Evaluation of proposed common standards for benthos monitoring in the Arctic-Atlantic – pilot study in Greenland (INAMon)

Technical report no. 105, 2017

Pinngortitaleriffik, Greenland Institute of Natural Resources
Title: Evaluation of proposed common standards for benthos monitoring in the Arctic-Atlantic – pilot study in Greenland (INAMon)

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Serial title and number: Technical report no. 105

Publisher: Pinngortitaleriffik, Greenland Institute of Natural Resources
This report is part of the project, *Initiating North Atlantic Benthos Monitoring* (INAMon), which were financially supported by the Greenland Institute of Natural Resources, North Atlantic Cooperation (nora.fo; J. nr. 510-151), Sustainable Fisheries Greenland, the Ministry for Research in Greenland (IKIIN), and the Environmental Protection Agency (Dancea) of the Ministry of Environment and Food of Denmark (J. nr. mst-112-00272). The work is also part of the Danish Presidency project in Nordic Council of Ministers, *Mapping seafloor biodiversity and vulnerability in the Arctic and North Atlantic* (Proj. nr. 15002).

**Cover photo:**  
Top: Photo of seabed off West Greenland, **bottom left:** RV Pâmiut; **bottom middle:** example of sponge bycatch in demersal trawl; **bottom right:** sorted bycatch and species photos for identification catalogue (Source: GINR)

**ISBN:** 87-91214-82-3  
**ISSN:** 1397-3657  
**EAN:** 9788791214820


**Contact address:** The report is only available in electronic format. You can download a PDF-file of the report at this homepage http://www.natur.gl/publikationer/tekniske_rapporter

It is possible to achieve a print of the report here:

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Abstract
In 2015, the Greenland Institute of Natural Resources realized a concept for long-term and large-scale monitoring of marine bottom-living invertebrate fauna (benthos) in the Arctic-Atlantic as part of the international research project, *Initiating North-Atlantic Benthos Monitoring* (INAMon) (Blicher et al. 2015). The initiative was, first of all, motivated by a large gap in knowledge about the benthic ecosystem in the Arctic in general, and about the influence of climate, trawling, oil exploitation and other potential anthropogenic and natural drivers. However, the high cost of benthos studies using conventional methods, and limited financial, logistic and scientific capacities have prevented most Arctic nations to address these gaps in knowledge on the relevant geographical and temporal scales. Therefore, a main goal of INAMon was to develop a cost-efficient approach to benthos monitoring, realistic to be implemented across the Arctic. A “trawl bycatch-program” was integrated on national fisheries research surveys in Greenland waters. Besides producing high-quality information about focal components of the benthic community in Greenland, the surveys also acted as a platform for knowledge exchange between Arctic benthos specialists in order to ensure methodological consistency and data comparability across nations.

During 2015 and 2016 we have reached more than 1100 sampling stations in Greenland, covering a depth range from 40 to 1500 meters, and a latitudinal range from 60 to 76°N. We have documented a total of >900 different benthos species/taxa and a wide range of communities. We have significantly increased the knowledge about the occurrence of sponge grounds and dense concentrations of cold-water corals, which are regarded indicators of Vulnerable Marine Ecosystem (VME) habitats. In this report, we show examples of our results, and evaluate the monitoring concept in relation to the identified needs.

Background
In 2011 an Arctic Marine Biodiversity Monitoring Plan was launched by a Marine Expert Monitoring Group (MEMG) of the Circumpolar Biodiversity Monitoring Program (CBMP-Marine) under the Conservation of Arctic Flora and Fauna (CAFF) in Arctic Council (Gill et al. 2011). The overall goal of the CBMP-Marine Plan was to facilitate an improvement of the ability to detect and understand the causes of long-term change in the composition, structure and function of Arctic marine ecosystems, as well as to develop authoritative assessments of key elements of Arctic marine biodiversity (e.g. key indicators, ecologically pivotal, and/or other important taxa). At this point, many/most Arctic marine areas remain poorly studied, and without a proper baseline understanding of the ecosystem components, or its natural dynamics or variation. Being able to document long-term changes on large geographical scales would then seem as a highly demanding task, also considering the logistical challenges in the vast marine areas comprising the Arctic. This was recognized by the MEMG and therefore the CBMP-Marine Plan was mainly meant to be a driver to promote, facilitate, coordinate, and harmonize existing marine biodiversity monitoring activities across the
Arctic, and in this way improve capacity to detect change. However, for many regions there is no existing monitoring or research activities and new initiatives will be necessary to be able to contribute the ambition of the CBMP-Marine Plan. Ongoing climate changes and the expansion of commercial activities into previously inaccessible areas only underlines the need for initiatives that addresses ecosystem change on long-term and large geographical scales.

The benthos community (i.e. seabed fauna) is a key component for elemental cycling and food web dynamics in the marine Arctic (Bluhm & Gradinger 2008, Blicher et al. 2009, Blicher et al. 2011, Piepenburg et al. 2011), and as a habitat for other species. The seabed hosts a very high biodiversity. To this date >4000 species of benthic invertebrates has been registered, and it is estimated that the true number of species is much higher (Bluhm et al. 2011). The benthos community is very likely to be affected directly or indirectly by climate changes as well as anthropogenic activities, such as oil & gas exploration/exploitation, commercial trawl fishery and pollution (Jones 1992, Rogers 1999, Collie et al. 2000, Hall-Spencer et al. 2002, Orr et al. 2005, Grebmeier et al. 2006, Olsen et al. 2007, Fabry et al. 2008, Althaus et al. 2009, Wassmann et al. 2010, Grebmeier 2012). It is also well-known that large and habitat forming epifauna, such as sponges and corals that may create biodiversity hot spots and act as nursery habitats for fish and invertebrates, are highly vulnerable to physical disturbance. Establishing large-scale mapping and monitoring of benthic communities is therefore essential to be able to provide solid information for knowledge based management of the Arctic marine ecosystem. It is, however, also clear that this is likely to require a very large economical, logistical and scientific capacity, and that this could remain to prevent its realization. It is therefore necessary to develop a viable concept for benthos monitoring in the Arctic.

In 2014 a group of benthos specialists representing Greenland, Iceland, Faroe Islands, Norway, Canada and Russia established a project called *Initiating North Atlantic Benthos Monitoring* (INAMon) with the specific aim to identify some minimum standards for benthos monitoring that: 1) are realistic to be implemented given the logistical, scientific and economical settings within each country in the Arctic-Atlantic, 2) will provide a description of key components in benthos fauna communities, and 3) has the potential to document large-scale and long-term trends in benthic indicators in relation to climate, trawling, oil exploitation and other potential anthropogenic and natural drivers.

Based on an overview of existing logistical capacities in the Arctic-Atlantic region, and experiences from Ecosystem Surveys in the Barents Sea (Anisimova et al. 2010), the INAMon network suggested a concept for regional-scale benthos monitoring: A cost-efficient “trawl bycatch-program” could be implemented as an integrated part of national fisheries research surveys in the region. By using these existing logistic platforms it could be possible to get comparable information about benthic key components on a regular basis in an area ranging from the sub- to high-Arctic, and Davis Strait/Baffin Bay in West to the Barents Sea in East (Blicher et al. 2015).
In 2015 the INAMon network launched a pilot project in Greenland waters onboard Greenland Institute of Natural Resources’ research trawler, RV Pâmiut. The pilot project had two specific objectives besides producing high-quality data from Greenland: 1) to develop some common Arctic-Atlantic standards for benthos monitoring (collection, sorting, species identification, data storage etc.), and 2) to run a cross-national program for knowledge exchange to build up the scientific capacity needed to implement standardized monitoring in each participating country.

Scope of report
The objective with this report is to show examples of the type of data/products that INAMon has produced in Greenland waters during 2015 and 2016, and to evaluate the monitoring concept in relation to the identified needs. It is also discussed how the knowledge exchange program has contributed to building up scientific capacity and a common reference across Arctic-Atlantic nations.

Material and Methods

Ship and survey design
Every year from June to September fisheries surveys are conducted from RV Pâmiut on the continental shelf and slope off the Greenland West coast from 59°30’N up to 72°30’N, and off the East coast from 59°30’N up to 67°N. Two types of surveys are conducted in both West Greenland and East Greenland: 1) Combined shrimp-fish surveys using a Cosmos 2000 trawl with a 20 mm mesh size in the cod-end with ‘rock-hopper’ ground gear comprising steel bobbins and rubber disks on depths from 50 meter down to 600 meter (Fig. 1 left photo). Towing time is 15 minutes and towing speed is between 2.0 and 2.5 knots. Stations are positioned using ‘buffered random’ sampling, and about 50% of the stations included in the preceding year’s design have been repeated as fixed stations in the following year. 2) Greenland halibut surveys using an Alfredo III trawl with a mesh size of 140 mm and a 30 mm mesh-liner in the cod-end. The depth interval surveyed is from 400 to 1500 meter. Towing time is 30 minutes and average towing speed is 3.0 knots. Station positions are based on random allocation with a buffer zone around each station.

On the combined fish-shrimp surveys in West Greenland in 2015 and 2016 night-time was available for additional sampling with a heavy-duty research Beam trawl (weight in air c. 1000 kg) with a 2.52 m wide opening, and 10mm mesh size in the cod-end (see Fig. 1 right photo). Towing time was 5 minutes with a towing speed of 1-2 knots. The sampling depth range of the beam trawl was 39 to 632 meter. Time was not available for beam trawl sampling in East Greenland and in the deep Davis Strait basin.

In 2016 an additional survey outside the standard survey area was conducted in Melville Bay, Northwest Greenland using Cosmos and Beam trawls.
Fig. 1. RV Pâmiut gear types. **Left photo**: The Cosmos trawl with a large bycatch of Geodia sponges. **Right photo**: The Beam trawl rigged with the trawl sensor (yellow unit), and UW camera and strobes.

All trawls were equipped with trawl sensors (Furuno Marport) sending live information about depth, temperature, bottom contact, and pitch and roll for most effective trawling. For all stations metadata (position, depth, bottom temperature, wire length, gear type etc.) were entered directly into GINR’s Access database.

Sorting and species identification of benthos
We followed the recommendation of Blicher et al. (2015) and incorporated the benthos protocol for sampling, sorting, species identification, photo documentation, preservation of focus taxa and data entry into the standard routines for the existing fisheries surveys to the greatest extent possible (see Suppl. Appendix). For this purpose 3 or 4 benthos specialists from the INAMon network attended each of six annual surveys. By doing so, all steps in the process from sampling to data entry could be completed onboard, with the result of being able to retrieve a complete dataset shortly after the ending of surveys.

Data entry and storage
Our strategy was to link the benthos program to the existing fisheries survey capacities to the largest extent possible to maximize cost-efficiency. This also included data entry and storage. Therefore, we created a benthos extension to an existing survey database (Microsoft Access) for fish and shrimps used by the Department for Fish and Shellfish at GINR. We also adopted their routines for obtaining sampling station metadata (e.g. bottom temperature, depth, coordinates, wire length). While sampling and handling procedures can be adopted directly from INAMon to other national surveys, the practical approach to data entry and storage, will need to be adapted to the existing platforms, which is likely to vary between nations. Therefore, the Greenlandic database only acts as an example to demonstrate some of the principles that needs to be followed to ensure consistency in data and its metadata across nations.

Knowledge exchange program
Another aspect of data consistency is standardization of species/taxon identification. The number of Arctic benthos taxonomists has been decreasing over the recent decades, and there is an urgent need for capacity building to realize the ambition of standardized Arctic-Atlantic benthos monitoring. Therefore, besides producing high-
quality data in Greenland, the INAMon surveys were also intended to act as a hub for knowledge sharing by bringing together bentholists from all Arctic-Atlantic nations. Besides developing a standardized sampling protocol, we wanted to ensure the highest possible standards for species/taxon identification, not only in Greenland, but also in any future monitoring programs in other parts of the Arctic. Therefore, the INAMon surveys were also used to produce photos and descriptions of reference specimens for an extensive Fauna Atlas that will work as a common identification tool for Arctic benthos.

Results

A total of 23 benthologists representing 11 research institutions attended the INAMon surveys with RV Pâmiut in Greenland in 2015 and 2016. It was highly prioritized to give time to knowledge sharing, development of common standards, and continuous documentation of this knowledge and standards.

Overall, we completed 1161 sampling stations in 2015 and 2016, of which 655 were from Cosmos trawl, 282 from Alfredo trawl, and 224 from beam trawl (fig. 2, see figure section starting at p. 17). A total of 936 benthic invertebrate species/taxa were registered, of which 537 were identified to species level. 539 species/taxa were registered in Cosmos trawl samples, 331 in Alfredo samples, and 761 in beam trawl samples. In this dataset we have not included any species of shrimps. Thousands of photos were taken of reference specimens and their key characters, and extensive amounts of preserved material were kept for reference collections. A first version of a fauna catalogue with these photos and species descriptions is planned to be published and made freely available as a tool to ensure common-standards for species identification on trawl surveys across the Arctic (Grant et al. In prep.). The catalogue will be under continues development by the INAMon network.

The Greenlandic surveys also supported specialist groups outside the INAMon network with samples for numerous detailed studies (e.g. taxonomy, genetics, food web structure, physiology, autecology, substrate mapping). Some of these groups were invited to attend the surveys and conduct experiments onboard, while others received preserved samples subsequent to the surveys.

In the following section, results for some key parameters are presented. It is meant to present an overview of the data material that is available from the INAMon pilot project, and to give an idea of its scientific value and its potential for supporting knowledge based management as stated in the project goals (see above). But an in-depth analysis of the vast amount of data is not the scope of this report. Results will be presented separately for each of the sampling gear types used, and evaluated accordingly.

Species/taxon richness

The benthos fauna was identified to the highest possible taxon according to the INAMon standards (Grant et al. In prep.) The total species/taxon richness (species/taxon count) per sample is a simple measure for the complexity or
heterogeneity of a habitat. It does not consider the identity or the abundance of the different taxa. Rare, endemic or vulnerable taxa are generally considered to have higher conservation value. Still, total richness can be used as a criterion when assessing the relative conservation values of habitats.

The species/taxon counts per sample are illustrated in figure 3 and 4, for Beam trawl samples, and Cosmos and Alfredo trawl samples, respectively. For the Beam trawl samples collected in West Greenland, the average species/taxon count per haul was 40.1 (range 2 to 91, stdev 17.6). For Cosmos and Alfredo bycatch samples in West and East Greenland these numbers were 11.9 (range 1 to 47, stdev 8.0) and 9.2 (range 1 to 34, stdev 6.5), respectively. There was great variability between stations. While some of this variation is linked to temperature, substrate type, depth and other natural drivers, a part of it may also be driven by anthropogenic activities, such as trawling (Yesson et al. 2016). Regionally, there seem to be a tendency towards higher richness in samples from the Southwest and East Greenland shelves, compared to West- and Northwest Greenland. This tendency is most clear for Cosmos and Alfredo samples. Because of the lack of sampling in East Greenland, this comparison was not done for Beam trawl samples.

Total biomass
Total biomass of the benthos community is another parameter that can contribute to the description of habitat complexity or the function of the ecosystem. High benthos biomass is most likely to be found in undisturbed or stable environments, and/or in areas with high food production (i.e. phytoplankton) or strong sedimentation or advection of food items (fresh or detritus).

The total biomass of benthos per trawl haul was converted to total biomass (in grams) per 100 m² swept area. Swept area is a calculation based on the width of the trawl opening and the distance from start to end positions of active trawling, based on live information from trawl sensors mounted on the trawl. The average swept area for Cosmos and Alfredo trawl hauls were 0.031 km² and 0.073 km², respectively, while the average swept area of a beam trawl haul was only 0.0012 km². The total biomass of benthos in Cosmos and Alfredo trawls was ranging from a few grams to several kilograms per 100m² swept area. As for species/taxon richness, the area from the southern tip of Greenland and towards the East Greenland shelf shows remarkably high values compared to the West Greenland Shelf (fig. 5).

On average, the area-weighted total biomass was considerably higher in Beam trawl catches compared to the Cosmos catches in the shelf area in West Greenland, not surprisingly indicating an overall higher benthos catch efficiency of the Beam trawl (fig. 6), which was also indicated by the higher species/taxon richness in samples (see below).

Community assemblages
To assess the differences in species/taxon composition between stations in the study area a similarity analysis (Bray-Curtis, square-transformed data) was applied to main
taxon-biomass data for each gear type. A SIMPROF analysis made it possible to split up trawl stations in clades that were statistically significantly different in regard of taxon composition and biomass. For Beam trawl hauls in West Greenland this resulted in 14 distinct clades/communities, which are plotted with symbols in a map of the survey area in figure 7. Furthermore the relative taxon composition for the 10 most station-rich clades are shown (fig. 8). The four most abundant taxa in the two clades represented by most Beam trawl stations, l in North and n in South, are sponges, sea anemones, brittle stars and sea stars for clade l, and sea cucumbers, sea urchins, brittle stars and sea squirts for clade n.

To include both East and West Greenland shelves in such an analysis, it was necessary to rely on fisheries trawl (Cosmos) data, although, clearly representing fewer taxa/species of the benthos community (see above). Anyway, the analysis divided the data into three big clades, with l and j dominating the Western and Eastern shelves, respectively, and clade k being represented on both shelves, with particular dominance in Southwest Greenland (fig. 9). The dominating taxa in these three clades were: j) Porifera (90%) and Alcyonacea. This clade had relatively high total biomasses; k) Porifera (>80%), Holothuridea, Cephalopoda and Actinaria and l) Hydrozoa (incl. medusae), Actinaria, Cephalopoda and Asteroidea. The biomasses at stations belonging to clade l and k were generally considerably lower compared to clade j (data not shown, but see figures 3 to 6 (tot biomass and richness)).

Presence of focus species or species groups

Several international fora have presented their definition of species or species groups (i.e. taxa) that need specific attention in marine conservation and resource management, such as NAFO, ICES, OSPAR, IUCN/WCPA, FAO and CBO/EBSA1.

Vulnerable Marine Ecosystem (VME) indicator species or species groups are typically nominated based on their contribution to habitat complexity, biodiversity and ecosystem function, and their vulnerability towards anthropogenic stressors, such as pollution and bottom trawling. Endemic or rare taxa, and habitats, are generally considered to have higher conservation value. For Valued Ecosystem Components (VEC’s), elements such as the economic, scientific, cultural or aesthetic importance are considered.

Two species groups that are considered as Vulnerable Marine Ecosystem (VME) components are sponges (Porifera) and cold water corals. This is mainly based on the understanding that sponges and corals can create large biogenic structures that can add to the complexity of the benthic habitat and act as habitat for other species, and in that way have a significant effect on biodiversity and ecosystem function (e.g. as nursery ground for fish). It is also based on the fact that these large erect, sessile and

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slow-growing organisms are particularly vulnerable to physical disturbance, such as bottom trawling, and that habitats will regenerate slowly. Even though sponges and corals were frequently observed in the Beam trawl catches in West Greenland their total biomass only exceeded 1000g and 10g per 100m² swept area for sponges and corals, respectively, at c. 5% of the beam trawl sampling stations (data not shown). For a regional comparison also including East Greenland, catches of sponges in Cosmos and Alfredo trawls are illustrated in figure 10. This indicates that the heaviest concentrations of sponges are found in East Greenland, particularly in the area North of 63°N, with many catches up to several hundred kilos per haul. Such high amounts were not observed in the survey area in West Greenland. A similar regional comparison was done for the coral taxa present in the area: Antipatharia (black corals),Pennatulacea (sea pens), Scleractinia (hard corals) and Alcyonacea (soft corals) (fig. 11). Corals were not caught in the same amounts as sponges. But some aspects of the coral distribution in the survey area are worth mentioning: The densest concentrations of Pennatulacea were found in two rather well-defined areas in East Greenland between 65 and 67°N, and in West Greenland in the Northern Baffin Bay (i.e. Melville Bay North of 74°). Also several observations were made in the deep survey area in the Northern Davis Strait. Different species of soft corals, Alcyonacea, were frequently observed on the East Greenland shelf and slope, and especially between 64 and 66°N. The largest catches consisted of some very big exemplars of Paragorgia arborea (bubblegum coral). Scleractinia and Antipatharia were almost exclusively found in the deep part of the survey area in Davis Strait (fig. 11).

Thus, it is quite remarkable that the fisheries survey area on the West Greenland shelf appear to have so low abundance of VME indicator taxa. The only exception being the large Pennatulacea concentrations that were observed in Melville Bay North of 73°30′N, which was only recently opened for commercial test fishery for shrimps (Burmeister & Christensen 2016), and still not covered by GINR’s annual standard surveys.

Other taxa that have received specific attention based on their potential vulnerability to trawling based on their risk of being caught in a groundfish trawl includes species of Crinoidea (sea lilies and feather stars), Holothuridea (sea cucumbers), Actinaria (sea anemones), Gorgonocephalus sp. (basket stars), and cephalopods (Jorgensen et al. 2016). These taxa were also commonly observed in our samples, and in some cases in such high amounts that it could be relevant to conduct a more detailed local mapping of the biotopes (data not shown).

Gear catchability
As mentioned above, the catch efficiency of benthos differed between the three trawl types used in the surveys. Total biomass per 100m² swept area were generally much lower in Cosmos and Alfredo trawl samples compared to Beam trawl samples. Also, beam trawl samples were more species/taxon rich, with the invertebrate bycatch in Cosmos and Alfredo samples often being dominated by sponges (Porifera) in terms of biomass. It is however not surprising that large-sized (i.e. mega-fauna) and erect
benthos taxa are dominant in the Cosmos and Alfredo trawls, while the beam trawl samples cover a more broad size-range, also including macrofauna, but maybe not catching the biggest fauna effectively due to the smaller trawl opening.

However, on the standard fisheries surveys different trawls types also covers different depth strata and regions that most likely cover different types of benthos communities. Also, beam trawl sampling was not a part of surveys in East Greenland and the deep part of Davis Strait, thus not covering the big sponge grounds and areas with highest bycatch of corals. This complicates a formal comparison of gear catchability. However, on an extraordinary survey in Melville Bay, NW Greenland, in 2016 (North of 73°30’N outside the standard survey area), Cosmos and Beam trawl sampling were conducted on the same stations for direct comparison. This showed that average species/taxa counts per haul were 7.2 (n = 60) and 34.9 (n = 60) in Cosmos and Beam, respectively. The average total biomass per 100m² swept area was 4.89g (stdev 7.25) and 448.7g (stdev 867.1) for Cosmos and Beam, respectively. A station per station comparison of total biomass per 100m² swept area showed an average catch efficiency of the Cosmos trawl compared to the Beam trawl of 2.74% (stdev 5.12) for the Melville Bay.

Discussion

Knowledge exchange program and standardization process
During the project period we have developed common standardized protocols for sampling, sorting and identification of benthic fauna, and for data entry and storage. These products will be made freely available. Benthologists from six Arctic nations have participated in field work and scientific workshops to build up the competences to establish identical sampling programs in their respective national waters. At the time of writing this report, the INAMon protocol is being adopted to Canadian and Icelandic fisheries research surveys, respectively (Principal investigators: Virginie Roy and Steinunn Olafsdottir) and the joint annual Norwegian/Russian ecosystem surveys in the Barents Sea continue to be operational (PI’s Lis Lindal Jørgensen and Natalia Strelkova). Moreover, the benthos bycatch approach is being implemented on the bi-annual Norwegian TUNU research surveys in Northeast Greenland (PI’s Jørgen Schou Christiansen and Bodil Bluhm). Thus, the competences and logistic capacity is now available across the Atlantic Arctic making it possible to implement this cost-efficient protocol for long-term benthos monitoring at an unprecedented geographical scale.

Methodology
In the following, we will discuss the potential of the INAMon protocol for living up to the scientific minimum standards for benthos monitoring as outlined earlier in this report (see INAMon background).

Description of key components
Two sampling methods have been used in INAMon: 1) Commercial standard bottom trawls (Alfredo and Cosmos), and 2) Scientific beam trawl. The two methods have different advantages.
Trawl bycatch (Alfredo and Cosmos): The commercial standard trawls are obviously not designed to catch non-target species, such as benthos, and fishing routines are set up to minimize direct bottom contact, e.g. through adjustments of trawling speed and trawl wire length. Thus, benthos bycatch is per definition not intended and the overall catch efficiency of benthos is therefore low. In addition the catches in Cosmos and Alfredo trawls are mainly restricted to mega-epifauna with large and erect species, such as sponges, as the most abundant in catches. Logically, the catches also represent those species that are expected to be most vulnerable to commercial bottom trawling, and to physical disturbance in general. The patchy distribution of such taxa, and their habitat preference, also makes is less likely to find them in samples collected with conventional scientific sampling methods such as grab or dredge. Thus, from the data available we have significantly increased the knowledge about the occurrence of sponge grounds and dense concentrations of corals in the survey area (fig. 10 and 11).

Scientific beam trawl: The beam trawl is designed to collect epibenthos and, unlike commercial trawls it has direct bottom contact across the entire width. The trawl sensor is a valuable tool for the documentation and standardization of the methodology (i.e. time on and off bottom, swept area, tilt angle). Our catches included both macro- and megafauna. Epifauna were caught most effectively, but infauna was also present at stations with soft substrate, and the samples were more species rich and represented by more different taxa compared to commercial trawls. The largest exemplars of corals and sponges may not be caught in the beam trawl due to their low abundance, and the small opening of the beam trawl and a cross bar meant to prevent big rocks entering the trawl. But given the overall higher catch efficiency compared to Alfredo and Cosmos, and still covering a relatively large sampling area, it is more suitable for producing a measure for the overall benthos biomass and species/taxa richness. Beam trawl sampling during traditional fishery surveys requires that time is available for such extra activities. On the surveys in Greenland, night time is available for beam trawl sampling only in West Greenland. In East Greenland Alfredo/Cosmos trawling is conducted 24 hours per day, and extra ship-time is needed to implement other sampling methods.

Combined approach: The two sampling methods seem to complement each other well. Both are primarily collecting fauna living on the substrate or in the uppermost sediment layer and in a size range from macro- to mega fauna. None of them are suitable for complete quantitative descriptions of the infauna community, but in combination the two approaches can produce semi-quantitative information about VME indicators or other focus taxa, and about potential hot spots in species richness and biomass of macro- and mega-epibenthos.

Melville Bay example: In the following, data from Melville Bay, NW Greenland, are used to give an example of the type of information that can be delivered through a combined sampling approach. In contrast to most of the Greenland shelf, which has been commercially trawled for decades, Melville Bay was only opened for a commercial exploratory fishery for shrimps in 2014, and up until our investigations in 2016, the commercial trawling in 2014 and 2015 had been concentrated in two restricted areas.
Therefore it was possible to compare recently trawled areas with pristine habitats in the same depth interval (200-500m), and to evaluate the suitability of our sampling approach as a method to detect spatial changes in key components in relation to a severe human stressor. In figures 12 and 13 the total biomass and species/taxa richness in beam trawl samples are illustrated together with the commercial trawl hauls based on start and stop positions from log books. Within the two areas where trawling have been concentrated, the average biomass and species/taxon richness were significantly less compared to untrawled areas (Mann-Whitney U-test, p<0.05). One WME species were found in particularly high concentrations at some localities in Melville Bay, namely the colonial octocoral, Umbellula encrinus (Pennatulacea, sea pen), which stands upright on the sea bed in up to >2m height. It is regarded highly sensitive to physical disturbance, such as trawling. Our survey indicated that the smaller size of the beam trawl opening prevented large sea pens to be caught effectively. However, at several occasions we found large sea pens entangled in bobbins and rock-hoppers of the commercial trawl (Cosmos). Umbellula encrinus were almost entirely absent in the commercially trawled areas (fig. 14).

Assuming that the group of untrawled and trawled localities were inhabited by similar benthos communities before the initiation of commercial trawling, these results suggest a significant impact of trawling on the benthos community in the very early phase of a developing fishery. This would also confirm that our sampling approach effectively describes a part of the benthos community that responds rapidly to disturbance. It also shows that this type of results reflect dynamics on a geographical scale that is relevant in relation to the management of fisheries and marine habitats on both regional and local scales.

These results were communicated to the fisheries organization, Sustainable Fisheries Greenland (SFG), and to the fisheries authorities in Greenland. In 2013 the Greenlandic shrimp fishery was certified as a sustainable and well-managed fishery after the Marine Stewardship Council (MSC) standards (https://www.msc.org/). The geographical expansion of the shrimp fishery into previously unfished habitats was already in itself causing some concern, because it could be in conflict with the principles of the Marine Stewardship Council (MSC) and potentially putting the 2018-recertification at risk. The geographical footprint of the fishery in Melville Bay further expanded in the 2016 fishing season (fig. 15). As a direct consequence of our results, SFG decided to send out an official appeal to the relevant ship owners to freeze the geographic footprint of the fishery in Melville Bay for the 2017 season. Subsequently, in late 2017, a process was initiated by the Ministry of Fisheries and Hunting to incorporate this geographic definition of the area open to trawling in Melville Bay, and restrictions in previously unfished areas into shrimp fishing license conditions, and to completely close most localities with known occurrences of sea pens for fishing with a c. 100km² buffer zone (field code) for each observation (Ministry for Fishery and Hunting, 2017², Fig. 16). This

was the first example of use of INAMon results in marine resource management in Greenland.

**Functional characteristics**

Besides pure taxonomic analyses, the generated data can also be used to assess the functional characteristics of the benthos community. Species/taxa can be grouped according to their biological traits, such as feeding strategy, habitat preference, motility, body form etc., which can give an indication of the functional characteristics of the communities (data not shown, but see e.g. Bremner et al. 2006). A complementing method is to collect tissue samples from representative specimens of the community and assess food web structure through the analysis of stable isotopes (e.g. Divine et al. 2015, Bell et al. 2016, Blicher et al. *In prep.*).

Moreover, secondary production and carbon turn over can be estimated with empirical models from individual biomass and taxonomic information to give an indication of the turnover of the community (Brey 2012), and thus the ability to regenerate from detrimental disturbance (Fuhrman et al., *In prep*).

Species/taxa can be regarded either Arctic or boreal, and changes in the relative contribution of Arctic versus boreal taxa can provide information for monitoring purposes (e.g. Anisimova et al. 2010). But knowledge about their actual temperature thresholds are only known to a limited extent. Our data coupled with bottom temperature from sampling localities can be used to assess such thresholds and to evaluate the potential vulnerability of benthos communities to climate change. For the documentation of such impacts, regular monitoring is needed.

**Temporal trends**

One of the overall objective with INAMon was to develop a cost-efficient approach to long-term monitoring of the benthos community with the capability to document potential temporal changes related to natural or anthropogenic drivers. To make such temporal comparisons it is crucial that all steps from sampling to data storage is standardized and documented properly. INAMon has benefitted from using existing routines on fisheries surveys (e.g. station log and database) and gear (e.g. Trawl sensor, temperature logger). The standardization and documentation procedures, together with continuous updating of taxonomic information according to WoRMS standards (http://marinespecies.org/), secure that localities and areas can be revisited and that data are suitable for detailed temporal comparisons.

**Geographical coverage and spatial resolution**

By incorporating benthos monitoring into existing fisheries surveys, we have benefitted economically through reduced costs for a logistic platform. Also, the program greatly profited from the existing standards and routines, and scientific capacity.

However, an obvious limitation is that benthos sampling will be restricted to the fisheries survey area/stations. The strategy for station layout on national fisheries surveys differ from nation to nation. For example, ecosystem-surveys in the Barents
Sea rely on a fixed station grid that covers areas both with and without commercial interest, and also includes a diverse standard sampling program (Eriksen 2014).

Fisheries surveys in Greenland cover the continental shelf on the Greenland West coast from 59°30’N up to 72°30’N, and on the East coast from 59°30’N up to 67°N. Additional sampling (e.g. other gear, areas) is only possible to a limited extent dependent on the schedule of the survey targeting shrimp and fish. Therefore beam trawling was only conducted on the West Greenland shelf, while surveys in East Greenland and the basin in West Greenland left no time for such activity. The station layout in Greenland is based on previous years’ variation in catches of shrimp, cod and Greenland halibut within pre-defined sub-areas and depth-strata. Therefore, data from fishery surveys are inevitably biased towards more trawling-impacted habitats. Un-trawled areas that sustain a more pristine fauna are under-represented in the data set. There are currently no fisheries surveys in the northernmost part of Greenland, and the mapping and monitoring of benthos will continue to rely on occasional project-based research surveys, such as the one described for Melville Bay.

Conclusion
Despite limitations of the sampling program due to relatively low and biased catch efficiency of bottom trawls and its restriction to the existing fisheries survey areas, the concept has proven effective for documenting qualitative and semi-quantitative large-scale patterns in benthic community structure. It also enables the initial detection of potential vulnerable habitats, valuable ecosystem components or areas subject to dramatic changes (e.g. biodiversity hot spots, coral or sponge grounds, nursery grounds). As a management action, the detection of such potential focus areas could be followed up by more targeted benthos research using conventional sampling methods (e.g. seabed photo/video, grab, acoustic mapping) at a higher spatial resolution. Such actions would obviously depend on additional logistic and financial capacity. The methodological approach described in this report is therefore recommended as a minimum standard for long-term and large-scale monitoring of benthos communities in the Arctic-Atlantic.

To ensure consistent and knowledge-based management of benthic biotopes in the future, it is crucial to increase the awareness of the data being produced, and to get fisheries and environmental managers involved in discussions of concrete definitions of focal ecosystem components and detailed assessment criteria.

Acknowledgements
*Initiating North Atlantic Benthos Monitoring* (INAMon) were financially supported by the Greenland Institute of Natural Resources, North Atlantic Cooperation (nora.fo; J. nr. 510-151), Sustainable Fisheries Greenland, the Ministry for Research in Greenland (IKIIN), and the Environmental Protection Agency (Dancea) of the Ministry of Environment and Food of Denmark (J. nr. mst-112-00272). The work is also part of the Danish Presidency project in Nordic Council of Ministers, *Mapping seabed biodiversity and vulnerability in the Arctic and North Atlantic* (Proj. nr. 15002).
References


Bluhm BA, Gradinger R (2008) REGIONAL VARIABILITY IN FOOD AVAILABILITY FOR ARCTIC MARINE MAMMALS. Ecological Applications 18:S77-S96


Figures
On the following pages 17 to 31, you will find the series of figures 2 to 16, which are presenting some of the results of the INAMon investigations, as referred to in the text above.
Fig. 2. Overview of sampling localities with the three different types of trawls; Cosmos, Alfredo and Beam during 2015-16. Notice that all stations north of 73°N consist of both Cosmos and Beam trawl samples.
Fig. 3. Species/taxon counts per haul for Beam trawl samples in West Greenland in 2015-16. Notice, fishery surveys in East Greenland, and the deep basin in West Greenland, did not allow time for beam trawl sampling.
Fig. 4. Species/taxon counts per sample for Cosmos (CO26) and Alfredo (ALF3) trawl bycatch samples in 2015-16.
Fig. 5. Total benthos biomass per sample (grams per 100m² swept area) for Cosmos (CO26) and Alfredo (ALF3) trawl bycatch samples in 2015-16.
Fig. 6. Total benthos biomass per sample (grams per 100m² swept area) for Beam trawl samples in West Greenland 2015-16.
Fig. 6. Beam trawl samples (2015-16): Distribution of stations belonging to different clades based on main taxon-biomass data (square transformation, Bray-Curtis similarities, SIMPROF 1%). See Results and Fig. 8 for more information.
Fig. 6. Beam trawl samples (2015-16): Pie charts showing the relative distribution (biomass) of main taxa in the 10 most station-rich clades (square transformation, Bray-Curtis similarities, SIMPROF 1%). Number of stations (n), average total biomass (avg, g 100m⁻² swept area) and standard deviation (stdev) per clade are given below each pie chart. See Results and Fig. 7 for more information.
Fig. 9. Cosmos (CO26) trawl bycatch samples (2015-16): Distribution of stations belonging to different clades based on main taxon-biomass data (square transformation, Bray-Curtis similarities, SIMPROF 1%). See Results for more information.
Fig. 10. Cosmos (CO26) and Alfredo (ALF3) trawl bycatch samples (2015-16): Total biomass (kg per haul) of sponges (Porifera).
Fig. 11. Cosmos (CO26) and Alfredo (ALF3) trawl bycatch samples (2015-16): Total biomass (kg per haul) of corals belonging to four main taxonomic groups (see legend).

Initiating North Atlantic Benthos Monitoring (INAMon)

Demersal trawl bycatch 2015-16 (kg per haul)

Antipatharia (Black coral)
- 0.02 - 0.2
- 0.2 - 0.5
- 0.5 - 0.8
- 0.8 - 1.0

Pennatulacea (Sea pen)
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0

Scleractinia (Hard coral)
- 0.02 - 0.2
- 0.2 - 0.5
- 0.5 - 0.8

Alcyonacea (Soft coral)
- 0.05 - 1
- 1 - 5
- 5 - 10
- 10 - 50
- 50 - 221

Stations < minimum values

Symbol shapes:
- Cosmos trawl (15 min haul)
- Alfredo trawl (30 min haul)

Fig. 11. Cosmos (CO26) and Alfredo (ALF3) trawl bycatch samples (2015-16): Total biomass (kg per haul) of corals belonging to four main taxonomic groups (see legend).
Fig. 12. Total benthos biomass (g 100m⁻² swept area) of Beam trawl samples in Melville Bay, NW Greenland in 2016. Commercial trawl hauls during exploratory shrimp fishing before our investigations in 2016 are shown as black lines, based on start and end positions from ship log books (source: Greenland Fishery and License Control).
Fig. 13. Species/taxon count of Beam trawl samples in Melville Bay, NW Greenland in 2016. Commercial trawl hauls during exploratory shrimp fishing before our investigations in 2016 are shown as black lines, based on start and end positions from ship log books (source: Greenland Fishery and License Control)

Initiating North Atlantic Benthos Monitoring (INAMon)

Melville Bay 2016

Beam trawl
Species/taxon count per haul
- 15 - 28
- 28 - 41
- 41 - 53
- 53 - 66
- 66 - 79

2014-15 commercial trawl hauls

IBCAO 1000m contours
IBCAO 500m contours
IBCAO 100m contours

Fig. 13. Species/taxon count of Beam trawl samples in Melville Bay, NW Greenland in 2016. Commercial trawl hauls during exploratory shrimp fishing before our investigations in 2016 are shown as black lines, based on start and end positions from ship log books (source: Greenland Fishery and License Control)
Fig. 14. GINR’s observations from 2016 of a taxon known to be vulnerable to physical disturbance, Pennatulacea or ‘sea pens’, a group of colonial octocorals, in the Cosmos trawl. Commercial trawl hauls during exploratory shrimp fishing before our investigations in 2016 are shown as black lines, based on start and end positions from ship log books (source: Greenland Fishery and License Control).
In 2016, there was a change in the geographic footprint of the fishery in Melville Bay compared to 2014-15. Commercial trawl hauls during exploratory shrimp fishing before our investigations in 2016 are shown as black lines, while trawl hauls from the 2016 season, after our scientific survey, are shown as red lines. Both are based on start and end positions from ship log books (source: Greenland Fisheries and License Control).

**Fig. 15.** In 2016, there was a change in the geographic footprint of the fishery in Melville Bay compared to 2014-15. Commercial trawl hauls during exploratory shrimp fishing before our investigations in 2016 are shown as black lines, while trawl hauls from the 2016 season, after our scientific survey, are shown as red lines. Both are based on start and end positions from ship log books (source: Greenland Fisheries and License Control).
Fig. 16. Map of Melville Bay, NW Greenland, showing fishing areas (green), and areas closed to fishing, as suggested in a memorandum from the Ministry of Fisheries and Hunting in late 2017. At the time of publication of this report, these definitions were still in a process of being incorporated into the shrimp fishing license conditions. See figures 12-15 for comparison.
**Supplementary appendix:** Evaluation of proposed common standards for benthos monitoring in the Arctic-Atlantic – pilot study in Greenland (INAMon)

**PROTOCOL FOR HANDLING, SORTING AND REGISTERING TRAWL-BENTHOS**

The following protocol is based on a consensus reached within the INAMon network consisting of national representatives from Norway, Russia, Faroe Islands, Iceland, Greenland and Canada, and described in detail in Blicher et al. (2015). The main conclusion here is that Arctic-Atlantic large-scale and long-term monitoring of benthos can be implemented cost-effectively by using existing national groundfish assessment surveys as platforms, and through **onboard identification of the invertebrate trawl bycatch** on these surveys. This means that the national benthos programs can make use of the already existing routines, but also have to be adapted to those routines. This includes equipment handling, registration of metadata and some basic calculations (e.g. subsampling, swept area).

In 2014-2016 a team of international specialists have worked together on MT Paamiut in Greenland to develop skills and common standards for sampling, sorting and identifying the invertebrate trawl bycatch and samples collected with a scientific beam.

Here we present the standards for how to handle, subsample, sort and register invertebrates caught in groundfish trawl or beam trawl to ensure high quality and consistency in data. Standards for the identification of species are treated separately in our fauna ID-catalogue (Grant et al. in prep), and is only mentioned briefly here. While many of these routines and principles can be adopted directly to other national programs, the data registration methodology needs to be adjusted according to the possibilities onboard. However, it is crucial that that the registration of fauna data and metadata is standardised nationally, and follows some basic principles that ensures that data are compatible and comparable with data from other nations in the network. In Greenland, we have relied on an existing Access database for fish and shrimps that has been extended with benthos with help from the Department for Fisheries and Shrimps at GINR. We have also copied their routines for obtaining sampling station metadata (e.g. bottom temperature, depth, coordinates) (see Appendix). This has made it easier to develop routine procedures for registration of benthos data onboard. In the text below we have described the standard handling and sorting procedures on the INAMon surveys and used the Greenlandic database as an example to demonstrate some of the principles that we have developed in INAMon to ensure consistency in data.
When trawl coming up:

1. Name the station with the erasable marker on the laminated label with info on station number: YYYY-PA-XX-ZZZ, where YYYY is year, PA is for Paamiut, XX for leg number and ZZZ for station number. Also add trawl type (Beam, Cosmos or Alfredo)

2. Before each processing, take a picture of station label so every picture taking after this are related to this station. For large catches that needs to be subsampled (see below) remember to take a picture of the entire unsorted catch (on deck or in the factory).

Once catch on the conveyor belt:

3. Sort the catch. From the beginning, try to separate more abundant species (as Actiniaria or big jellyfish) from the rest. Big or abundant specimens can be placed in buckets. Smallest or rare specimen in trays. Keep specimens in seawater if you are not able to process the sample immediately.

4. Once general sorting done, sort the benthic catch into species or to the best level possible. When the catch is sorted, take a picture of those different groups with the label with the station identification no. YYYY-PA-XX-ZZZ.

5. Count and weigh each species (check the weight unit, scale and Malotus are in kg), report it on the benthos datasheet. It is very important to note whether the
species is taken from a FullSample or as a Subsample from the RestSample and to note the weights.

**Remember Always to Register:**

a. Weight of Full Sample Species  
b. Weight of the Rest Sample  
c. Subsample weight(s) of the Rest Sample

6. You can now start to enter data the database. See **Appendix 2** and the “Macrobetnos identification protocol” section for details.

7. At the end of the working period, transfer the picture to the camera to a laptop dedicated to that purpose in a folder named **Photos INAMon 2016** then subfolder named as **Ship-leg#_year** (PA-XX_2016) and subfolder for each station: **Station ID** (2016 PA-XX-ZZZ).

**Subsampling:**

If catch is too big to process, subsampling must be done in a methodologically consistent way. See **Appendix 1** for a detailed protocol.

Note all information on the benthos sheet (someone else should be able to use the sheet and understand what you did!).

**Organism pictures:**

If pictures of organisms are needed (check in Quick ID-catalogue), place the specimen in the photobox in the dry lab.

Take a first picture with a label indicating project and station ID (PA-XX-ZZZ) and name of the specimen. Then take every picture needed.

At the end of the working period, copy the pictures into the station-specific folders as decribed above: **Photos INAMon 2016** then subfolder **Year-Ship-leg#** (2016-PA-XX) and subfolder for each station: **Station ID** (2016 PA-XX-ZZZ).

**Voucher specimens and special collections:**

Before discarding the organisms, check if any of the specimens are needed as vouchers (see Quick ID-catalogue) or for other specific scientific purposes (see
sheets: ‘Applications for benthos collections’). Follow the guidelines for collecting and preserving the organisms.

Remarks

1. Be sure that Station ID is readable.

2. Do not consider empty Bivalvia, Gastropoda or empty tubes from worms. Ensure they are really empty by trying opening shells and tubes.

MACROBENTHOS IDENTIFICATION PROTOCOL

1. Once the sorting is done, the species identification can start. Be sure that rare and or thin specimen that can dry quickly are placed in seawater (same if one station has to wait before being processed) to avoid desiccation.

2. The catalogue “Benthos from the Arctic” and plates specifically designed for the survey can help you to identify specimens. Refer to the plate to find assigned taxonomic group name.

3. For each group/family/genus or species identified record number of specimen and weight.

4. Depending on the ID level reached, each identified group/family/genus or species, write abundance and weight on the benthos ID registration sheet (see Appendix) (check the weight unit, scale and Malotus are in kg).

5. Enter the data into the Malotus database. See Appendix 2 for instructions.
**APPENDIX 1: SUBSAMPLING:**

**BENTHOS SAMPLES UP TO 100KG (c. 4 FULL BASKETS):**

**Beam trawl** *(5 min. bottom time at 1-1.5 knots speed over ground):*

- If possible, empty the trawl directly on a sieve sorting frame.
- Otherwise, the sample will be put on the deck and then transferred/shoveled into baskets or sieve sorting frame.
- Discard big stones, but pay attention to collect any epifauna attached to the stones.
- Flush carefully with seawater to clean the sample for mud.
- Sort the entire sample for rare, big and vulnerable species (e.g. Asteroidea, Echinoidea, Holothuridea, Cnidaria, Brachyura) in a sieve sorting frame on deck (Fig. 1)
- Mark these specimens as “full sample species” (i.e. 1 specimen counts for 1 in the full sample). Take care not to mix them with the rest of the sample.
- Register the weight of the rest of the sample.
- Ensure homogeneity in the rest sample, and subsample “blindly” using a sample splitter (Fig. 1) 10 to 25% of the rest sample weight (dependent on size and homogeneity) for analysis of all species (e.g. sample equal amount from each basket). This is referred to as **subsample #1**
- If some species only appear one or two times in subsample #1, you need to sort for those species in a second subsample, or in the entire rest sample to ensure an accurate count. The summed weight and counts of the two subsamples is referred to as **subsample #2**.
- **Do not register the same species in both subsample #1 and subsample #2**
**Supplementary appendix:** Evaluation of proposed common standards for benthos monitoring in the Arctic-Atlantic – pilot study in Greenland (INAMon)

**Fig. 1.** The sorting sieve table on deck, and the sample splitter used for taking random subsamples.

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**Shrimp/fish trawl:**

- Consider the possibility of subsampling only one codend (shrimp/fish trawl) – discuss with survey leader.
- If possible, either put the sample directly in the baskets. Otherwise it will go into the binger.
- Sort the entire catch of fish and benthos in the factory under deck. Follow the instructions of the survey leader.
- Rare and/or big benthos species (e.g. Asteroidea, Echinoidea, Holothuridea, Cnidaria, Brachyura) are sorted and registered from the entire catch to avoid a bias of sub-sampling. Mark these specimens as “full sample species” (i.e. 1 specimen counts for 1 in the full sample). Take care not to blend them with the rest of the sample if subsampling is needed.
- Register the weight of the rest of the sample.
- If subsampling is necessary, ensure homogeneity in the rest sample, and subsample “blindly” with a sample splitter 10 to 25% of the rest sample weight (dependent on size and homogeneity) for analysis of all species (e.g. sample equal amount from each basket). This is referred to as subsample #1 in the sorting sheet.

- If some species only appear once or twice in subsample #1, you need to sort for those species in a second subsample, or in the entire rest sample, to ensure an accurate count. The summed weight and counts of the two subsamples is referred to as subsample #2 in the sorting).

- Do not register the same species in both subsample #1 and subsample #2

Data entry on ID sheets

- In the entry sheet clearly indicate which specimens are subsampled and which represents the Full Sample.
- Register weight of species picked from Full Sample
- Register weight of Rest Sample
- Register the Sub weight of subsample #1
- Register the Sub weight of subsample #2
- Do not register the same species in both subsample #1 and subsample #2
BENTHOS SAMPLES >100KG (e.g. BIG GEODIA SPONGE CATCHES):

- For Shrimp/fish trawl hauls: choose one of the two cod-ends in the trawl for analysis (i.e. 50% sub-sample, will be entered in the database).
- The catch will be put on the deck, not in the binger.
- Start by processing the Geodia before the rest of the sample on deck
- Fill baskets randomly with Geodia by hand or with a shovel, register the weight of each basket on the deck scale (Fig. 2).

Subsample a minimum of 5 baskets of Geodia for closer examination – the rest of the Geodia are discarded. Take out subsample baskets at pre-set intervals (f.ex. every fourth). If this ends up to be too many, select randomly. Register total/sub-sample weight for estimation of total abundance and weight of associated fauna as described above.
- **Smaller fauna (non-Geodia catch)** may be unevenly distributed and left on the deck, and has to be treated separately either as “full sample species” or by subsampling as described above. Depending on the volume and diversity.

- **Specimens may be non-randomly picked**; meaning that they are selectively taken from the sample for some reason. This needs to be **clearly specified** in the data entry sheet.

**Data entry**

- The total weight and the sub weight of Geodia-baskets is entered in the data entry sheet (in the comments section).

- For smaller/other fauna (non-Geodia catch):
  - Enter rest-sample/sub-sample weight on data entry sheet.
  - In the entry sheet clearly indicate which specimens are subsampled and which represents the full sample.
  - Specimens that are **non-randomly picked** from the catch needs to be entered into the database as such by choosing “BenthoNonRandom” in the “Species subdiv” field (Fig. 3).
  - Go to the formular Benthos Species (Fig. 4).
  - Choose station and BenthoNonRandom and start entering the species which are collected non-randomly (Fig. 5).

![Fig. 3.](image)

For non-randomly picked specimens first enter benthos under species, select BenthoNonRandom in the “Species SubDiv” field, click upload (Alt+U).
**Supplementary appendix:** Evaluation of proposed common standards for benthos monitoring in the Arctic-Atlantic – pilot study in Greenland (INAMon)

**Fig. 4.** For registering which specimens are non-randomly picked go to Benthos Species

**Fig. 5.** Choose station and BenthoNonRandom and start entering the species which are collected non-randomly

**MUD SAMPLE WITH BEAM TRAWL:**

- In case of a big mud sample ask the skipper to wash the trawl in the sea. It may be necessary to also wash the sample in the cod-end on deck with water from the sea-water hose.
- Transfer the sample either to baskets or to the sieve-sorting table for further washing.
- If you need to sub-sample from a big sample of mud, take equal amounts of sample from each basket with a bucket or shovel. Weigh both on deck and register total/sub-sample weight for estimation of total abundance and weight as described above.
The weight of mud or stones, still in the sample after washing is registered by choosing Benthos Waste in the Benthos Species form.
APPENDIX 2: ENTERING BENTHOS DATA IN THE MALOTUS DATABASE

When using the Cosmos trawl and Alfredo trawl, a person from the shrimp/fish group will create the station taken in the database.

When using the beamtrawl

Assuming that the station has been made start by opening the Catch form by pressing this button on the front page:

This will take you to this form:
**Supplementary appendix:** Evaluation of proposed common standards for benthos monitoring in the Arctic-Atlantic – pilot study in Greenland (INAMon)

Start by selecting the relevant StationSubGear (marked in red)

Choose Benthos under species and then choose Species subdiv.:
**Supplementary appendix:** Evaluation of proposed common standards for benthos monitoring in the Arctic-Atlantic – pilot study in Greenland (INAMon)

BenthoFullSample: Use when ALL of the catch is processed or for those species sorted from the entire sample (e.g. rare, big and vulnerable species such as Asteroidea, Echinoidea, Holothuridea, Cnidaria, Brachyura) in a sieve sorting frame on deck. Mark these specimens as “full sample species” (i.e. 1 specimen counts for 1 in the full sample). Take care not to mix them with the rest of the sample.

BenthoRestSamp1: Ensure homogeneity in the rest sample, and subsample “blindly” using a sample splitter (Fig. 1) 10 to 25% of the rest sample weight (dependent on size and homogeneity). This is referred to as **subsample #1** (BenthoRestSamp1 in database).

BenthoRestSamp2: If some species only appear one or two times in subsample #1, you need to sort for those species in a **second subsample** (BenthoRestSamp2 in the database), or in the entire rest sample to ensure an accurate count.

BenthoNonRandom: Benthos picked non-randomly

**Full Sample Species:**
Choose Benthos in Species.
Choose BenthoFullSamp in Species subdiv.
Do not enter any weights.

**Subsample#1:**
Choose Benthos in Species.
Choose BenthoRestSamp1 in Species subdiv.
Enter weight of the rest of the sample and weight of subsample#1 in the database.
Subsample#2:
Choose Benthos in Species.
Choose BenthoRestSamp2 in Species subdiv.
Enter weight of the rest of the sample (same weight as before) and the summed weight of subsample#1 and subsample#2.

Do not register the same species in both subsample #1 and subsample #2, but only under subsample#2 (BenthosRestSamp2 in the database).
The only exception, to entering benthos under species, is, if the catch of benthos for some reason is not processed and recorded on the station. Then this has to be indicated in the database in order to distinguish from a zero catch of benthos:
Choose Benthos not recorded on station and the empty line. No weights are entered.

To enter the benthos catch at a species level, choose Benthos Species:

In this form you can enter the counts and weights for the different species for the different fractions of the sample:
Choose station AND which fraction of the sample you are entering under StationData.

Choose your name code in the field to the right.

Then enter each species along with its count and weight.

Press label if you need a label for the species (they are liquid proof).

You can enter the species name (or genus or family etc.) in this form, but if you need to find a species name for a certain group press the button Choose species and you will get to this form:
This list is restricted to Benthos corresponding to the chosen group.