FOCUS ON *MARINE RESEARCH*

NORWEGIAN MAPPING
AUTHORITY
HYDROGRAPHIC SERVICE

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collecting marine knowledge

NGU
Geological Survey of Norway

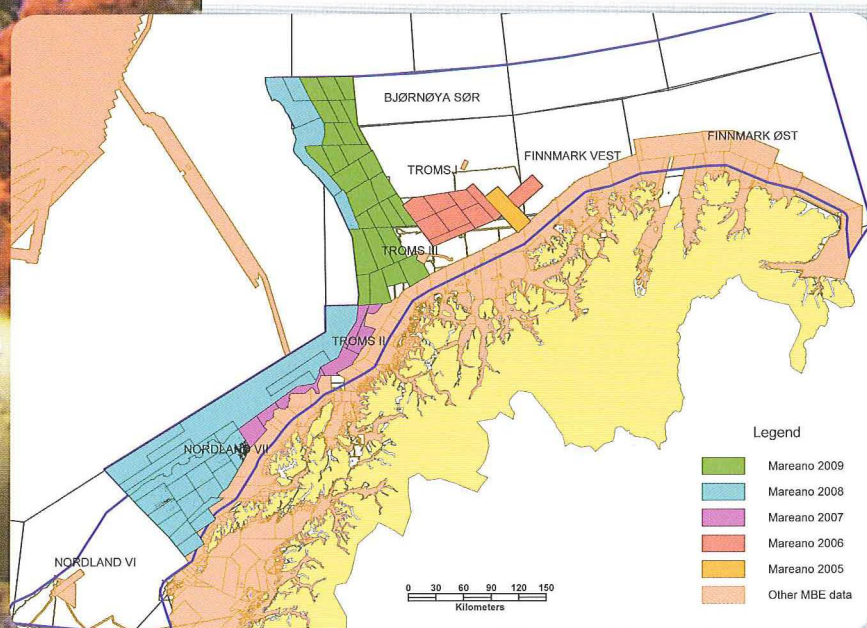**INSTITUTE OF MARINE RESEARCH**
HAVFORSKNINGSINSTITUTTET
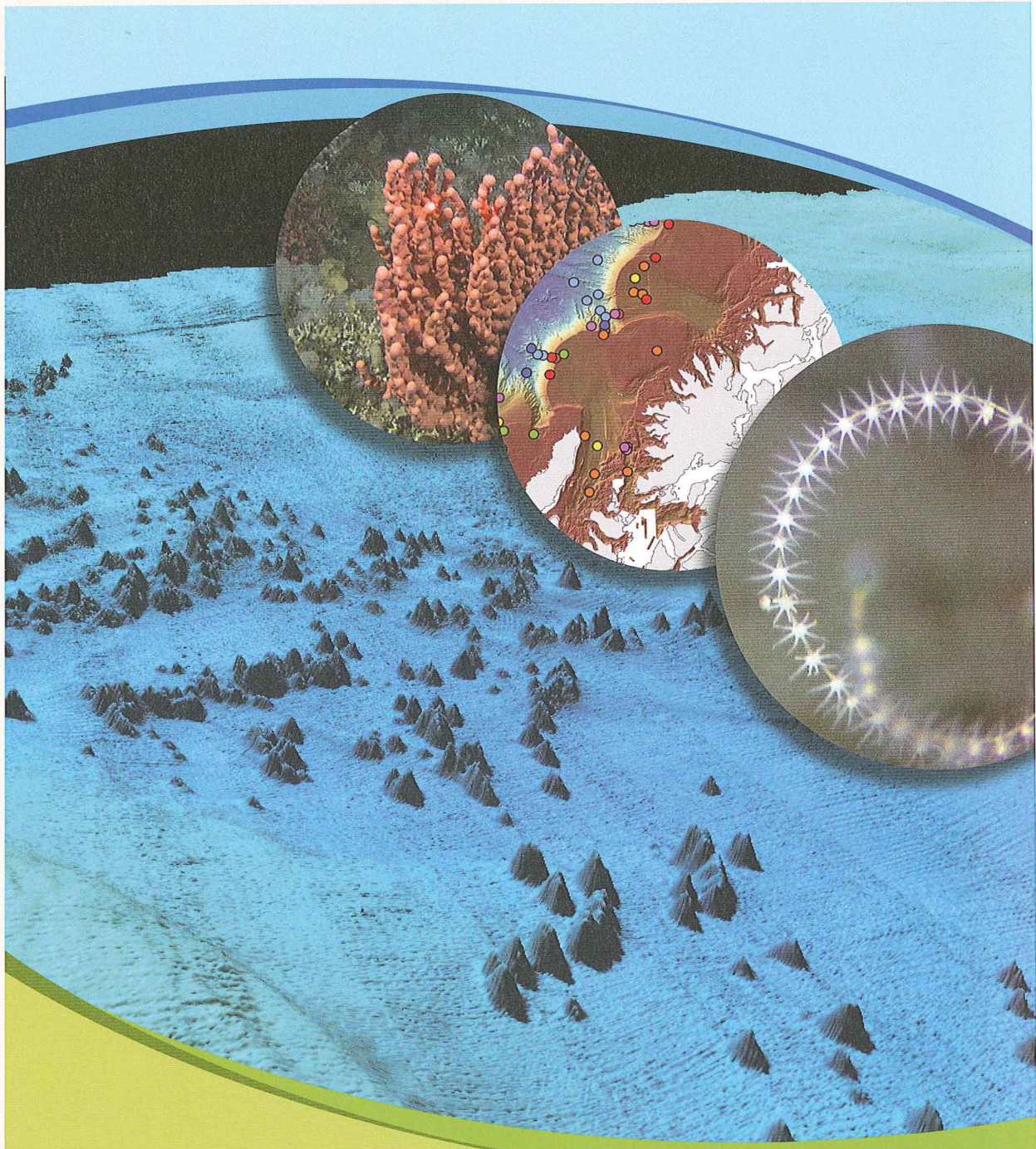
mareano
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The aim of the MAREANO programme is to fill gaps in knowledge about seabed conditions, habitats and biodiversity through detailed mapping of depth, sediments, bottom fauna and pollutants in Norwegian waters. The results are available on our website www.mareano.no, visualised with maps.

The MAREANO programme (Marine AREAl database for NOrwegian waters) provides baseline data that will allow us to answer questions such as:

- What does the marine landscape look like on the Norwegian continental shelf and slope?
- What does the seabed consist of?
- How is biodiversity distributed on the seabed?
- How are benthic habitats distributed?
- What are the links between variations in the physical environment, biodiversity and habitats?
- Are the sediments contaminated?

The MAREANO programme is coordinated by the Institute of Marine Research (IMR), working in collaboration with the Geological Survey of Norway (NGU) and the Norwegian Hydrographic Service (NHS). The programme is financed by the Ministry of Fisheries and Coastal Affairs, the Ministry of the Environment and the Ministry of Trade and Industry.

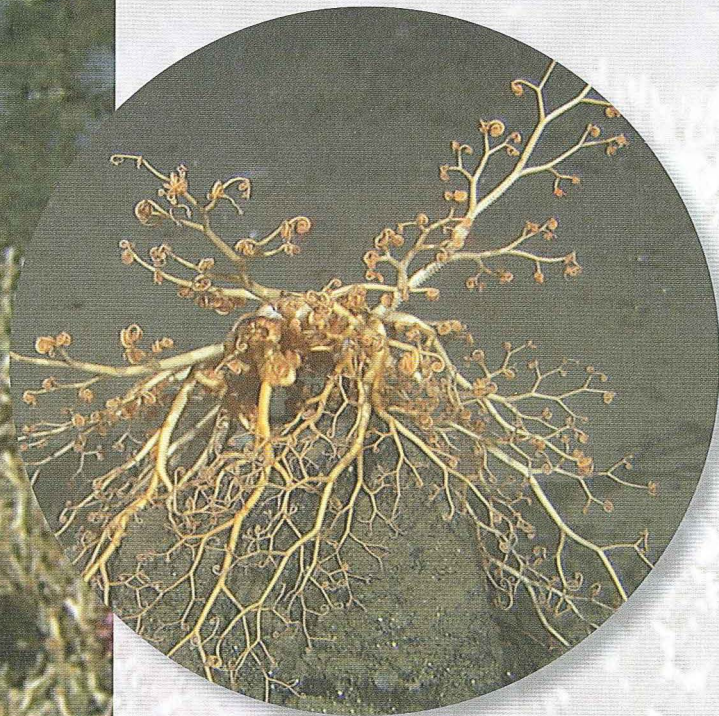Coverage of multibeam echo sounder data in the MAREANO region.

- Information about sediment types, habitats and geological conditions
- Information about the distribution of benthic fauna, marine communities, biodiversity and production
- Information about the contamination levels of sediments
- Detailed bathymetric maps
- A database and map service with systematic information about Norwegian coastal areas and seas

MAPPING THE SEABED

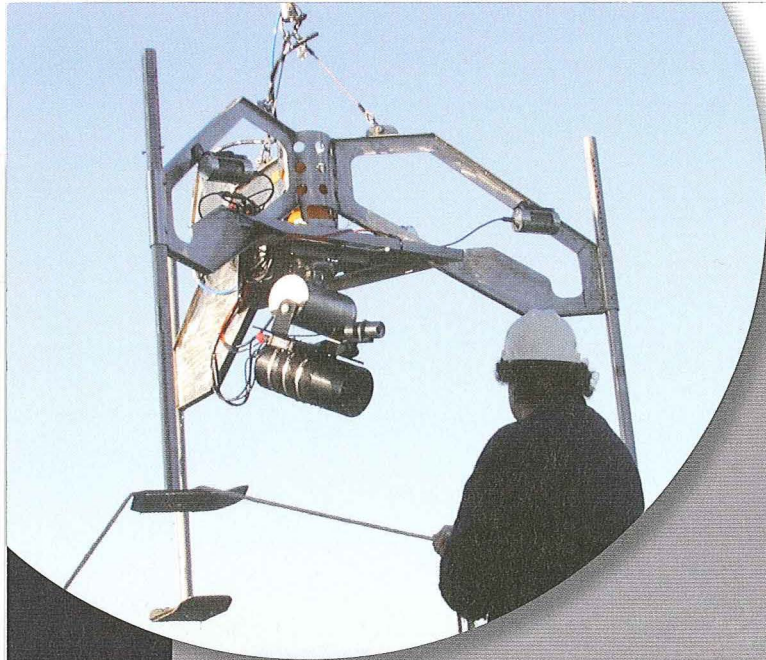### MAREANO surveys – biology, geology and chemistry

The MAREANO partners are responsible for a wide range of survey activities. On the continental slope and in canyons, the depth can vary from 200 to 2500 metres over short distances. These great topographical variations demand densely distributed observation sites to provide realistic maps. This makes the mapping time-consuming and expensive, but the information from the surveys is of great value and will serve as baseline for management and future monitoring programmes.

With the exception of areas with mud, clay and sand, it is difficult to take samples of the seabed. It is therefore necessary to use visual documentation.

Joint mapping cruises are conducted by IMR and NGU. Video transects provide visual documentation of sediment and fauna, and samples verify sediment and fauna composition and content of pollutants. MAREANO provides a unique overview of benthic biodiversity by using a variety of sampling equipment, thus ensuring a wide collection of organisms from all types of seabed.

Bathymetric Surveying

The Norwegian Hydrographic Service provides detailed bathymetric survey data.

MAIN PRODUCTS

In the run-up phase to the revision of the management plan for the Barents Sea in 2010, MAREANO shall provide:

1. The Campod video rig has been specially developed for MAREANO, and plays an important role in the mapping process. The high definition video camera provides quantitative information about seabed substrates, features and biota larger than about 3 mm in size from all types of seabed.

2. The multicorer samples the sediments without destroying the layers and surface structures. With this gear geologists and chemists can describe time series of changes in deposition of natural as well as anthropogenic chemical components.

3. Larger epifauna are best collected with a small epibenthic trawl. MAREANO uses a 2 m wide beam trawl for this purpose. The specimens collected are valuable as ground truthing of species observed on the video.

4. Grab and boxcorer collect infauna (animals living in the sediments) quantitatively. The boxcorer also enables subsampling with smaller cores. The grab used by MAREANO is a van Veen with a sampling area of 0.25 m^2.

5. The organisms that live in the water just above the seabed are best collected with a hyperbenthic sled. These animals are mainly represented by small crustaceans, an important food source for demersal fishes.

Measurements are performed by ships equipped with multi-beam echo sounders (MBES). The surveys span from 70 m depth to about 3000 m. Since 2006 the Kongsberg Simrad echo sounder EM710 has been used down to about 1000 m. For deeper waters echo sounder EM300 has been used.

From data to seabed biotope maps

The seabed biotope map is the culmination of a complex process. The map employs various analyses of high quality data on composition of biological communities and characteristics of the physical environment. The MAREANO programme develops modelling approaches to predict the distribution of seabed habitats and biotopes.

The three partners work in close collaboration to generate data and maps from the areas investigated. NHS produces detailed maps of the seabed topography from surveys with MBES. NGU produces geological seabed classification maps by interpretation of the topography and the acoustic signals from the MBES. Based on this information representative observation points for documenting sediment, benthic fauna and environmental contamination are selected using a semi-random stratified sampling design.

Depth and marine landscapes

The marine landscapes are as varied as the terrestrial ones, comprising mountains and valleys, large plains and steep slopes. Modern technology allows us to map this seascape very accurately, down to features that are only a few metres wide.
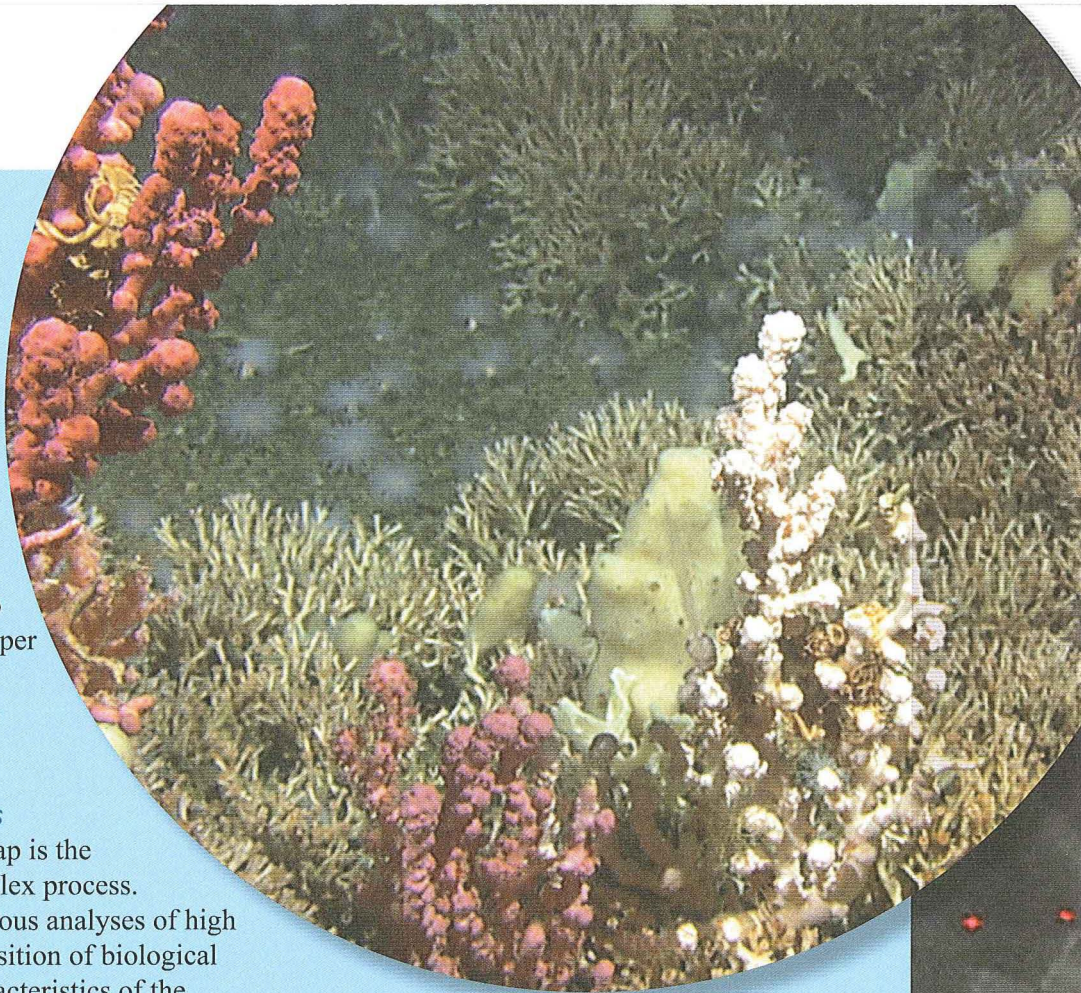
For bathymetrical mapping in offshore areas MAREANO uses the resolution of 5x5 metres, but within Norwegian territorial waters (12 nm) all information more detailed than 50x50 metres is classified.

Detailed depth and backscatter data of this kind plays an important role in the planning of MAREANO's surveys. Detailed bathymetrical and backscatter data are also crucial for generating full-coverage information about sediments and habitats in areas where samples have not been taken.

"All Norwegian waters will be mapped to secure a thorough, complete and environmentally safe management. The goal is to avoid all activities that can threaten the environment."

The Norwegian Minister of Environment, Helen Bjørnøy, when launching the management plan for the Barents Sea.
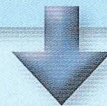
Bottom topography and landscape:
*NHS delivers detailed topographical maps based on surveys with multibeam echo sounder.*
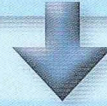
Sediment and fine scale topography and pollutants:
NGU delivers sediment maps based on the interpretation of signals from MBES (NHS), video (IMR) and sediment samples (NGU and IMR). NGU deliver terrain analysis based on topography maps (NHS).

Natural resources, species, biomass and community:
IMR delivers maps on occurrence of bottom fauna (species, biomass and communities) based on information from video, sampling with grab, epibenthic sled and beam trawl.
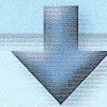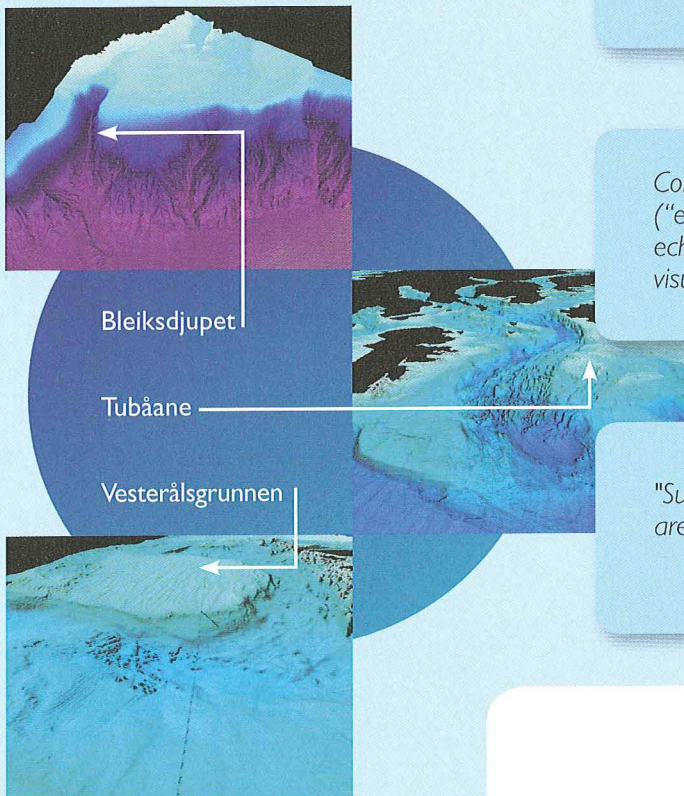
Biotopes:
IMR and NGU develop models based on the relation between occurrence of biological communities and bottom environment to generate biotope maps.

Habitat and biotope prediction

Multivariate statistical methods are used to relate bottom environment and distribution of bottom communities. The goal is to find objective criteria for defining habitats and biotopes by connecting bottom characteristics (depth, substratum, inclination, rugosity and current speed) to fauna distribution, production etc. This is crucial to the ability to predict the occurrence of bottom communities based on topography and substrate indications.

The strategy is to conduct detailed studies in selected areas that can provide the foundation for successful prediction of the distribution of habitats and biotopes in adjacent areas that will be studied in less detail.

For future MAREANO cruises, an important task will be to ground truth predicted occurrences of bottom fauna/biotopes based on observed relationships and to test the reliability of these predictions.


Bleiksdjupet

Tubåane

Vesterålsgrunnen

Strategy for characterization and prediction of biotopes:

Multivariate analyses of species data from seabed video recordings in order to identify groups of similar localities with respect to species composition.

Identification of environmental variables (i.e. depth, sediment composition, topography etc.) that best correlates with the species composition.

Comparison of explanation strength by variables ("environmental proxies") derived from multibeam echo sounder data and parameters estimated during visual inspection.

"Supervised" GIS analysis based on classification of the areas' "environmental-proxies" with full areal coverage.
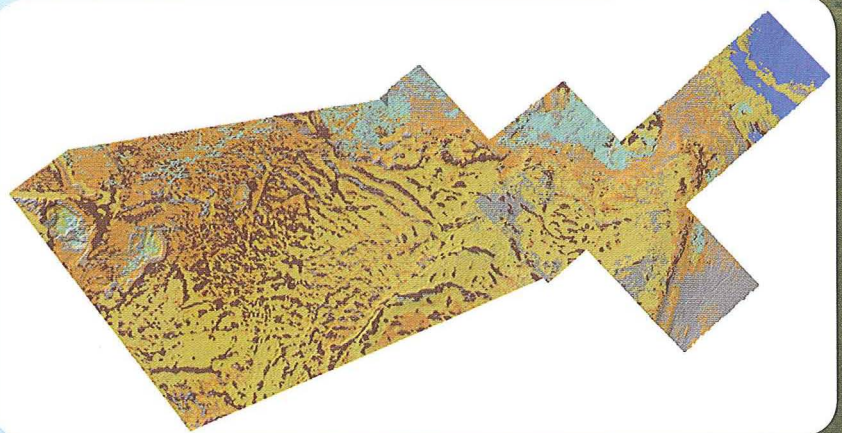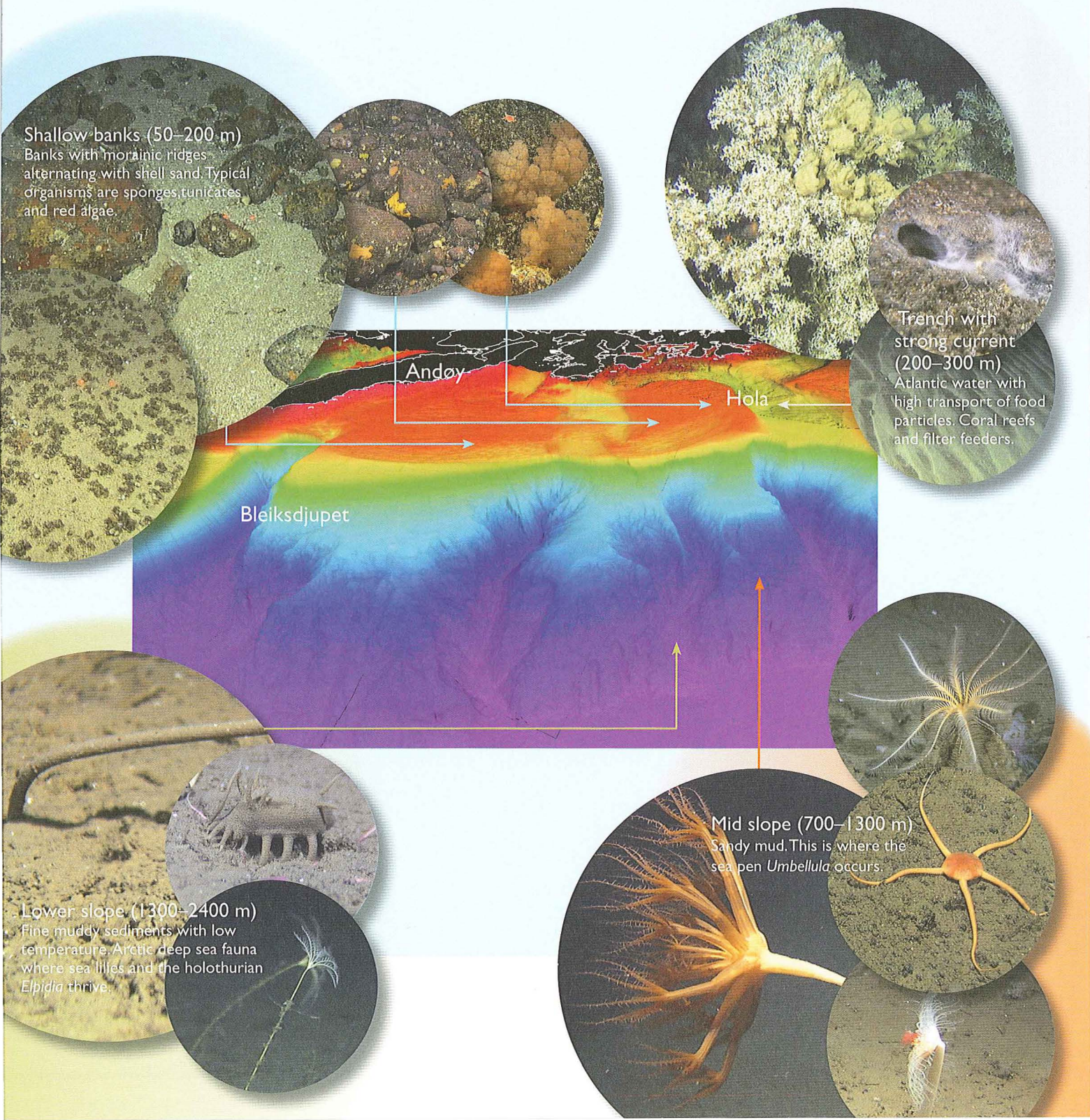

Predicted biotopes.

MAPPED AREAS IN THE BARENTS SEA

The areas off Nordland and Troms have Norway's most varied seabed: large banks separated by deep troughs, submarine valleys and canyons. The marine landscapes have been shaped by several ice ages, the last ended around 11 000 years ago. As they headed west from mainland Norway towards the shelf edge, the glaciers moved at uneven speeds, carving out great trenches such as Andfjorden and Vestfjorden where the ice moved quickly, while the banks were covered by slow-moving ice.

The Norwegian Continental Shelf is at its narrowest point outside the Vesterålen islands, reaching a width less than 10 km off the island of Andøya. This is also where Norway's largest underwater canyon, Bleiksdjupet, cuts into the shelf. In the North Sea and Barents Sea the shelf is often several hundred kilometres wide.

Shallow banks (50–200 m)
Banks with morainic ridges alternating with shell sand. Typical organisms are sponges, tunicates and red algae.

Trench with strong current (200–300 m)
Atlantic water with high transport of food particles. Coral reefs and filter feeders.

Andøy

Hola

Bleiksdjupet

Lower slope (1300–2400 m)
Fine muddy sediments with low temperature. Arctic deep sea fauna where sea lilies and the holothurian Elpidia thrive.

Mid slope (700–1300 m)
Sandy mud. This is where the sea pen Umbellula occurs.

The canyons represent landscape elements with increased heterogeneity of sediment composition. The great differences in fauna composition relate to the bathymetric distribution of cold (Arctic intermediate water and Norwegian Sea deep water) below the warm North Atlantic water.

The continental slope between Lofoten and Senja is unusual, featuring canyons close to 1000 metres deep. These run from the shelf edge to the abyssal plains, situated more than 2000 metres below sea level. Terrain models show clear evidence of major slides several kilometres wide, and several hundred metres thick.

Sediments

Where the bedrock is not exposed, the seabed is covered by different sediments, ranging from mud to stones. The composition of the sediments, their shapes and location tell us which processes have formed the seabed. Just like the land above sea level, the seabed comes in a variety of shapes and substrate compositions. All of them can be found here, from polished rock and stone, to soft clay.

Seabed classification

The seabed of the Norwegian Continental Shelf is varied, making it a technical challenge to obtain samples. Some of the most common seabed types include:
- soft, watery mud in sediment basins
- hard-packed gravelly clay with boulders and hard-packed diamicton
- rocks and boulders
- sand
- gravel
- bedrock

Many places these seabed types are mixed. The type of seabed tells us about past geological processes and active sedimentary processes. These prosesses are an important factor of living environment for plants and animals, thus controlling the composition of flora and fauna in different areas.

Habitats and biotopes

On land, most habitats have a name, which is crucial to an appropriate management of different areas. In the sea, on the other hand, so little of the seabed has been mapped and many habitats have not yet been described or named. MAREANO will help to resolve this problem, and over the next two years, large areas of the seabed off northern Norway will be classified into different marine habitats. Habitats can be defined on a variety of scales, from detailed substrate and ecosystem levels to landscape level. MAREANO produces full-coverage maps of habitats at ecosystem and landscape level, based on visual inspections (videos), surveys of environmental conditions (sampling) and the interpretation of multibeam survey data.

MAREANO provides information underpinning the definition of habitats and biotopes occurring in deeper water where the relationships between marine landscapes, environmental settings and fauna composition are poorly understood.

Tromsøflaket case study area

On Tromsøflaket bank six biotopes have been identified. These have been classified on the basis of the relation between distribution of species and the environment (substrate type, depth and topography).

"MAREANO is a result of our desire to know more. We want more detailed knowledge about an important part of Norwegian territorial waters – simply, as a part of the Norwegian kingdom that cannot easily be seen with the naked eye. Much exiting features can be hidden there. The government is interested in MAREANO, and I want to highlight the importance of a sustainable management of our living marine resources. Increased knowledge provides a basement for improved management decisions."

The Norwegian Minister of Fisheries and Coastal Affairs, Helga Pedersen, at the opening of the MAREANO conference 2006.
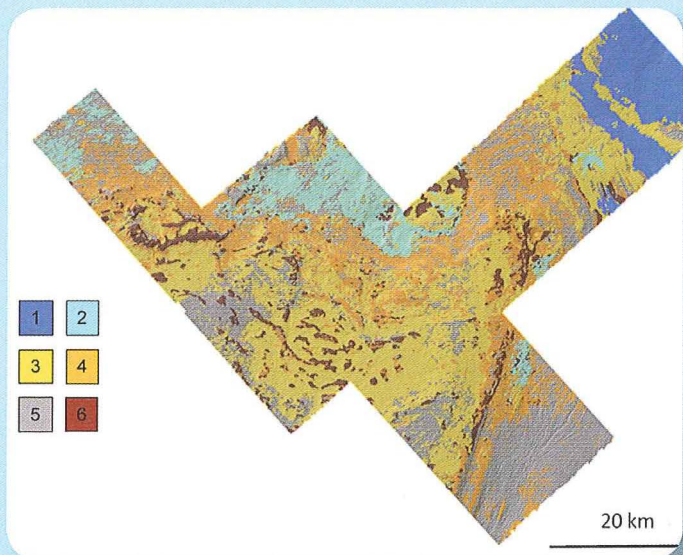
The dark blue area in the top right is a deep, muddy basin with pockmarks and glass sponges. The shallowest areas with moraine ridges (dark red areas) stretch into areas with two different types of habitat with gravelly-sandy bottom (yellow and orange areas). The turquoise areas are where you can expect to find the largest concentrations of large sponge species.

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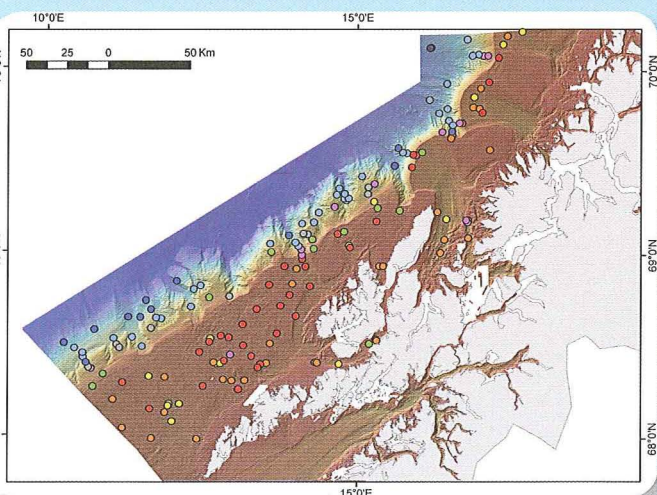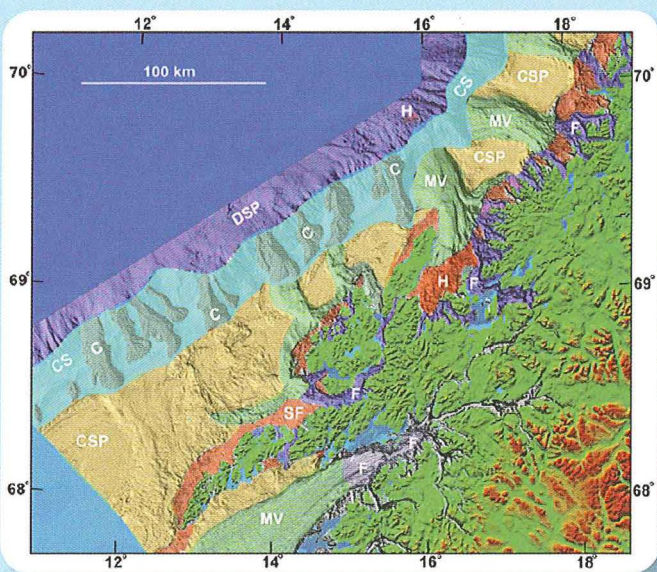
Nordland VII field observations

Nordland VII has a high biodiversity at broad as well as fine scale levels. Sharp shifts in hydrography, geology and fauna characterize the area. Eight pronounced canyons occur in this area, stretching from 100–2500 m depth. The habitats identified from analyses of results from the visual surveys clearly show that the communities are distributed in relation to landscapes, sediment composition and water masses.

Fauna composition and biodiversity

In the sea, the greatest biodiversity is found on the seabed. Around 80% of the animal species in the Barents Sea live on or near the bottom of the sea. Through the baseline mapping made by MAREANO, distribution of bottom fauna and biodiversity is documented. Biodiversity refers to the variation in the composition of biological entities such as genes, species, populations and habitats.

By using several different sampling gears, MAREANO is able to document a large proportion of the overall biodiversity. On Tromsøflaket we found 604 species, as well as 143 undetermined species. Most of the species (83%) were captured only by one of the gears used. Only one percent was captured by all sampling gears. The greatest biodiversity was found on the edge of Tromsøflaket, and in the trough in the south-eastern part of the surveyed area. The seabed at both habitats consists of gravelly sand with cobbles and boulders.

Contamination of the seabed

One of the most important tasks of MAREANO is to document sediment contamination levels prior to petroleum industry activities, in order

1. Landscapes in the Nordland VII area: DSP – deep sea plain; CS – continental slope; C – canyon; CSP – continental shelf plain; SF – strandflat; H – hill landscape; MV – marine valley; F – fjord.

2. Multivariate analyses of standardised field observations at intermediate scale (landscape element), indicate nine habitats with characteristic communities.

to identify background levels and potential sources of pollution. This includes identifying natural sources of PAHs (polycyclic aromatic hydrocarbons), a group consisting of many different compounds, some of which are toxic, mutagenic and carcinogenic. PAHs in nature are generally considered to be the result of human activity, often through the incomplete combustion of fossil fuels. However, in areas where oil, gas and coal are found, PAHs can be naturally occurring, as they are one of the components of fossil fuels.

The provisional results of sediment core analyses performed on samples from a muddy area with numerous pockmarks show slightly elevated values of PAHs below the seabed. This may be the result of leaks from deeper layers of the seabed. The area in question is close to the Goliath oil field. Many exploratory wells in the Barents Sea have produced disappointing results; dry wells. In some of the wells there have only been traces of hydrocarbons, whilst the valuable hydrocarbons appear to have leaked out. From other parts of the Barents Sea, e.g. south of the Bear Island, the seabed is known to contain slightly elevated levels of hydrocarbon due to leakage from the deep.

Levels of heavy metals in the sediments are also recorded. Time series from dated cores in the sediment basins indicate slight increase for selected metals, but the levels are still very low.

MAREANO WEB PRESENTATION

Data collected through MAREANO are made accessible to all users and various purposes. It is possible to view and search a selection of relevant georeferenced data through the online map service at *www.mareano.no* or through the websites of the various agencies involved in the project. Public sector users will be able to view or download data through Norway Digital, the national georeferenced data infrastructure. Other users will be able to access data through the agencies responsible for the individual data sets, for example obtain sea depth data from the Norwegian
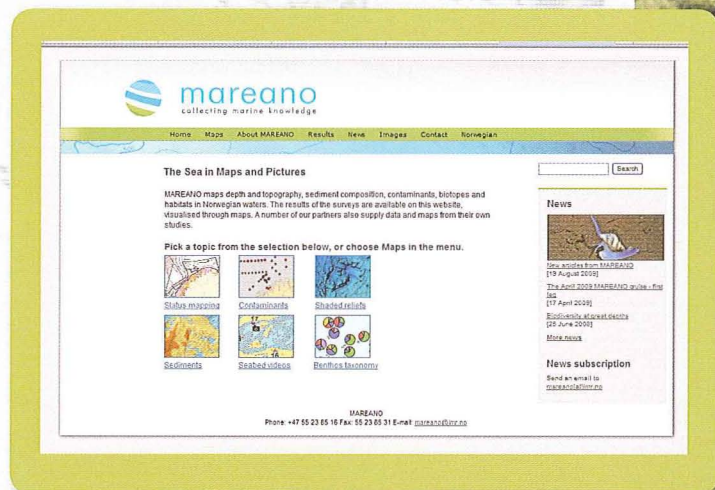
Hydrographic Service, geological data from the Geological Survey of Norway and data on biology from the Institute of Marine Research.

THE MAREANO CONCEPT IN AN INTERNATIONAL CONTEXT

The EU is currently working on a marine strategy, the main focus is sustainable development of European seas and coastal areas. The Norwegian approach integrates area mapping and studies of benthic ecosystems. It involves relatively detailed studies of large areas, and may be a model relevant to other European coastal nations. On a worldwide basis, several similar programmes are planned or initiated. Ireland has already mapped the depth and geology of its seas, and is in the process of expanding the programme to cover ecosystems and coastal areas. Communicating and cooperating with the mapping program-mes of other countries is important to MAREANO, and will ensure that the data collected and presented meets international standards.

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