SURVEYING THE OCEANS – HOW WE STUDY THE SEABED

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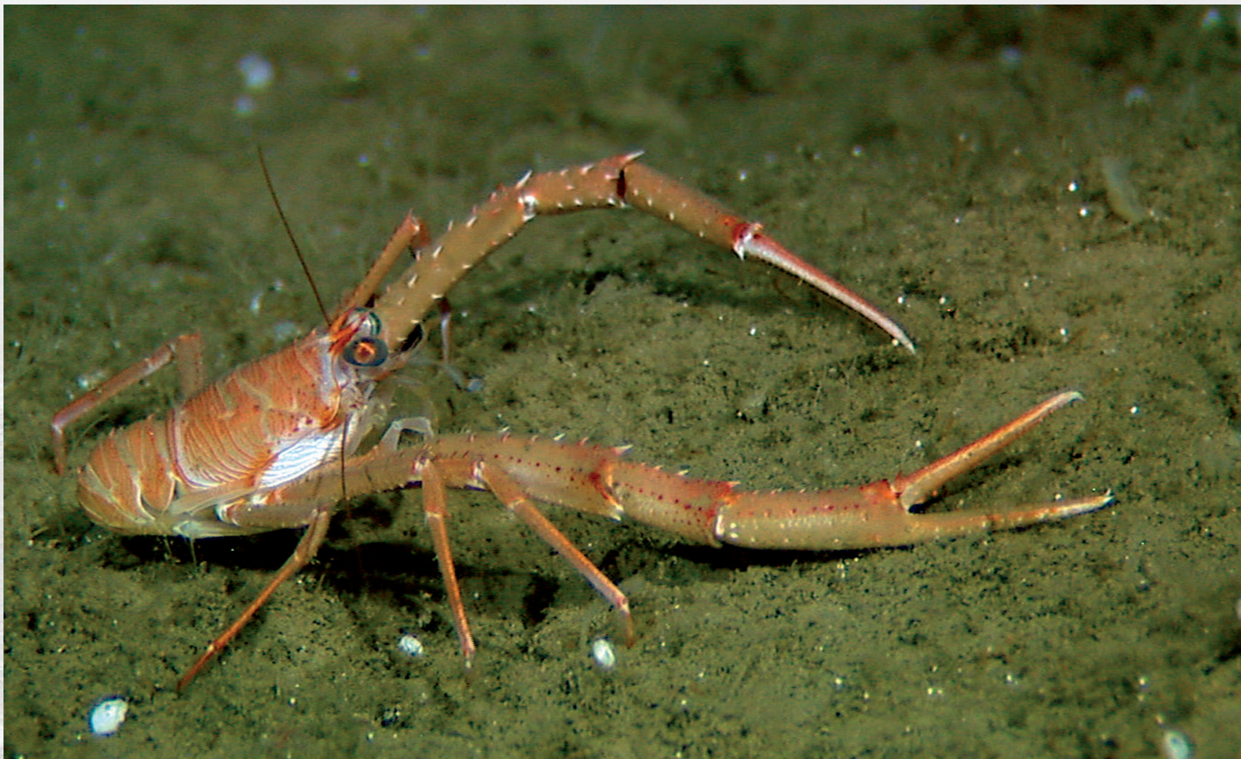


Figure 1. Squat lobster – *Munida sarsi.*

500 metres below the surface in the Eggakant area, midway between Tromsø and Bear Island: from the opening of its burrow under a rock, a squat lobster (figure 1) is hunting for shrimp and other creatures shooting past along the seabed. Suddenly an unusual light appears from above, clearly something different than the tiny amount of light that normally reaches these depths. The light gets closer and closer, becomes uncomfortably bright and ... thump ... hits the ground right next to the rock, where it stirs up a cloud of sand. The lobster retreats far into its burrow. It cannot see what goes on outside but the light seems to be looking for something, moving back and forth around the rock. Thirty minutes later the light finally takes off, stirring up another cloud of sand. Slowly it moves away as the sand settles on the bottom again and the usual darkness swallows up the little rock.

2.1 SEARCHING FOR THE SECRETS OF THE OCEANS

MAREANO, the Two-stage Rocket

The ocean depths present us with extraordinary dimensions, vast unexplored areas and the impression of an immense, infinite expanse. In that sense, the exploration of the sea can be compared to space science. Roughly speaking, MAREANO maps the seabed in the same way that NASA studies Mars. Just like NASA starts by sending a spacecraft in orbit around the planet, we send out ships to investigate the seabed from the surface. Based on the collected data, detailed maps are drafted, which then become an important basis for the next stage: direct observations on the planet – or the seabed. Space scientists send out unmanned landers, while MAREANO explores the seabed using video cameras and other sampling gear.

For space scientists, distance is a major challenge. For MAREANO, visibility is the main difficulty. How can we produce maps of the seabed through thousands of metres of dark water? Our methods are not as complicated as they may seem. The instruments work according to the same, simple principles that seamen have followed for centuries.

A Way out of the Fog

Hustadvika off Møre, a summer afternoon in the mid-50s: the fishing vessel, *Neptun*, is on its way south when it hits a wall of sea fog. The skipper decides to turn back towards Kristiansund but a few minutes later *Neptun* is caught in the dense fog. Within minutes, all sight of land and the numerous rocks in the area has gone. The trip back will be difficult, as navigation by radio (or DECCA) is impossible this close to land.

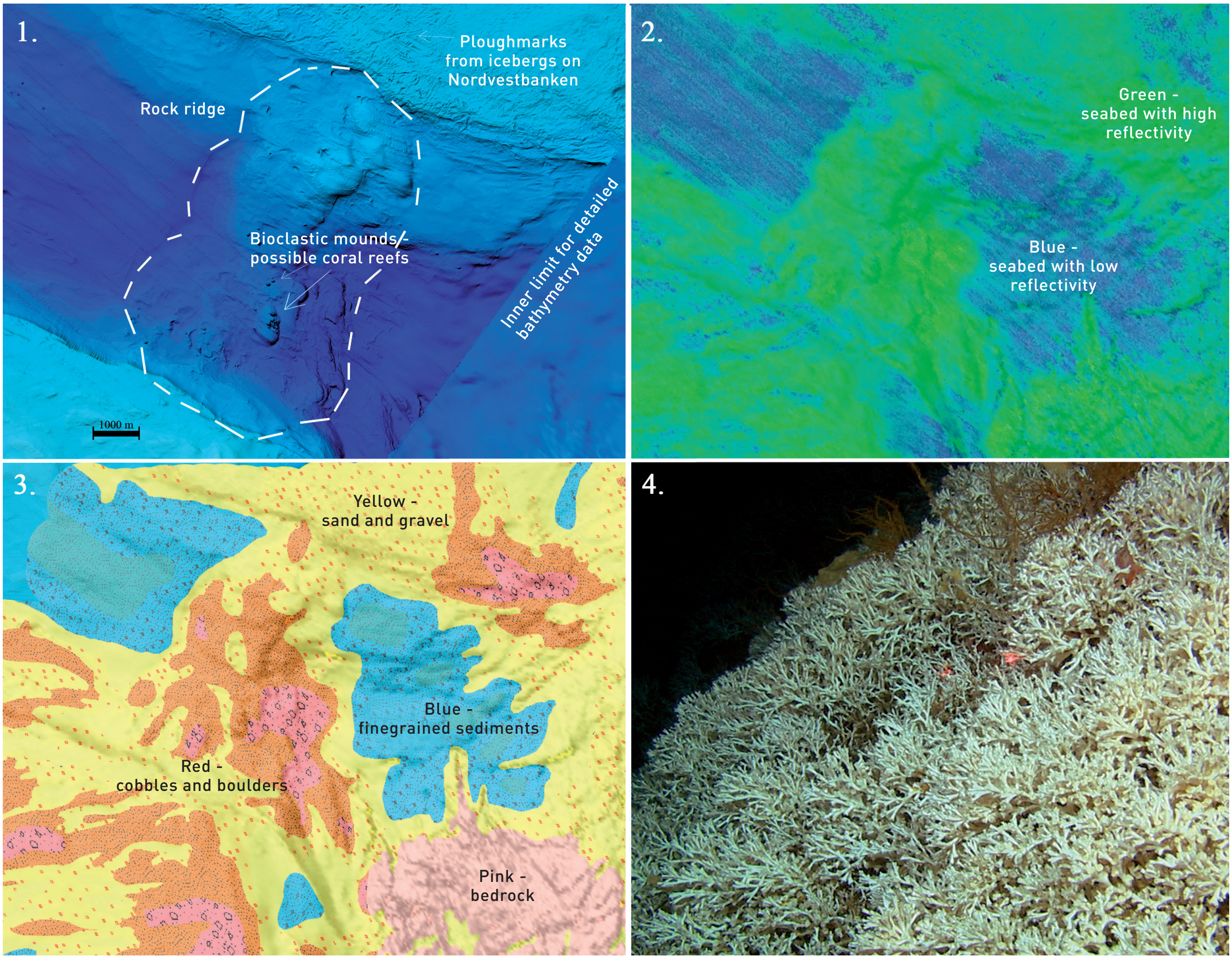
All the crew are called on deck. Little can be seen through the fog but the crew listen out for waves lapping around the ship. Some of them hear the surf hitting land far away, out to starboard. From the port side, others hear the repeating whistles of *Hurtigruten* (the Coastal Express) moving south, guided through the fog by its radar.

After a while the anchor is lowered and the engine stopped. The fog is still thick but on deck the men can still hear echoes from the cliffs on all sides. *Neptun* is in a narrow bay. Protected from the open ocean, the men can go to bed knowing that the ship is safe until the fog lifts.

A Little "Ping" in the Sea

When a sound wave hits a surface, part of the sound is reflected back to where it came from. The crew on *Neptun* knew this and today ships

Figure 2. Launching the MAREANO video rig.



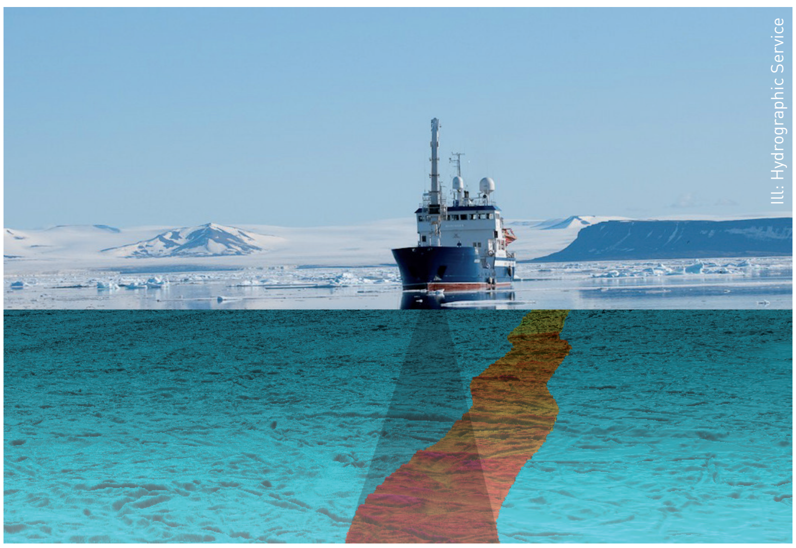


Figure 4. The exploration of the Malangsrevet:

1: An elevated area appears on the terrain model. On a ridge, there are several mounds that may indicate coral reefs.

2: Further analysis of backscatter data from the multibeam echo sounder indicate a hard seabed on the ridge.

3: The map of seabed types shows a seabed covered in cobbles and boulders. Seismic data and core samples indicate to the geologists that they are looking at sedimentary rock covered by a thin moraine layer.

4: Corals are discovered on video recordings of the seabed. The knowledge gained from this observation can be used to evaluate whether there may be corals in similar terrain in other places.

Figure 3. The Hydrographic Service's ship *Hydrograf* during a mapping survey in Svalbard.

still make use of the same principle. We have radars ”listening” for rocks and approaching ships and GPS devices ”listening” to radio signals from satellites. To assess depth we use echo sounders. But the echo sounders have developed a lot since *Neptun*’s days.

All echo sounders measure the time a sound – or a ping – takes to travel from the seabed to the surface. In the mapping of the Barents Sea, MAREANO utilises so-called multibeam echo sounders. They send pings out in a fan shape in order to map a wide belt of the seabed (figure 3).

After several weeks at sea, we head back to shore where we make a three-dimensional model based on all recorded spots of the seabed. On the screen, we can ”fly” around in the model almost like in a computer game. From this model we also produce images detailed enough to spot any formation bigger than five meters.

A Stone Ridge Beneath the Surface

17,000 years ago on the continental shelf off Ringvassøya in Troms county: the ice is receding all over the northern hemisphere. Within 500 years, the ice that has been weighing Scandinavia down for thousands of years has retreated from the shelf edge to the coastline. But then the glacier starts growing again. Over a few decades it pushes back out to the fishing banks, Malangsgrunnen and Nordvestbanken. Was the retreat just another of those brief warmer periods that have appeared during the 100,000 year long Ice Age?

The two banks are separated by a trough – a slightly deeper underwater valley carved out by massive glacier erosion. In the eastern part of the trough, there is a ridge of hard sandy rock where the glacier stops and starts rubbing against the ridge. It struggles to climb the hill. For years it stays put. It deposits some cobbles and boulders before it finally recedes back towards the coast. This push forward turned out to be the final ”growl” of the icecap and the glaciers disappear into the fjords. There will still be icebergs on the shelf for thousands of years. Due to the low sea level, many of them struggle to get across or round the banks to the deep sea.

10,000 years ago, the Ice Age ends. The Gulfstream can run freely along the Norwegian coast. The warm water brings a multitude of new animal species to the coastal waters. Some of these are so-called reef-building species, corals that accumulate when they die and over time form large reefs. Corals need a hard seabed to grow, a seabed such as that ridge off Ringvassøya. Around the ridge a strong bottom current prevents sand and silt from settling.

The Ocean – a Treasure Chest

”Lophelia reef!” says the log from the MAREANO spring cruise 2007. The discovery of the Malangsrevet did not come as a big surprise but even so, it is not every day that new reefs are discovered in Norway. When the camera rig landed on the seabed it was almost like a mini moon landing, a tremendous reward for all of the long preparations as amazing images finally popped up on the screen.

As any other ”rocket science”, marine science requires thorough preparation (figure 4). MAREANO cannot explore the whole of the seabed by camera. Based on echosounder data, the Malangsrevet was quickly singled out as an important site to visit. In addition to the elevated area apparent on the terrain model, analyses showed that there was a ridge consisting of rock, not sand or mud. A hard seabed reflects a strong signal, while soft sediments give a weaker signal.

But corals are only one of many animal groups living on the bottom of the oceans. MAREANO aims to provide the best possible overview of all species. Even tiny species can turn out to be critical to the ecosystem. To identify these, good tools are essential. The video rig has been specially developed to work at great depths and provide images allowing us to identify species down to five millimetres.

Photo: Odd Harald Selboskar

Figure 5. From the control room on *G.O. Sars*.

Photo: Odd Harald Selboskar

Figure 6. Large amounts of sponge in the catch northwest of Tromsøflaket.

"Houston - we have a new species!"

We are back in the Eggakant area further north in the Barents Sea: a little worm resting on the sand is visited by the same light that frightened the squat lobster. The worm has nowhere to hide so it just lies there quietly - is it trying to "play dead"?

But suddenly, out of nowhere, it skyrockets. Like a projectile it shoots up then heads away from the camera in flapping movements.

"Wow!" people cheer in the control room onboard *G.O. Sars* (figure 5). Six pairs of eyes are riveted on the screen showing live images from the deep.

"It's like the one we saw in the Varangerfjord. A *Polychaete*. They can move quite far like that, says log writer, Inger Marie.

Later, a large sea spider turns up. This time, there is more uncertainty in the air.

"Is it a *Colossede*... uhm... a *Colossendeis*... or what?" It is rapidly recorded as "a large sea spider with stripes". Further analyses in the lab will help to establish the exact species.

Before MAREANO, Norwegian waters had never been mapped so systematically. Several times, MAREANO has come across animal species never before observed in Norway. Identifying the animals is an extensive task - besides encyclopaedias and identification guides there is not much to go on. Hard work at sea is not enough. It has to be followed up by thorough video analyses to identify all the animals, which is a time consuming job. And it is not the only work *G.O. Sars* brings back from sea.

The Prick of a Needle

”Spicules!” is a common warning on board *G.O. Sars* during the mapping around Tromsøflaket. Due to the sharp needles from all the sponges living on the seabed in the area, good gloves are essential when working with bottom samples. The trawl is filled with live sponges and the sediment samples are littered with needles from dead ones.

Maybe it is only fair that when MAREANO pricks the seabed we get pricked back. And the samples are just as important as the blood test you take at the doctor's. The sediment samples are analysed for pollutants and the animals collected by trawl are compared to the ones we see on the video recordings.

Filled with data and samples, the ship returns to shore. Most of the work in MAREANO happens at the computer, in the lab and during long discussions with colleagues.

A Mysterious World

In recent years, space scientists have changed their minds about how many planets there are in the Solar System. Is Pluto a planet or a dwarf planet? It can be just as difficult to keep a steady course in MAREANO. Before we start, we are not quite sure where we will be sampling - and even less sure about what we are going to find.

At mareano.no you will find up-to-date information about the environment in Norwegian waters, including maps that give you direct access to our databases. As soon as we have analysed the data from a particular area the information is published in the database. The maps are probably not as easy to understand as those of the Solar System, yet – but there is also quite a bit of background information on the website.

For more details, visit *kartverket.no*, *imr.no* and *ngu.no*. Or what about following us on Facebook?

2.2 MAPPING THE MYRIAD ON THE SEABED

From Dot to Surface

The vast majority of marine species live in association with the seabed. They are not evenly distributed but occur in patches linked to various environments and types of seabed. It is important to know the distribution of species in order to manage the seabed sustainably. For instance: where are there vulnerable areas rich in biodiversity that may be damaged by oil and gas drilling? And what areas are more vulnerable to bottom trawling than others?

To answer these questions, maps showing only a few spots are worthless. The managers need maps that show what is everywhere. How can we manage unknown areas? The answer is: ”Start by studying what is down there” and that is how MAREANO came about. For the project, the main challenge is thus to move from dot to surface.

There are two ways of doing this: Provide pinpoint information that is detailed enough to allow us to define areas on the map. Or use detailed information about the environment as a basis to predict what we can expect to find there. The objection to the first solution is that sampling at sea is expensive. Analysis of bottom samples is extremely time consuming; whether it is sediments collected by grab or sledge or video recordings to study in detail. The objection to the second is that we do not know enough about the link between environment and species distribution to predict the latter based simply on knowledge of the environment. Generally, we do not know how various environmental factors work together - and where we do have this knowledge the interaction is ”disturbed” by biological factors. This is why MAREANO focuses on predicting biotopes, because they are less likely to be influenced by environmental variations than single species. The term ”biotope” is key in MAREANO. A biotope is a combination of recognisable species and environment. The notion is close to the notion of ecosystem used by the Norwegian Biodiversity Information Centre (www.artsdatabanken.no). For the sake of simplicity, we will use the term ecosystem in this book.

The seabed is vast and largely unexplored. What is the most efficient way of studying it? The important thing is to use the knowledge we do have to direct our efforts. Previous geological and biological surveys of the Barents Sea are not directly applicable at the scale MAREANO is aiming for. So the best starting point for MAREANO is the new area maps that are produced in the first phase of the MAREANO mapping.

DESCRIBING AND PREDICTING BIOTOPES

A biotope can be defined as a location with characteristic species composition and environmental settings. When characterising the biotopes, it makes sense to start with identifying the different communities. The video recordings are analysed in order to compare and divide the seabed into types or classes based on the observed bottom fauna. Samples with different communities are then grouped, and their characteristic environmental settings are described. These seabed classes turn out to have much in common when it comes to depth, strength of acoustic signal, seabed topography as well as other indicators extracted from the multi-beam echo sounder data. It is to a large extent the environment that determines the combination of species we can find at a location, but without the guidance of the species composition we cannot define which environmental settings are relevant for the community.

Knowledge about how the different environmental factors in combination determine the type of community and is essential for predicting the biotopes. Climate, hydrology, topography and geology are the main determining factors. We use this information to predict which biotopes can be found in other areas, including areas with no video recordings.

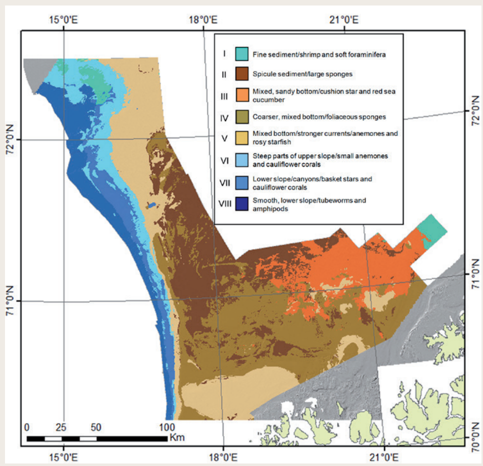


Figure 1. Example of map showing predicted biotopes in the Tromsøflaket-Eggakanten area.

basic facts

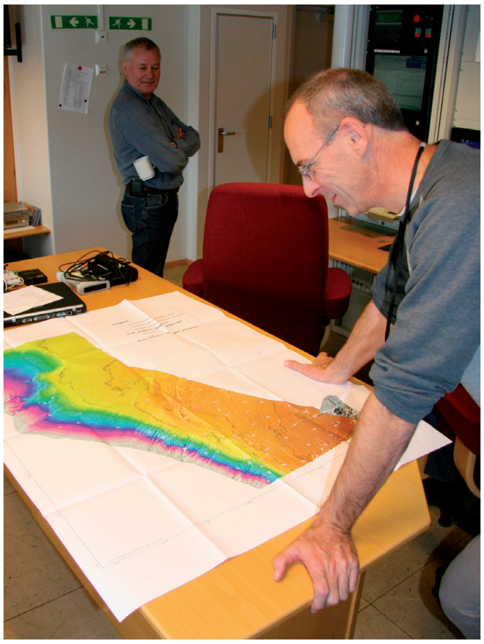


Figure 2. Reidulv is studying the multibeam map of Eggakanten.

The detailed bottom maps are vital to optimise the following investigations. The bathymetric charts have a "pixel"-resolution of down to 5x5 metres. On these charts we can identify fine structures on the seabed such as coral reefs, gas vents and glacier lineation (formed when the ice disappeared around 10,000 years ago). Wrecks and other objects and structures of less than 20 metres, however, are difficult to identify on these maps.

MAREANO uses the bathymetric charts to divide the seabed into regions according to depth zones, sediment hardness and topography. Based on this first interpretation of the seabed, locations for video recordings and sampling are selected.

From the Bottom Up

Video recordings of the seabed are a good basis for comparing areas and can be done independently of sediments and topography. They also provide an opportunity to observe organisms in their own environment with minimal risk of damaging the habitats and the species living there. Sampling with a grab, on the other hand, is difficult and risky on a hard bottom. A grab cannot sample sediments on rock, and where the sediments contain gravel and stone the grab will not close properly

Figure 3. The video rig, Campod, is an important tool in MAREANO. It can record down to 6000 metres. It is lowered down on the seabed where it can zoom in on details - it is also towed slowly over the bottom, ensuring that details are not blurred. In addition to two video cameras, the Campod is equipped with a depth gauge, and a laser scale, as well as sensors to measure temperature, particle content, current and height above the seabed. In order to know where the rig is at all times, it is equipped with a so-called transponder that sends information back to the ship about its position and depth.

and thus allow sand and mud to escape, leaving us with an empty grab back on deck. A sledge pulled over uneven terrain will often be damaged, the worst-case scenario being that the wire snaps and the equipment is left on the seabed.

On average, MAREANO does one video recording per 100 square kilometres. This may not seem a lot but is quite considerable taking into account the expanse. The locations are partly selected based on landscape and seabed structures that can easily be overlooked if the selection is totally random. Each location is filmed over a stretch of 700 metres, in order to document large organisms that are rarely caught in a grab. 700 metres was chosen as a standard length based on preliminary studies, which showed that more than 90% of the species detectable on video were observed before the camera had covered 700 metres.

While the seabed is filmed with a high-definition camera the geologists and biologists pay close attention to the screen transmitting live images from the deep. Good image quality is essential to identify species and compare bottom substrates. Lighting is equally important. The video rig Campod is equipped with two powerful spotlights with so-called HID (High Intensity Discharge) lamps – the equivalent of 1400 watt. All observations cannot be recorded there and then. In some places the seabed is uniform and virtually devoid of visible life. Other places are so filled with life that each square metre needs to be studied for several minutes to record all visible organisms. To allow comparison between observations and to make the job manageable, the procedure for recording field observations have been standardised into 230 metre long stretches. Firm identification of species, as well as biomass estimates, take place in the lab where the recordings can be paused and the images studied in peace and quiet.

There are four times as many video stations as sampling stations. Bottom samples are collected by grab, corer, sledge and beam trawl in order to document the biodiversity in the sediments (infauna), on the sediments (epifauna) and swimming just over the seabed (hyperfauna). The grab and corer provide samples that are more or less intact, whereas the sledge and beam trawl are dragged along

Figure 5. Sieving removes most of the sediments from the samples and simplifies the sample collection considerably. The beam trawl is meant to capture the large fauna living on the seabed and just under the surface but on a soft bottom it sometimes digs into the seabed, bringing back large amounts of clay and silt. Everything is then sieved through coarse and fine meshes before the samples are put in formaldehyde. The sieve, in the lower picture, is used for grab samples. The content is retained as several size fractions by the sieves.

Figure 4. The box corer gives us a virtually undisturbed sample of the seabed but it is difficult to use on a rocky bottom. The image shows a gravelly surface where the box corer has closed nicely further down in the sediment.

the seabed in a way that leaves the finer particles behind, while organisms living on the seabed are caught in the net. The sampling instruments often come back with a multitude of species and the analysis is time consuming, particularly in the deep and northernmost areas where there have been far fewer surveys than in the shallower areas further south. The identification and biomass estimates are important for assigning a ”value” to the various biotopes that are mapped and described by MAREANO.

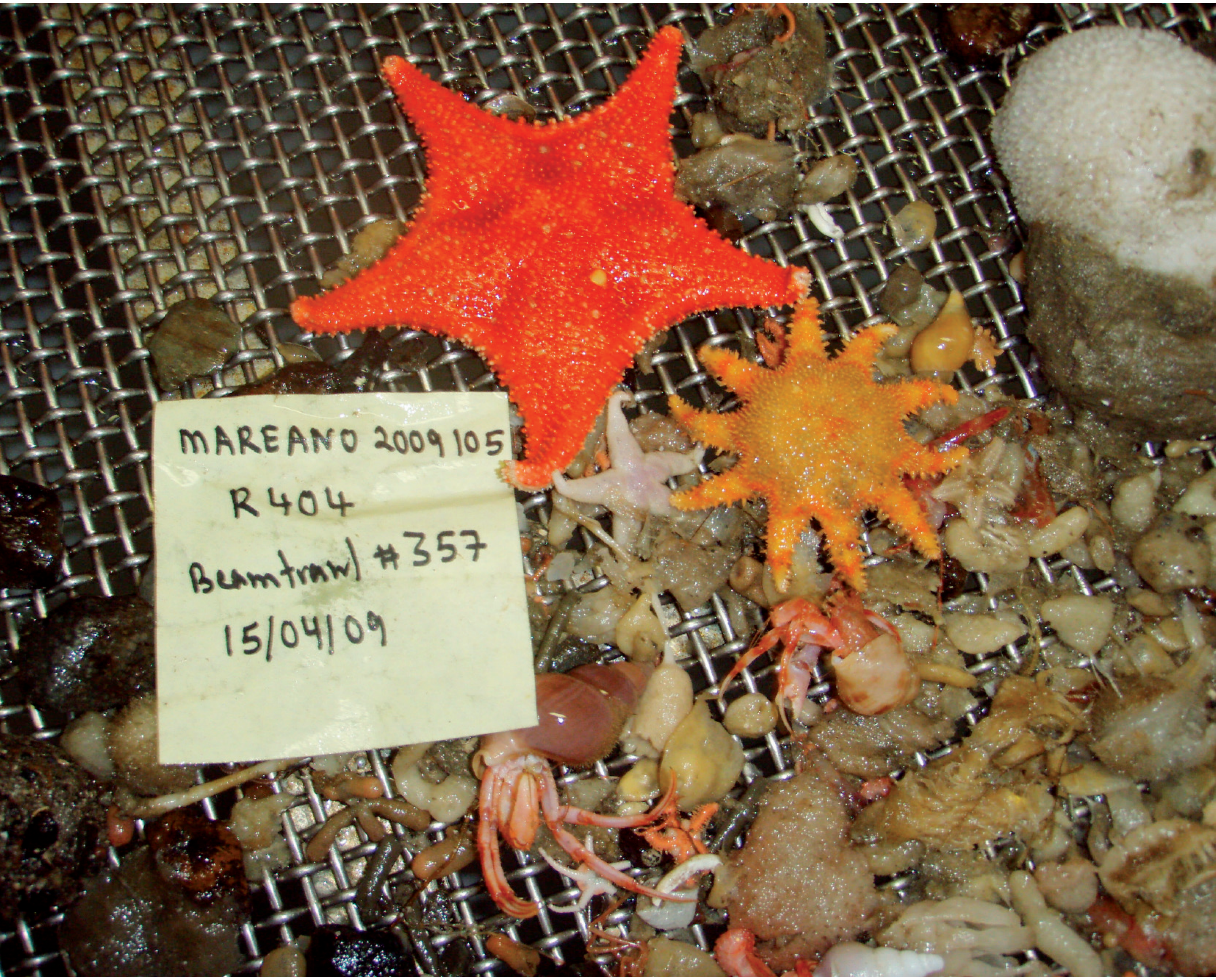


Figure 6: An example of how a sample taken from a beam trawl can look after it has been sieved. On the coarse sieve lies several species of starfish, hermit crabs, snails and sponges, but most organisms are smaller and have passed through to the finer sieve below.