

I-2011

MARINE RESEARCH TOPICS



# Revealing the secrets of the sea floor



**mareano**  
collecting marine knowledge

*The MAREANO programme  
(Marine AREA database for NOwegian waters)*



Redfish often seek shelter in coral reefs, where they have good access to food, thanks to the wide variety of potential prey.

### REVEALING THE SECRETS OF THE SEA FLOOR

For more than six years, the MAREANO programme has been mapping the sea floor off northern Norway. We have discovered a rich diversity of fauna living in a dramatic landscape of deep ravines, sandy plains and high “mountain peaks”.

This detailed survey of the sea floor was started after the adoption of the management plan for the Barents Sea and the seas off Lofoten and Vesterålen in 2005. The work on the management plan uncovered a number of gaps in our knowledge of the sea floor landscape and about the fauna and flora that live there. The MAREANO programme was designed to fill these gaps, and when the management plan was updated in early 2011, a lot of new information had been provided.

### EIGHT MONTHS OF FIELD WORK

To study the sea floor is a complex process. First, the seabed terrain is surveyed, after which detailed maps are produced. Only then it is decided which areas should be studied more closely in terms of their sediment composition and fauna. The final result is detailed sea floor maps showing the types of habitats, sediment and landscape, as well as any presence of heavy metals, organic environmental contaminants and hydrocarbons. Unique videos and samples are taken from an area normally inaccessible to us.

Every year, the research vessel “G.O. Sars” carries out several MAREANO research cruises, lasting a total of eight months. In addition to this, there is the time spent mapping the bathymetry. By the end of 2010, approximately 67 000 km<sup>2</sup> of the sea floor were mapped in the areas Nordland V–VII, Troms II–III, Tromsøflaket and Eggakanten, in the southwest Barents Sea. These are valuable and vulnerable waters with large fish resources and petroleum reserves.

### FUTURE WORK

Although the MAREANO programme has already increased our knowledge, a great deal of work remains before all Norwegian waters are mapped. The agreement reached on a permanent continental shelf boundary between Norway and Russia affects the areas that will be mapped in the coming years. Data collection in the Nordland VI area off the Lofoten Islands is being completed. In addition, work has started in the Norwegian part of the previously disputed area close to the agreed delimitation line between Norway and Russia, as well as on the banks off Finnmark. This booklet presents the results from the MAREANO programme over the period 2005–2010 by topic, with the main emphasis being 2010.

Aksel R. Eikemo  
Head of MAREANO’s Programme Group  
October 2011



Saithe are often attracted by the cones of light produced by the video rig, where they sometimes feed on small crustaceans that are also attracted by the light.

## MAREANO – MAPPING FOR THE FUTURE

Norway is a maritime nation, and our territorial waters cover an area seven times as large as the land area. In order to properly manage these extensive territorial waters, we need to know more about the sea floor. That is why the sea floor mapping carried out in the MAREANO programme is so important. It provides us with information about the physical appearance of the sea floor, and about the organisms that live there, which again may help the authorities to decide which commercial activities should be allowed and what conservation measures should be implemented in Norwegian waters.

In 2011, work on mapping the new Norwegian areas started as soon as the delimitation line between Norway and Russia in the eastern Barents Sea was agreed upon. Meanwhile, we continue to map other areas, based on scientific criteria, and the long-term goal is to map all Norwegian waters.

The MAREANO programme is providing a platform for developing a system of ecosystem-based management, and constitutes a knowledge bank for us and future generations. The data produced by the programme give a reliable baseline, allowing us to monitor changes to the sea bottom over time.

As the MAREANO data is supposed to cover our future requirements for information, it must be robust, suitable for use in a variety of fields of research, and capable of giving answers in relation to any new issue that may arise. To achieve this, highly-qualified biologists, geologists, and other technical experts are working on the MAREANO programme, and ensuring that quality is being given top priority from data collection through analysis to presentation.

The results of the programme are being used by the authorities, businesses, researchers and others who need basic information about Norwegian waters. The programme has received a great deal of international recognition, and has helped to develop a methodology for mapping the sea floor. We are proud of what have been achieved through the MAREANO programme, and we are sure that its importance will only increase in the future.

MAREANO's Steering Group  
October 2011

## 2010 – A MILESTONE YEAR

2010 was an important year for the MAREANO collaboration. In April, the results of the MAREANO programme's activities over the period 2005-2010 were presented to the Norwegian government in a joint report, produced by the technical forum, the monitoring group and the risk management group. A popular science book presenting the results in words and pictures was also produced. The book was launched at MAREANO's annual user conference, where also the results of the MAREANO programme were formally handed over to the government. All results have now been published at [www.mareano.no](http://www.mareano.no). In 2010, 17 thematic maps were updated, and 35 news stories were published.

Meanwhile, we continued to collect data and samples from new areas. In 2010, bathymetry data was collected for a total area of 7,069 km<sup>2</sup> in the North Cape corridor, the remaining areas off Troms (Troms III) and the Lofoten area (Nordland VI). In addition, Statoil provided depth data collected in 2003. Geological and biological sampling was completed in the Troms III area, started in Nordland VI, and carried out in the North Cape corridor. Consequently, geological and biological data were collected from an area covering a total of 16,000 km<sup>2</sup>.

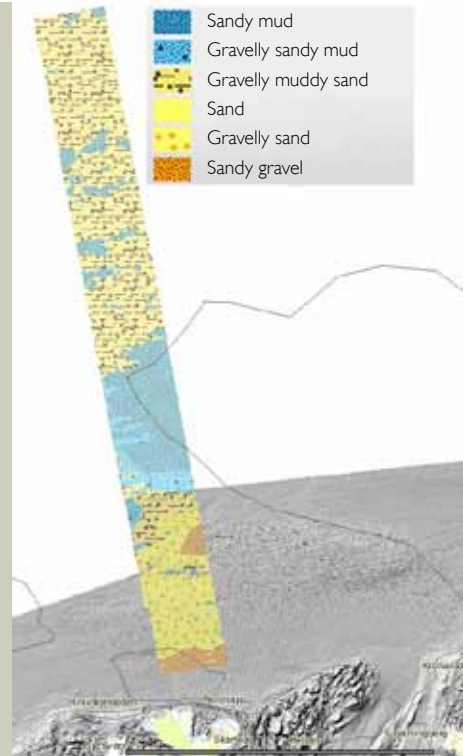
In addition to helping the Norwegian authorities by filling the gaps in their knowledge, the results from MAREANO can also be used by private companies, schools, various business organisations, etc. For example, in 2010 MAREANO started working with the Norwegian Fishermen's Association to put together detailed sea floor data for use on fishing vessels.

# The sea floor north of North Cape

Off North Cape, we have surveyed the sea floor along a 150 km corridor. In these northernmost Norwegian coastal waters, the seabed sediments, terrain and benthic fauna are all relatively uniform in comparison with e.g. the banks off Nordland and Troms. The water here is also colder than it is further south. Although we have classified the fauna as being less rich in the North Cape transect than in other areas that have been studied during the MAREANO programme, there are some species here that have not been found on research cruises further south. Based on our observations, the typical animals in this area appear to be various species of sponges, the *Ceramaster granularis* (a starfish), the *Flabellum macandrewi* (a non-colony-forming stony coral) and the “Neptune’s veil” (a moss animal).



A curled up eelpout observed in the North Cape corridor.



Off North Cape, we have surveyed a 150 km long corridor. Near the coast, the sea floor consists of gravel and sand, but approximately 50 km from land you reach an area of fine sediments. Beyond this lies the North Cape bank, which is slightly shallower. Here gravelly and silty sand dominate, and the sea floor is furrowed by iceberg plough marks, made when the ice sheet retreated around 10,000 years ago.

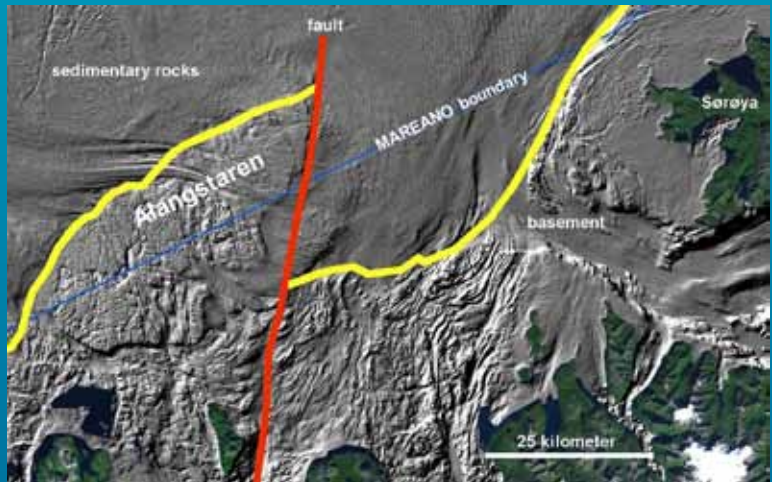


A shrimp shelters in a funnel-shaped sponge (*Phakellia*) on the North Cape bank.

The stony coral *Flabellum* on the North Cape bank.

## KELP FOREST IN THE SEA OFF FINNMAR

In most areas, the sea floor consists of soft sedimentary rocks covered by sediment. This kind of landscape is much flatter than the one we find in the coastal zone, where basement rock forms the seabed terrain. Normally, the boundary between the basement and the younger sedimentary rocks runs 5–20 kilometres from the coast, but in some places, such as Alangstaren, to the west of Hammerfest, faults have moved the boundary further out. This means that shallow areas of basement rock can sometimes be found far out to sea. Alangstaren was surveyed by MAREANO in the autumn of 2010. The video survey revealed a rich and dense kelp forest down to depths of 32 metres. As in the case of the coral reefs, which are found in deeper waters, there is a great deal of biodiversity in kelp forests. This was also observed at Alangstaren, where the most common animals include starfish and brittle stars, sea spiders, brittle worms, moss animals, sea squirts, toad crabs, squat lobsters and various species of molluscs.

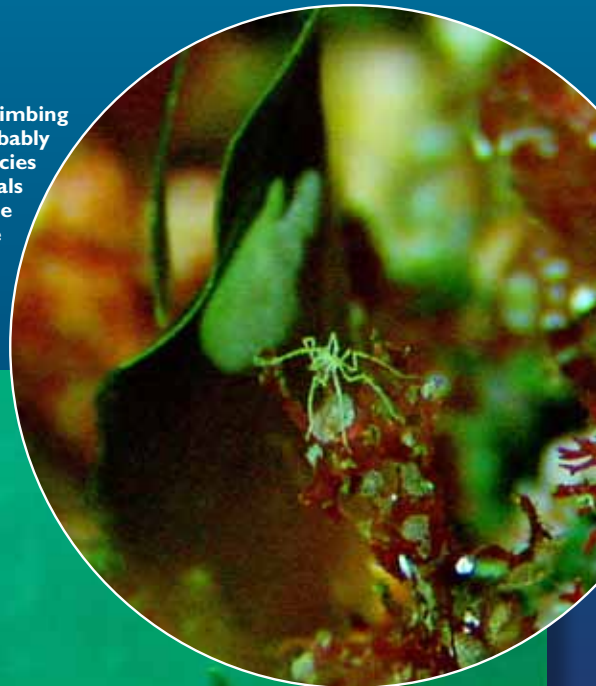


Boundary between hard basement rock in the coastal zone and softer sedimentary rock on the continental shelf (yellow line), fault (red line) and the inner boundary for the MAREANO programme (blue line).

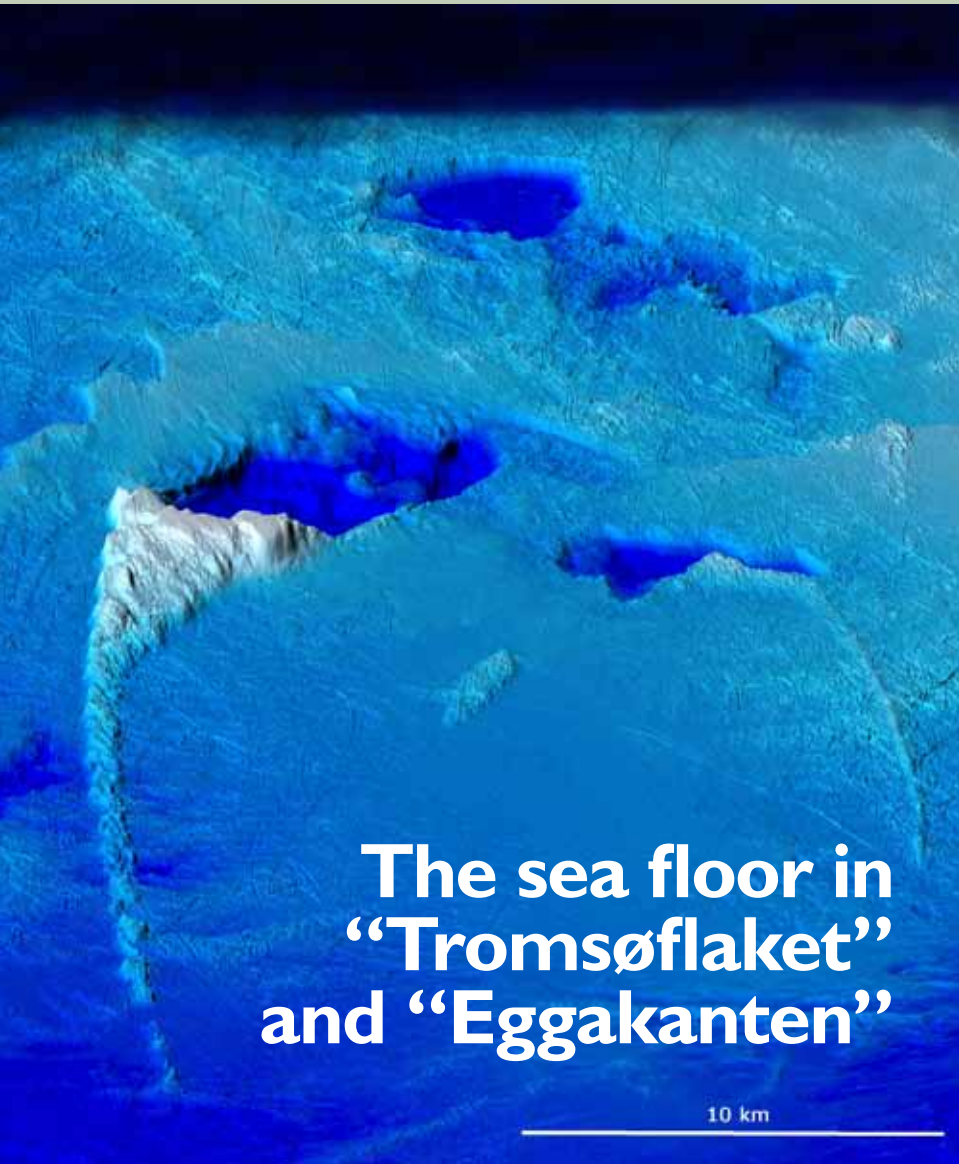


Common starfish (*Asterias rubens*). This starfish is a member of the phylum Echinodermata (“spiny-skinned” animals; echino means spine and dermis means skin).

A sea spider (*Pycnogonida*) climbing up a brown algae, probably hunting for food. Some species of sea spiders eat moss animals (*Bryozoa*), which can be seen as white spots on the algae. These sea spiders use their proboscis to suck up the prey from the moss animal colony.



In some places, the basement rock almost protrudes right up to the sea surface. Here you often find kelp forests, such as this one at Alangstaren, to the west of Hammerfest. This picture was taken at a depth of 32 metres. The white spots on the leaves of the kelp are moss animals.



## The sea floor in “Tromsøflaket” and “Eggakanten”

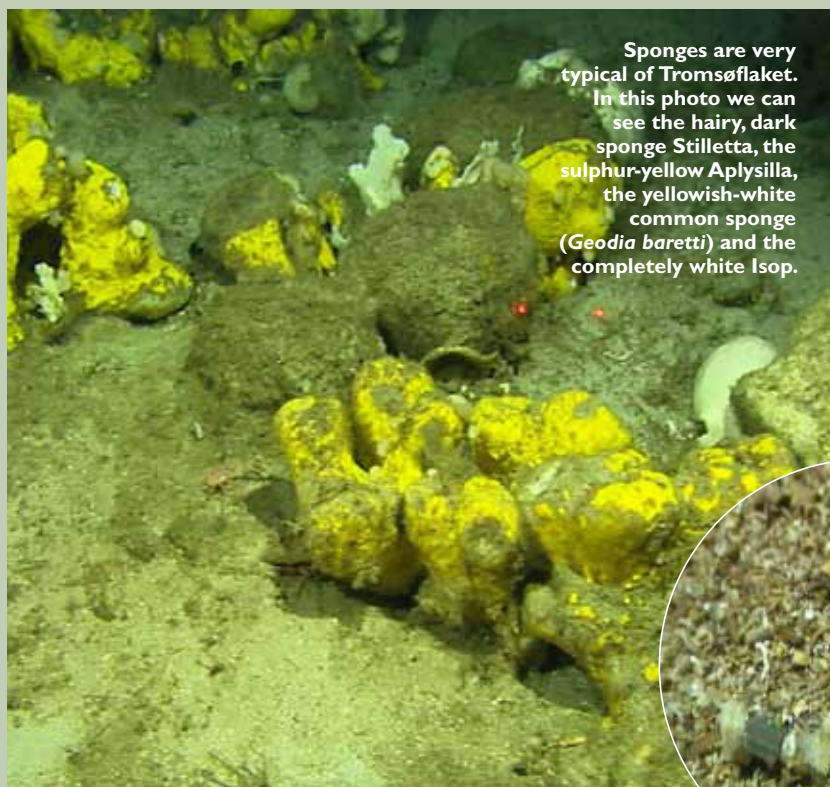
10 km

Almost 100 metres high, Steinbitryggen in Tromsøflaket was pushed up by ice masses around 15,000 years ago. The depression excavated when this happened is called Soppola. “Sopp” is the name that local fishermen use for sponges, and “hola” means depression.

*Tromsøflaket* is a shallow area of around 25,000 km<sup>2</sup>, northeast of the island of Sørøya, off the coast of Finnmark. The water depth varies between 160 and 350 metres (in the Ingøydjupet glacial trough). The shallowest parts of the area are dominated by moraine deposits, which contain everything from clay to large boulders. In the Ingøydjupet trough, the sea floor is predominantly covered in mud.

In general there is a relatively high biodiversity in Tromsøflaket, combined with a wide range of habitat types. The shallowest parts of the bank are mainly covered in sandy gravel, stones and boulders, and are best known for the many different species of sponges that abound there. So far, around 200 benthic species have been observed in the videos that were taken. Animals such as squat lobsters, prawns, hydroids, sea feathers, sea anemones and moss animals, as well as fish like redfish and saithe, thrive in a benthic environment where, in many places, sponges completely dominate the landscape. In the deeper areas with a silty sea floor, fewer than 50 species have been observed.

Six different habitat types were recorded in Tromsøflaket, each of which is associated with different kinds of dominating animals. These habitats are home to a varied and rich fauna, with more than 800 different species in this particular region of the Barent Sea.



Sponges are very typical of Tromsøflaket. In this photo we can see the hairy, dark sponge *Stilletta*, the sulphur-yellow *Aplysilla*, the yellowish-white common sponge (*Geodia baretii*) and the completely white *Isop*.



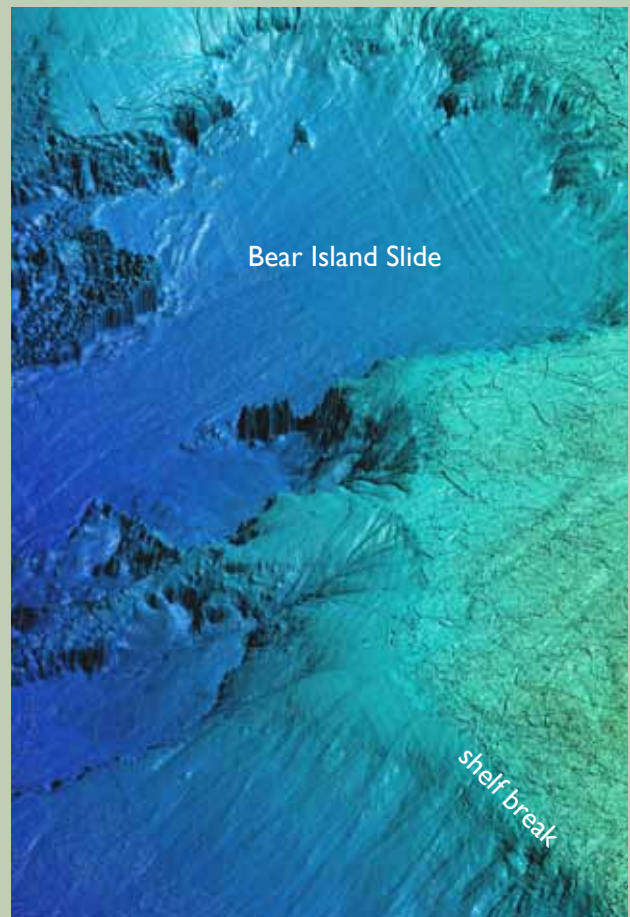
The tube-forming bristle worm *Nothria conchylega* is a predator that hunts for prey on the surface of the sea floor sediments. The species was first described in 1835 by the well-known Norwegian marine scientist Michael Sars.



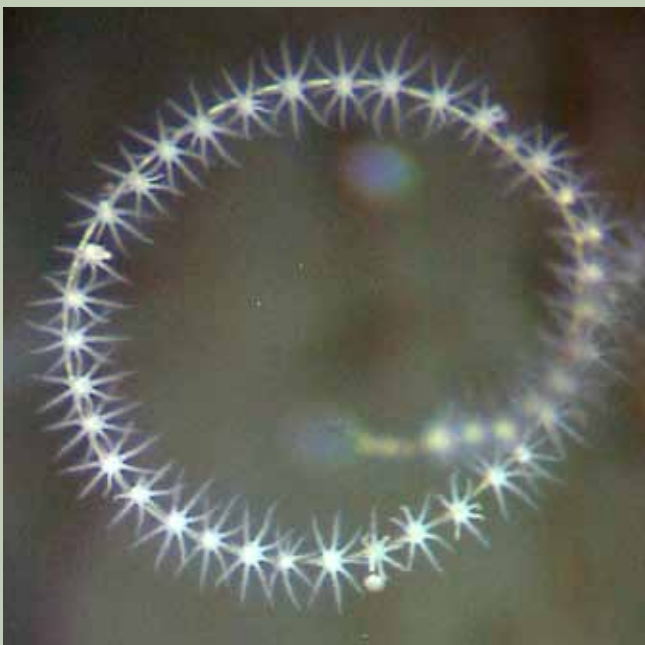
**Gorgon's head on boulder.** This is a common place to find this brittle star, which lives by filtering food particles from the water, and therefore favours raised rocky platforms like this.

**Eggakanten** is the area that lies northwest of Tromsøflaket. In Norwegian, "eggakanten" means "the shelf break" (the boundary between the continental shelf and the continental slope, which runs the whole way along the coastline). In Eggakanten, the MAREANO programme has mapped an area that stretches from the flat continental shelf over the shelf break at a depth of approximately 400 metres, and some way down the continental slope (to a depth of 1,000 metres). On the flat continental shelf there are moraine ridges and large areas with iceberg plough marks. The shallowest parts of Eggakanten are dominated by sandy sediments containing gravel, stones, and mud. In many places on the shelf, you can find large sponges alongside starfish and smaller sponges. The redfish is a frequent visitor because it can find shelter and food here. Channels cutting into the ground run from the shelf break-down to depths of more than 1,000 metres. Here, the typical fauna includes sea anemones and deepwater soft corals. In the northernmost part of Eggakanten, at depths of over 800 metres, there are significant numbers of glass sponges and a group of brittle stars known as gorgon's heads. Several of the habitats found in Tromsøflaket continue northwest into Eggakanten, but the communities of animals change noticeably as the water depth increases. Here small sponges and sea anemones predominate.

In the deeper parts of the surveyed area, at depths approaching 1,000 metres, there are a lot of small crustaceans and tube-forming bristle worms. When you get even deeper, typical fauna include gorgon's heads and a carnivorous deep-water sponge.



**At the far north of the Eggakanten area, there is a large depression created by a huge underwater landslide 200,000 years ago. The depression is home to the only known pigtail coral colony in Norway. The water depth here ranges from 400 to 1,000 metres, and the depression is around 40 km across.**

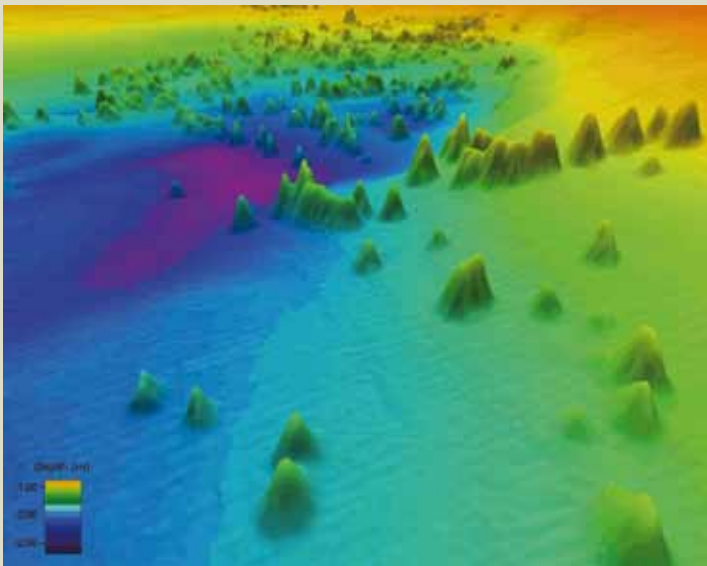


**The pigtail coral (*Radicipes*) was first discovered in Norwegian waters in 2009, and as the dominant species here it has given its name to a new, red-listed marine nature type: "softbottom coral garden".**



Coral reefs consist of both living and dead corals. The living corals are mainly found on the side of the reef facing the current, where there is best access to nutrients. In the rest of the reef, there are mainly dead corals, providing a three-dimensional “home” for a variety of small creatures.

## The continental shelf off Lofoten, Vesterålen and Troms



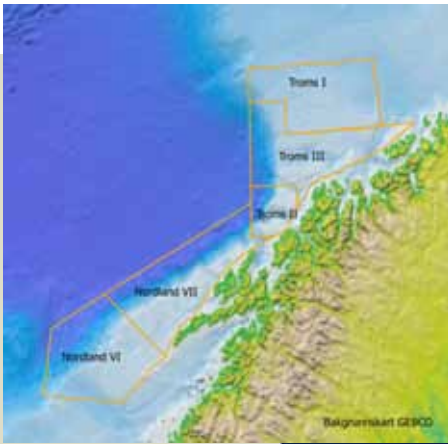
**Hola off Vesterålen.** One of the world’s biggest cold-water coral systems. The largest individual reefs are up to 400 metres long and 30–40 metres high.

The fishing banks off Lofoten, Vesterålen and Troms, are important habitats for species such as cod and halibut. The fishing banks lie on what is known as the continental shelf, which is the area between the coastal islands and skerries that fringe the coast, and the shelf break, where the sea floor starts sloping down more steeply. In this area, in Nordland VII and Troms II, it is also expected to host large reserves of petroleum; oil and gas.

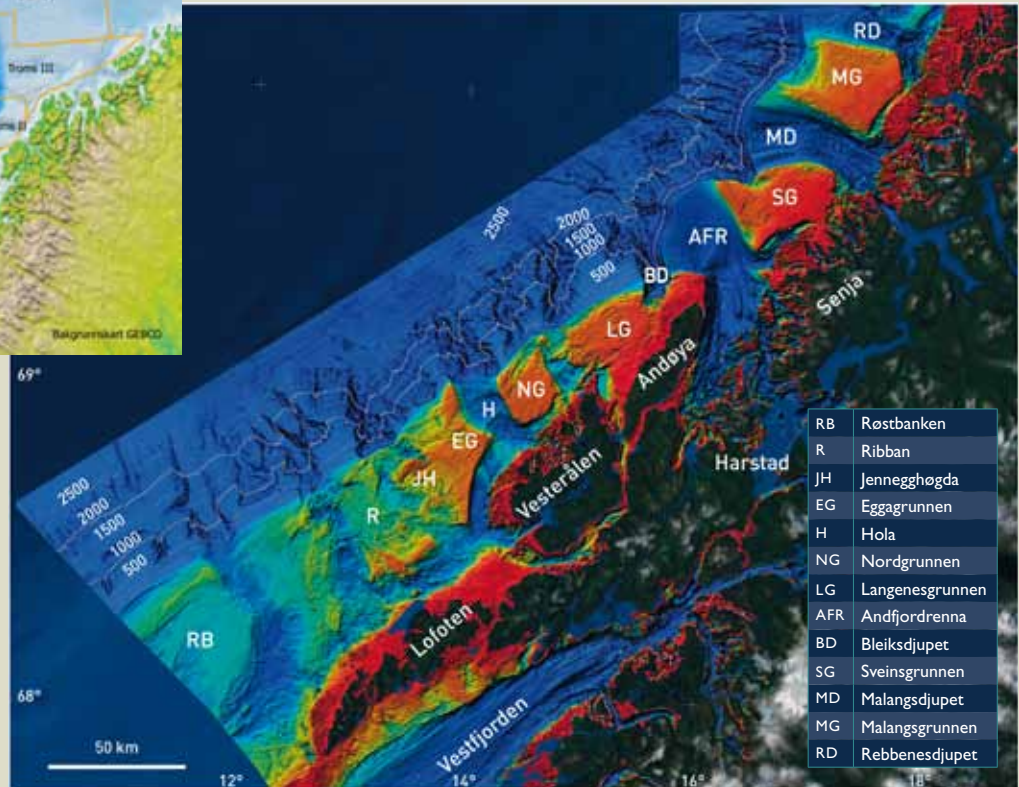
The depth of the banks varies from almost 200 metres in the case of Røstbanken in the south, to less than 100 metres for Sveinsgrunnen and Malanggrunnen, to the west and north of Senja, respectively. Between the shallow banks, there are 200–500 metre-deep furrows carved out by the retreating ice during the last ice age, where the sea floor consists of finer sediments than you find up on the banks. In the shallow waters, gravel, stones and boulders predominate, along with moraine ridges that rise up above the surrounding sea floor. This diverse landscape, alternating between sand/gravel, boulders and bedrock, provides the foundations for the rich and varied benthic fauna that you typically find on the banks off the Norwegian coast.

In some places encrusting red algae blanket the bedrock and stones. MAREANO’s videos observed algae as far down as 100 metres, which is unusual, as algae





The Norwegian Petroleum Directorate's names for some of the areas being mapped in the MAREANO programme.



Map of shallows and basins off Lofoten, Vesterålen and Troms. Note that the colour scale from red to blue only extends from 0 to 500 metres, in order to highlight the structures on the continental shelf.

require light in order to grow. The algae provide biomass and help to increase the productivity of the sea floor.

Biodiversity is particularly great in areas with reef-building, cold-water corals, which are found in several places on the continental shelf off the coast of Nordland and Troms, and provide a habitat for many different forms of life. The reefs are built up of both living and dead corals.

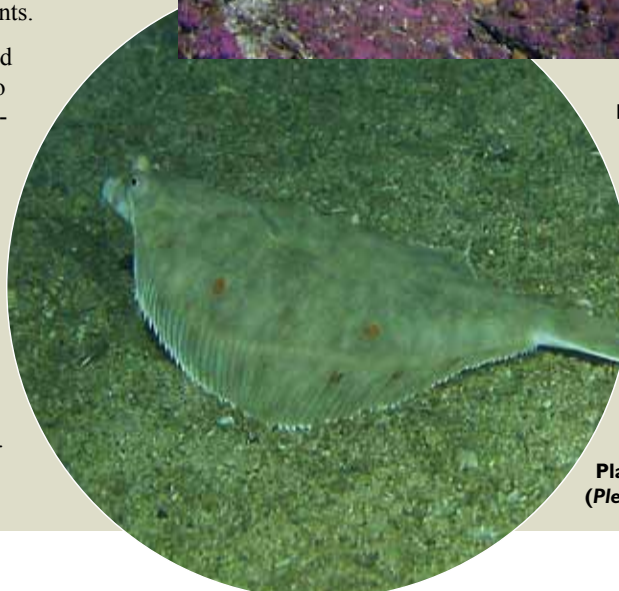
Between 20 and 60 kilometres northwest of Lofoten, the Ribban area is found. Here, ridges and depressions run in various directions, creating an unusual landscape.

Outside Lofoten, there is normally a 50–200 metre layer of sediments on the sea floor. However, at Jennegghøgda, the basement rock protrudes through the floor, rising up to between 50 and 100 metres below sea level. This provides a completely different environment for organisms living on the sea floor: hard rock, along with sand, gravel, stones and boulders, instead of soft sea floor sediments.

In the channel between Fugløybanken and Nordvestbanken, off northern Troms, two long coral reefs have been found. In addition to these two major reefs, numerous small coral reefs are scattered around the area. Here there is a strong current, and the sea floor consists of sand, gravel and stone, making the environment highly reminiscent of the one found in the areas rich in coral reefs off Vesterålen. In comparison with the surrounding flat seabed, the reefs off northern Troms teem with animals, including lots of fish, particularly redfish.



The hard basement rock protrudes through the sea floor at Jennegghøgda, so organisms that like hard sea bottoms thrive there.

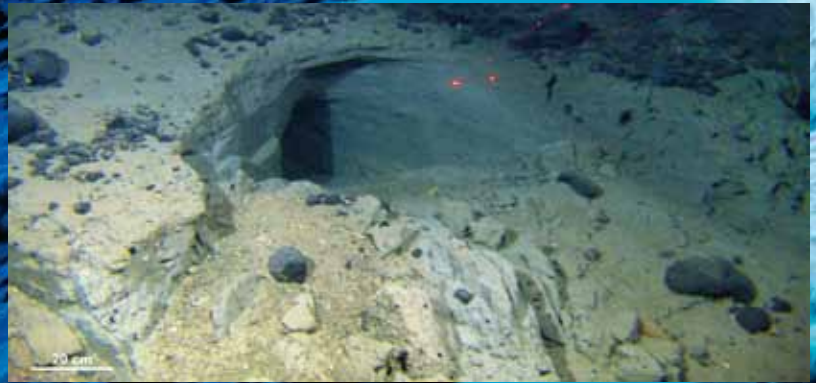


Plaice (*Pleuronectes platessa*).



The continental slope is rich in fauna, often being dominated by dense colonies of deepwater soft corals, gorgon's heads and sponges. There is less biodiversity in the middle part of the slope.

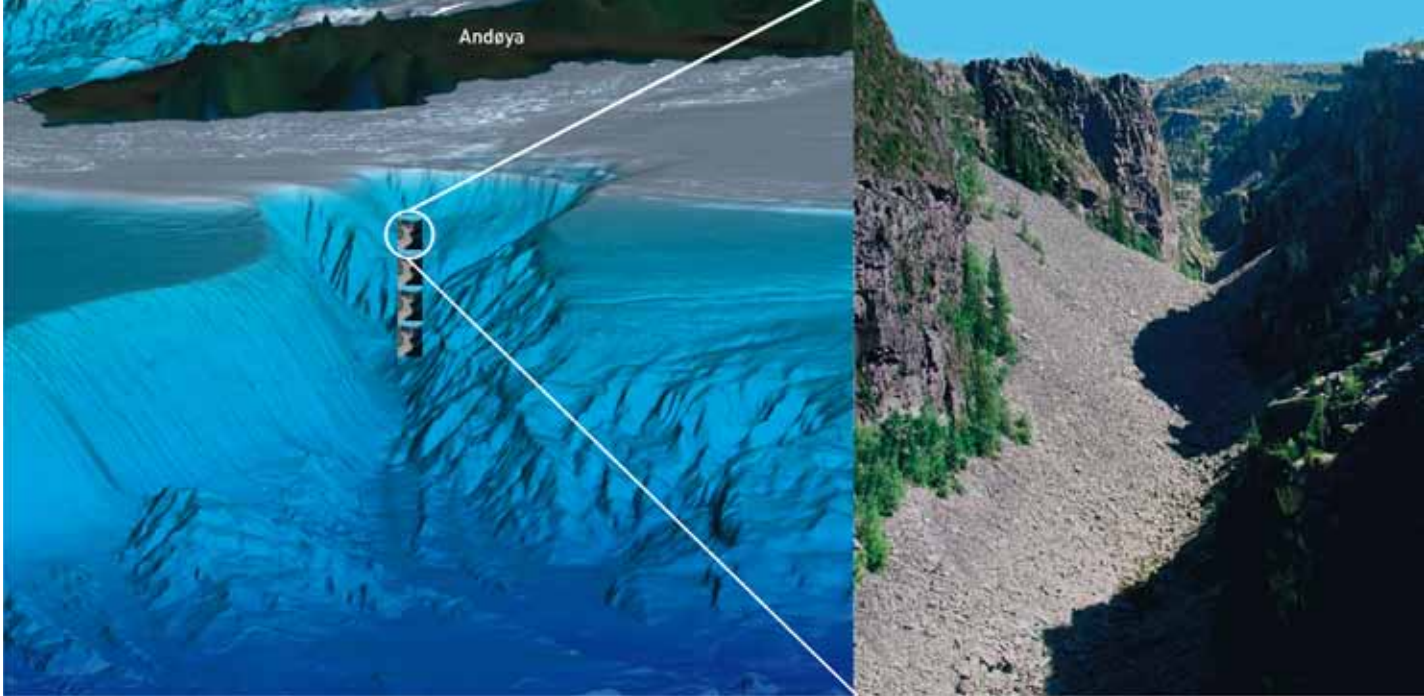
In some places we have found holes on the sea floor. Bacterial coatings on stones in the vicinity suggest that they may have been created by gases or liquids from deeper layers seeping out the sea floor.



Towards the bottom of the continental slope, i.e. at water depths of 1,000–2,400 metres, where the water temperature is below 0 °C, typical species include stalked sea lilies (pictured), starfish, glass sponges and sea cucumbers. Tube anemones are one of the most common groups of animals below 1,300 metres.



As you approach depths of 3,000 metres, there is little access to food from shallower areas, and the water is cold. As a result, there is generally little fauna.



**Bleiksdjupet off Andøya is up to 1,000 metres deep, or four times as deep as Jutulhogget, a canyon between the Østerdalen and Rendalen valleys in Hedmark. Source for Jutulhogget: Wikimedia.**

# The deep sea off Lofoten, Vesterålen and Troms

Beyond the shelf break, to the west of the continental shelf, lies the deep sea. From the shelf break, at a depth of approximately 400 metres, the sea floor slopes steeply down to the abyssal plain, approximately 2,000 metres below the surface. This slope is called the continental slope.

The continental slope off Lofoten, Vesterålen and Troms, which is just over 300 kilometres long, is furrowed with canyons of all sizes. The biggest one is called Bleiksdjupet: it is almost 10 kilometres wide, 30 kilometres long and 1 kilometre deep. The canyon cuts into thick layers of sediment and sedimentary rocks, and at the bottom of the canyon there is a channel that continues far out onto the abyssal plain. The slope off Lofoten, Vesterålen and Troms is the only place in Norway where you find these big canyons.

Below the continental slope you reach the abyssal plain, where in many places you can find deposits of sediments transported down through the canyons and out

onto the plain. These are deposited in a fan shape, not unlike avalanches. The materials deposited by past landslides, including large boulders, cover large areas of the abyssal plains.

These materials are now covered in gravel, sand and silt. At first sight they are not home to much fauna, but when we take samples of the mud on the sea floor during MAREANO research cruises, we always find large numbers of burrowing organisms not visible in videos showing the surface of the sea floor. These “invisible” organisms, collected using a specially designed grab, are very important to our understanding of the overall biodiversity on the sea floor. This biodiversity is often used to judge the marine environment’s “state of health”.

**Swimming sea lily at a depth of 2,311 metres.**



**A deep-water sea cucumber (*Elpidia* sp.). In Norwegian it is often referred to as a “sea pig”.**



As the water depth increases down the continental slope, the food available to the animals living on the sea floor changes. There is no light at these depths to allow algal production, while the temperature and terrain change. One of the important characteristics of the slope is the significant fall in temperature with increasing water depth. At the sea surface, the temperature is around 9–10 °C, whereas it is -1 °C or colder when you get below 1,000 metres. The change in temperature affects which species you find at different depths. The clearest boundary exists at approximately 700 metres, where the temperature is around 0 °C, but at approximately 1,000 metres there is another clear change in the composition of the benthic communities.

Organic materials from the highly productive shallow banks are continuously transported over the shelf break and down the continental slope to deeper and less productive areas. The animals living towards the bottom of the continental slope and on the abyssal plain, are dependent on these food particles being transported down from the banks.

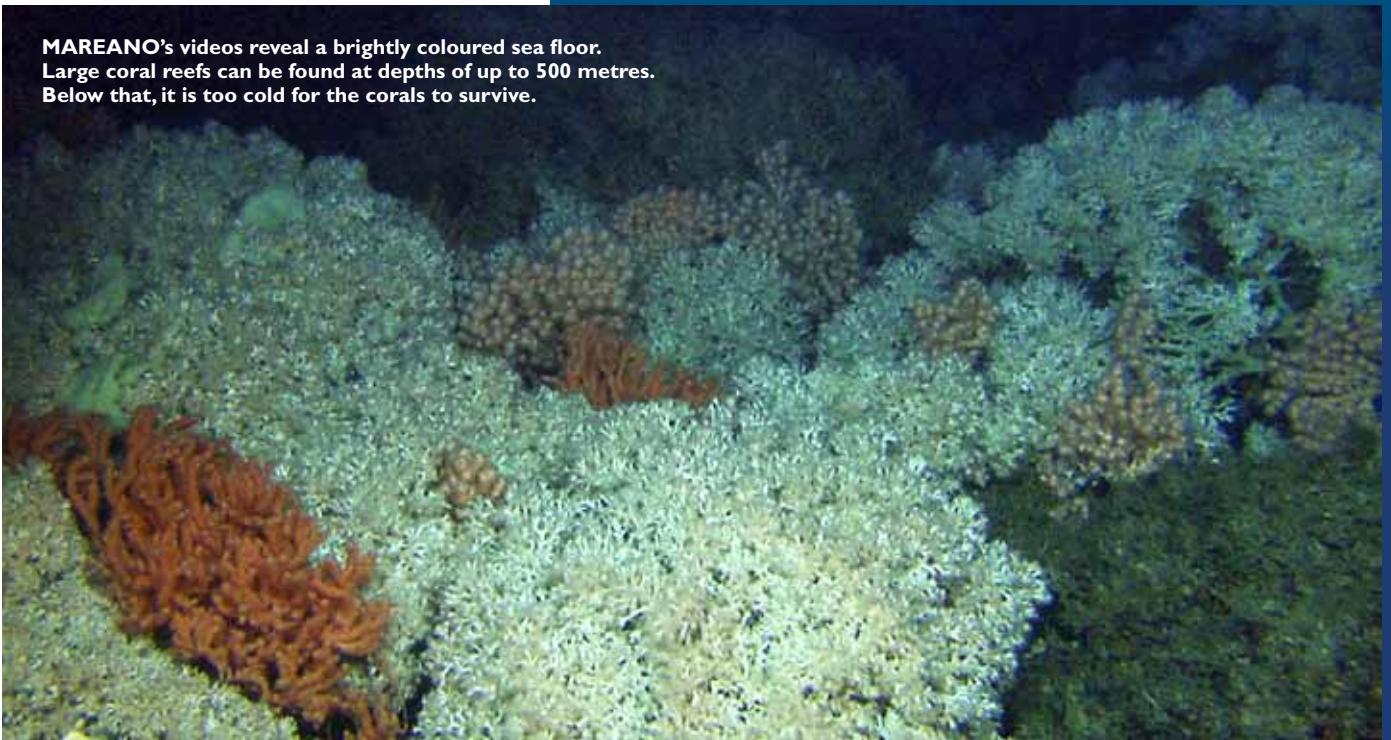
## RØSTRETVET – SEVERAL HUNDRED CORAL REEFS

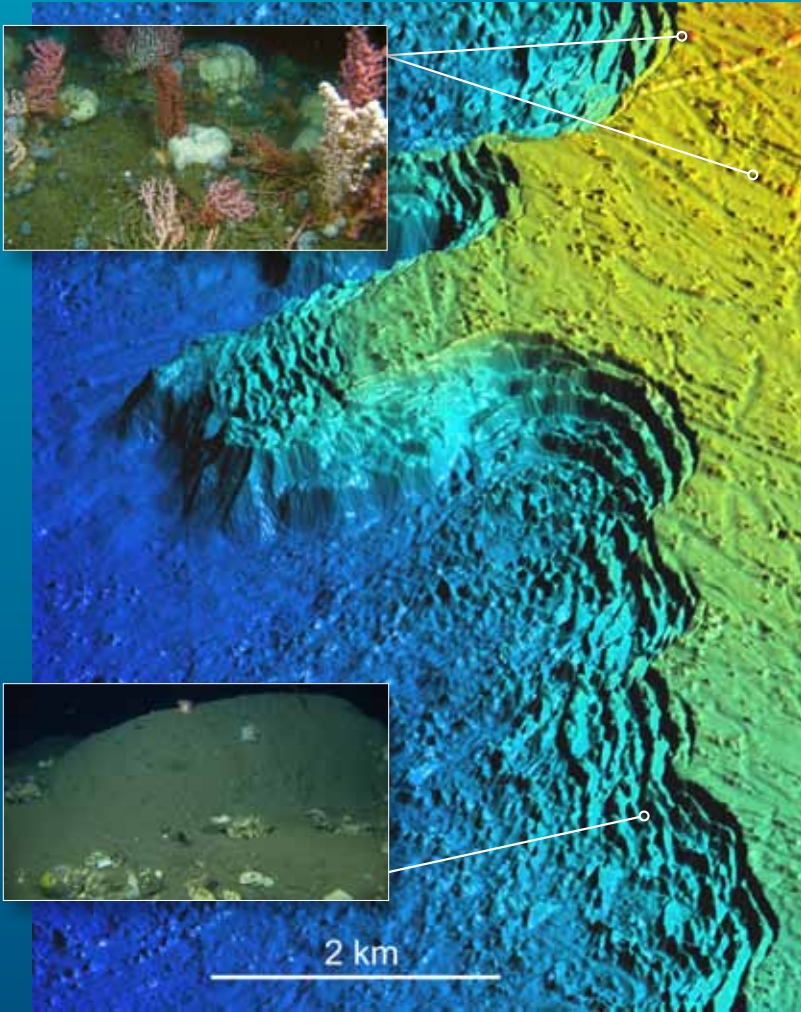
At the edge of the continental shelf, approximately 100 km west of Skomvær, lies Røstrevet, the world's most famous coral system formed by the cold-water coral *Lophelia pertusa*. Røstrevet is situated at the outer edge of the Trænadjupet basin. Here the shelf break coincides with the back edge of the major Trænadjupet slide. The "steps" just below the shelf break are made of large blocks left by the landslide.

There are coral reefs both on the flat shelf in the outer part of Trænadjupet and on the slide blocks in the upper part of the slide. On the continental shelf, the coral reefs look like small mounds. These mounds are often found along the edge of elongated depressions, which are plough marks from drifting icebergs around 10,000 years ago (see the 3D model of Røstrevet on p. 13). At the top of the slide blocks, corals, sponges and other organisms are abundant. The slide blocks provide a good foundation for them, and the rough terrain protects them against trawling.

On the slope beyond Røstbanken, which in Nordland VI goes down to 2,100 metres, much of the sea floor consists of materials deposited by landslides, including occasional large blocks made of compact mud. Communities of glass sponges, stalked sea lilies, tube anemones, and gorgon's heads are found in many places.

**MAREANO's videos reveal a brightly coloured sea floor. Large coral reefs can be found at depths of up to 500 metres. Below that, it is too cold for the corals to survive.**



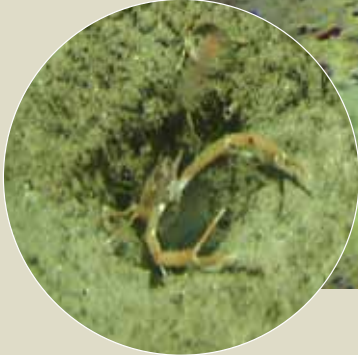


Shrimps and other crustaceans often climb up vertical organisms in order to gain height when hunting for drifting food particles.

A huge underwater landslide 4,000 years ago created a dramatic underwater landscape, which provides a good environment for corals and protects them against trawling. The landslide started at the shelf break on the right of the photo (depth: approximately 390 m), and moved to the left (maximum depth: 600 m). Note the "steps" formed by large slide blocks on the slope. The small mounds on the right of the photo are coral reefs.



Coral forest below Røstrevet consisting of the deep-sea coral *Primnoa resediformis*; in the background, a redfish can be seen.



**MAREANO's videos from Troms III were recorded shortly after the area had been trawled, and show that the mud on the sea floor whirls up into the water, before settling and covering the sponges on the seabed. The disturbed mud also seems to damage the holes inhabited by the (often numerous) squat lobsters. Moreover, the videos show few signs of animal life in and around the trawl tracks.**

### IMPACTS OF HUMAN ACTIVITIES

Human activities can affect the ecosystems on the sea floor. In the MAREANO programme, we have particularly studied the impact of fishing activities, while also documenting levels of long-range pollution in the sea floor sediments.

#### *Trawl marks*

Analyses of the videos taken during the MAREANO research cruises reveal that trawl marks on the sea floor are common in the Barents Sea. At 93 % of the locations filmed in Troms III during summer 2010, trawl marks were found. This is not unexpected, as bottom trawl is widely used in the fisheries, but this is the first time that the density of trawl marks has been systematically documented over such a large area.

In general, we know little about what harm is caused to benthic communities by bottom trawling. However, we know that animals such as corals, sponges and sea pens can easily be hurt by trawling. Several institutions are currently doing extensive research in an attempt to develop types of trawls with less impact on the benthic environment than current equipment.

#### *Pollution*

During MAREANO research cruises, samples are taken to measure levels of heavy metals and organic environmental pollutants in fine sediments. In the surface sediments, levels of



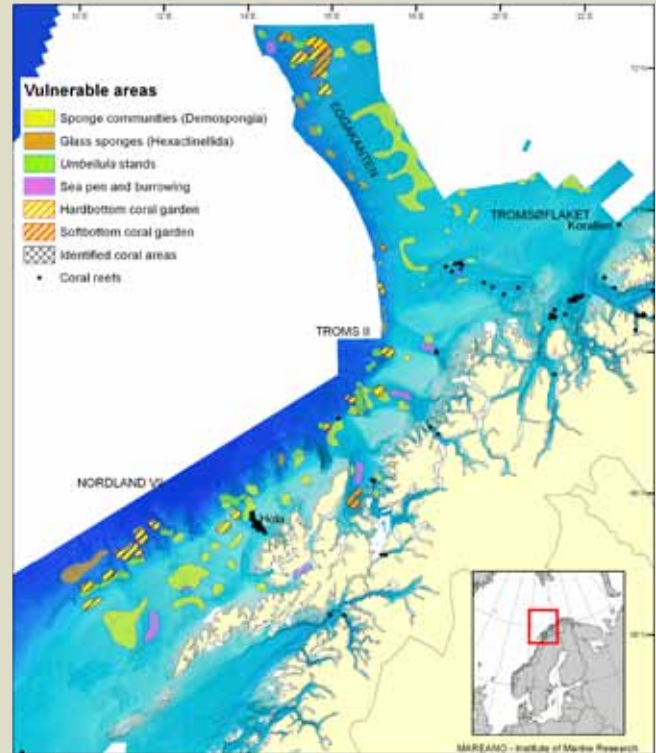
**Three of the seven newly discovered coral reefs in Troms III have suffered visible damage.**

heavy metals are generally low, although levels of lead and nickel are elevated in some places. In the case of nickel, this is due to natural variation. Core samples taken from the sediments, reflecting pollution over the past few centuries, reveal that mercury and lead levels have risen slightly from their natural background levels around the mid-19<sup>th</sup> century.

PAH (polycyclic aromatic hydrocarbon) and THC (total hydrocarbon content) levels are low, being at or close to background levels. Just south of Svalbard, sediments were found with elevated PAH, THC and arsenic levels. This is a natural phenomenon, and is due to the fact that the sediments have been formed by the erosion of coal seams on Svalbard.



**In order to investigate what substances are found naturally on the sea floor and if there is any human pollution, sediment core samples are taken. After the end of each research cruise, these are chemically analysed.**



**Vulnerable habitats observed during the MAREANO programme.**

### **VULNERABLE HABITATS**

As the sea floor around Norway has never previously been mapped as thoroughly as it has in the MAREANO programme, there has been a lack of knowledge about the biodiversity and types of habitat found there. Some of the current work involves defining offshore habitats. As we study the videos and analyse the samples taken from the sea floor, we find that some of the habitats and species encountered are defined as vulnerable according to international standards.

So far, eight vulnerable habitats have been identified. They all have in common that they are either threatened or home to key species that are in decline, including rare species in unique natural environments. For example, there is only one known pigtail coral colony (*Radicipes*) in Norwegian waters. It has been observed in parts of the Bjørnøya landslide in Eggakanten, where it constitutes a key species in a vulnerable habitat.

## COLLABORATION AND ORGANISATIONAL STRUCTURE

The MAREANO programme is a collaboration between The Institute of Marine Research, the Geological Survey of Norway, and the Norwegian Hydrographic Service. The three agencies have relevant specialist expertise, and together they form the executive group responsible for planning and implementing day-to-day activities. Overall operational responsibility lies with the Programme Group, led by the Directorate of Fisheries. The group includes representatives of the Norwegian Directorate for Nature Management, the Norwegian Polar Institute, the Norwegian Petroleum Directorate, the Climate and Pollution Agency, the Coastal Administration, The Institute of Marine Research, the Geological Survey of Norway and the Norwegian Mapping Authority Hydrographic Service. A Reference Group with an advisory role has also been established. The Steering Group, which is the highest authority in the programme, has representatives from the Ministry of Fisheries and Coastal Affairs, Ministry of the Environment, Ministry of Trade and Industry, and Ministry of Petroleum and Energy. MAREANO is financed by these ministries through the national budget. In 2011, NOK 96.4 million has been allocated to MAREANO.



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