, with broken shells and sediment filling the cracks around them. Urchin grazed barren with very few tufts of red algae.
DSC_886
Bedrock covered in encrusting red algae in the centre, large leafy red algae surrounding it.
DSC_0888
Small patch of clean encrusted bedrock surrounded by leafy red algae tufts. Small amount of broken shell, stone, and sediment at the bottom of the photo.
DSC_0892
Small amount of encrusted bedrock showing. Lots of red algae tufts protruding, a large piece of filamentous brown algae covering a large portion of the photo.

FUGLEFJELLA

DSD_0741
Very soft bottom. A single dead Mya truncata.
DSD_0749
Muddy sediment covering the whole photo, two medium sized drop stones one with a piece of filamentous brown algae attached.
DSD_0753
Very soft bottom.
DSD_0765
Very soft bottom
DSD_0766
Very soft bottom. One or two old shells.
DSD_0770
Very soft bottom
DSC_1127
Very soft bottom with one dead sea urchin in the centre, some small dead shells.
DSC_1133
Very soft bottom. Large drop stone in the centre of the frame with some filamentous brown algae attached to it.
DSC_1137
Very soft bottom.
DSC_1139

Very soft bottom.
DSC_1141
Very soft bottom. One dead shell in the center.
DSC_1142
Very soft bottom, one cluster of Balanus making a very small hard bottom. A couple of algae which look like they are attached to a small stone.
DSC_1143
Very soft bottom nothing apart from fine mud.
DSC_1144
Very soft bottom
DSC_1147
Very soft bottom.
DSC_1150
Very soft bottom.
DSC_1151
Very soft bottom
DSC_1154
Very soft bottom with a small stone that is covered in calcareous red algae.
DSC_1155
Very soft bottom
DSC_1157
Very soft bottom
DSC_1159
Very soft bottom

KAPP STAROSTIN

DSC_1064
Bedrock with a large patch of sediment, fine mixed with some broken shells and a little rock.
DSC_1066
Bedrock with a large patch of fine sediment mixed with broken shells and some smaller rocks.
DSC_1071
Bedrock to the centre of the photo and continuing towards the left hand side. Towards the right is fairly course substrate consisting of small stones, sand, and broken shells. There looks to be a couple of bedrock outcrops. All the bedrock is covered in the calcareous encrusting red algae.
DSC_1072
Bedrock to the centre and left of the photo, some small indents covered/filled with fine sediment. All bedrock covered by encrusting calcareous red algae. The right is made of coarse sediments consisting mainly of broken shells, it has also a mixture of sand and fine mud in it. A couple of bedrock outcrops can also be seen.
DSC_1074

Bedrock to the left hand side of the photo. Mostly coarse sediment made of broken shells and small rocks, soft sediments filling up the gaps between them. Bedrock is covered by calcareous red algae.
DSC_1078
Mostly bare bedrock covered in calcareous red algae, grazed urchin area?
DSC_1083
Photo seems to be complete bedrock but covered mainly in algae, the few spaces where bedrock can be seen is covered in calcareous red algae.
DSC_1085
Hard bedrock covered with red algae, some bare patches but covered in red calcareous algae. Some kelp holdfasts.
DSC_1086
Hard bedrock covered in red algae, small clear patch indicates bedrock covered in encrusting calcareous red algae.
DSC_1088
Hard bedrock covered in encrusting calcareous red algae, small indentations are filled with fine sediment.
DSC_1096
Hard bedrock covered with encrusting red algae. One bare patch in the centre has no algae on it.
DSD_0645
Hard bedrock covered in red algae and colonial ascidians, only a few small gaps indicating encrusting algae. The bottom right hand corner is fine sediment with a couple of small rocks and broken shells in it, looks like it could be an indentation.
DSD_0649
Hard bedrock covered in encrusting red algae. What looks like either an indentation or a fissure in the rock is filled with sediment, many broken shells and small stones. The bottom of the photo looks like an urchin grazing barren.
DSD_0650
Hard bedrock covered in encrusting red algae. What looks like two distinct indentations or fissures within the rock covered in sediment, broken shells and small stones.
DSD_0651
Hard bedrock covered in encrusting red algae, looks like an urchin barren. Large indentation covered in sediment, broken shells, small/medium sized stones.
DSD_0656
Hard bedrock covered in encrusting red algae.
DSD_0665
Hard bedrock covered in encrusting red algae. Looks like a grazed urchin barren.
DSD_0667
Hard bedrock covered mostly in encrusting red algae. Looks to be the base of kelp forest. Lots of weed covering the rock.

DSD_0670
Hard bedrock covered in encrusting red algae. Looks like start of kelp forest. Small amount of fine sediment with broken shells in the bottom left hand corner.
DSD_0673
Hard bedrock covered in encrusting red algae.
DSD_0673
Hard bedrock presumed due to the organisms on it. Very few small bare patches but those that are showing are covered with encrusting red algae.
DSD_0683
Hard bedrock covered in encrusting red algae.
DSD_0689
Hard bedrock covered in organisms, very few bare patches but those that are present are covered in encrusting red algae.
DSD_0695
Hard bedrock covered in organisms, very few bare patches but those that are present are covered in encrusting red algae.

SALPYNTEN

DSC_0818
Hard bedrock dispersed with soft sandy sediments, mixed with dead shells. These areas may be indentations within the rock.
DSC_0821
No bottom seen due to Laminaria frond, only added in documentation due to small snailfish on the frond.
DSC_0822
Hard bedrock with indentations filled with sandy substrate. A couple of small stones and very few broken shells in the mix also.
DSC_0823
Presumed hard bedrock under the red algae. Some patches where the bottom can be seen with most of them being sandy sediment with some small broken shells.
DSC_0825
Presumed bedrock where Porifera is located. Around is clean sandy sediment infilling the indentations.
DSC_0827
Gravelly sand, some coarse bits of rock and broken shell scattered throughout the entire photo.
DSC_0829
Gravelly sand with some coarse bits of rock and broken shell scattered throughout the entire photo. Most of the coarse rock and shell are to the bottom left hand corner of the photo.
DSC_0832

Possibly bedrock due to the fauna/flora identified. Very small isolated patches of bare rock can be viewed which are covered mostly in encrusting red algae although there is a smallish bare patch of rock.

DSC_0833

Bedrock covered with encrusting red algae. Indentations filled with clean coarse sand.

DSC_0834

Difficult to make out the bottom type due to kelp fronds obstructing view. The small patches that can be seen suggest bare bedrock with a little encrusting red algae.

DSC_0837

Bedrock is exposed but the centre of the photo is mainly an indentation filled with coarse sandy gravel. There are medium sized pebbles with a few broken shells filling the indentation.

DSC_0839

Hard bedrock.

DSC_0842

Main part of the photo consists of relatively large rocks jumbled together, some clean and some covered in encrusting red algae (perhaps indicating age they have been there). Broken shells lie between and on these rocks. Coarse sediments seen between the rocks and increases towards the bottom and right of the photo.

DSC_0845

Not much of the bottom to be seen due to fauna. Small gaps indicate hard rock covered in encrusting red algae, other parts seem to show cracks/indentations filled with coarse sandy gravel with or one two pieces of broken shell.

DSC_0846

No bottom to be viewed due to kelp lamina obstructing view.

VARDEBUKTA

DSC_0757

Soft muddy sand bottom covered in polychaete tubes. One large drop rock on the left hand side of the photo. Laminaria is present but may be on a drop stone brought to the area.

DSC_0758

Soft muddy sand bottom covered in polychaete tubes. Laminaria seem to be attached to drop rocks.

DSC_0759

Soft muddy sand bottom covered in polychaete tubes. Laminaria seems to be growing directly upon the soft surface with its own community within the hold fast. A large amount of filamentous brown algae and fluffy brown algae taking up most of the photo.

DSC_0767

Soft muddy sand bottom covered in polychaete tubes. Large rock with all the laminarias growing on it as well as other rocky bottom fauna.

DSC_0769

Soft muddy sand bottom covered in polychaete tubes

DSC_0771
Soft muddy sand bottom covered in polychaete tubes
Small amount of what appears to be loose algae.
DSC_0772
Soft muddy sand bottom covered in polychaete tubes.
DSC_0774
Soft muddy sand bottom covered in polychaete tubes. Some loose algae, laminaria frond in the foreground.
DSC_0777
Soft muddy sand bottom with many polychaete tubes there appears to be a kelp forest in the background.
DSC_0779
Soft muddy sand bottom with many amphipod tubes (?). A couple bits of Laminaria attached to drop stones.
DSC_0780
Soft muddy sand with many polycheate tubes. Some Laminaria lamina in the foreground and what looks like may be in the background.
DSC_0783
Soft muddy sand with many tubes. Laminaria seems to be growing in the distance.
DSC_0786
Soft muddy sand with many tubes, small patches of fine sand in between the tubes. Laminaria seems to be growing in the distance

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