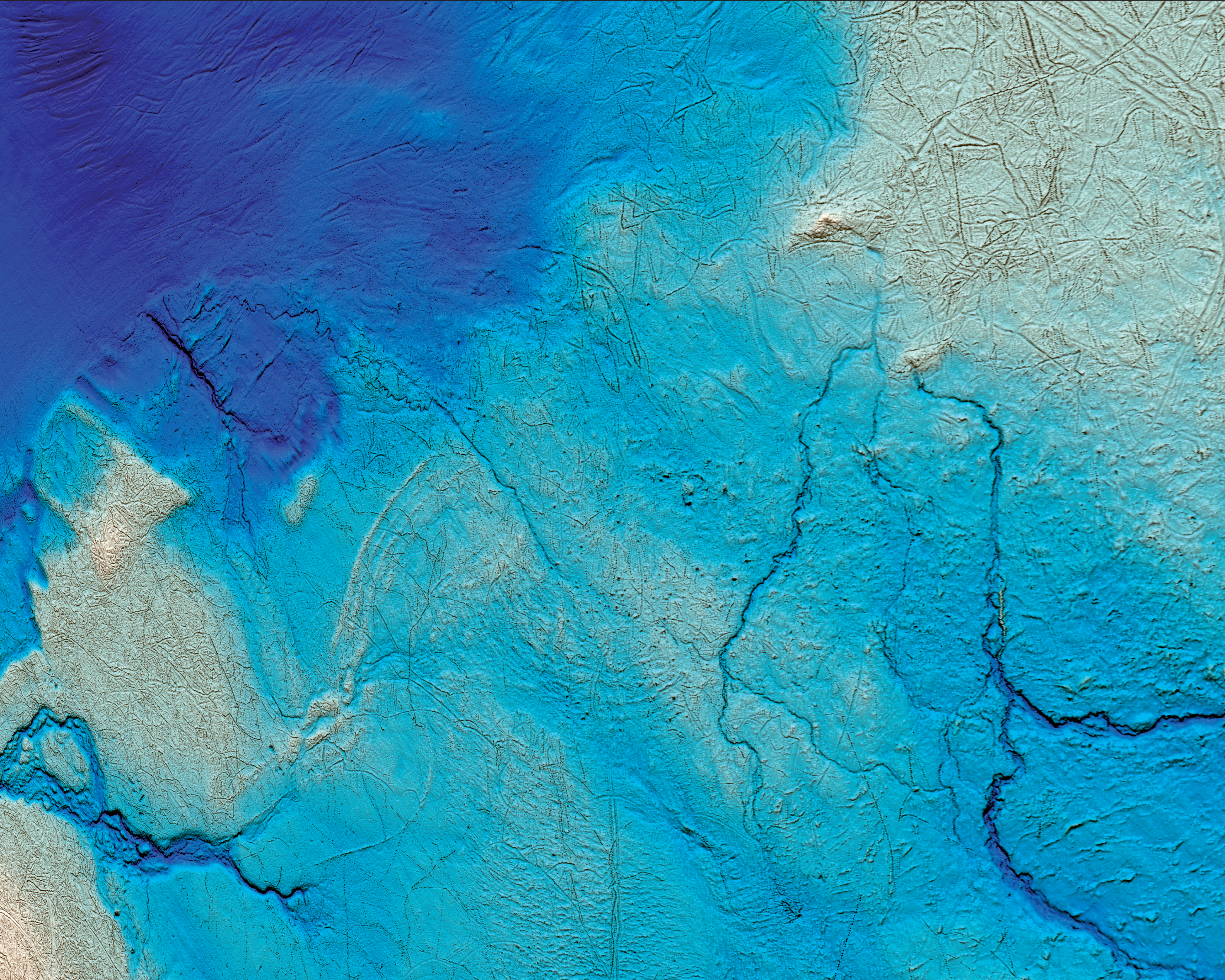


BARENTS SEA AND COAST OF FINNMARK

8.1. Lilja Rún Bjarnadóttir, Valérie Bellec, Dag Ottesen, Hanne Hodnesdal, Terje Thorsnes, Heidi Olsen, Reidulv Bøe
8.2. Genoveva Gonzalez-Mirelis, Børge Holte, Pål Buhl-Mortensen, Lene Buhl-Mortensen

A lemon sole (*Microstomus kitt*) perfectly camouflaged, found off the coast of Finnmark.

This chapter focuses on the marine area offshore eastern Finnmark and the Norwegian area along the border with Russia in the southern and central Barents Sea (Figure 1). The latter area in the Barents Sea was the subject of a long-standing territorial negotiation between Norway and Russia, which was finally resolved in 2011. MAREANO started bathymetric mapping of this part of the Barents Sea in 2012, and the first cruise acquiring video footage and physical samples from the seabed took place in 2013. The first MAREANO maps from the area include seabed sediments (grain size, genesis, sedimentary environment, geomorphology). Video-based fauna analyses are ongoing and the first maps of nature types and vulnerable areas are to be published in the coming year.

8.1 THE SEAFLOOR - LANDSCAPE, GEOLOGY AND PROCESSES

8.1.1 Landscape – a flat continental shelf with shallow banks and deep troughs

The Barents Sea is located offshore Norway and Russia, north of the main Eurasian landmass, and covers one of the widest continental shelves in the world. Compared to the steep continental slope outside Lofoten and Vesterålen with canyons and large slide scars, the relatively flat and shallow seafloor of the Barents Sea may appear monotonous (figure 1). The landscape is characterized by alternating elongated troughs, typically 300-500 m deepand trending east-west or north-south, and much shallower banks, typically 100-200 m deep.

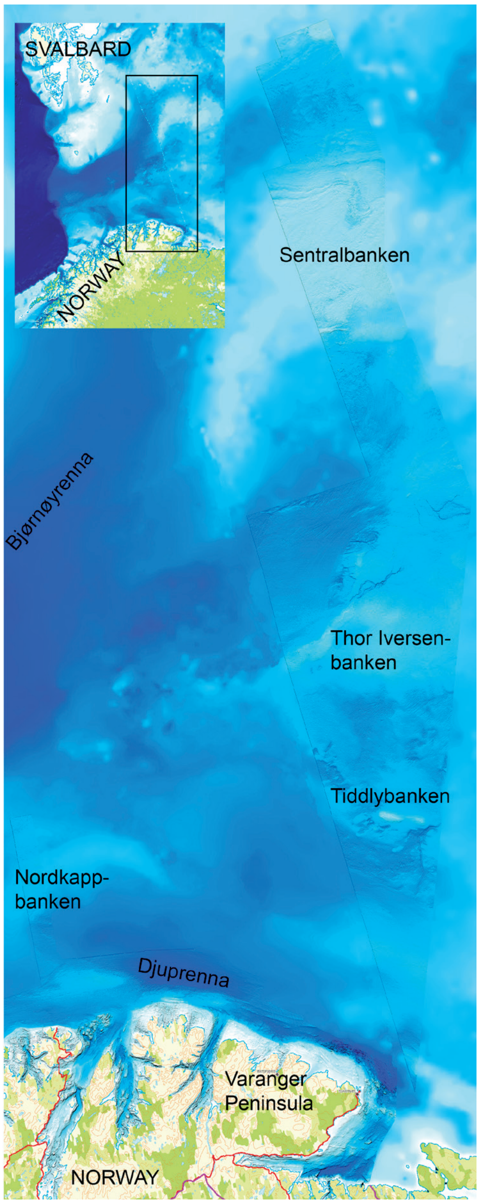


Figure 1: Regional view of the seabed landscape in the eastern Norwegian Barents Sea. Major troughs and bank areas are indicated with names. The inset figure shows the location of the image.

A landscape sculpted by glaciers

The bedrock in this part of the Barents Sea is diverse. The oldest rocks are found in the easternmost part around Kirkenes, where they consist of hard, crystalline basement rocks of the Baltic shield that are older than 2.5 billion years. Farther west, the Varanger peninsula and other areas consist of younger, Neoproterozoic (1000-540 million years old) sedimentary rocks, and rocks of Cambrian-Silurian age (540-420 million years old) (figure 1). Farther offshore, the bedrock comprises Palaeozoic and Mesozoic sedimentary strata that become progressively younger towards the east and north. The youngest rocks, which are of Tertiary age, occur in the Hammerfest Basin. Sandy and clayey sediments deposited in a shallow, warm sea during the Triassic, Jurassic and Cretaceous periods about 100-250 million years ago cover the major part of the Barents Sea. The Barents Sea has been influenced by several tectonic events such as the Caledonian Orogeny 490-390 million years ago, which caused uplift, down-warping, tilting and folding as well as erosion of the sedimentary rocks (see chapter 3.1 for more information about the tectonic history of the Barents Sea).

During the last 2.6 million years, the Barents Sea has been repeatedly covered by vast ice sheets. This period, known as the Quaternary, also accounts for the majority of younger sediments of the area. The ice sheets moulded and shaped the underlying sediments and bed-rock in many ways. Through extensive glacial erosion of the seafloor, several hundred metres of sedimentary bedrock were removed from the interior and dumped at the shelf edge. On the continental slope in the western part of the Barents Sea, the Quaternary sediment cover is up to 3 km thick. Over most of the eastern shelf areas the Quaternary sediment cover is much thinner, and in some places completely missing with bedrock cropping out at the seabed.

Banks and troughs

The present seafloor morphology of deep glacial troughs and shallower banks was formed by selective glacial erosion. The troughs were filled with fast-flowing ice streams, ensuring efficient delivery of sediments to the shelf edge and continental slope (figure 2).

The ice also covered the banks, although it seems to have been less active there. Ice moves under its own weight but it's dynamic are directly influenced by temperature at the base of the ice, softness of the substrate, amount

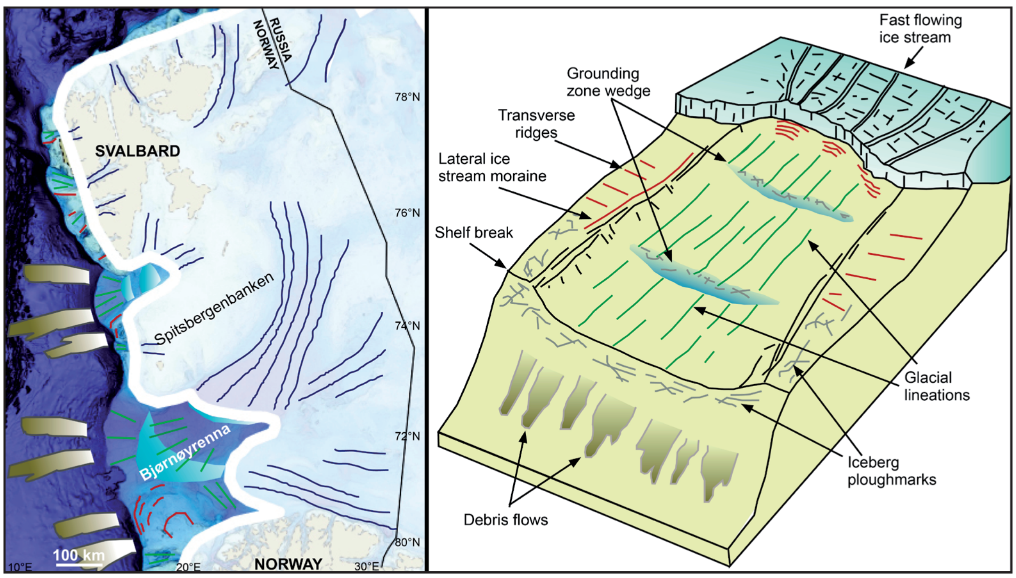


Figure 2. Left: Schematic map of the Barents Sea showing the Barents Sea ice sheet during the last deglaciation and some main glacial landforms; Right: Conceptual model showing typical glacial landforms associated with ice streams (modified from Ottesen et al. 2009).

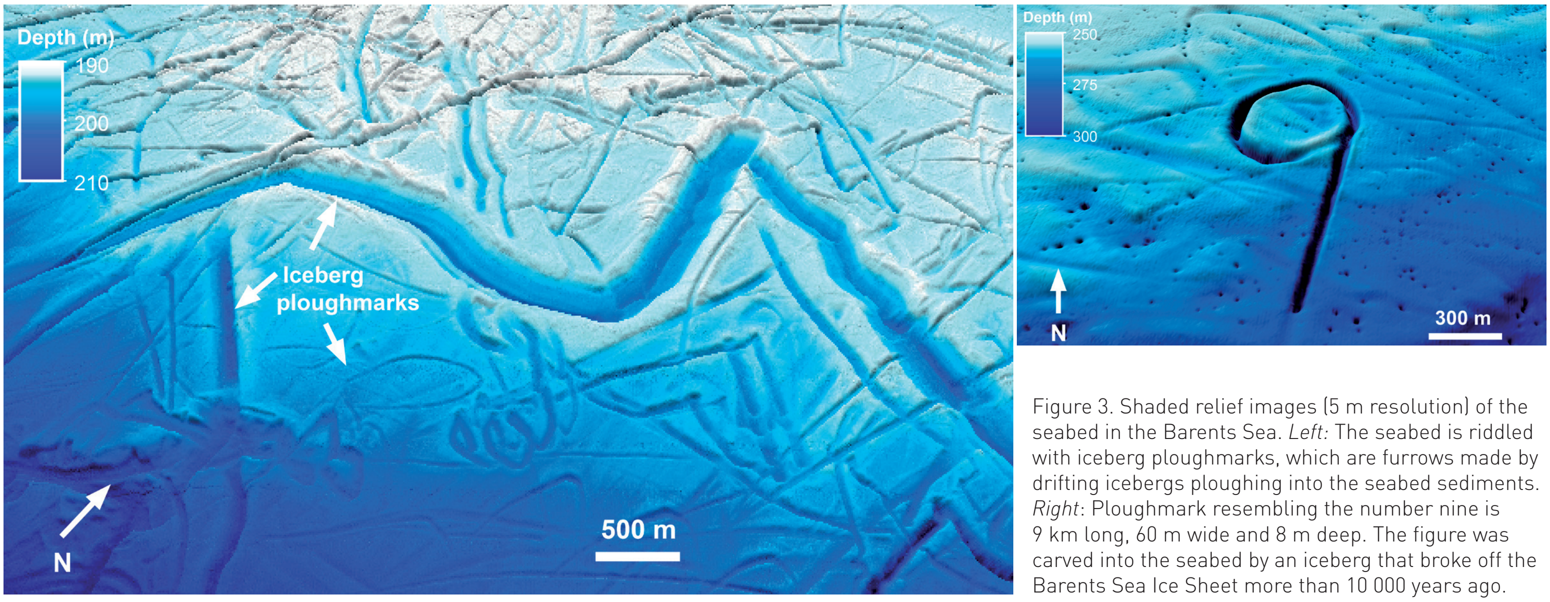


Figure 3. Shaded relief images (5 m resolution) of the seabed in the Barents Sea. *Left:* The seabed is riddled with iceberg ploughmarks, which are furrows made by drifting icebergs ploughing into the seabed sediments. *Right*: Ploughmark resembling the number nine is 9 km long, 60 m wide and 8 m deep. The figure was carved into the seabed by an iceberg that broke off the Barents Sea Ice Sheet more than 10 000 years ago.

of subglacial sediments, and availability of melt water beneath the ice, amongst other factors. For these reasons, glaciers tend to leave different sets of imprints depending on the physical setting. These imprints consist of special landforms and characteristic sediment signatures which can be identified in acoustic data (e.g. bathymetry and seismic data). They allow former ice sheets to be recognised as well as telling us a great deal about the behaviour of the ice sheet.

Glacial processes shaping the seabed

The tell-tale signs of glaciation are visible almost everywhere in the Barents Sea. The most striking fingerprints are the many furrows incised into the seabed by the keels of drifting icebergs that floated around during the deglaciation. These *iceberg ploughmarks* come in many shapes and sizes (figure 3).

The big ice sheets covering Antarctica and Greenland today are drained by fast-flowing ice streams. *Ice streams* leave a very distinct signature of highly elongated and parallel ridges and depressions called *glacial lineations* (figure 4). At the front of the ice streams, large *moraine ridges* or *grounding zone sediment wedges* (figure 4) are deposited. Numerous such features have been observed in the eastern Norwegian Barents Sea, bearing witness to a large palaeo-ice sheet drained by ice streams.

In slower-flowing parts of the ice sheet (often indicated by lack of glacial lineations) moraine ridges were deposited where the ice halted.

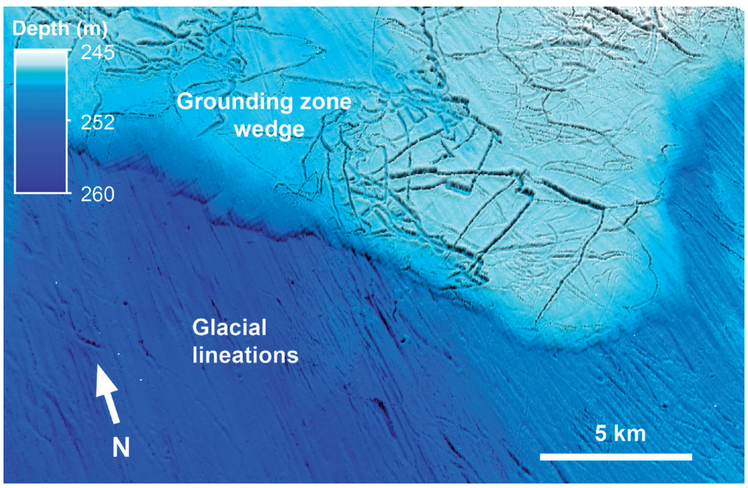


Figure 4. Glacial geomorphic features on the seabed. The NW-SE-trending, parallel groove-ridge features are glacial lineations. They occur beneath and in front a large, convex sediment accumulation – a grounding zone wedge with irregular iceberg ploughmarks on the surface.

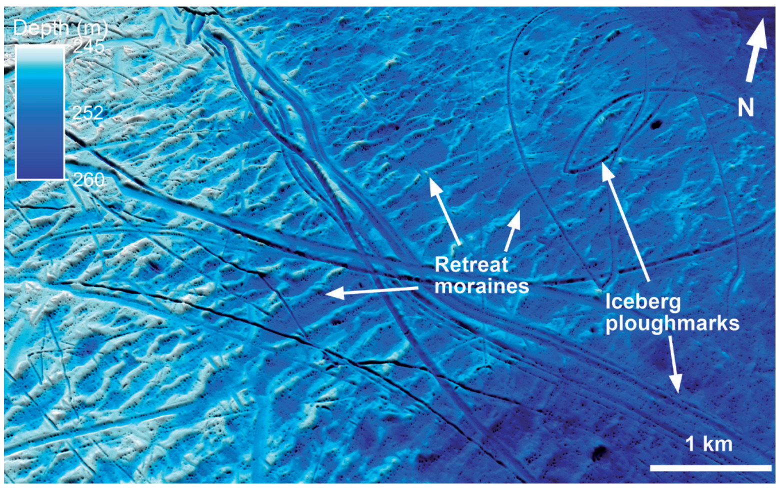


Figure 5. Numerous moraine ridges pushed up by the Barents Sea ice sheet during smaller advances/stillstands during the overall ice retreat at the end of the last glaciation.

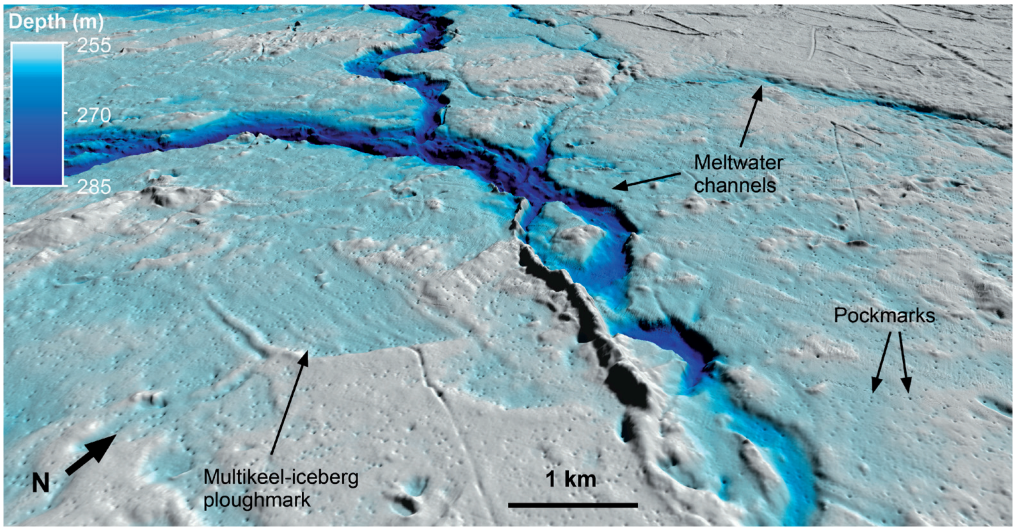


Figure 6. Terrain model (5 m resolution) from the seabed in the eastern Norwegian Barents Sea. The glacial geomorphic features shown include meltwater channels, eskers and iceberg ploughmarks. Also visible are numerous pockmarks (see Basic facts in 8.1.3).

These can be recognised on the seabed as large, long ridges made up of coarser sediments, often with large boulders (figure 5).

On Thor Iversen-banken, a number of meltwater channels have been mapped (figure 6). These were formed by subglacial meltwater beneath the ice sheet, but the exact timing of their formation is not known. Within, or close to several of the meltwater channels, sinuous ridges occur. These are eskers which were formed by sediment deposition within meltwater channels beneath or within the glacier ice.

Sedimentation from the Ice Age to the present

Throughout the Quaternary (last 2.6 million years), large amounts of glacial sediments were deposited on the seafloor by the Barents Sea ice sheet. Some of these sediments were deposited directly beneath the ice (till) and in front of the ice sheet (grounding zone sediments), while others were transported farther away.

Considerable amounts of sediments were carried into the sea by plumes of glacial meltwater. Icebergs breaking off the glacier (calving), also contained sediments, which were carried into the seas, while some sediments melted right out of the ice and dropped onto the seabed. The sediments were deposited on the seabed through suspension settling and dropping from ice.

Glacial sediments deposited in a marine environment are generally referred to as glacimarine. These sediments are typically very muddy (figure 8), but occasionally with sand-rich layers and dropstones. A unit of glacimarine sediments (commonly 2-5 m thick) covers large parts of the eastern Norwegian Barents Sea, whereas in the deepest troughs

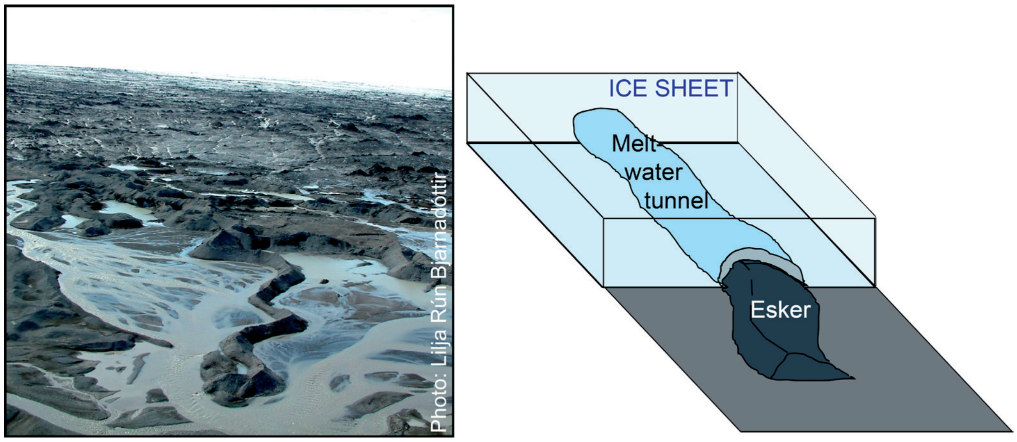


Figure 7. *Left:* Photo of esker (several metres high and wide) melting out of Brúarjökull, Iceland. *Right:* Conceptual model showing how eskers form in meltwater tunnels beneath ice sheets.

Figure 8. The soft, muddy seabed in the eastern Barents Sea yield enormous dredge samples.

up to 15 metres of glacimarine sediments have been deposited.

After the ice disappeared from the Barents Sea some 10-15 thousand years ago, little sediment has been deposited on the seafloor.

8.1.2 Sediments and bottom types

A typical vertical section through the uppermost seabed of the Barents Sea consists of till at the base, then a middle unit of glacimarine sediments, and finally a thin drape of recent seabed surface sediments (figure 9). However, the seabed surface sediments display considerable variation, especially comparing the coastal areas off Finnmark with the central Barents Sea.

Offshore eastern Finnmark

The bedrock of Varangerhalvøya is made up of late Precambrian sedimentary rocks, comprising alternating sandstone, shale and dolomite. The rocks extend some kilometres onto the shelf and are exposed on the seafloor. Such rocks are also found in deeper areas, and give a very rugged and irregular appearance. Seawards, younger, Palaeozoic, Mesozoic and Cenozoic rocks occur. These sedimentary rocks can occasionally be seen on the seabed as dipping, elongated escarpments of exposed bedrock (figure 10).

Large areas off the Finnmark coast are covered by till, deposited directly below the ice sheet. The till locally has a very coarse composition with gravel, cobbles and even boulders (figure 11). Other areas, often in deeper waters, have a till cover with more clay-rich, sticky sediments (figure 11) and can reach up to a few tens of metres in thickness. The surface of these sediments is often characterised by a criss-cross

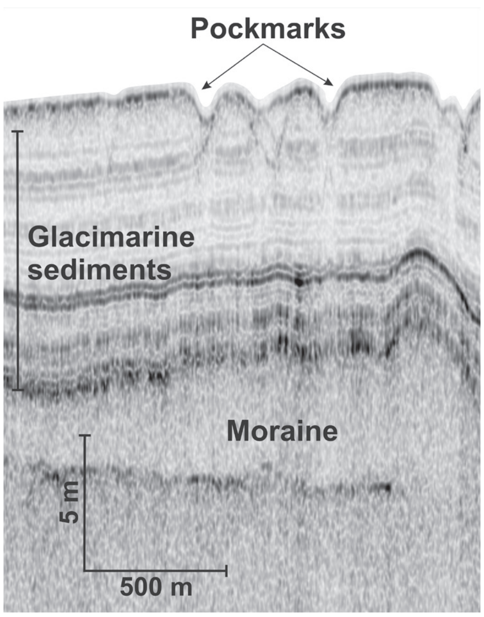


Figure 9. Example of bottom penetrating sonar data (TOPAS) from the Djuprenna glacial trough.

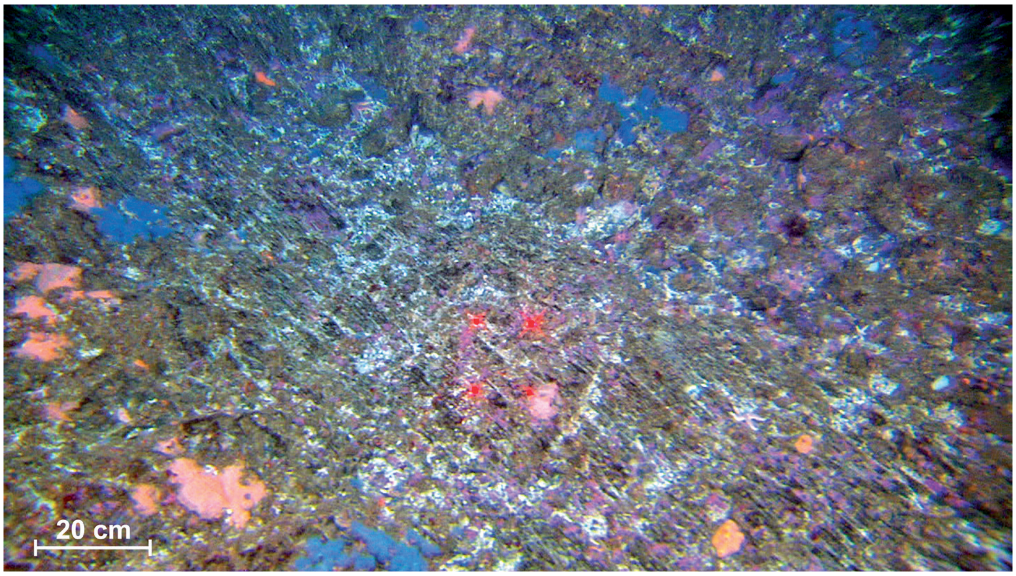


Figure 10. Bedrock close to the coast of Nordkinnhalvøya.

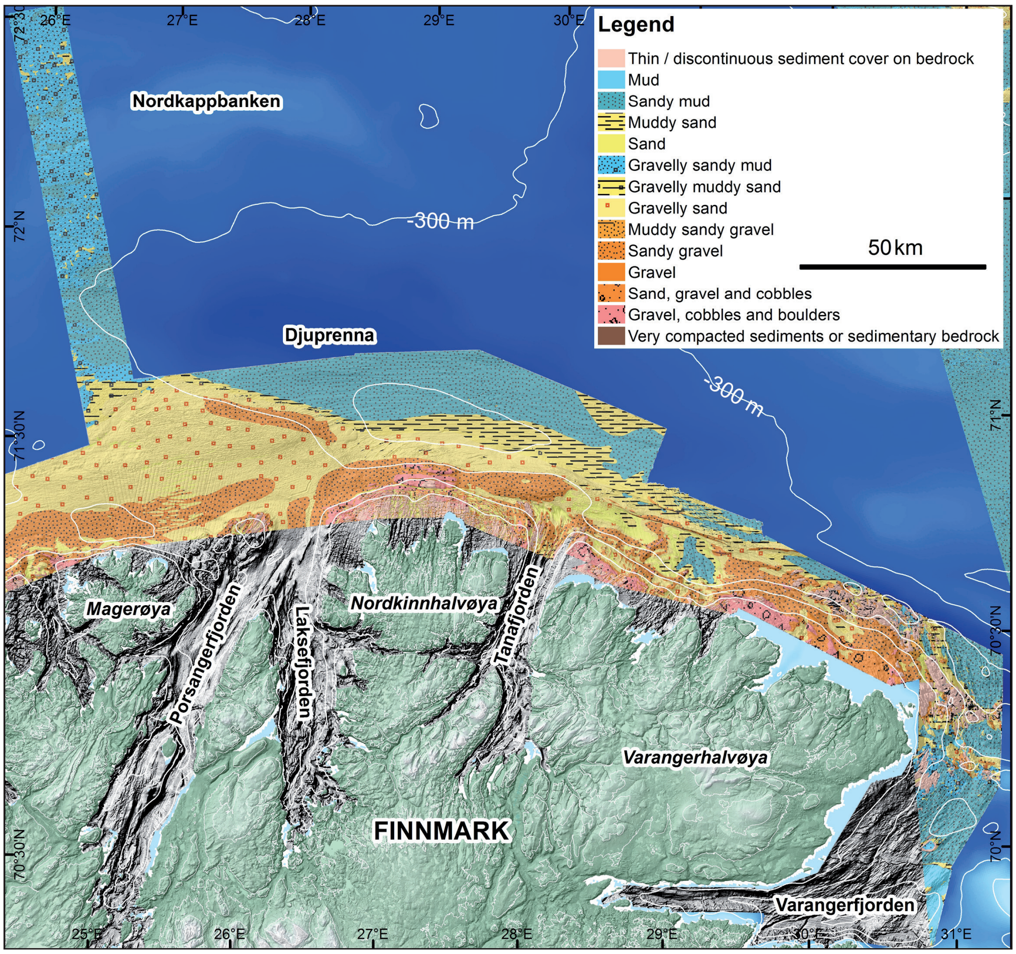


Figure 11. Seabed sediment grain-size map of the coastal areas off the Finnmark coast.

pattern of ploughmarks generated by the keels of floating icebergs.

In depressions in the deepest parts of the mapped area, a several metres thick cover of layered sediments is found. The sediments were deposited during the deglaciation by rivers emanating from the melting ice sheet. In these areas we frequently find large occurrences of small, circular pockmarks, a few metres deep and up to 200 m wide. The pockmarks are formed by fluids and gases escaping from the underground.

Some areas off the Finnmark coast have a thin cover of sand (figure 11). These are exposed to strong bottom currents which sort the sediments and wash out the fine-grained material.

A layer of fine-grained Holocene sediments, usually less than 1 m and often less than 30 cm thick, covers the area.

The seabed in the coastal areas off Finnmark is dominated by coarse sediments (sandy gravel to boulders) or bedrock (figure 12). Strong currents have formed sand wave and sand ripple fields (See figure 20). Farther off the coast, in deeper water, the grain-size of seabed sediments changes from sandy gravel or gravelly sand (figure13), to gravelly muddy sand (figure 14) and finally to sandy mud in the Djuprenna trough (figure 11). In Varangerfjorden, the sediments are much finer grained, and mud and sandy mud dominate (figure 15).

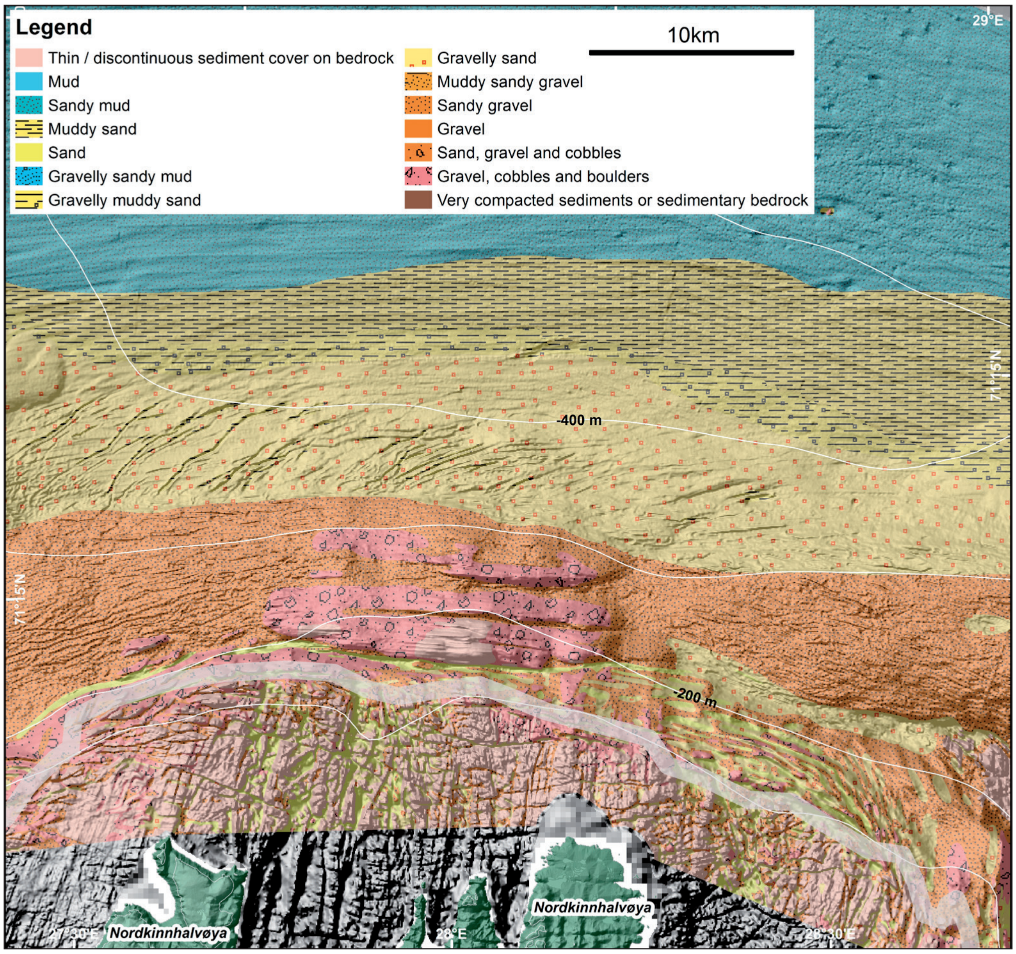


Figure 12. Detail of the seabed sediments (grain size) map off Finnmark showing bedrock outcrops and coarse sediments close to the coast, and decreasing sediment grain size northwards. The grey line indicates the approximate boundary between bedrock areas with thin sediment cover, and areas with much thicker sediment deposits.

Eastern Norwegian Barents Sea

The eastern Norwegian Barents Sea seabed is characterized by muddy sediments: mud, sandy mud, gravelly sandy mud and gravelly muddy sand. Only small areas have sediments coarser than muddy sand (figure 16), usually shallower than 200-250 m water depth, e.g. Tiddlybanken (figure 17).

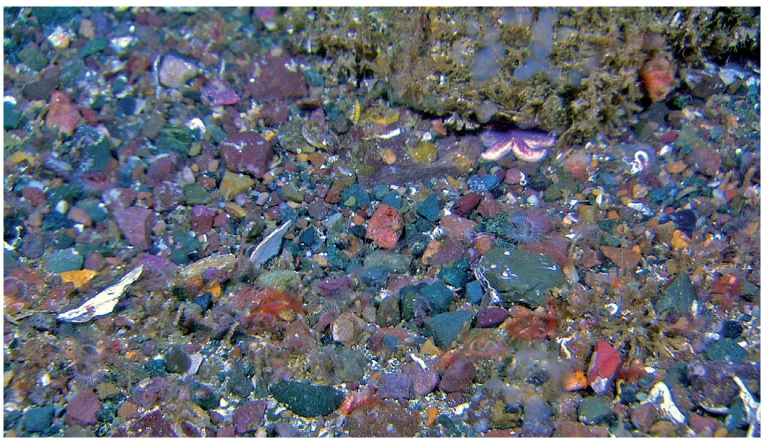


Figure 13. Gravel on the bottom of Tanafjorden.

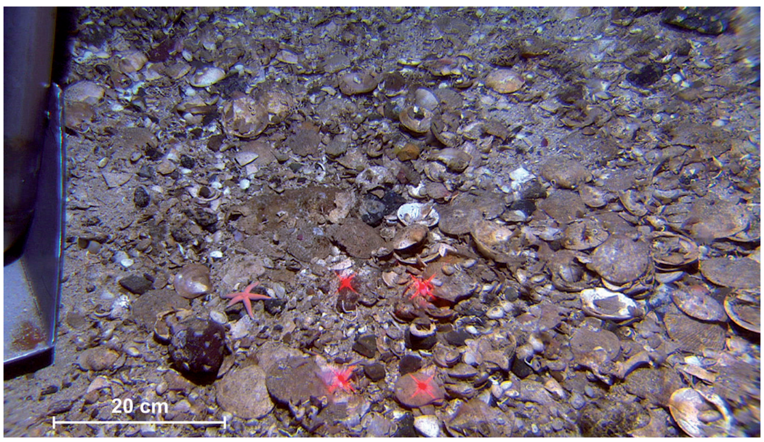


Figure 14. Gravelly muddy sand, consisting largely of bioclastic sediments with whole shells and shell fragments, close to the coast of Varangerhalvøya.

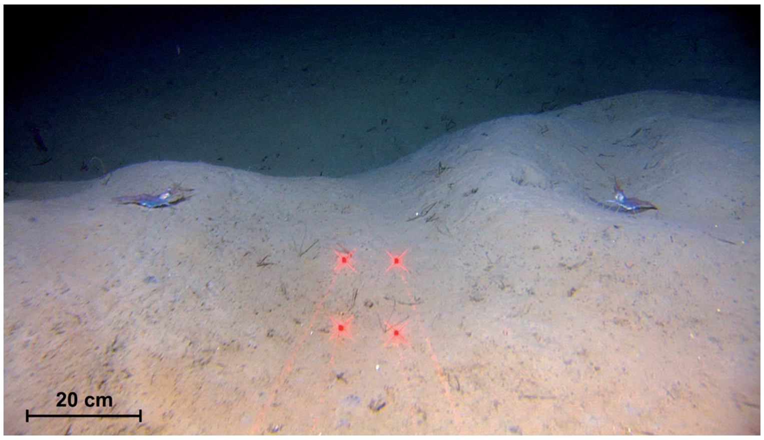


Figure 15. Mud/sandy mud in Varangerfjorden. Two shrimps are visible in the picture.

8.1.3 A changing seabed environment - processes and special features

The seabed changes over both short and long timescales, it is constantly shaped by a range of geological processes. In the previous chapter, a number of glacial processes were described. Here we shed light on some of the other processes that have influenced the seafloor morphology of the Barents Sea shelf.

Salt on the move

Some processes have shaped the seascape in this area continually over a very long time. During the Permian (about 300-250 mill. years ago), warm conditions allowed for evaporation of seawater in shallow basins and extensive deposition of salt. Salt is lighter than other sedimentary rocks and therefore rises through the sedimentary column as plugs over time. This process is known as salt diapirism. The rising salt forms pillar or mushroom shaped towers known as salt diapirs. As a salt diapir rises it pushes overlying sediments aside. The movement results in faulting and tilting of layers, and oil or gas is often present in traps related to these structures. For this reason, information about salt diapirs is of great interest to the petroleum industry.

In some places, salt diapirs reach the seabed forming characteristic bumps on the seafloor. Examples of this have been observed in the eastern Norwegian Barents Sea (figure 18).

In the summer of 2015, MAREANO mapped the seabed around The Helmet. Several video surveys were acquired from the area, including one long transect across The Helmet. The video footage revealed that The Helmet stands out in more than one way, as great variations

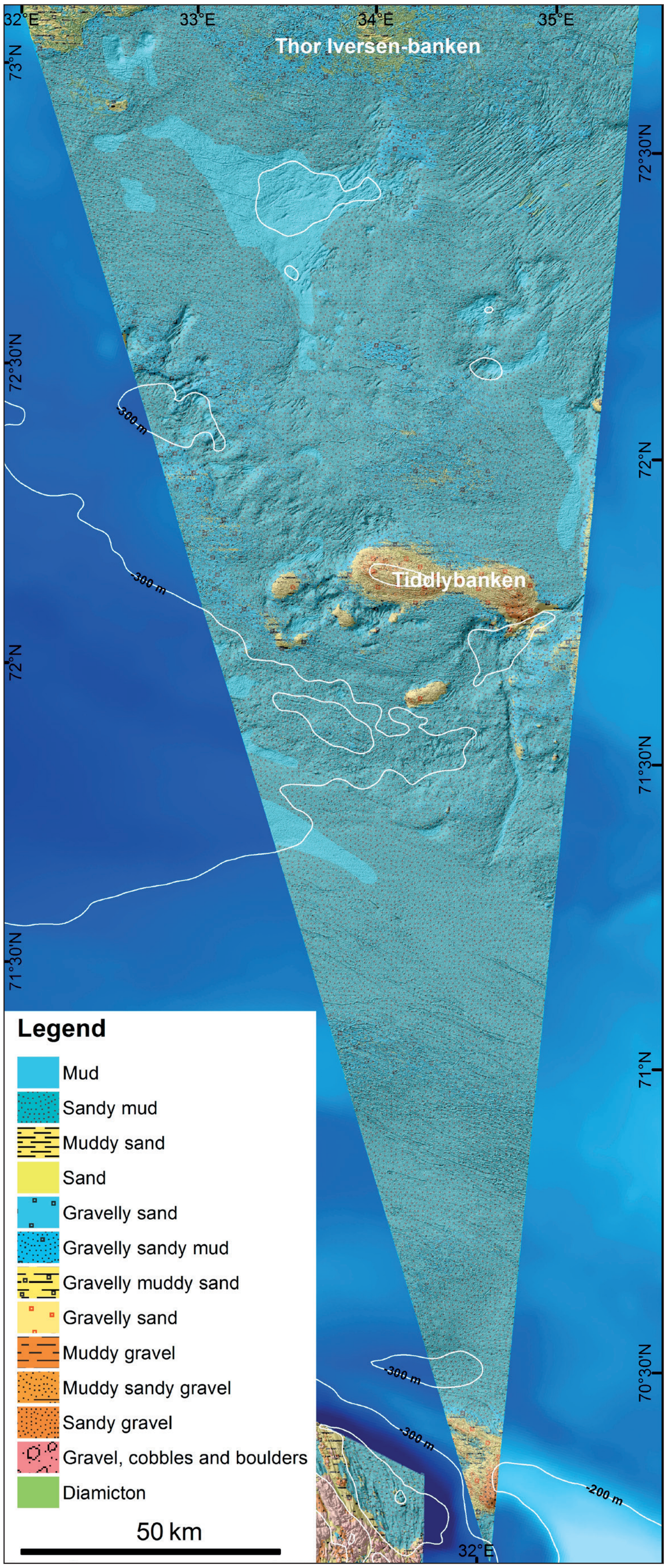


Figure 16. Seabed sediments (grain size) map from the eastern Norwegian Barents Sea.

Leaking gas and fluids – pockmarks

Gas and fluids leak from the deeper geo-sphere into the water column through the seabed. This may take place over long periods, with pulses of more intense activity. This gives rise to special features at the seabed, such as carbonate crusts (see chapter 7 – Basic facts) and pockmarks. Pockmarks are circular or elongated crater-like depressions in the seafloor, with diameter from less than ten metres to more than one kilometre. The "recording medium" of pockmarks is generally soft, fine-grained sediments, that occur extensively in the eastern Norwegian Barents Sea (figure 19). Eighty five percent of the seafloor explored by MAREANO south of 72°30'N is covered by pockmarks (300 to 800 per km^2). The pockmarks are small, generally 20-30 m wide and 2-4 m deep.

Pockmarks are formed by the escape of gas or fluids from the deeper geo-sphere, either sediments or sedimentary rocks. They may be associated with rapid sediment burial rates, high groundwater flux, dissolution of gas hydrates or leaking gas reservoirs. Many of the pockmarks were formed several thousand years ago, and are not active today.

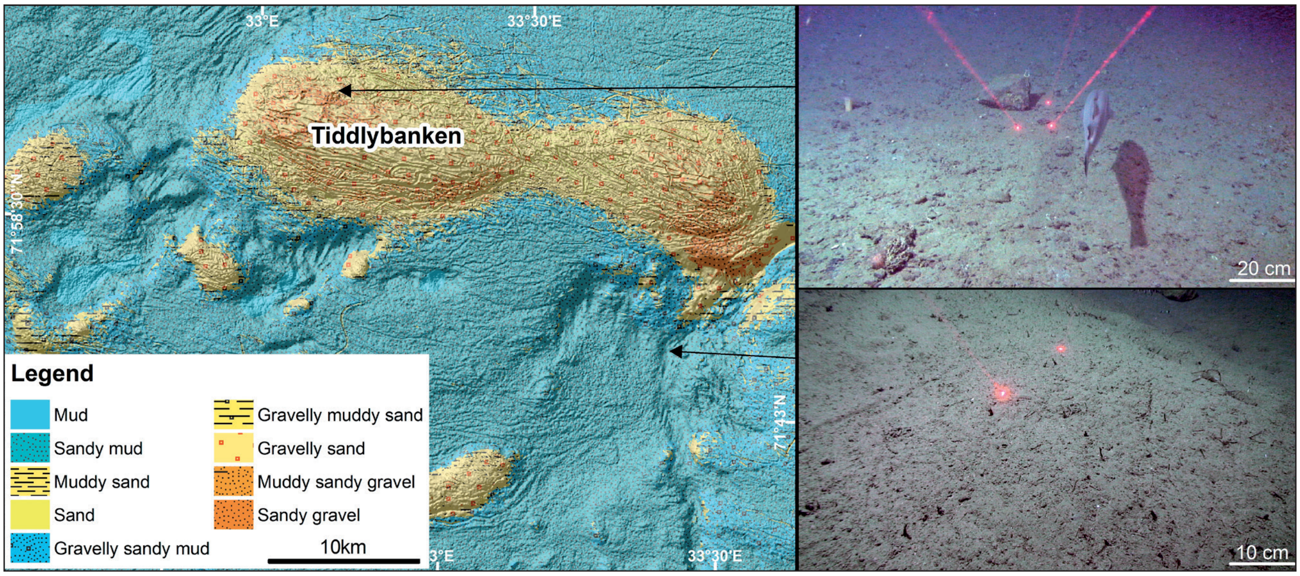


Figure 17. Sediment grain size map from Tiddlybanken. The pictures to the right show gravelly sand and sandy gravel on Tiddlybanken (top, 190 m water depth) and soft sandy mud south of Tiddlybanken (bottom, 320 m water depth).

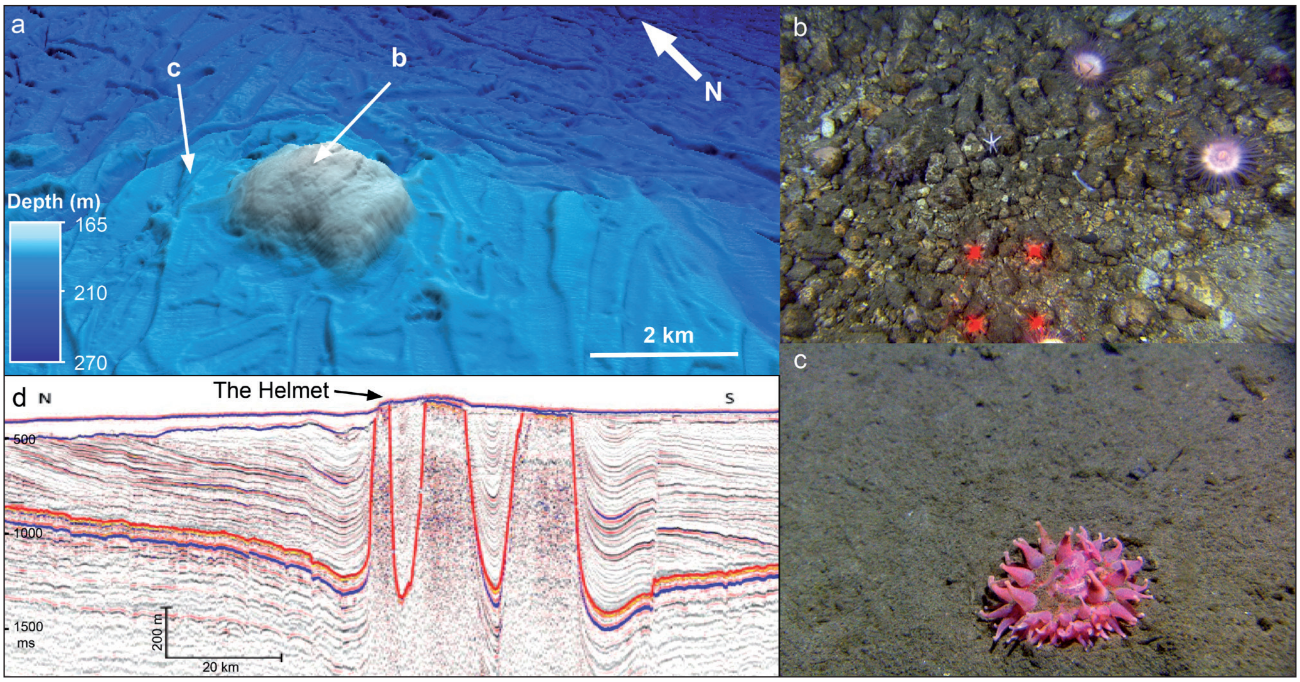


Figure 18. a) This special landform, dubbed The Helmet by MAREANO, was discovered during multibeam mapping. The Helmet is a 35 m high bump with an 800 m diameter. b) Beautifully arranged gravel with a sprinkle of pink anemones (*Hormathidae*) at a depth of about 170 m. c) A lone anemone on a soft muddy bottom at a depth of about 215 m. d) Data from the Norwegian Petroleum Directorate clearly show both the layering within the subsurface, and how The Helmet comprises a salt plug rising from the deep layers.

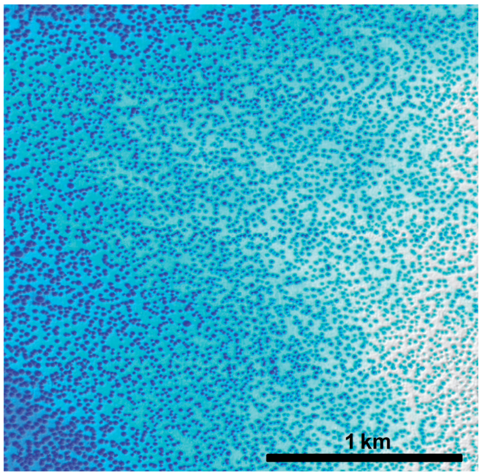


Figure19. High-density coverage of small pockmarks in the eastern Norwegian Barents Sea. The pockmarks are about 20 m wide and 2-3 m deep.

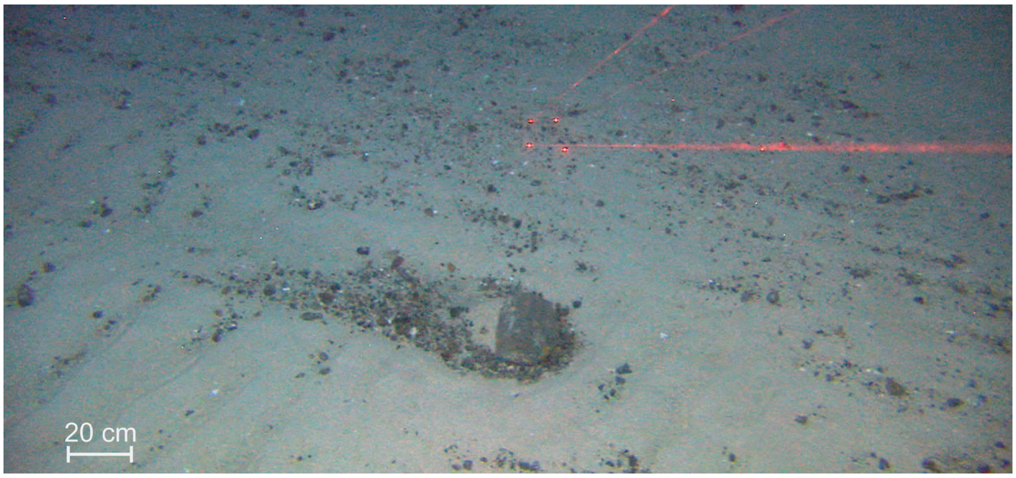


Figure 20. Current ripples in sandy sediments. The asymmetric form of the individual ripples demonstrates that the current has moved from right to left across the image. A 'comet mark' is developed in the centre of the image and is due to current erosion around the stone. The current ripples are a few centimetres high. The image is from the seabed north of Nordkapp, in 215 m water depth.

in seafloor sediment types were observed. The seabed surrounding The Helmet consists of thick deposits of soft muddy sediments, whereas coarser (and harder) sediments were observed on the slopes and seabed surface of The Helmet. The sediments gradually become more gravelly towards its top, where exposed bedrock (salt) occurs (see figure 18).

Current ripples and comet marks

Still other processes may shape the seafloor over shorter interval, for example in response to variations in current strength and/or patterns. The strength of bottom currents close to the seabed dictate whether erosion or deposition occur. Bedforms such as sediment waves, current ripples and comet marks (figure 20) are formed where currents erode, transport and deposit sediments. The size and geometry of the bedforms and grain size of the sediments tell a great deal about the strength of the current which deposited them. The selective deposition of sediments on lee sides of obstacles indicates the current direction

Sandwaves, ripples and comet marks occur frequently along the Finnmark coast (figure 20). Such features do not occur in the eastern Norwegian Barents Sea (figure 16), because bottom current speeds are much lower there.

Shipwrecks at the bottom of the sea

The Barents Sea seabed is the graveyard for many sunken ships. Four shipwrecks have been discovered at 200-300 m water depth using multibeam echosounder bathymetry and water column data (figure 21).The four shipwrecks are 120 to 140 metres long, 15 to 21 metres wide and 13 to 16 m high. It is likely that three northern most ships were part of the Murmansk-convoys of the second world war. The southern most wreck is probably from the first world war (ref. Erling Skjold, Norwegian wreck archive).

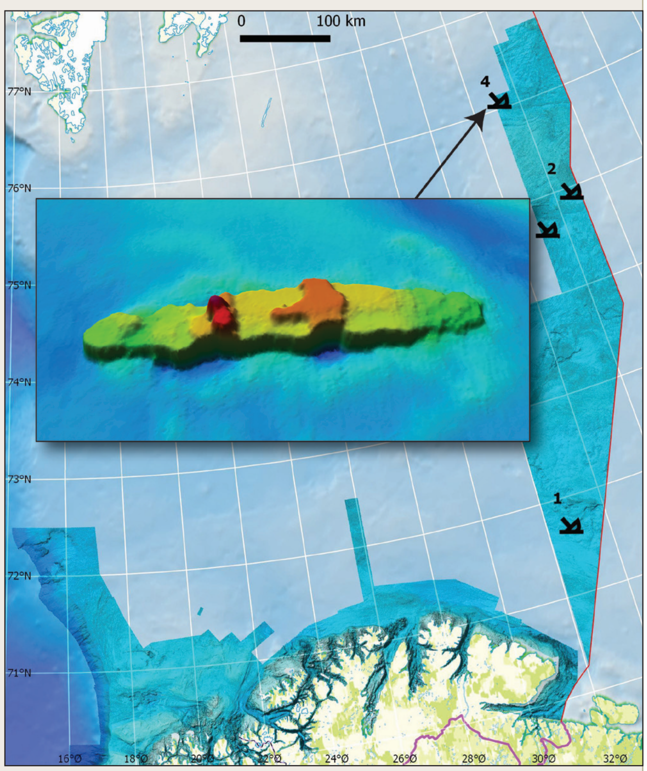


Figure 21. Shaded relief map of the Barents Sea. Map: The four shipwrecks are marked by shipwreck symbols. The numbers indicate the order in which the areas were surveyed. Inset: Terrain model from the area of shipwreck number four. The shape sticking up on the seabed is recognisable as a ship.

basic facts

8.2 THE BOTTOM FAUNA

The Barents Sea is a productive though relatively-simple ecosystem, where pelagic fishes (mainly capelin, and herring) feeding on krill represent the main food source for the cod. Even though the seabed fauna in the Barents Sea is diverse, Arctic marine systems are in general known to consist of fewer species than more temperate marine areas. This attribute makes these ecosystems particularly vulnerable to environmental changes as the fewer the species, the more each individual species counts, ecologically. Impacts on one trophic level can therefore have significant "cascade" effects on the transfer of energy through the food web, both from the top down, and from the bottom up.

The Barents Sea is a shallow shelf sea, and unlike the deeper Norwegian Sea, the deep scattering zooplankton layer is absent. However, even without this layer, the plankton production in the Barents Sea is very important. Phytoplankton production takes place over a period of just a few weeks in the spring. From this biomass, a larger proportion sinks to the bottom than at lower latitudes. On the seabed, as well as on its way down to the seabed, dead organic matter from production in the upper water column undergoes bacterial remineralisation. After being recirculated to the upper water masses by currents, the nutrients released through this process will be available for growth of new plant biomass. By feeding on such organic matter, the seabed fauna is part of the remineralisation cycle and thus constitutes an essential link to primary production. Indeed, it has been suggested that in the Barents Sea, the bottom fauna is the part of the ecosystem that fulfills the ecological role of the deep scattering plankton layer. In turn, the faecal deposits from the benthic fauna form an ideal food source for the abundant seabed bacteria, which have a major energy-recycling role in the marine environment. Changes in the composition of species in the bottom fauna caused by e.g. fisheries or climate change may thus affect this vital, annual spring "pulse" production of phytoplankton in the Barents Sea.

To date, the MAREANO programme has carried out surveys in the newly-delimited area at the open sea at a total of 157 sites (figure 22). This means that all those locations have been investigated with the underwater video

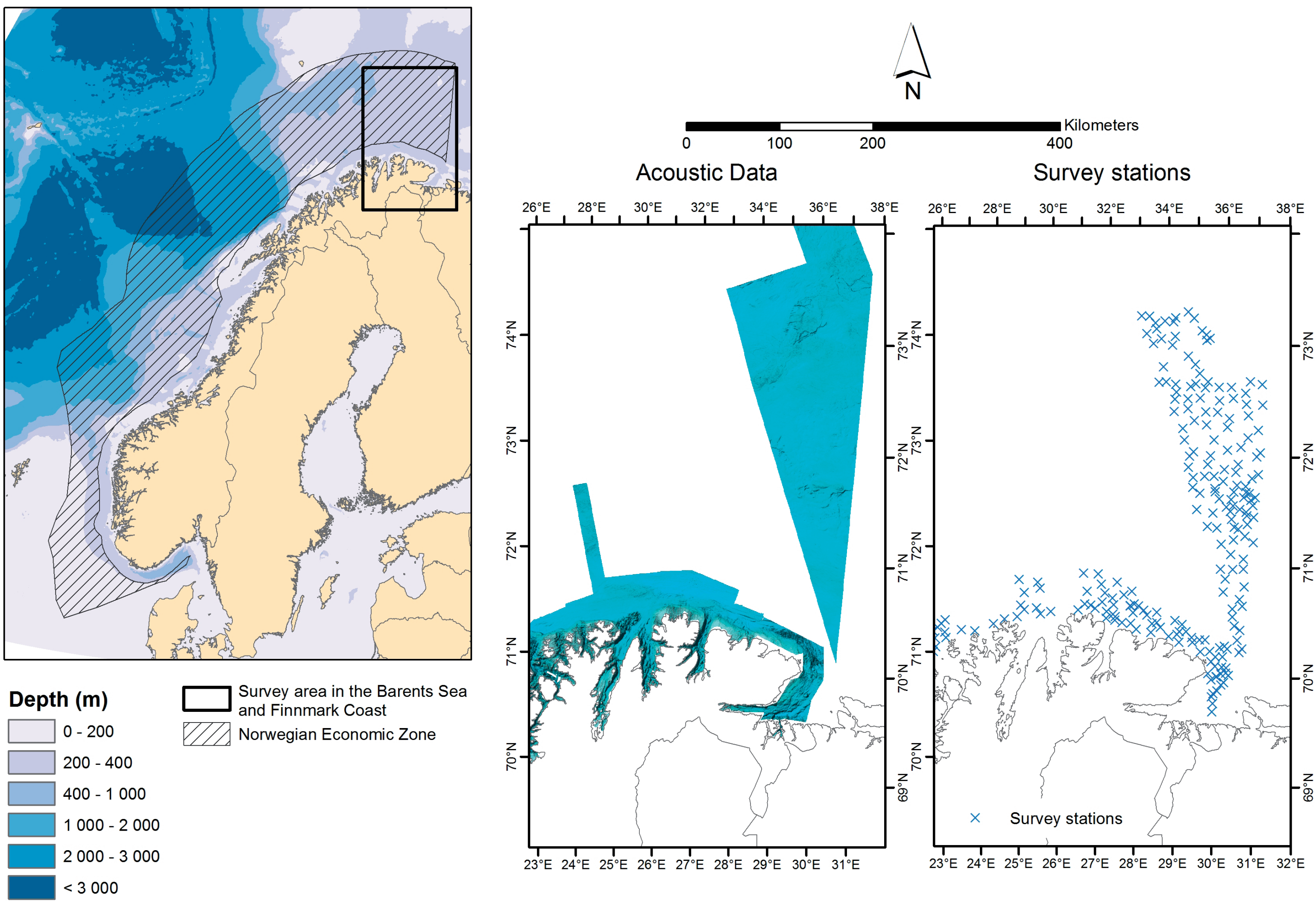
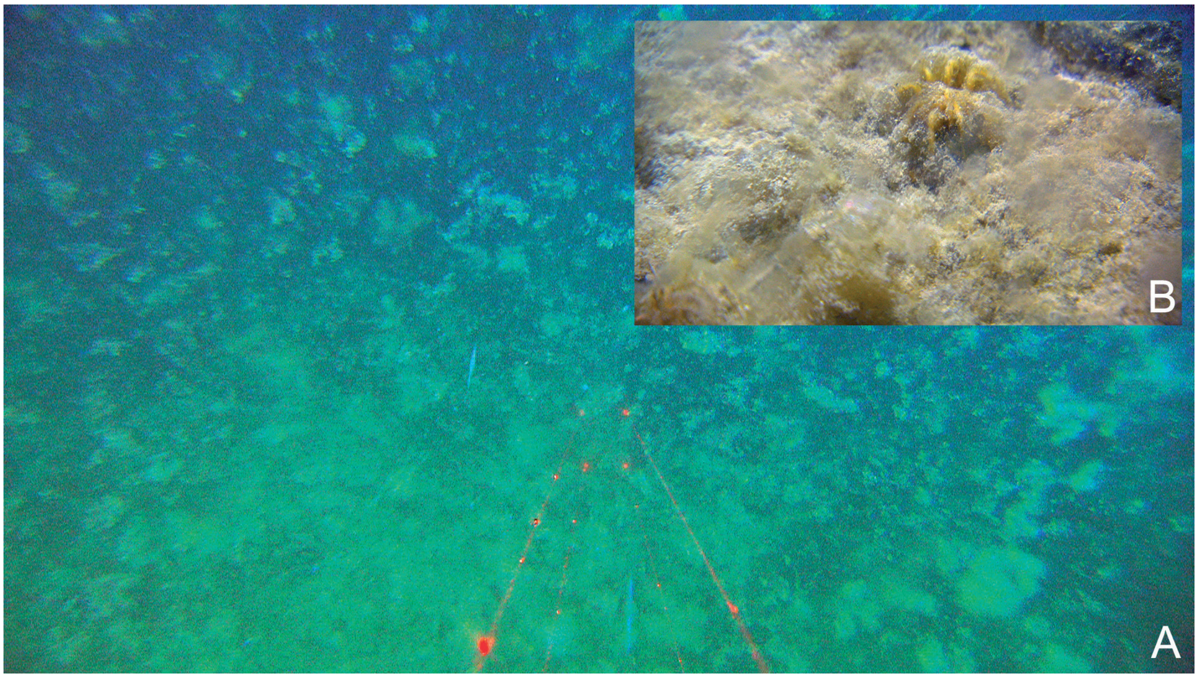


Figure 22.Map showing the area that has been surveyed by MAREANO in the newly-delimited area in the Barents Sea and off the coast of Finnmark.

Figure 23. "Marine snow" (A) and sea spider getting "snowed under" (B). Because the load of organic matter is very high and particles are large, much of this production can completely cover the sediment surface with organic gelatinous matter.



platform, which provides visual data (video footage). Specimens and bottom samples have been collected at 27 of those including beam trawl, grab, and epibenthic sled samples, along with chemical and sedimentological samples (see Chapter 2 for details on sampling methodologies). Within the coastal band, 140 stations have been video-surveyed, and bottom samples have been collected at 23 sites.

In total, we have amassed over 450 hours of seabed footage and recovered material from 50 bottom samples for nearly every type of sampling gear used by MAREANO. This wealth of data will be analysed by experts at the laboratory to document and quantify the abundance and distribution of all benthic fauna. Meanwhile, since the footage from the underwater camera platform is viewed and annotated in real time by the scientists on board during cruises, MAREANO scientists have already started to form a picture of the main features of the epibenthic megafauna both off Finnmark and further offshore, into the Barents Sea. We are also beginning to unravel the processes that cause and maintain the distribution patterns of these communities. Our first and preliminary observations indicate that the faunal composition offshore is mainly influenced by oceanographic processes, whereas closer to shore seafloor heterogeneity and depth gradients are the main environmental drivers. In this chapter we present some of the findings that are starting to emerge from these surveys.

8.2.1 The benthic fauna in offshore areas

The bottom temperature in the Barents Sea generally decreases towards the east and north due to cooling of the relatively warm Atlantic water flowing north-eastward from the Norwegian Sea. In addition, cold Arctic water flows towards the southwest and west, north of the Polar Front (figure 1, Chapter 14). However, cold bottom water associated with winter convection and ice-freezing processes on the various bank structures in the Barents Sea occasionally influences the temperature regime also south of the Polar Front. In 2015, MAREANO measured temperatures of -1 °C at the bottom, and 4-5 °C at the surface at the northernmost part of the surveyed area.

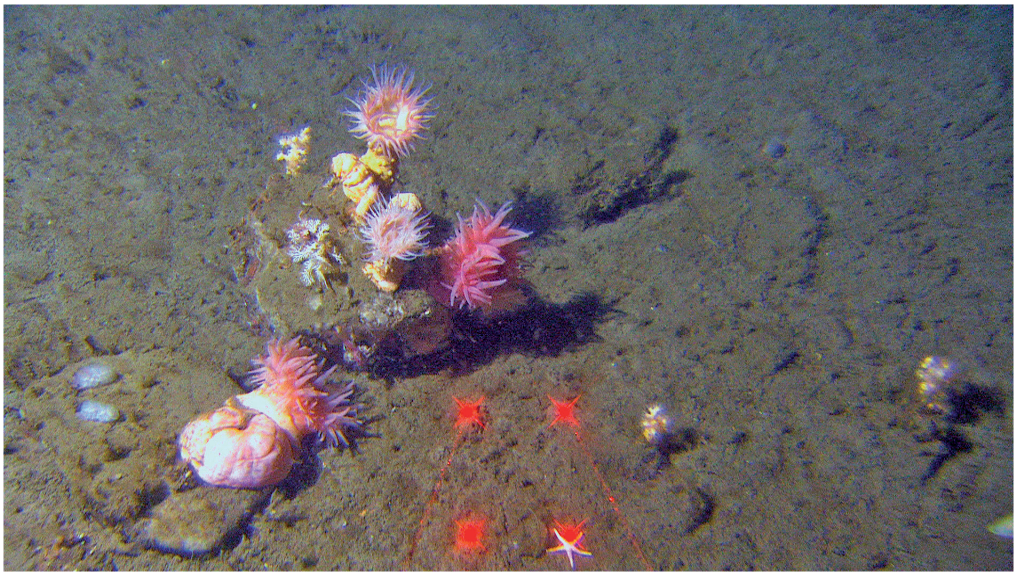


Figure 24. Boulders colonized by sea anemones (Actiniaria). For size reference, notice that the distance between the pair of laser pointers is 10 cm.

Figure 25. The sea anemone *Hormathia* sp. attached to the shell of a hermit crab.

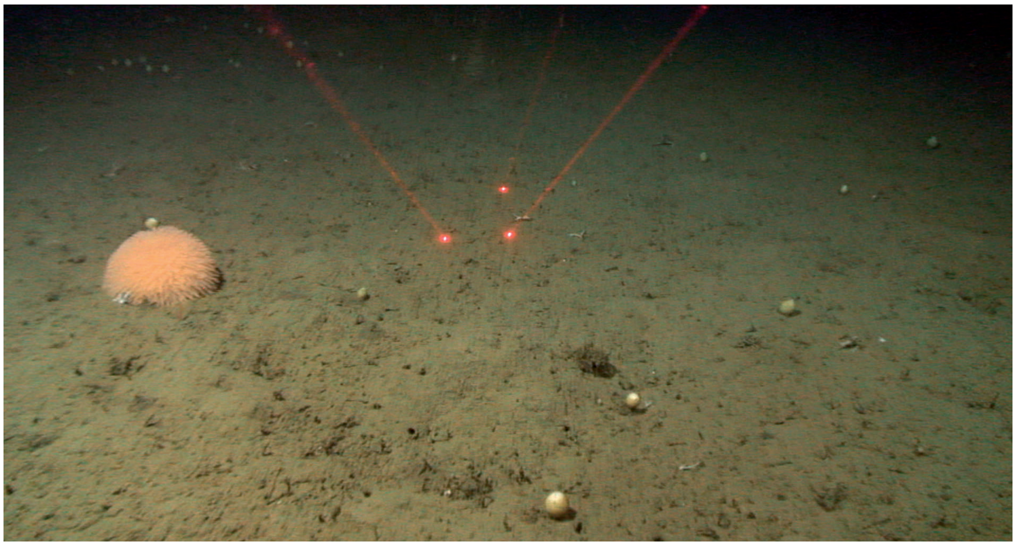


Figure 26. The arctic pompom anemone *Liponema multicornis*. The distance between the pair of laser pointers is 10 cm.

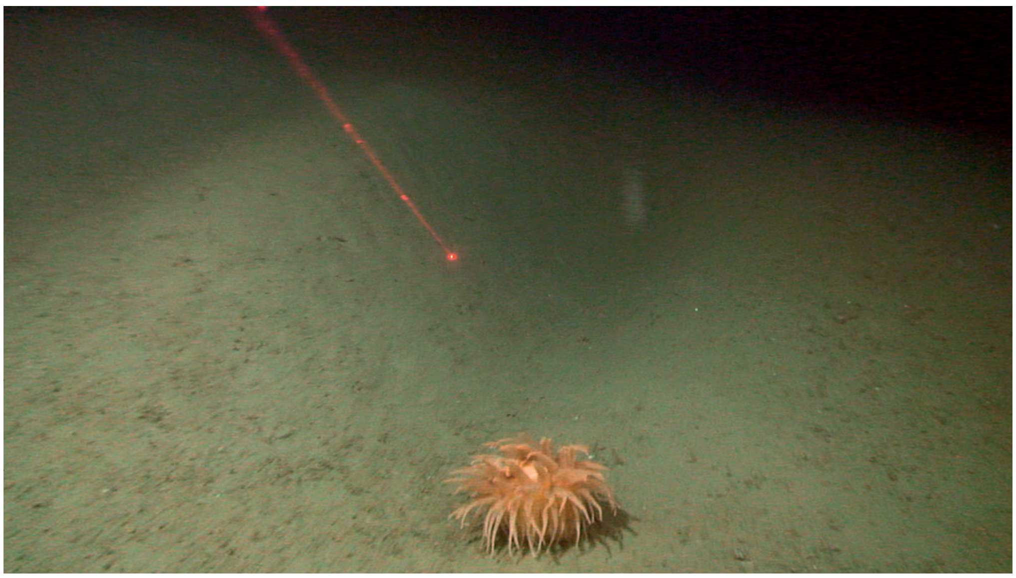


Figure 27. Anemone of the species *Bolocera* in the "valley" of a trawl mark

As the Barents Sea is very productive, living marine resources are abundant. MAREANO has observed and documented populations of cod, haddock, redfish, flatfish (Greenland halibut, long rough dab, etc), wolfish and skates. These, along with other biological resources including various crustaceans (northern prawn among others) attract an intense fishery.

We have also captured images of the effects of the spring bloom, which can be observed in the fall of dead organic matter on to the seabed. In these highly productive areas the amount of organic particles produced during spring blooms can be so abundant in the water column that it looks like a snowstorm; this phenomenon has been called "marine snow" (figure 23).

In contrast to the rugged terrain close to the coast, the bottom in the open offshore areas has a very low relief, with a depth range between 200 and 300 m. These areas are dominated by silt and clay, but coarse sediment (e.g. cobbles, boulders) can be found sprinkled throughout the entire area and are typically colonized by hard-substrate species. Sea anemones are the primary dwellers on these islands of firm substrate (figure 24). These animals were abundant in the northernmost parts of the surveyed area.

The most common sea anemones in this area belong to the family Hormathiidae (including *Hormathia digitata* and *H. nodosa*), and they can also be observed attached to the shell of hermit crabs (figure 25). In addition to providing the anemone with solid substrate, this position also offers possibilities for catching food spill from the hermit crab. The anemone returns the favour by providing protection from predators through its sting cells. This cooperation demonstrates a well developed symbiosis to the benefit of the involved species and individuals.

Sea anemones do not only live attached to cobbles and boulders, or other hard surfaces. Some species are adapted to stand directly on the mud. One of these, *Liponema multicornis* (figure 26), an arctic pompom anemone, is a peculiar looking anemone that can have up to 900 short tentacles. This species, which is rare in the Southwestern part of the Barents Sea, was present in high numbers in the northern parts of the surveyed open-sea area.

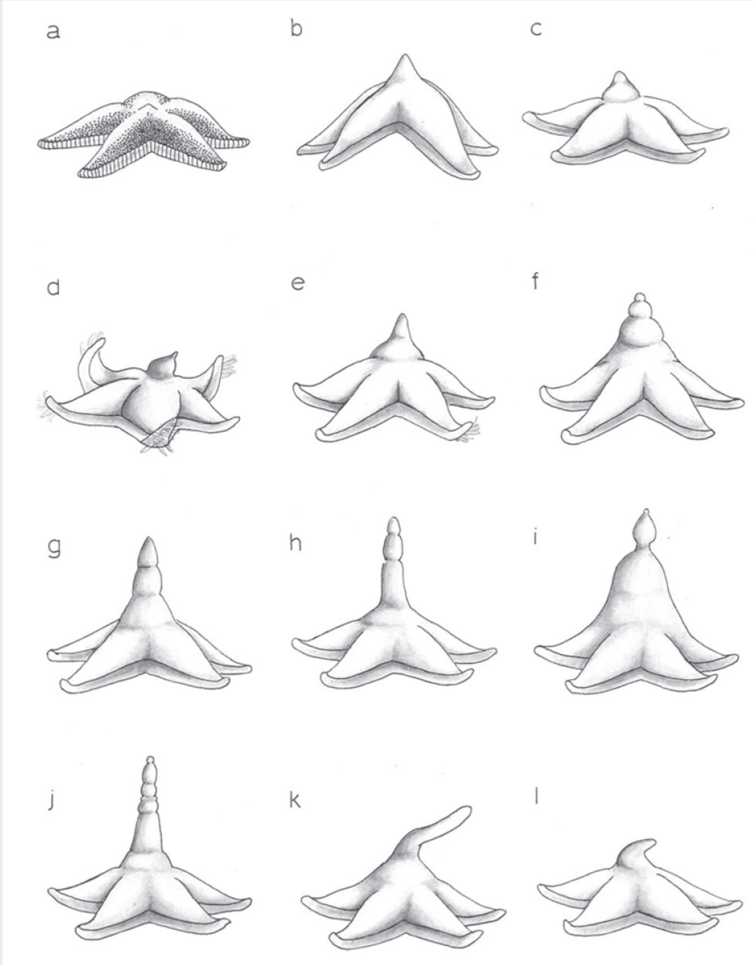
Anemones can also serve as habitat for other species. For example, the northern prawn (*Pandalus borealis*) is known to use some species as a shelter against predators. Amphipods can also live within the tentacles of sea anemones.

A highly adapted starfish

Estimations made by MAREANO experts indicate that the mud star (*Ctenodiscus crispatus*, bottom) probably contributes largely to the total biomass of the benthic ecosystem of the Barents Sea. This species is adapted to live buried just underneath the sediment surface. It is a non-selective, deposit feeder, which means that this species ingests the sediments without any discrimination of content. It feeds by opening its mouth and filling its entire disk with mud, slowly digesting the organic material, which is then absorbed in the gut system.

The environment within the mud occasionally experiences hypoxia, a condition where the oxygen concentration falls below a critical level. The mud star has what is known as an "epiproctal cone" (right). This cone is an outpocket of the body which can be projected upwards through the sediment and into the top layer of the sediment where oxygen-rich water is found.

The mud star, *Ctenodiscus crispatus*. Although usually buried and difficult to "catch on tape", sometimes this organism can be seen active on the surface of the sediment.



Diagrammatic representations of aspects of the mud star's behavior involving the epiproctal cone. (a) Specimen at rest or moving on the sediment surface; (b-l) series of responses to exposure to hypoxia and hydrogen sulfide. Source: JM Shick (1976).

MAREANO has also observed that sea anemones (particularly *Liponema multicornis* and *Bolocera* sp.) are frequently found at the bottom of tracks created by the trawling gear of fishing vessels (figure 27), although the process behind this observation is as yet unclear.

Other organisms that were commonly encountered in these parts include the starfishes *Ctenodiscus crispatus* (the mud star), *Urasterias lincki* (figure 28), and *Icasterias panopla*, the soft coral *Gersemia rubiformis*, and the calcareous bryozoan *Smittina jeffreysi*.

Among the material recovered from beam trawl and grab one of the most typically-occurring animals was the bivalve *Bathyarca glacialis*. This is an Arctic bivalve that occurs in the Barents Sea and, among other areas, at Svalbard as well as in deep water in sub-Arctic coastal areas where the bottom water is relatively cold. *Bathyarca* belongs to a group of bivalves that do

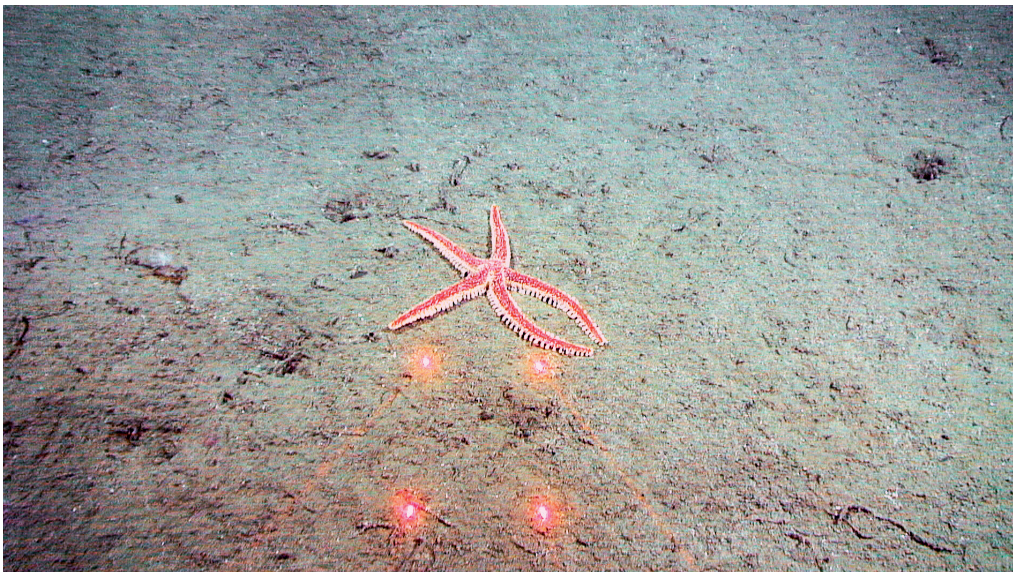


Figure 28. The star fish *Urasterias lincki*. This species is found from Nova Scotia to northern Norway, at depths up to 2000 m. For size reference, notice that the distance between the pair of laser pointers is 10 cm.

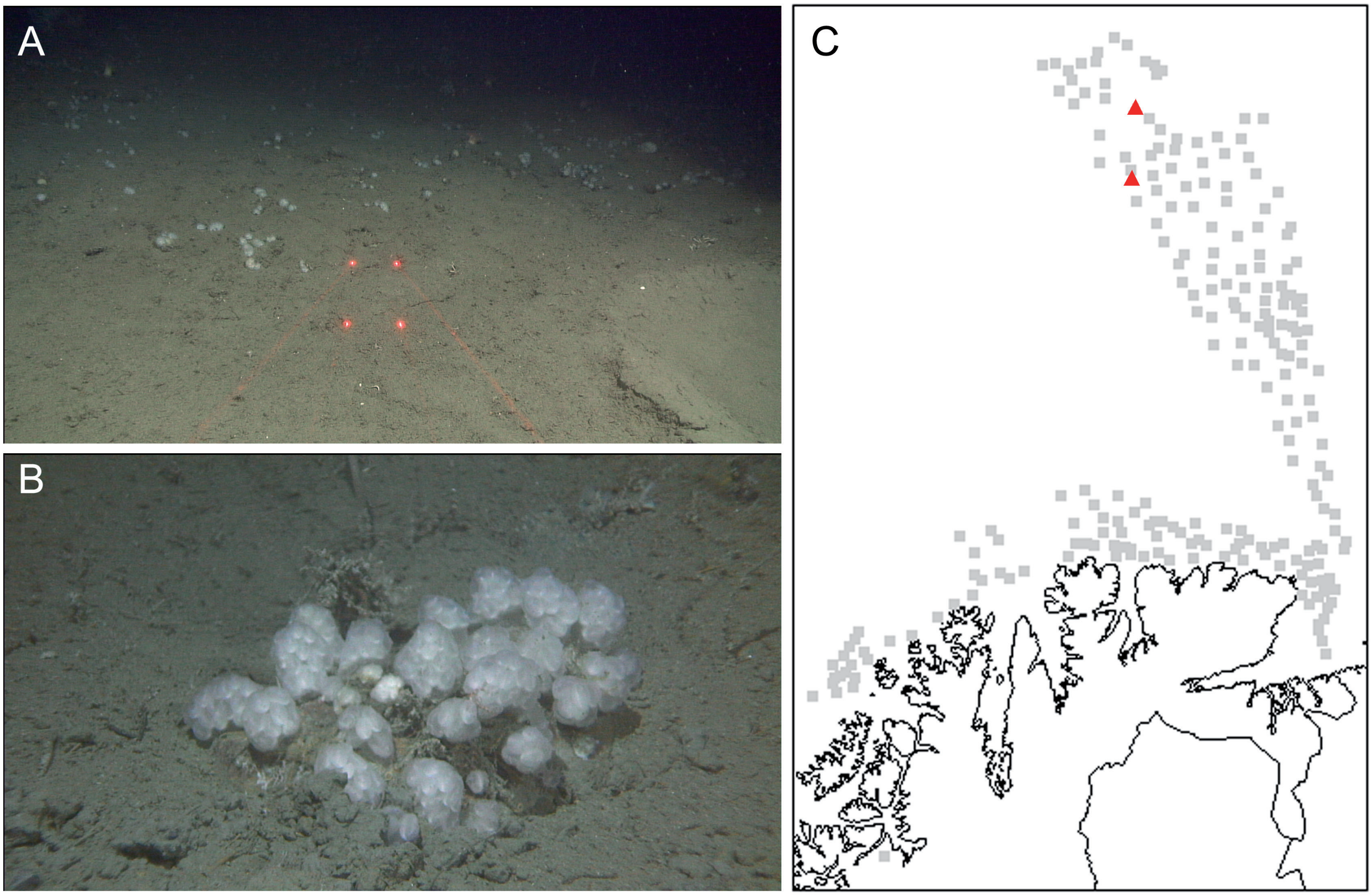


Figure 29. Field of an unidentified species of a colonial tunicate of the family Polyclinidae in the Barents Sea (A), with a closeup photo from video (B). The map (C) shows the two only locations (red triangles) where these fields were observed.

not have siphons and therefore need to live in the oxygen-rich, top layer of the sediments. This group has a unique adaptation in the presence of mantle flaps that extend beyond the shell edge when feeding. This enables the inhalant and exhalant flows to be separated and may help in conditions of high suspended matter.

The bristle worm *Spiochaetopterus* sp. made up a large part of the material retrieved from grab samples. When sampling, the animal is recognised by its characteristic, often 10-15 cm long and a couple of mm wide, semi-transparent tube. Using its "legs" (notopodia) to set up a water stream into its tube, the animal captures food particles from the bottom water and samples these within a jelly mass, well-protected inside the tube, until the mass is big enough for eating. This particular group of bristle worms may, in periods of shortage of food particles in the water, just as well stretch their two palps out of the tube opening and catch organic particles from the sediment surface. This double feeding mechanism probably increases its chances of survival and may explain its often high density in the muddy areas of the Barents Sea.

Vast fields of an unidentified colonial polyclinid tunicate were found at a few locations close to the northernmost edge of the sampling area (figure 29). The species is yet to be determined, and although this tunicate has been observed in other areas surveyed by MAREANO, more data is needed to ascertain the species, as well as explain its ecological functionality.

The composition of the seabed communities changes as one heads south towards the coast and the temperature at the bottom increases. There appears to be a community-shift approximately at the point where the water is 3.5°C (figure 30). The predatory "pipe cleaner" sponge (*Asbestopluma pennatula*) and the starfish known as rigid cushion star (*Hippasteria phrygiana*) occurred only in sites where the mean bottom temperature was higher than 3.5 °C, although further statistical analyses will be required to confirm this relationship. This will be very important, because tight coupling between temperature data and the occurrence of certain organisms can be indicative of the effects that may take place if changes in temperature occur.

8.2.2 The benthic fauna off eastern Finnmark

The marine landscape off the coast of Finnmark stands in stark contrast to the open waters of the Barents Sea. Here, we find an intricate mosaic of habitats including bedrock, shell hash, and sand, representing a more complex and diverse ecosystem. Besides the habitat heterogeneity, a depth gradient from 50 to 400 m is another important source of faunal variability.

Bedrock and hard substrates with high relief can offer habitat to a great variety of sessile animals such as spiral tube worms, soft corals, sponges (both encrusting and erect), hydroids, and tunicates. Other common animals are echinoderms such as sea urchins and starfish, and crustaceans. One can also see the squat lobster *Munida*, a lobster-like crustacean that is closely related to hermit crabs. Unlike their relatives, however, squat lobsters don't live inside shells. Instead, they protect their bodies by squeezing into crevices in the rock or in burrows in the soft sediment. With their long claws they pick up food, scoop up sand in order to find prey, or simply fight other squat lobsters!

The invasive red king crab *Paralithodes camtschaticus* (figure 31) was found at several locations close to the coastal areas. This species can reach more than 1 m in size between the leg-tips. They can move fast and potentially, they eat all kinds of invertebrates they may find in their way. The species was transferred here from the northern Pacific Ocean in the 1960's and it is likely that the presence of red king crab in the ecosystem will change the composition of benthic communities.

Across the more shallow areas, between 50 and 80 meters, just enough light from the sun penetrates to allow for the existence of kelp forests (figure 33), interweaved with the rich fauna. Here, the display of colors can be remarkable, including the pink of the broccoli coral *Drifa* sp., and the purple of the encrusting alga *Lithothamnion* sp. among others (figures 34-35). The colonial tunicate *Kukenthalia borealis* can be found often under the coral, adding blue shades to the color palette. While the corals catch their food just as miniature anemones using their stinging tentacles, the tunicates filter tiny particles through the gills inside their body, which are surrounded by a mucus net.

Immediately north of the island of Sørøya one can find dense stands of the broccoli coral. These corals are habitat to juvenile brittle stars of the genus *Gorgonocephalus*. We have

Figure 30. This map shows the survey stations in relation to annual, mean temperature at the seafloor. The area with an annual mean temperature > 3.5°C appears to corresponds to the distribution of the most temperature-sensitive species, such as the pipe cleaner sponge and the rigid cushion starfish.

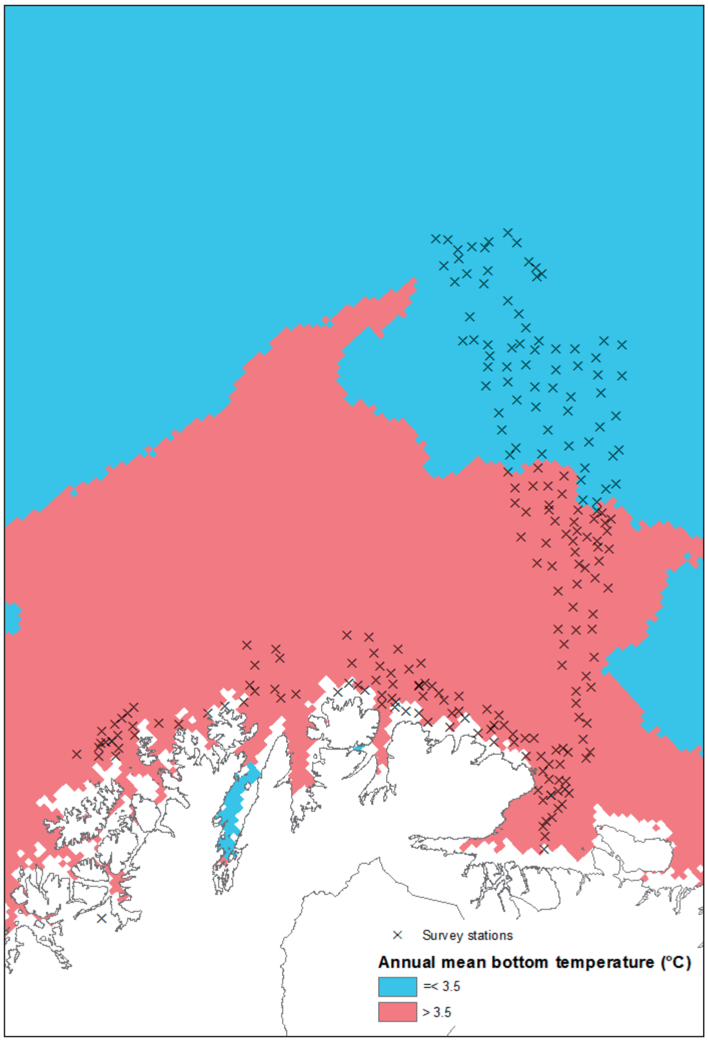


Figure 31. The invasive red king crab (*Paralithodes camtschaticus*) were observed off the coast of Finnmark.

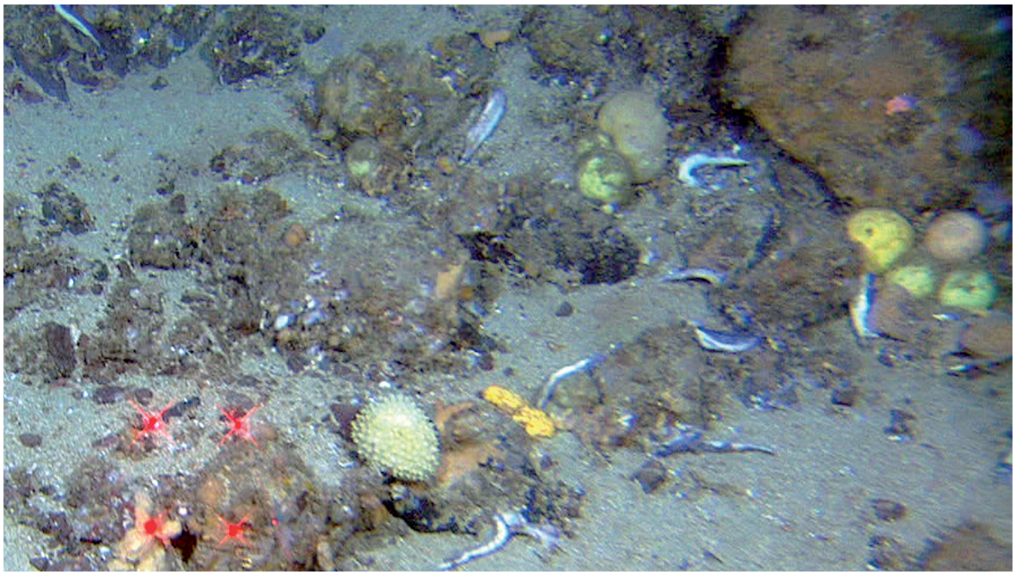


Figure 32. Capelin that has died after spawning can during the spring be found in the spawning areas along the coast of Finnmark.

also observed the presence of the rice coral (*Primnoa resedaeformis*) at what probably is its easternmost location along the Norwegian coast.

Sandy patches are interspersed with rocky outcrops in accumulation basins. Sand comprises grains of rocks, minerals and hard parts of dead animals smaller than 2 mm, but larger than clay and silt (figure 37). This is a habitat where burrowing animals such as heart urchins (*Echinocardium flavescens*) can easily plow right under the sediment surface, and holothurians and starfishes are often found on the surface together with flatfish and skates.

The shell hash we find in this area mainly consists of bits and pieces of dead hydroids, brachiopods and mussels, forming habitats consisting of coarse particles that allow fresh and oxygen-rich bottom water to penetrate into the sediments. The carnivorous bristle worm *Nothria* builds tubes of the shell in this sediment, and is perfectly camouflaged in the shell hash when hunting for prey that live in the oxygen-rich upper part of the sediments (figure 38). At some locations *Nothria* was registered in remarkably high densities.

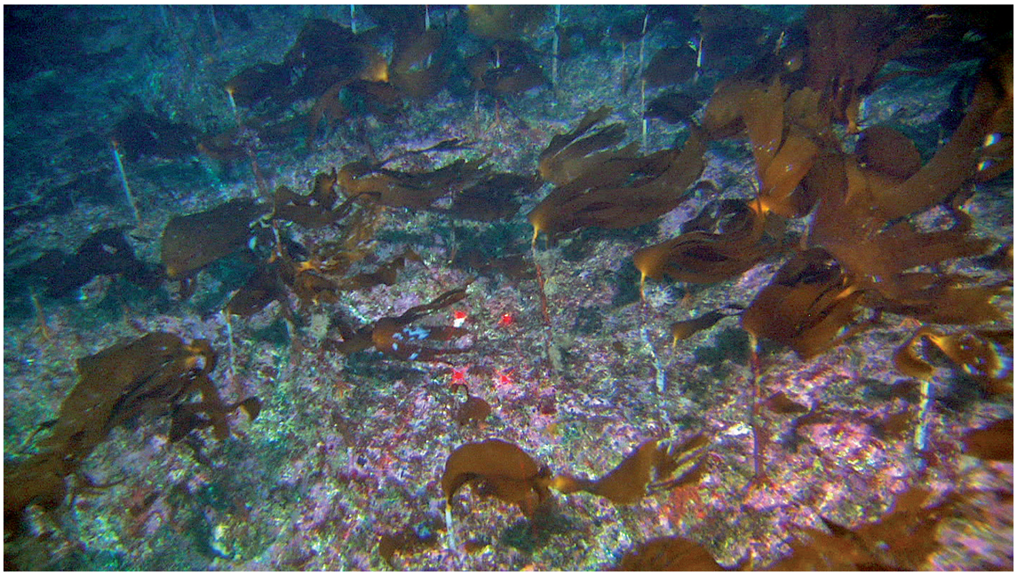


Figure 33. Kelp (*Laminaria digitata*) is a common feature of the more shallow areas off the coast of Finnmark, where just enough light from the sun penetrates into the water allowing the presence of plant life.

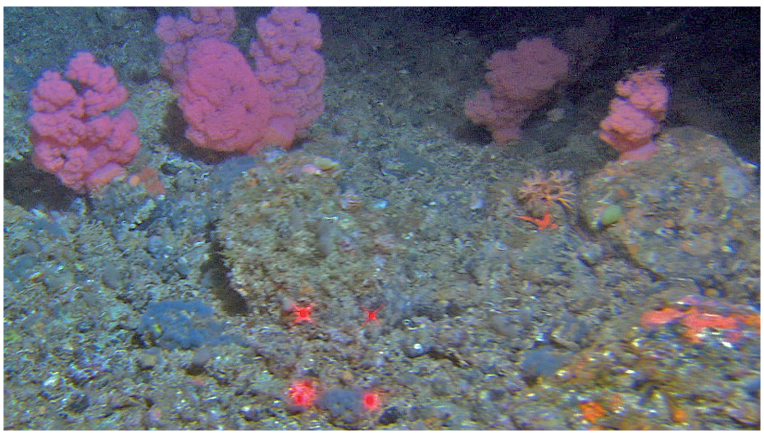


Figure 34. The broccoli coral *Drifa* sp. together with the blue colonial tunicate *Kukenthalia borealis*.

Figure 35. The broccoli coral (*Drifa* sp.) is habitat to smaller organisms. If you look closely you will see the arms of a juvenile brittle star (*Gorgonochephalus* sp.) peeking out from the back.

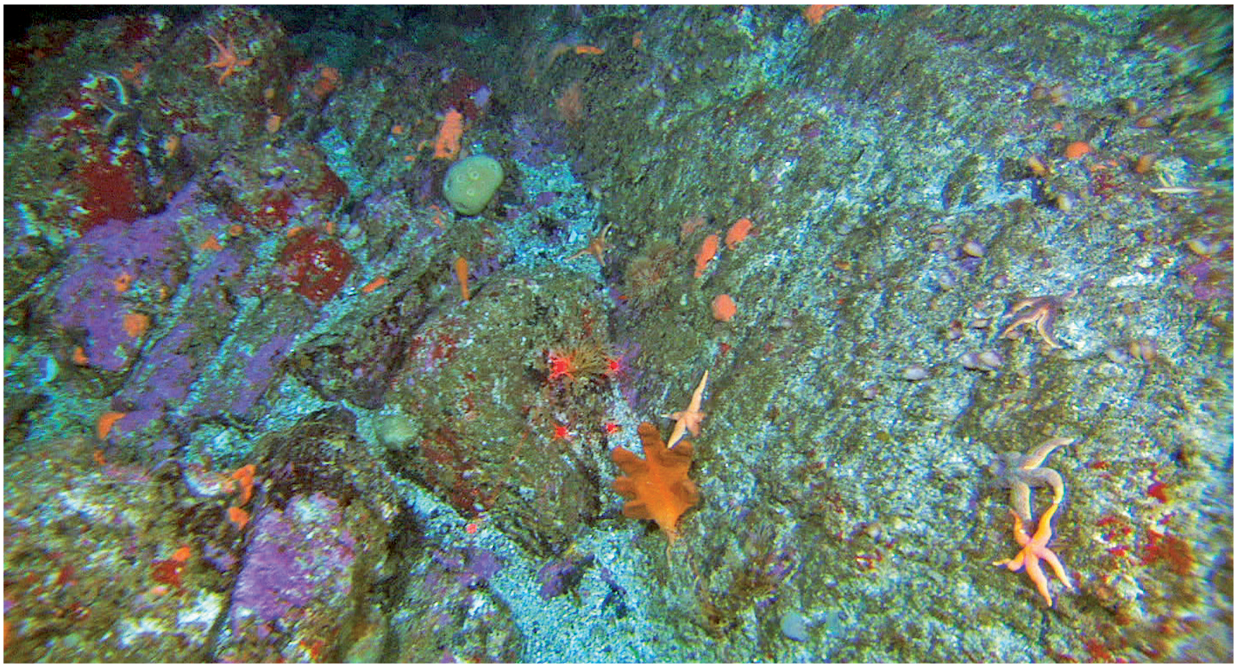


Figure 36. A colorful community including the pink encrusting algae (*Lithothamnion* sp.), together with other sessile organisms including a sponge remarkably resembling a six-fingered hand!

8.2.3 Human impacts and habitats of conservation value

The biological resources of the Barents Sea, including fish and shrimp, attract an intense fishery to what is one of the world's most nutritious and productive seas. The disturbance created on the sediment by trawling gear used by the fishing fleet leaves very visible imprints on the soft seafloor (figure 40). From these trawl marks, physical impact from fishing can be calculated. The highest densities of these marks on the seabed (over 10 per 100 metres of video transect) were observed in the eastern part of the newly-delimited Norwegian areas at the open sea (figure 41). More information on effects of fishing on benthos is provided in Chapter 10.

MAREANO has discovered new areas with slow growing and potentially vulnerable seapens at the Coast of Finnmark, especially at Varanger Fjord, and intermittently along the coastline up to the entrance of Tana Fjord. Seapens are colonies of individual or groups of polyps attached to a straight, single stalk. The polyps look like miniature sea anemones, and like them, they catch food particles from the water. Hard-bottom, deep sea sponge aggregations featuring species like *Mycale lingua*, *Phakellia*, *Axinella infundibuliformis*, *Antho dichotoma* have also been found at various locations (and varying densities)

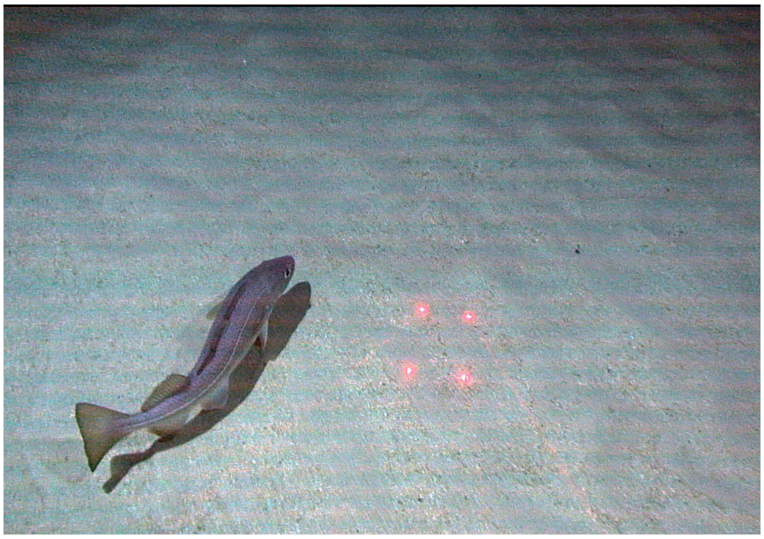


Figure 37. Sandy habitats can host a variety of free-living organisms, not least demersal fish, like the cod in this picture.

Figure 38.The bristle worm *Nothria* sp. builds tubes from pieces of shell and sand grains, and can be difficult to detect.

Figure 39. Firm substrates that allow for filter feeding organisms to get away from the bottom and into the current transporting food particles is often scarce. On a hydroid colony we found a group of the stalked cirriped *Ornatoscalpellum stroemii*.

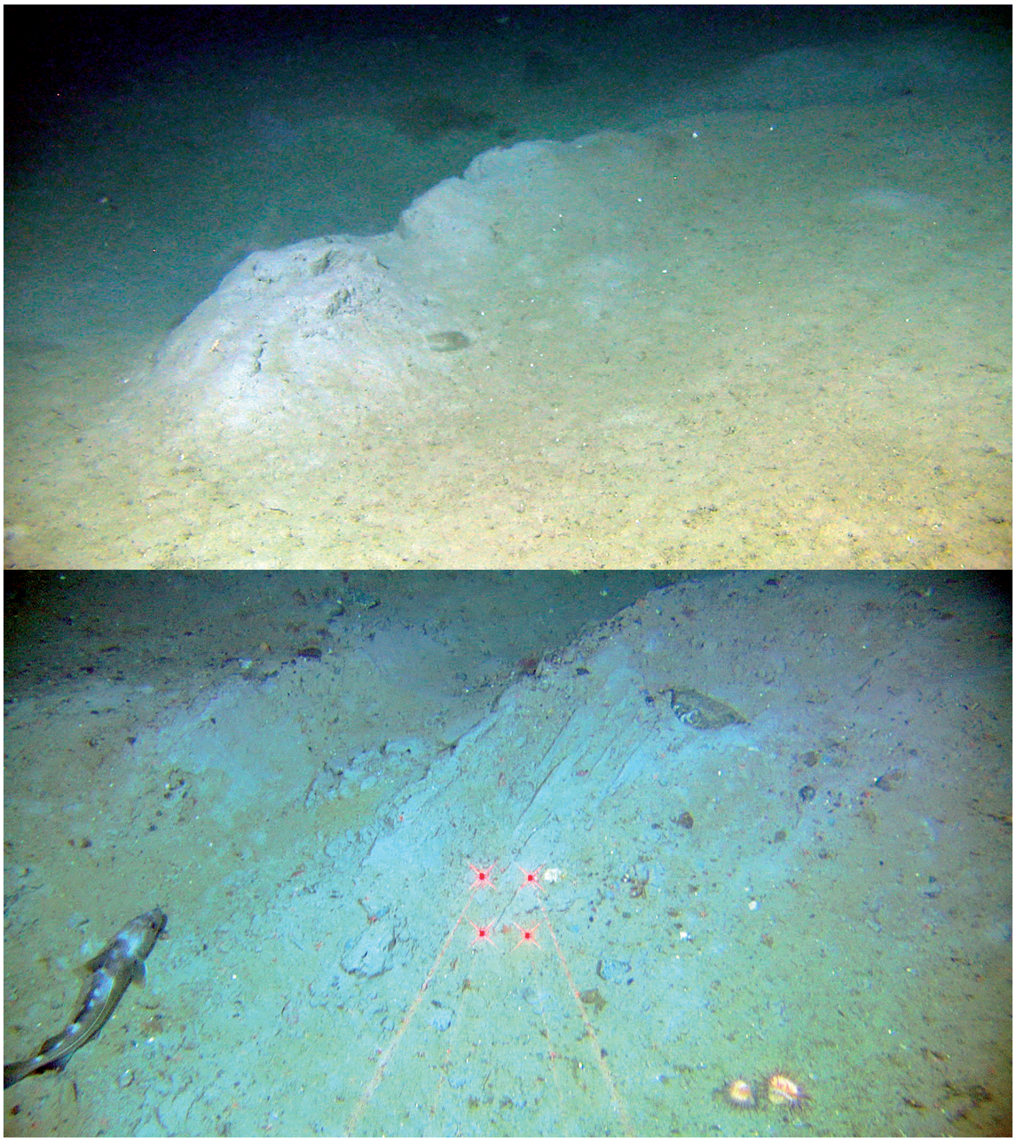


Figure 40. Trawling gear from fishing vessels can leave very deep imprints in the sediment. The more intense the fishery in the area, the more abundant these "trawl marks" are.

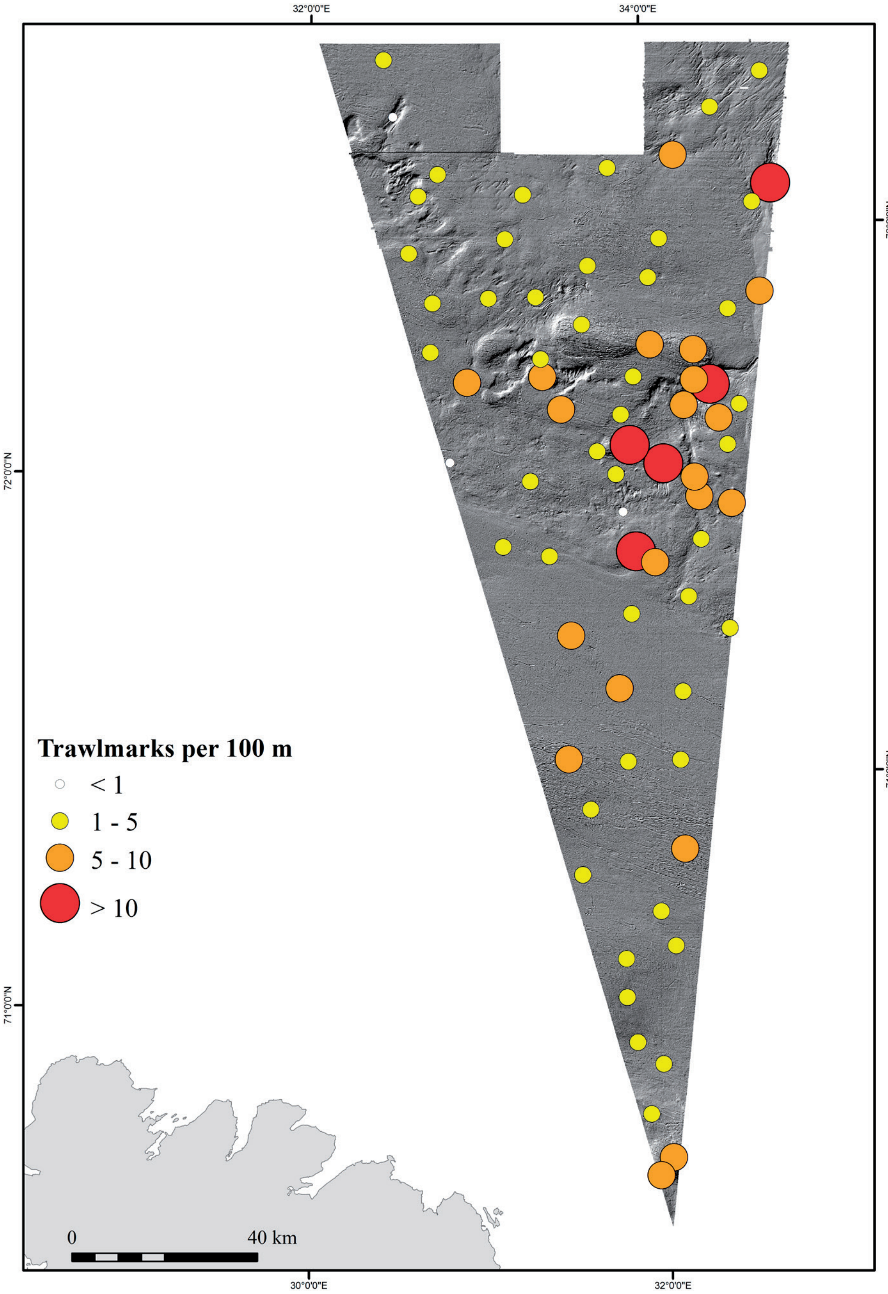


Figure 41 This map shows the distribution of trawl marks along 100 meter seafloor documented by video at the southwest Barents Sea. The background is a shaded-relief image.

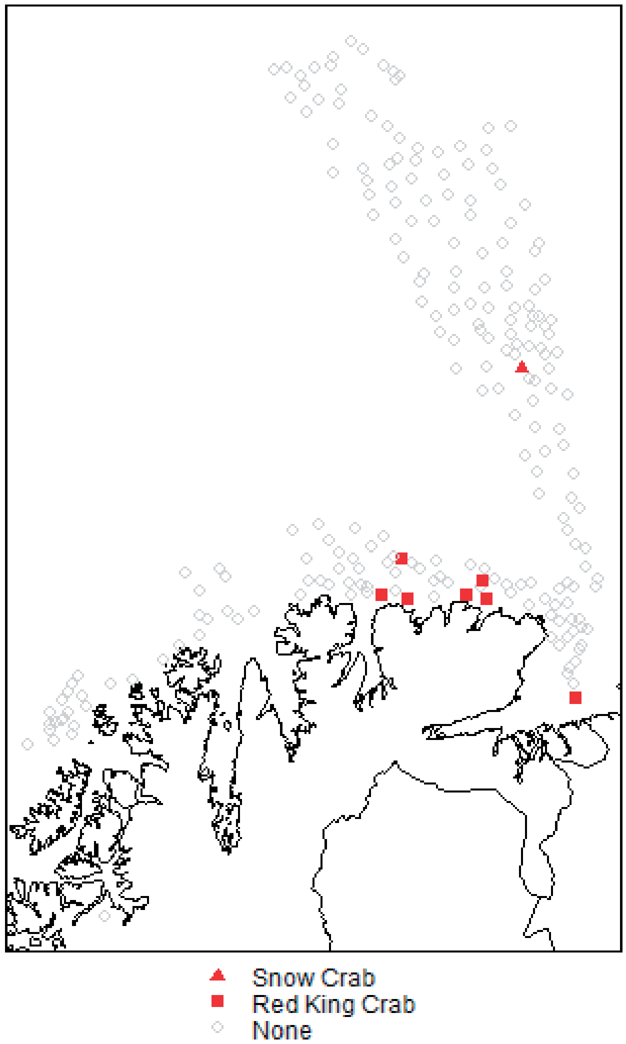


Figure 42. The map shows the locations where invasive species were observed. While red king crab was transferred to this area from the Pacific, the snow crab seems to have been introduced due to a natural increase of its distribution area.

throughout the Coast of Finnmark. Just as the deep-sea sponge and seapen communities, the rice coral population discovered here also has conservation interest, not only for being at the edge of its known distribution, but also because it is a hard bottom coral and as such, international regulations may apply. Data may prove that these "megafaunal habitats" correspond with those which have been listed by the OSPAR Convention as threatened and/or declining, and management of human activities will be particularly necessary at selected sites to ensure that no further damaged is brought to them. A serious aspect of a possible loss of vulnerable fauna is the loss of habitat for a large amount of associated fauna. The species that make up these habitats are particularly sensitive to physical impact, not least from demersal fishing, and this can also be a cause for concern.

The functions that these habitats fulfill within the larger ecosystem are as of yet poorly known, and this is an active area of research in MAREANO. We expect that these habitats will be proven to provide a wide range of ecosystem goods (e.g. fish) and services, whose loss would in turn have effects on the economy of the local communities.