THE BOTTOM FAUNA FROM LOFOTEN TO FINNMARK

Fauna collected using beamtrawl, sled and grab

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Shrimps are delicious food both for fish and humans and it is a good strategy to hide amongst algae debris in a depression to avoid predators on the otherwise level soft bottom.

The fauna collected by MAREANO represents a wealth of different life-forms, from sea cucumbers retrieved from 3000 meters depth to small crustaceans hidden in the sediments of fishing banks. They are all adapted for the environment in which they are living.

Their morphology and behavior are fine-tuned to the specific environment they are living in, and their state of health indicates environmental changes they may have been exposed to. The MAREANO mapping approach is designed to provide a comprehensive baseline documentation of this wealth of life on the sea floor.

6.1 THE FAUNA COMMUNITIES

Rich bottom fauna

Studying a handful of sediments using a magnifying glass, you probably will see tens of different macrofaunal species (> 1 mm) that inhabit what appears to be a grey and lifeless bottom. Among these small species, living buried in the sediment, an experienced eye may recognize predators equipped with sharp teeth, scavengers, filter feeders collecting food particles from the bottom water, sediment feeders, and algal feeders called herbivores. One thing they all have in common is that they cannot flee from environmental change like more mobile fauna such as fish or swimming crustaceans. Apart from the short pelagic life most of them experience as larvae, they are adapted to live buried in the sediments or anchored to a hard substrate.

Bottom fauna communities consist of many different species representing a variety of environmental preferences and feeding traits that are well-suited for environmental monitoring. A change in the environment may reduce the number of individuals, or locally wipe out species that are particularly sensitive to a specific environmental change e.g.chemical pollutants, changes in organic availability or physical disturbance, while other species are more resilient. Such a change in faunal composition is easy to detect through the use of statistical tools after the collected species have been identified and counted. The samples collected through the MAREANO programme provide a baseline documentation of the bottom fauna composition that, due to the broad sampling approach (see Chapter 2), is well-suited for future environmental monitoring.

From 40 to 2 700 m depth

The present chapter focuses on fauna sampled from 142 stations by using beam trawl, sled and grab during the period 2006–2011 (see Basic facts). The surveyed areas in this period cover ca. 90 000 km^2 ranging from 40 to 2700 m depth from off the Lofoten archipelago in the south to the areas off Finnmark County in the north (figure 1). In addition to the physical sampling, MAREANO have conducted

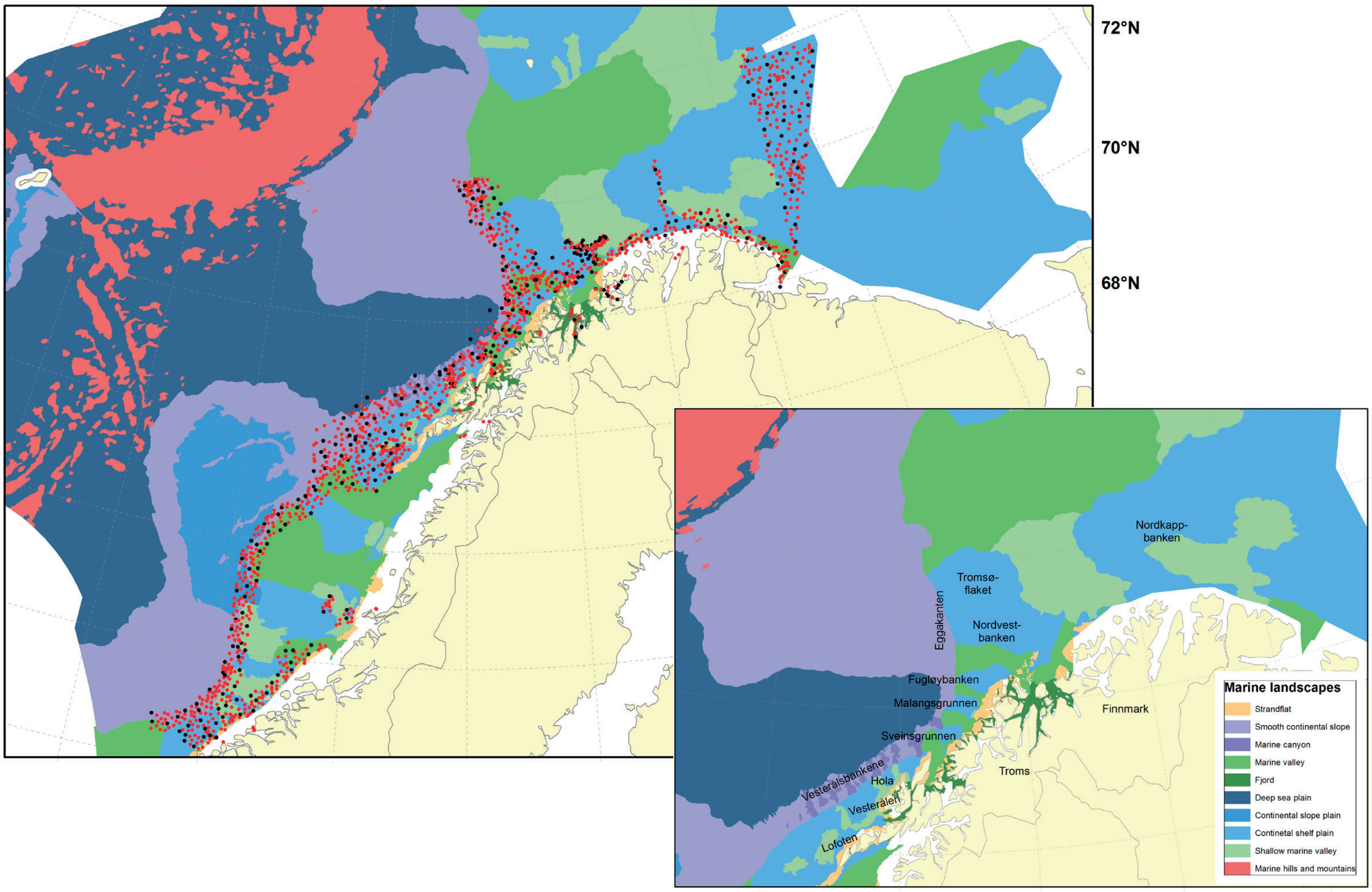


Figure1. Landscapes in the Norwegian Sea and the Barents Sea shown together with MAREANO-surveyed areas 2006–2015. The MAREANO data presented in this book was collected in the period 2006-2011 from areas between Lofoten in the south and the northwestern part of Finnmark in the north, including the Eggakanten (shelf edge) areas. The landscapes are defined by the Geological Survey of Norway (NGU) (for more information, see Chapter 3.1.1.).
Red points: Stations only documented with video. *Black points*: Stations that include video records and samples taken by using sled, beam trawl and grab.

visual mapping using video (see Chapter 2 for description), providing data of long lived megafauna that forms the background for biotope identification. This visual mapping allows identification of areas with high densities of vulnerable species, provide data for modelling of nature types and biotopes, and also other important information about benthic habitats.

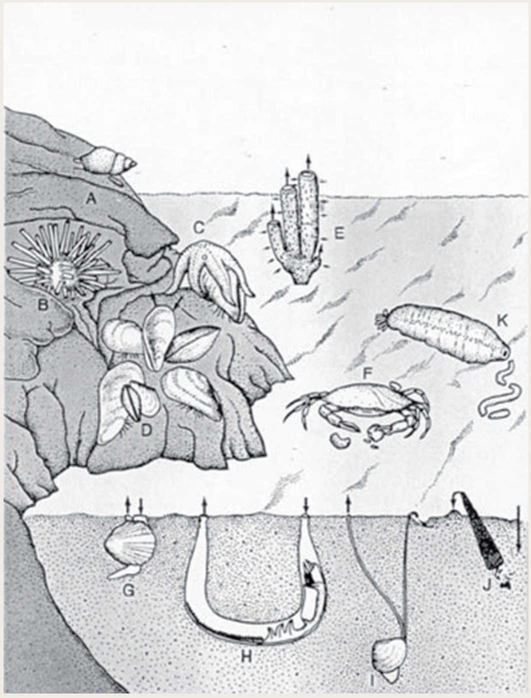
New species

About twenty new species have been discovered, of which several have been described both by MAREANO and scientific institutes domestically and abroad. The interest for the MAREANO material is increasing and analyses of species-dependent DNA sequences are undertaken by the Norwegian Biodiversity Information Centre (Artsdatabanken) in cooperation with the University Museum of Bergen, the Norwegian University of Science and Technology and the Norwegian Barcode of Life (NorBOL).

Future use of the material for species identification and morphological studies is secured by a continuous transfer of fauna to the University Museum of Bergen once species identification is finished.

A project supported by Norwegian Biodiversity Information Centre, focusing on cryptic bristle worm species, has identified new species by inspecting live material collected by MAREANO. Some beautiful photos from this project are shown in figure 2 and 3. A new amphipod species has been described from deep water samples (figure 4).

Feeding traits



A common feature for all bottom-dwelling and also bottom-dependent invertebrates, are their tight local affiliation, their various habitat-related adaptations regarding bottom currents and transport-mechanisms that are important for exploiting available food resources. After larval settling to the bottom substrate, the organisms are deemed to stay at the same spot throughout their lifetime. They cannot flee from any environmental change.

The communities are often complex, with a high number of species comprising of different feeding techniques and ecological roles. Some eat sediments and take out small organic particles that sink from the overlaying waters to the bottom. Others are filter feeders catching organic particles from the bottom water masses, thus contributing to the energy transfer to the seafloor communities through fecal deposition. Also the carnivores and scavengers are well-represented in the seafloor invertebrate communities.

Figure 2. *Eunice pennata*, one of the 566 bristle worm species sampled and identified by MAREANO. Eunice is a predator that crawls on top of the bottom sediments hunting for prey organisms. It may reach a length of 15 cm and live within a thin tube covered with small shell and stone particles. Photo courtesy Arne Nygren (Sjöfartsmuseet Akvariet i Göteborg) and "The Cryptic Fauna Project".

Figure 3. Another bristle worm, the predator *Dysponetus caecus* sampled by MAREANO from clay sediments at 300 m depth. This individual is about 2 mm long.
Photo courtesy Arne Nygren (Sjöfartsmuseet Akvariet i Göteborg) and "The Cryptic Fauna Project".

Figure 4. The 1cm long amphipod *Halirages helgae* is one of several new species that have been described based on material collected by MAREANO. Fifty individuals of this species were found at the continental slope off Troms County between 1000 and 2600 m depth (Ringvold & Tandberg, 2014). Photo courtesy Halldis Ringvold, Sea Snack Norway.

Climatic-induced faunal change?

Comparison of species distribution documented by MAREANO data with earlier records indicate that ca. 7 % of the species has a more northerly distribution while 0.1 % occur further south of what has been previously recorded. It can be argued that the increased temperatures resulting from global climate change can explain this distribution pattern towards higher latitudes. However, increased sampling effort in the mapped areas is likely a part of the explanation. Any future monitoring of MAREANO's baseline data may highlight whether such a possible change in species distribution may affect benthic production in particular areas.

Species richness

In total 1.6 million animals have been sorted out from the collected samples and identified by experts to the various taxonomic levels. 2300 taxa were identified and registered by MAREANO from the stations sampled in the period 2006–2011. Of these, 1450 were identified to species level.

The high number of taxa reflects the great variation in depth and sea floor terrain off the coast of Northern Norway – ranging from shallow and highly productive regions of the Barents Sea to the deep sea plains of the Norwegian Sea just below the continental slope. In contrast to homogeneous terrain, heterogeneous areas have a wide range of abiotic environments that meet species-dependent preferences relative to e.g. shelter, food, bottom type, temperature regime and current speed.

The fauna and sampling gears

The different gear types used by MAREANO collect clearly distinct parts of the bottom fauna (see Basic facts). The uniqueness of the fauna regarding common taxa/species between the three sampling gears is 70–89 %. 11 % common species were registered between grab and sled, 20 % between sled and beam trawl, and 30 % common taxa between grab and beam trawl. The highest number of taxa (1433) have been sampled by the grab while the lowest number of taxa (758) have come from the epibenthic sled, due to the fact that only the hyperfauna (crustaceans) is being reported from this gear (figure 5). Other fauna collected by the epibenthic sled is available to experts at the University Museum of Bergen. Comparing taxa obtained using the different gears show that 735 taxa (33 %) occurred in more than one gear, of these 145 taxa (6 %) occurred in all the three gears used. 1465 taxa was registered in one gear solely, giving a gear uniqueness of 67 %. These results indicate that all the three gears used by MAREANO sample in a manner that is complementary to each other and in the particular part of the seafloor community they are designed to catch.

The highest number of individuals was sampled by the beam trawl (80 % bristle worms) and the sled, probably due to their relatively high sampling area (300–500 m^2 per station). Although the grab samples cover a small area at each station (0.5 m^2) and catch a relatively small number of individuals (58 % bristle worms), it is well established and documented that grabs are a good quantitative sampling tool for documenting environmental status on muddy bottoms. The grab provides a good representation of sediment-living communities that often comprise relatively small animals living 10–20 cm down into the sediment, which are not sampled by the other gears. In general, the highest number of species/taxa occur for the arthropods (crustaceans mainly), demonstrating that the sled – largely collecting hyperfuna/crustaceans – is an important complementary sampling gear in the MAREANO seafloor mapping program.

Depth related faunal change

Benthic communities change with increasing depth. Species that sustain low temperatures and the decreasing amount of food particles with increasing depth take over where other species disappear. A general change in species composition is observed around 500 – 800

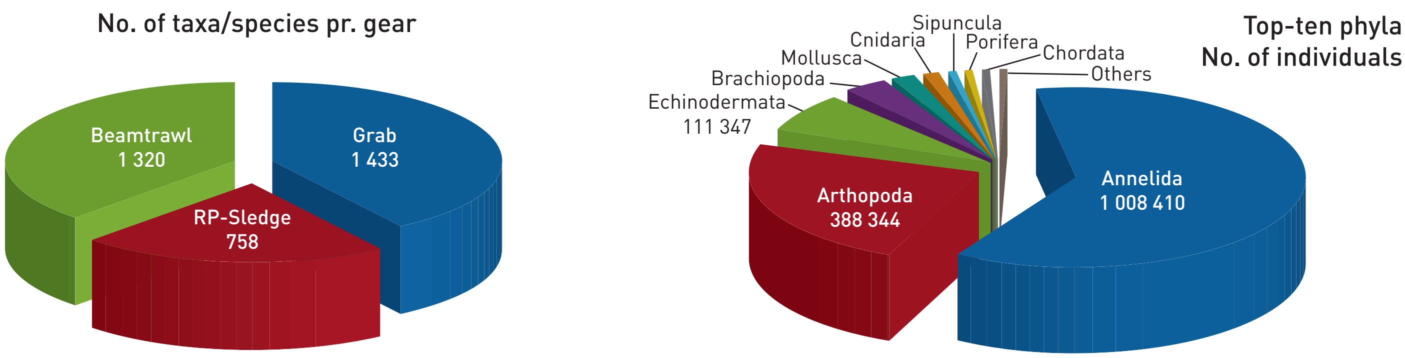


Figure 5. *Left*: Number of taxa/species collected for each of the three sampling gears used. *Right*: Total number of individuals sampled for each of the ten most abundant phyla.

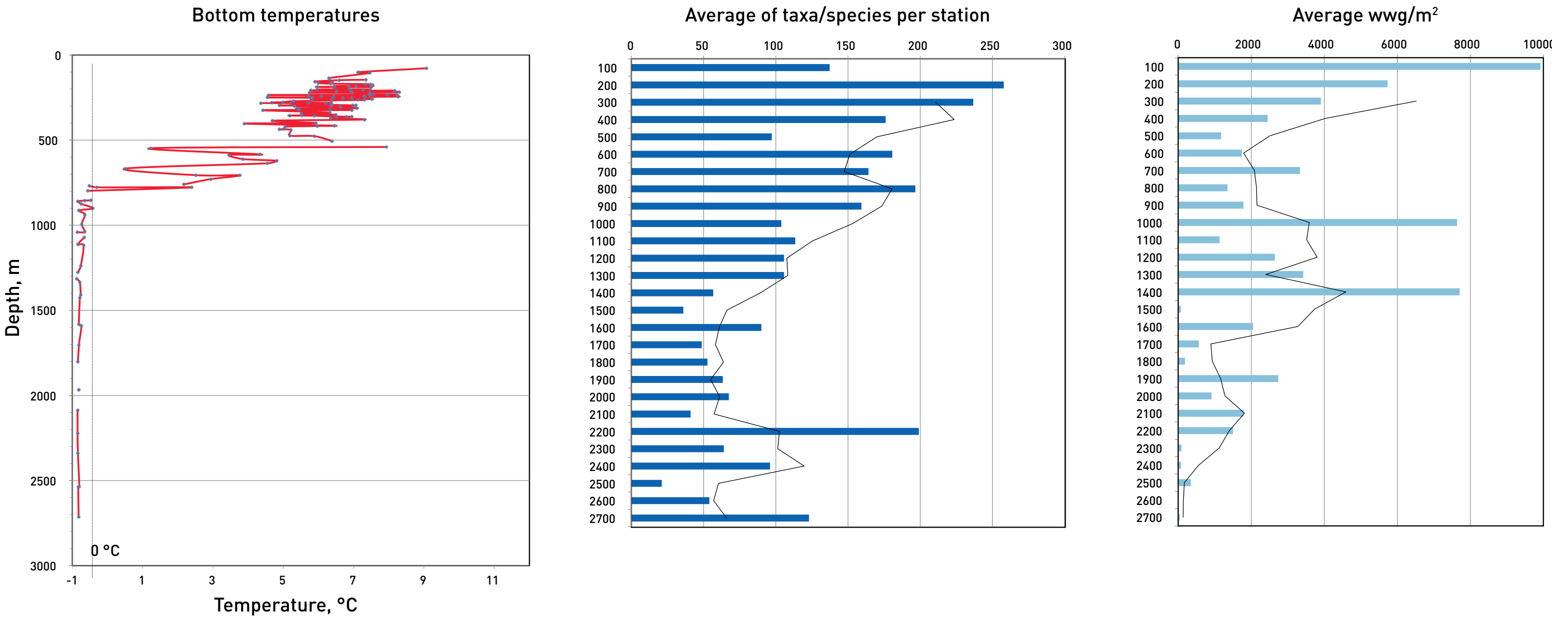


Figure 6. *The left figure* shows temperature readings made by MAREANO. Note the temperature transition zone in the depth interval 500–800 m. *The centered figure* shows average number of taxa/species with depth while *the right figure* shows the average biomass with depth. Note the increase in species richness, and also an indication of a slightly elevated biomass within the temperature transition zone.

meters depth along the continental slope, where a subzero temperature regime occurs (figure 6). This temperature transition zone represents the boundary layer between the cold Norwegian Sea Deep Water (< -0.5 °C) of Arctic origin and the North Atlantic Water (> 0.5 °C). In the MAREANO data it was noted that the trend of decreasing species richness with depth was broken within the transition zone. It may be speculated that representatives from both water masses occur in this particular zone, leading to somewhat increased species richness. There is also an indication of a slight increase in biomass within the zone.

A closer look at the MAREANO fauna lists reveal that the fauna sampled at the deepest areas (> 2000 m) is numerically dominated by species that are searching for food particles at the top of the bottom sediments. Among the bristle worms at these depths, that generally represent a wide range of feeding forms at shallower depths, only 2 % of the total number of specimens feed by filtering out particles from the bottom water. An interesting group of worms found in the deepest areas, the beard worms, have quite another way of feeding, namely by absorbing nutrients from bacteria. This feeding method probably reduces their competition for food at great depths where organic material is restricted.

Complementary sampling gears

Four different sampling gears are used to collect bottom fauna (see also Chapter 2): video, grab, sled and beam trawl, all with complementary sampling properties.

The video-rig is MAREANO's main gear for mapping of larger fauna living on top of the sediment (large epifauna) and their environment. Each video covers around 1500 m². The video-results deliver basic results for further production of biotope maps.

The Van Veen grab is designed to sample organisms living buried 10-20 cm down in the sediment (infauna). Often 40–60 % of the catch are bristle worms that represent a major part of the sediment's species richness. The grab normally covers 0.5 m² of the sea floor at each sampling position ("station").

The epibenthic sled is collecting mobile animals, mainly crustaceans, living at the sediment surface or swimming close to the bottom (hyperfauna). One sample covers ca. 300 m².

The beam trawl is specialized to collect epifauna organisms living on top of the bottom sediment and infauna down to a few centimetres in the sediment. A great part of the sampled fauna comprise snails, clams and brittle stars and one haul covers ca. 500 m².

6.2 THE BIOLOGY OF MARINE LANDSCAPES

The concept of marine landscapes, or 'seascapes' was first developed for Canadian waters. The classification was based on environmental factors such as water temperature, depth, light penetration, bottom substrate type, exposure to slopes, etc. In MAREANO the term "marine landscapes" is used to describe the main, broad-scale geomorphic features of the seabed. These are often influential on the benthic communities but are by no means the only factor affecting the distribution of different animals.

Besides the landscape, the strength of the bottom currents is decisive for the faunal composition of bottom communities. The direction and strength is a result of local topography, tidal amplitude and rotation of the earth (the Coriolis force). The bottom currents are essential for the seabed biotopes due to the transport of particles that affect the composition of the bottom substrate, and also by transporting food particles to the organisms that inhabit the sea floor.

Typically, we find mixed and gravelly sediments with well anchored filter feeders in areas with strong bottom currents. In contrast, muddy sediments dominate where currents are weak, resulting in an increased abundance of organisms feeding on organic particles that have settled on the seabed.

Highly-productive shelf landscapes

The Barents Sea is a highly productive shelf area that provides the seabed and the fauna living there with a high amount of organic material originating from the annual spring primary production. It harbours the world's largest cod stock with a diet that also includes bottom fauna, and fishing activities are high in the area. The shallow areas (200–300 meters) have, in general, stronger bottom currents than the deeper troughs (300–500 meter). The bottom environment changes not only between geographical regions, but also within local terrain and landscape variations. The famous fishing banks Nordvestbanken, Fugløybanken, Tromsøflaket, and Nordkapp-banken represent large and relatively homogenous shelf areas with high densities of bottom fauna (see map in figure 1). Further south, off Troms and Lofoten–Vesterålen, we find rich fisheries at the banks of Malangsgrunnen, Sveinsgrunnen, and Vesterålsbankene.

The continental slope

West of the Barents Sea we find the Norwegian Sea where the continental slope extends down to around 3000 meter depth. Both the topography and the physical environment across the slope change significantly over short distances, and the environment deviates substantially from the shelf areas of the Barents Sea.

Deep sea landslides

Several deep sea landslides have been recorded on the continental slope, and northwest of Lofoten a 4000 years old slide has created terraces with compact sediments and steep walls. This varied landscape hosts a corresponding variation in the composition of the bottom fauna. To the north, half way between Troms County and Bjørnøya, in the Eggakanten area the 2000 km^2 broad Bjørnøya slide dramatically changed the bottom topography around 200000 years ago, and the scarred landscape still affects the local bottom fauna (see Chapter 3).

The troughs

A typical feature of the marine landscape as one moves southwest from Troms to the areas off Lofoten, is the line of shallow banks divided by deeper troughs. Taking a closer look at the topography, these troughs are often connected to large fjords systems. It is easy to imagine how the ice was moving during last ice age from the Norwegian mainland towards the shelf, forming both the seafloor and mainland landscapes (see chapters 3.1; 4.1; 7.1).

The seafloor on the banks, with their strong currents, consists mainly of boulders, gravel and sand sitting on top of till including compact clay. By contrast, the terrain in low energetic areas of troughs and basins on the shelf largely comprise fine sediments. In the higher energy troughs, sandy and mixed

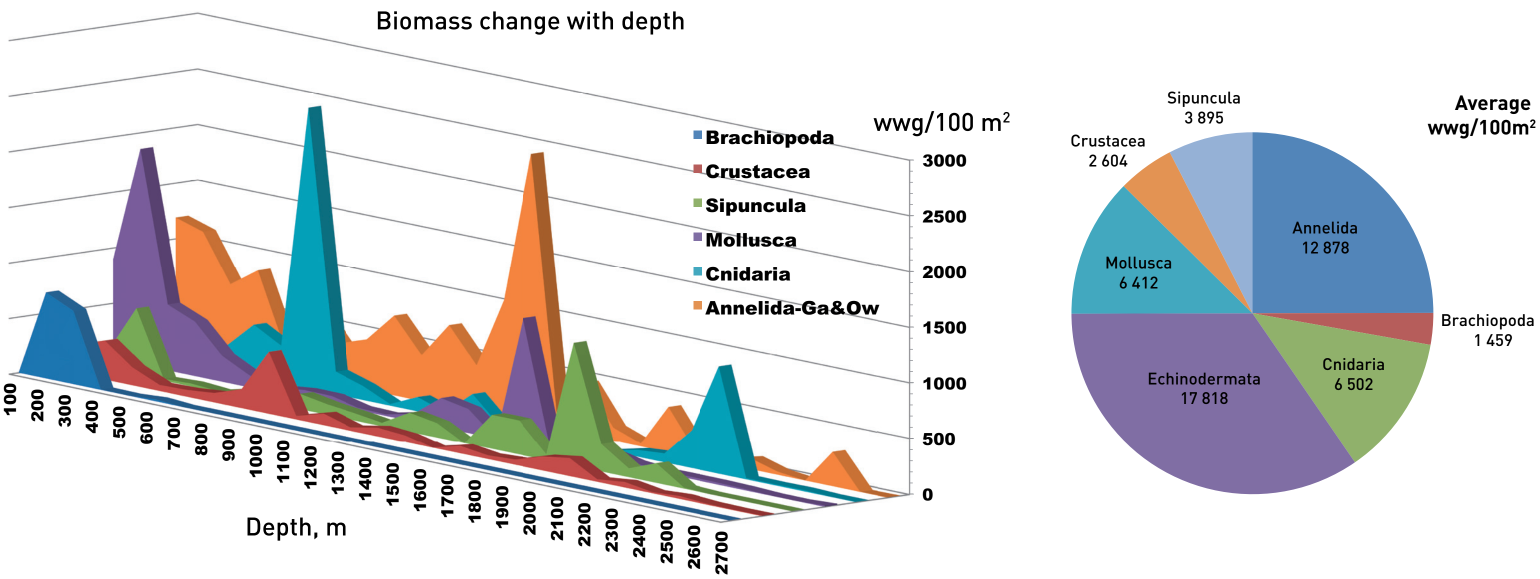


Figure 7. *The left figure* shows wet-weight biomass (g/100 m^2) with increasing depth for the most biomass-dominating phyla. Sponges (Porifera) are excluded due to their high biomass dominance at some stations (up to above 90 % of total biomass). The owenid bristle worm *Galathowenia fragilis* (Annelida) was excluded from both graphs shown due to its high occurrence at two stations at Tromsøflaket (38 % of total no. individuals for all stations). *The right figure* shows total biomass wet-weight for the most abundant phyla.

bottom types may occur, just as found in the Hola area off Vesterålen, where more than 300 coral reefs have been recorded (see Chapter 4).

6.3 BIOMASS

Studying the total biomass in the surveyed areas, the annelid (mainly bristle worms) and echinoderm biomass was by far the most dominant, with 17800 and 12800 g wet-weight pr. 100 m^2 bottom area, respectively (figure 7). Next most dominant were the molluscs and cnidarians with ca. 6500 kg for both groups.

The average total biomass per sampling station was calculated to 2800 g/m^2. The sponges, however, are contributing to very high biomass at some locations and regions. Excluding these, the calculated average biomass is reduced to 700 g/m^2. Figure 7 show the relative contribution to the total biomass from the most common faunal groups, exclusive of the sponges.

Deeper than the temperature transition zone, only the worm-like sipunculans show higher abundance than above the zone. This group of small organisms, often smaller than one centimetre, is known to inhabit most environments in quite high numbers, including the deep sea.

The crustaceans, cnidarians and annelids show a biomass peak within, or close to, the temperature transition zone. The annelids, mainly consisting of bristle worms, deviates from the two to other groups by being relatively well-represented also at shallower depths.

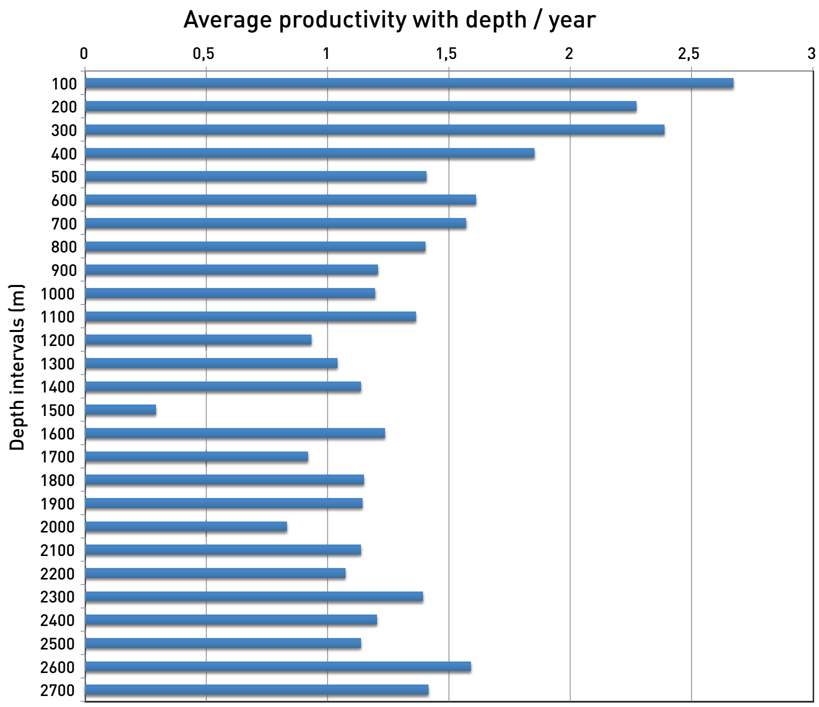


Figure 8A. Average productivity with depth. Productivity represents the annual energy growth proportion in the respective seafloor animal communities, giving a better ecological growth unit than biomass. Calculations of energy is, however, based on biomass measurements, and also known data about energy content for the species that form the total community.

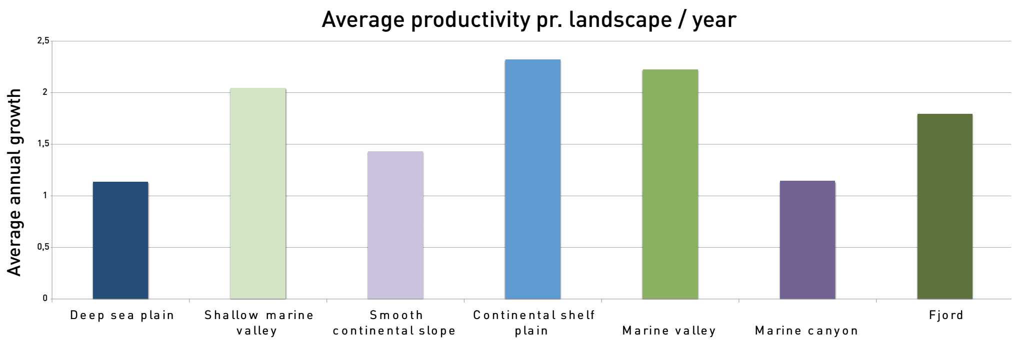


Figure 8B. Average productivity within the respective landscapes. See the distribution of landscapes in figure 1.

6.4 PRODUCTION

How much food, or energy, is being produced by the seafloor invertebrate communities? How much of this energy is transferred to higher predators as e.g. cod and crabs, and how much is returned from the seafloor to the plankton spring bloom in the surface waters?

Even though these questions are essential in order to adequately understand the energy flow within marine environments, much energy-related research remains. We are, however, working on the first pieces of the puzzle. Together with the Alfred Wegener Institute in Germany, MAREANO is examining the energy produced by seafloor faunal communities.

Based on the data collected by MAREANO, the average production over the surveyed area (Lofoten–Finnmark) is calculated, or modelled, to just below 1kJ pr. m^2 pr. year for the shallow shelf areas. There is a general decrease with increasing depth to values slightly above zero at the deep sea plains (2200–2700 meters depth). Supposing that the fauna largely consist of protein, 1 kJ may be associated with 1 gram of living fauna. In addition to variations with depth, the productivity varies from one shelf area to another. Thus, the highest production within the bottom sediments at the rich fishing bank Tromsøflaket, off Troms County, was calculated to be 53 kJ pr. m^2 pr. year while the lowest value in that area was 3.6 kJ pr. m^2 pr. year.

Looking at the amount of produced energy for an animal and comparing the calculated value to the animal's weight/size (biomass), the term "productivity" is introduced, slightly changing the pattern (figures 8A and 8B). This is because different species have different caloric values, and the productivity value reflects the annual growth of the animal. For example, bivalves are more fatty and protein-rich than sponges, and the relatively fast-growing bivalves will have a higher productivity than a slow-growing sponge. Many of the smaller animals we find in the deeper parts of the ocean are energy-rich, which explain the differences with the production pattern between shallow and deep-water stations. Thus, there is a general increase in the productivity pattern below 1200 m depth (figure 8A) while the production showed its lowest values in the deep sea plains.

With regard to landscapes, the seafloor communities at the shallow ”continental shelf plains” show the highest productivity followed by ”marine valleys” and ”shallow marine valleys” (figure 8b, see also landscape map in figure 1). The shelf plains are located at the shallowest depths in the surveyed area, and therefore have the shortest distance to the surface waters where the primary plankton production takes place, probably receiving a relatively high proportion of the annual organic sedimentation of dead plankton debris.

The shelf landscape ”shallow marine valley” does not occur much deeper than the water on the shelf plains, just as the ”marine valley”, which is being reflected in their quite high productivity. On the other hand, the canyons and the ”deep sea plains”, representing the deepest landscape types surveyed, show relative low productivity due to the reduced availability of sinking organic material from the surface water masses. As explained above, the productivity at the deep landscape types is relatively high compared to the total production due to the higher energy content (caloric value) in deep seafloor communities. It was noted that the productivity in the shelf areas are higher than the quite nutrient-rich fjords sampled by MAREANO in Troms and Finnmark counties in periods with bad offshore weather conditions.

We see a clear trend in both production and biomass if we examine the fauna collected with the different gears separately. This is as expected since the different gears sample different parts of the fauna. The beam-trawl samples the larger epifaunal groups such as sponges and sea stars, whereas the grab samples the smaller infauna such as various borrowing worms that often are known to be both prolific and fast-growing. Thus, we expect to see that both the infaunal production and productivity, caught by using grabs are higher than for the epibenthic sled-caught hyperfauna that mainly consist of tiny crustaceans.

6.5 THE BIOTOPES

A biotope is simply explained an area with uniform environmental conditions providing a living place for a specific assemblage of species. This term is almost synonymous with the term habitat, which is more commonly used. The subject of a habitat is a species or a

The sea spiders – scary creatures or graceful wonders of the seabed?

The scientific name of the sea spiders is Pycnogonida (phylum Arthropoda). The name and appearance make strong associations with ordinary spiders. The group contains more than thousand species worldwide, with MAREANO having cataloged 25 of these.

The size varies greatly, from a leg span of ca. 10 cm to the near microscopic species with body length a few mm. The sea spiders are all slow-moving predators, thus feeding on stationary animals like sea anemones by using their long proboscis to suck out the content from their prey.

All sea-spiders have eight segmented walking legs attached to a rather narrow body, and a long proboscis with jaws in front. On the dorsal side of the head is an eye tubercle. In addition, there are three pairs of specialized appendages attached to the head segment: The chelifores with chela comprise one fixed and one movable finger, the palps with sensory functions, and the ovigers used by the males to carry the egg clusters. Chelifores, palps or ovigers may be absent in some groups of species. The length of the walking-leg segments, coupled with the segments of the other appendages, are important identification characteristics.

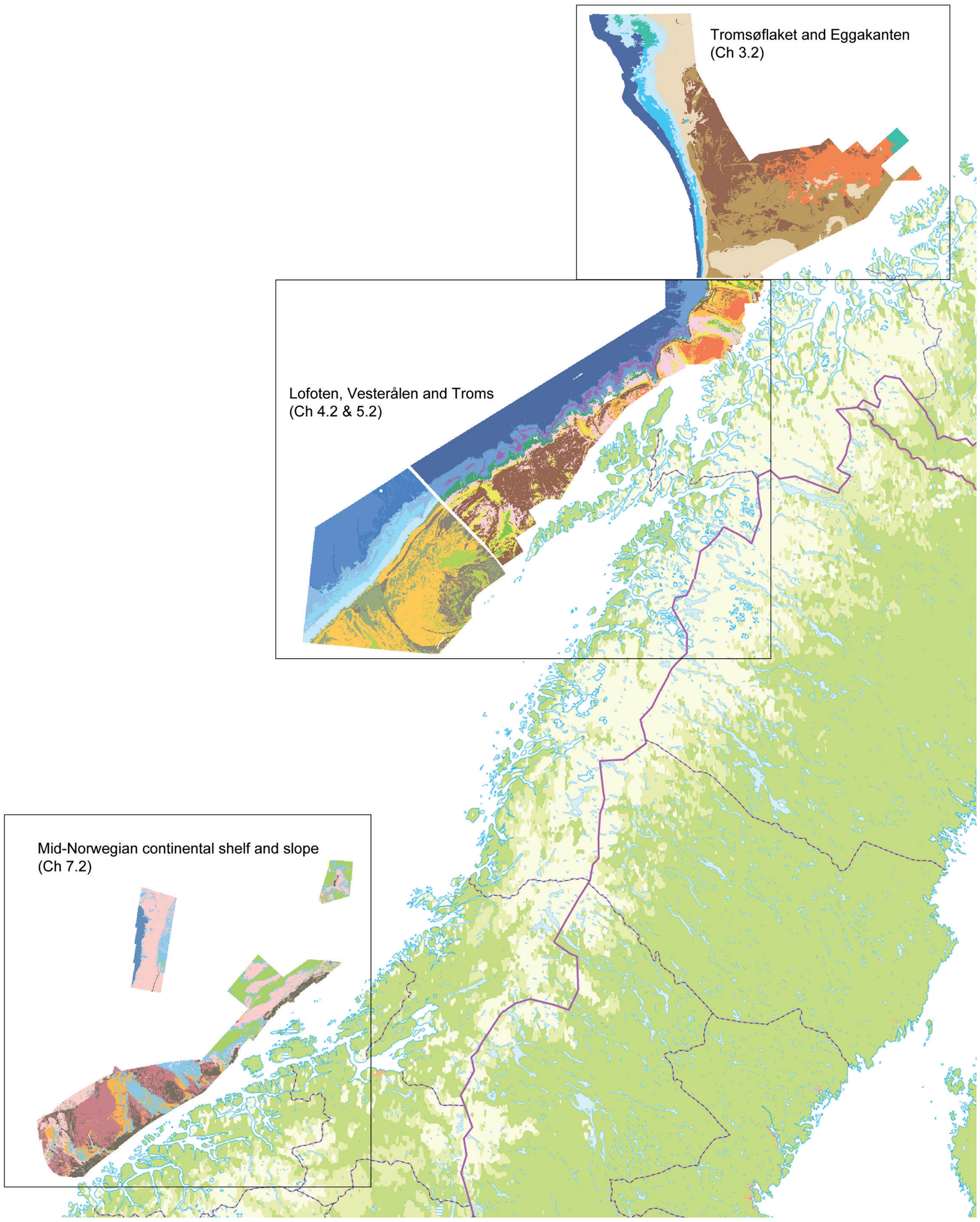


Figure 9. Broad-scale map of the modelled biotopes based on results from MAREANO's video surveys in the three areas from the mid-Norwegian continental shelf and slope in the south, to Tromsøflaket and Eggakanten in the north. The chapter in the book where the biotopes of the different regions are described are indicated for each region.

population, whereas the subject of a biotope is a biological community.

MAREANO identifies biotopes by statistical analyses of the quantitative composition of megafauna as identified from MAREANO's video records. The locations with similar species assemblages are defined and the environmental conditions associated with the assemblages determined. The environmental factors that best explain the different community groupings are used as predictors for habitat distribution modelling of the individual biotopes.

In MAREANO, biotopes have been described and data-modelled separately for combinations of different areas. A map of the four regions that have been modelled separately is shown in figure 9. The table gives a general overview of the characteristics of these biotopes, and reference to which chapter they are more thoroughly described. The modelling of biotopes using identified species assemblages in combination with environmental characteristics does not automatically identify identical biotopes between separately modelled areas. The issue of harmonization of biotope maps over larger regions of the Norwegian shelf and slope is an issue of high priority in MAREANO. The biotopes from the three different regions presented in this book are numbered differently to minimize the risk of confusion: roman numbers (Tromsøflaket/Eggakanten), numbers (shelf of Lofoten, Vesterålen and Troms), letters (deep-sea of Lofoten, Vesterålen and Troms), and "Biotope" + number for mid-Norway.

Some of the biotopes are characteristic and are recognised in separate models for the different areas. Some of those are hard bottom dominated by foliose sponges (Axinelldae) (biotopes B1 and IV), and marine valleys with sandy, muddy sediments, and seapens (biotopes 6 and B4). Of all 26 biotopes, 12 could probably be joined by a twin-biotope from another region, representing only six biotopes, leaving 20 different biotopes. However, this is work in progress and further analyses are needed to harmonize the description and distribution of various biotopes in the MAREANO mapping areas.

Biotopes and Landscapes

Some of the biotopes (1, 2 and III) identified by MAREANO are confined to only one specific marine landscapes, whereas most others occur in several. There is a clear indication of faunal groups and habitats relating to the different marine landscapes. In particular, the banks with coarse substrate are well defined, as are canyons whilst the intermediate depths of the upper slope constituting a species rich landscape, are less well defined. This is to be expected because the different landscape components (e.g. banks, troughs, canyons) contain several biotopes that are not unique. Thus, the pattern on this broader scale is blurred in relation to landscape types, and the biotope distribution responds to factors other than terrain. This blurring is particularly prominent at depths were different the water masses meet and form strong environmental gradients, where animals representative of both shallower and deeper biotopes may occur.

Biotopes and diversity

Many factors contribute to the environmental heterogeneity, an indicator of available ecological niches for benthic species. The megafaunal species diversity for instance, is related to spatial complexity (3D complexity). This is evident for the rugged near-shore areas and the shelf break (see Chapter 4.2, figure

22). By contrast, the deep water below 1000 m depth has a relatively low number of taxa together with the shallowest shelf area in table 1.

The environmental heterogeneity, or geographical complexity, may operate at different spatial scales. MAREANO's results suggest that a few easily visible key species related to specific communities and bottom types may be used as indicators of biotopes and their associated biodiversity.

Knowing the scale of spatial heterogeneity of the environment is a key factor for understanding the distribution of communities. The challenge is to apply the relevant scale of sampling to represent the natural variability to a degree that is not too detailed or to broad compared to the goals (management needs and research questions). The scale applied by MAREANO for biotope mapping (200 m gridding of the results from video analyses) surely contain a mosaic of smaller communities. However, together such "subbiotopes" or "community states" represent "stable signatures" reflecting the consistent environmental characteristics.

6.6 BOTTOM FAUNA MAPPING REQUIRES A BROAD APPROACH

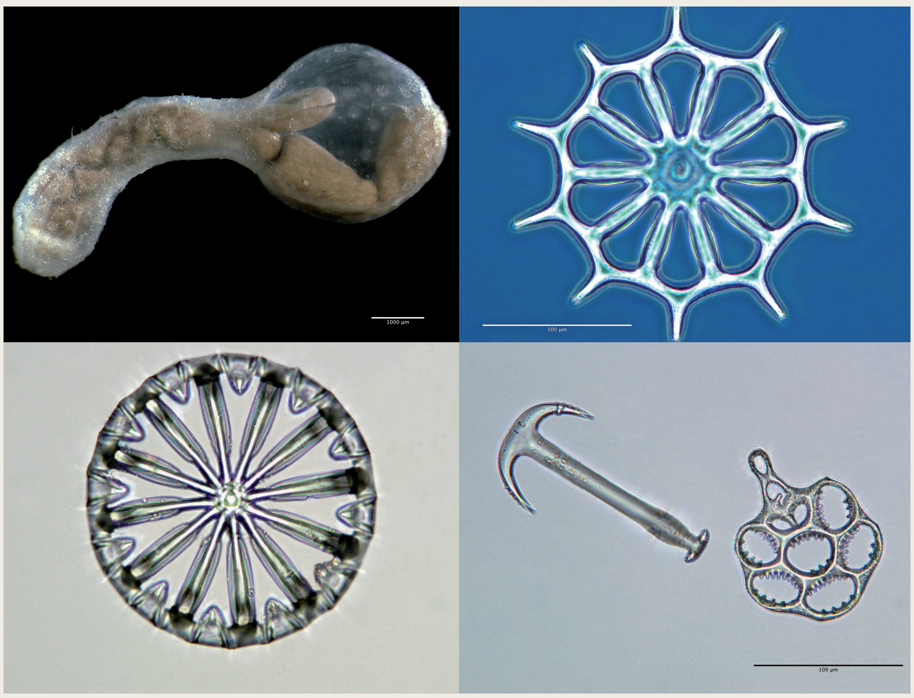
One main goal of the MAREANO baseline mapping programme is to provide data that can serve as a reference towards any future change in the bottom faunal composite caused by e.g. human-induced activities (e.g. climate change, fisheries, petroleum industry).

Conservation programmes often use biodiversity as a major criterion for identifying prioritised geographical regions. This has, in recent years, brought forward a reinforced focus on marine biodiversity and the conservation of this biodiversity has received substantial attention.

Different sampling gears are designed to document different parts of the bottom community e.g. grabs are used for infauna sampling while epi-benthic sleds sample motile bottom-associated crustacean. Experience from fieldwork has shown that different habitats cannot be equally sampled. Primarily because the composition of the seabed does not allow all gears to be used without damaging the sampling gears used, or in areas such as cold-water coral reefs, damaging the benthic communities themselves, resulting in reduced biological material sampled in some bottom types. Thus, it is not possible to provide biological diversity information for all major faunal components and habitats with one single sampling gear functioning adequately in all types of substrate or terrain.

The MAREANO mapping programme applies a wide set of sampling techniques (See Basic facts and Chapter 2) to provide the most comprehensive possible documentation of the bottom faunal diversity in different environments on the continental shelf and slope of the Norwegian Sea and the Barents Sea. This comprehensive sampling approach produces data that provides a unique opportunity to investigate the relation between species richness of infauna, epifauna and hyperbenthos (crustaceans living on top or swimming just above the bottom sediments). Factors to be studied may include diversity versus certain sediment constituents, productivity versus diversity, and how the composition of functional traits may vary relative to changes in diversity.

The sea-cucumber



The sea-cucumbers (Class Holothuroidea), with their pentagonal symmetry, belong to the echinoderms. While other echinoderms, the starfishes, brittle stars and the sea urchins, all have a rigid skeleton, the sea cucumbers only have a thin and rather flexible body wall. Microscopic studies of the skin and tube feet have shown that they contain number of small ossicles, tiny ornament-like calcareous sculptures helping to support and protect the body. The size of the ossicles is typically around 0.1-0.2 mm.

There are many kinds of ossicles: rods, tables, buttons etc. One of the most astonishing type of ossicles belong to the tiny *Acanthotrochus mirabilis*. Its ossicles have a striking resemblance to a ship's steering wheel, making the species identification an easy task. Another characteristic wheel-type ossicle belongs to the genus *Myriotrochus*, where the diameter and spoke number are species-defining features. Another species, *Labidoplax buski*, has a combination of a racket and an anchor.

From upper left to lower right: The sea cucumber *Acanthotrochus mirabilis*; "steering wheel" of *Acanthotrochus mirabilis*; "wheel" of *Myriotrochus* sp.; the anchor and racket (normally attached to each other) from *Labidoplax buski*.

Table 1. Biotopes and their characteristics in the areas from mid-Norway in the south to Tromsøflaket and Eggakanten in the north. The biotopes are sorted by depth, general temperature regime and general similarity between them.

Biotope number	Describe in chapter	Geographic area	Main depth range (m)	Temperature range	Biotope short description	Landscape description	Sediments	Landscape description
1	4,2	Lofoten, Vesterålen & Troms	70-80	Warm (> 4.5°C)	Shallow banks with coarse sediment, gorgonians and *Lithothamnion*	Shallow bank	Gravel	Gorgonacea, *Filograna*, Tunicata white, *Lithothamnion*, Serpulidae
III	3,2	Tromsøflaket/Eggakanten	200-350		Mixed, sandy bottom with cushion star and red sea cucumber	Shelf plain	Sand and Sandy gravel	*Ceramaster granularis, Parastichopus tremulus, Stylocordyla*
2	4,2	Lofoten, Vesterålen & Troms	150-300		Mixed sediments with *Pteraster* and cushion star	Shelf plain	Mixed sediments	*Ceramaster, Hippasteria, Stylocordyla*, Brachiopoda, *Trisopterus*, *Actinostola*, Aphroditidae
B 7	7,2	Mid-Norwegian continental shelf and slope	<350		Continental shelf plain with coarse sediments	Continental shelf plain	Sandy and coarser sediments	*Gadus morhua*, *Phakellia* sp., *Psolus squamatus*, Zoanthids
3	4,2	Lofoten, Vesterålen & Troms	150-250		Sandy sediment with *Funiculina* and *Ditrupa*	Shallow marine valley	Sand/ gravely sand	Seapens, *Asteronyx*, *Funiculina*, *Ditrupa*, *Flabellum*, *Pteraster*
6	4,2	Lofoten, Vesterålen & Troms	200-400		Marine valleys with sandy/ muddy sediments and sea pens	Marine valley	Muddy/sandy	Seapens, *Kophobelemnon*, *Stichopus*, Pandalidae, *Virgularia*, *Steletta*
B 4	7,2	Mid-Norwegian continental shelf and slope	200-450		Marine valleys with sandy/ muddy sediments and sea pens	Shallow wide marine valleys	Sandy mud	*Funiculina quadrangularis, Kophobelemnon stelliferum, Stylocordyla borealis, Thenea abyssorum, Asteronyx loveni*
B 6	7,2	Mid-Norwegian continental shelf and slope	90-200		Sand, muddy sand & gravel with Ditrupa	Continental shelf plain and marine valleys	Sand, muddy sand & gravel	*Ditrupa arietina, Luidia* sp., *Molva molva, Trisopterus* sp.
B 1	7,2	Mid-Norwegian continental shelf and slope	100-400		Hard bottom sponge communities	Rugged terrain	Coarse bottom: gravel, cobble and rock	*Phakellia* spp., *Axinella infundibuliformis* and *Antho dichotoma*
IV	3,2	Tromsøflaket/Eggakanten	150-500		Coarser, mixed bottom with foliaceous sponges	Marine valley, shelf and upper slope	Mixed gravelly sediments	*Polymastia* sp., *Poraniomorpha* spp., *Axinella infundibuliformis, Phakellia ventilabrum*
V	3,2	Tromsøflaket/Eggakanten	150-350	Warm (3 - 6 °C)	Mixed bottom with stronger currents	Shelf plain	Mixed sediments	*Hormathiidae, Gadus morhua, Stichastrella rosea, Echinus acutus*
4	4,2	Lofoten, Vesterålen & Troms	200-300		Deeper banks with mixed sediments and sponges	Deeper banks/shelf plain	Gravelly sand, cobbles	*Craniella zetlandica, Phakellia* spp., *Geodia* spp., *Stryphnus ponderosus, Mycale lingua*
B 2	7,2	Mid-Norwegian continental shelf and slope	120-600		Sandy, muddy sediments in marine valleys with Flabellum and tube anemones	Marine valleys	Sandy and muddy sediments	*Flabellum macandrewi, Pachycerianthus multiplicatus*
5	4,2	Lofoten, Vesterålen & Troms	200-500		Mixed sediments, varied topography with corals	Marine valleys, shelf break	Mixed sediments	Sponges and corals, *Phakellia* sp, *Mycale*, *Lophelia*, *Acesta*, *Axinella*, *Primnoa*, *Protanthea*
B 3	7,2	Mid-Norwegian continental shelf and slope	100-600		cold-water corals	Ridges and slopes on the shelf plain	Sandy gravelly sediments	*Lophelia pertusa, Primnoa resedaeformis, Paragorgia arborea, Cidaris cidaris*
II	3,2	Tromsøflaket/Eggakanten	100-400		Spicule sediments with large sponges	Shelf plain	Gravelly mud	Large sponges, *Aplysilla sulfurea, Geodia, Stryphnus, Munida* sp, *Phakellia, Geodia* sp, *Stelletta* sp
I	3,2	Tromsøflaket/Eggakanten	150-700		Fine sediment bottom with shrimp and soft foraminifera	Marine valley	Mud/sandy mud	*Caridea, Polymastia* sp, *Flabellum macandrewi, Radicipes*
VI	3,2	Tromsøflaket/Eggakanten	400-1000	Intermediate (0 - 5 °C)	Steep parts of upper slope with small anemones and broccoli corals	Upper slope and canyon	Mixed gravelly muddy sand	Broccoli corals, *Pennatulacea, Zoanthidae, Drifa glomerata, Gorgonocephalus eucnemis, Gersemia* sp.
A	5,2	Lofoten, Vesterålen & Troms	500-800		Upper Steep Continental Slope	Continental slope	coarse bottom	*Drifa glomerata, Gorgonocephalus eucnemis*
VII	3,2	Tromsøflaket/Eggakanten	500-700		Lower slope with canyons, basket stars and broccoli corals	Continental slope	Gravelly sandy sediments	Broccoli corals, *Chondrocladia gigantea, Gorgonocaphalus eucnemis*
VIII	3,2	Tromsøflaket/Eggakanten	700-1000	Cold (< -0.3°C)	Smooth, lower slope with tubeworms and amphipods	Continental slope	Mixed sandy, muddy sediments	Small crustaceans, Sabellidae, *Cleippides*
B	5,2	Lofoten, Vesterålen & Troms	700-1000		Mid Continental Slope with Canyons	Continental slope and canyon	Mixed sediments	*Chondrocladia*, *Lucernaria*, Pycnogonida, Umbellula, Ophiopleura
B 5	7,2	Mid-Norway	650-1500		Continental slope with basket stars and broccoli corals	Continental slope	Mixed soft and gravelly	*Gersemia rubiformis*, *Gorgonocephalus* sp., *Bythocaris* sp., *Cerianthus vogti*, and *Drifa glomerata*.
C	5,2	Lofoten, Vesterålen & Troms	1000-1500	Cold (< -0.3°C)	Mid-continental slope/ Faunal transition zone	Continental slope	Mud, and mixed sediments	Nemertini pink, Actiniaria small pink, Hexactinellida bush, *Lycodes* sp, *Bythocaris*
D	5,2	Lofoten, Vesterålen & Troms	1200-2000		Lower continental slope	Continental slope	Mixed sediments	*Rhizocrinus/Bathycrinus, Hymenaster, Caulophacus*
E	5,2	Lofoten, Vesterålen & Troms	2000-2700		Deep-sea plain with deep-sea holothurians	Deep-sea plain	Mud	*Elpidia glacialis, Kolga hyalina, Bathycrinus carpenteri, Bythocaris, Pourtalesia*