CM 2000/T: 13
Theme Session on Classification
and Mapping of Marine Habitats

Marine Habitat Mapping for the Norwegian Sea

Thomas Noji, Terje Thorsnes and Jan Helge Fosså

ABSTRACT

An initiative is currently being taken by several Norwegian organizations to obtain funds to intensify ongoing investigations on marine sea-floor mapping off Norway. Led by the Geological Survey of Norway and Institute of Marine Research, planning during the last two years has led to the inception of a large-scale mapping project entitled "MAREANO - Marine Areal Database for the Norwegian Sea". The investigation area covers 270 000 km^2 of the shelf and deep sea off the central part of western Norway. It is a commercially important region for fisheries and the petroleum industry and includes the world's largest system of cold-water coral reefs. The aim of MAREANO is to collect new as well as historical data elucidating the physical, chemical and biological characteristics of the seabed along the mid-Norwegian shelf and parts of the deeper Norwegian Sea. The project shall produce maps and/or provide information on seabed bathymetry, marine habitats, biological diversity and resources, mineralogical resources and geological features as well as habitat contamination. Stored in a GIS database, this information shall be available to environmental managers and interest groups as well as the fisheries, aquaculture and petroleum industries via a dedicated system on the intern&.

A description of the MAREANO project as well as some early results and their consequences for environmental management, e.g. establishing marine protected areas, shall be presented.

Thomas T. Noji and Jan Helge Foss& Institute of Marine Research, P.O. Box 1870 Nordnes, N-5817 Bergen, *Norway,[tel: +47* ***55238500,*** *fax: +47* ***55238584,*** ***e-mail:*** *Thomas.noji@imr.no]. Terje* ***Thorsnes, Geological Survey of Norway, 7491 Trondheim*** *,[tel: +47* ***73904011, fax: +47 73921620, e-mail: terje.*** *thorsnes@ngu.no].*

Norwegian resources from the ocean and sea floor

Marine resources play a key role in social and economic development in Norway. Within the next 30 years the production of oil and gas is expected to drop by about half of today's production. If the present-day standards of living are to be maintained in Norway, this reduction must be compensated by other resources. The ocean has the capacity to fulfill this demand.' Norwegian waters host intensive fisheries activities, which are regulated by national and international quota regulations. Earlier experiences with overfishing as well as today's situation with threatened stocks of harvestable fish, indicate that quota regulations should be supplemented with improved knowledge of the distribution and temporal development of stocks including those associated with sea-floor habitats. Further, the exploitation of oil and gas have expanded progressively to deeper parts of the Norwegian shelf and slope. Future activities shall include seabed engineering and the deplyment of associated cables and pipelines. These petroleum-related activities are dependent upon high-resolution bathymetric data, information on sediment type and geotechnical assessment. Notably, it is critical that such installations do not damage natural sea-floor habitats such as cold-water coral reefs or interfere with fisheries activities. , Not yet a harvested resource, gas hydrates on the Norwegian shelf may be an important fuel in the future and are triggering interest. Similarly, harvesting of sand and gravel may be a commercially important industry in the future, as it is now on the British, Dutch and Danish shelves. Terrestrial resources of sand are dwindling in some parts of Norway and the need for marine sand resources shall probably increase in the future, even though the potential resources in the Norwegian Sea are presently not economically feasible due to the water depths

The tasks

Norway is faced with the task of documenting the boundaries of its continental shelf with detailed bathymetric data by the year 2006, in accordance with UNCLOS convention, which Norway ratified in 1996. Recent developments in integrated habitat mapping techniques offer powerful tools for the management of sustainable deep-water resources. There is also a growing interest in OSPAR and ICES countries to conduct marine habitat mapping surveys. This is due to the growing dependency upon marine habitats for meeting current social and economic needs, and due to advances in acoustic as well as geographic database technology (GIS) enabling the rapid collection, archiving and presentation of survey and other data. Acknowledging the growing importance of marine habitat mapping for marine science and environmental management, the ICES Marine Habitat Committee decided to establish a Study Group on Marine Habitat Mapping (SGMHM) (C.Res.2:39; 1998), whose task is to provide advice on the development of a classification system for marine habitats and of a marine habitat quality tool, as well as their usefulness for assessing the effects of human-induced habitat change and pollutants on habitats and living resources. Accordingly, a workshop on "Deep Water Survey Technologies and the Development of Standards for Marine Habitat Mapping" shall be conducted in February 200 1 .[2]

The mapping of seabed habitats is the fundamental first step necessary for the management of fisheries[3] and the environment as well as for the assessment of human-induced reductions in biodiversity of benthic habitats! Investigations in the North Sea in the IMPACT I and II projects[5] clearly document the damage to benthic habitats caused by bottom trawling. Long-term monitoring of benthic habitats as well as direct visualization of seabed scoring due to trawling are desirable for management purposes. On. the other hand, fisheries can directly benefit from the use of high-resolution bathymetric charts. For example, the use of electronic

sea charts significantly increased operational efficiency and reduced net costs of scallop fisheries at the Canadian Browns Bank.[6] Further, bathymetric data are essential for offshore engineering associated e.g. with the petroleum industry.

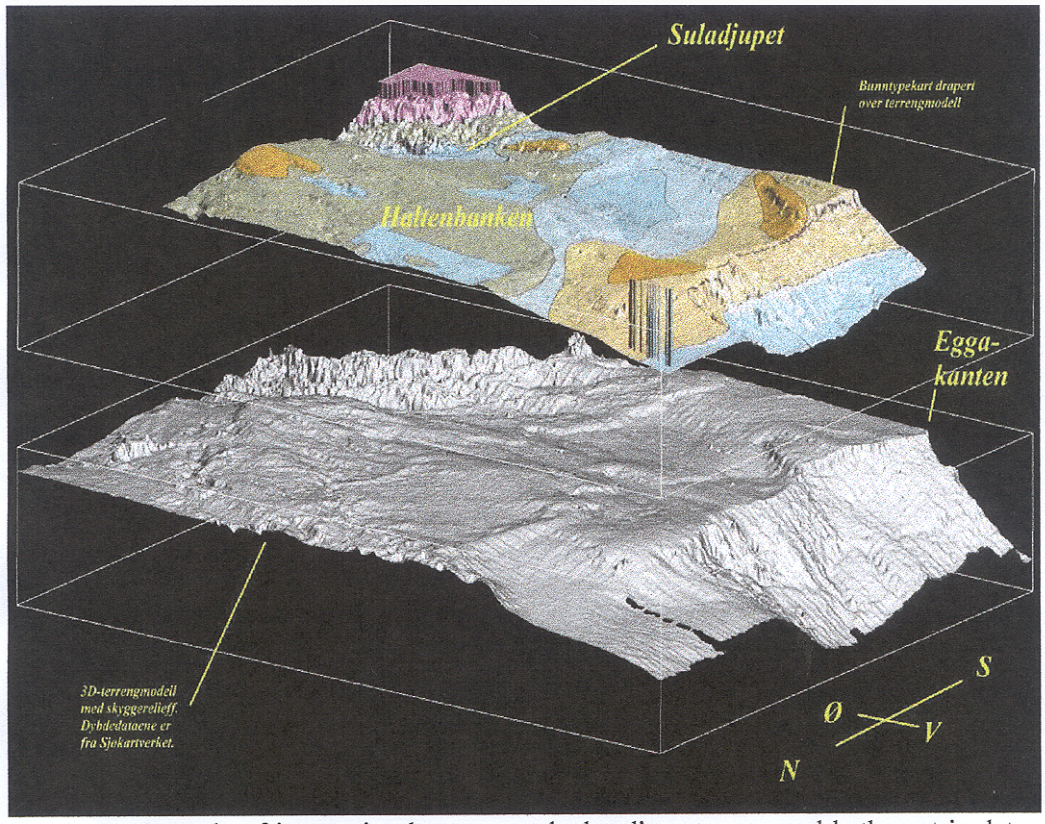

Figure 1. An example of integration between seabed sediment maps and bathymetric data using GIS/3D-modelling system (sediment map from IKU Petroleum Research Company; bathymetric data from the Norwegian Hydrogaphic Service).

The mapping of contaminants in sediments is also a prioritized activity in Norway's endeavors toward environmental management of marine resources. The sources for contaminants include the petroleum industry on the shelf and parts of the deeper Norwegian Sea. Further, a large fraction of contaminants along the Norwegian coast may originate from the North Sea and are transported northward with the Coastal Current. Another smaller fraction may flow from the Baltic through the Skagerrak to enter the Coastal Current. Forecasting the flux of such contaminants, in particular a suite of persistent organic pollutants as well as radionuclides, is an increasingly important activity for environmental management in Norway.

Despite intensified investigations on benthic communities off Norway in recent years, our knowledge of the habitats and species diversity on the shelf is very limited. It was, in fact. not until the late 1990s that extensive coral reefs were documented along the Norwegian coast. These coral ecosystems, dominated by *Lophelia pertusa*, are now considered to be precious national resources, which are particularly threatened by fisheries bottom trawling.

MAREANO - A Marine Areal Database for the Norwegian Sea

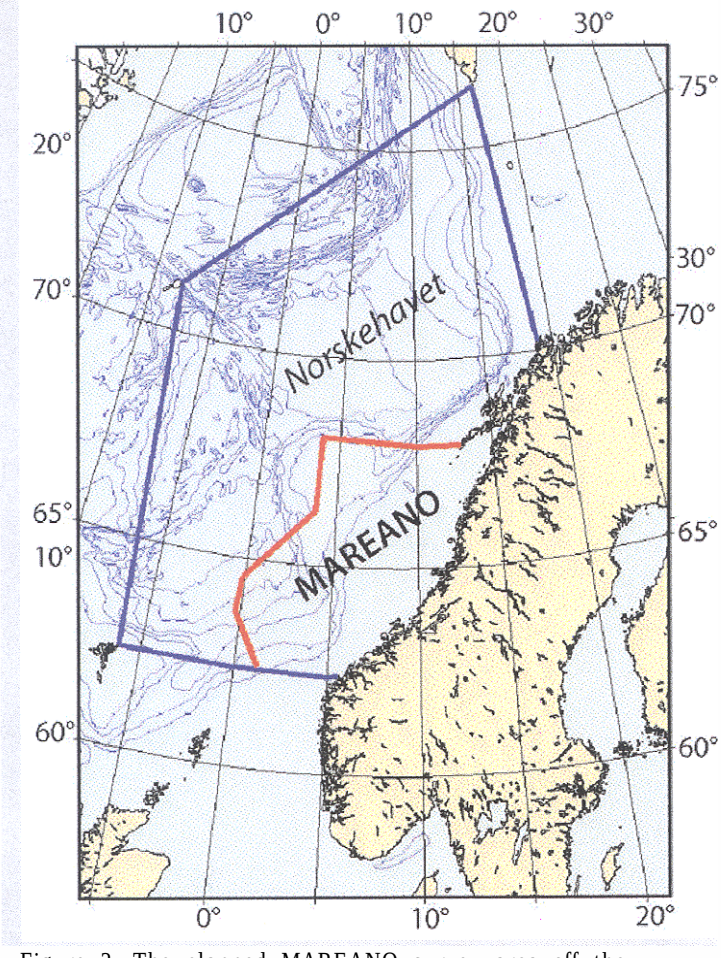

Figure 2. The planned MAREANO survey area off the western coast of Norway.

In order to improve our knowledge of the sea floor off Norway, a new project called MAREANO - A Marine Areal Database for the Norwegian Sea was initiated with pilot studies beginning in 1998. MAREANO is a multidisciplinary, interdepartmental program with major participants from the Geological Survey of Norway (NGU), Institute of Marine Research (IMR), Norwegian Hydrographic Service, State Pollution Control Authority, the Norwegian Petroleum Directorate and the Norwegian Polar Institute. The investigation area covers 270 000 km^2 of the shelf and deep sea off western Norway. It is a commercially important region for fisheries and the petroleum industry and includes the world's largest system of cold-water coral reefs.

MAREANO shall collect new data and refer to historical data for the seabed along the mid-Norwegian shelf and parts of the deeper Norwegian Sea. The project shall produce maps and provide information on:

- Bathymetric features of the seabed;
- Marine habitats, biological diversity and marine biological resources coupled to the seabed;
- Marine contaminants in sediments; and
- Sediment types, mineralogical resources and geological features.

The MAREANO GIS database shall be accessible via the internet to the fisheries industry, the petroleum industry, researcher organizations, environmental interest groups, community interests, marine aquaculture, and others. The project has conducted pilot investigations since 1998 and presently has a request for substantial funding submitted to several Norwegian ministries. This request is approximately 60 million NOK (roughly equivalent to 8 million Euros).

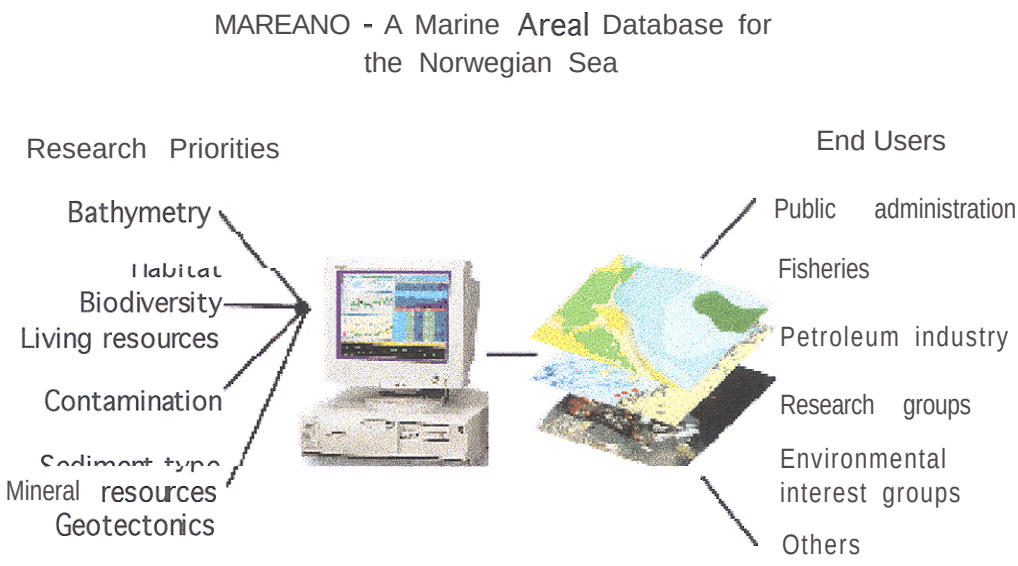

Figure **3. The MAREANO** concept.

Investigations on cold-water coral ecosystems lead to ecosystem management

Although MAREANO is in an early stage of development, several field investigations have been conducted within the program. In addition to a sampling survey on the Norwegian shelf (approx. 62" - 68°N) focused on contaminant distribution in sediments, three bathymetric surveys focusing on coral-reef ecosystems have been conducted on the shelf between 64 ° and 67 °N (Sula Ridge, Horseshoe Ridge, Træna Deep).

Multibeam bathymetric data were collected by the Norwegian Hydrographic Service in the three regions of the three coral ecosystems with a Simrad EM 1002 multibeam echosounder system. This system has 121 channels and operates by ensonifying a narrow strip of sea floor across track and detecting the bottom echo with narrow, cross-track listening beams. The swath of sea floor imaged in each survey line was about 1000 m in width. Navigation was by Differential Global Positioning System (GPS), providing accuracy of +/- few meters. Survey speeds averaged 5 knots; this speed was slower than the potential survey speed of closer to 10 knots. because shallow seismic equipment was towed simultaneously (not reported here). The multibeam bathymetry data were processed by the Norwegian Hydrographic Service to a digital terrain model, and the Geological Survey of Norway produced detailed maps using contouring and shaded relief techniques with the help of the GeoSoft and ErMapper software programs. which contain modules for gridding, contouring, shading and integration of various georeferenced data.

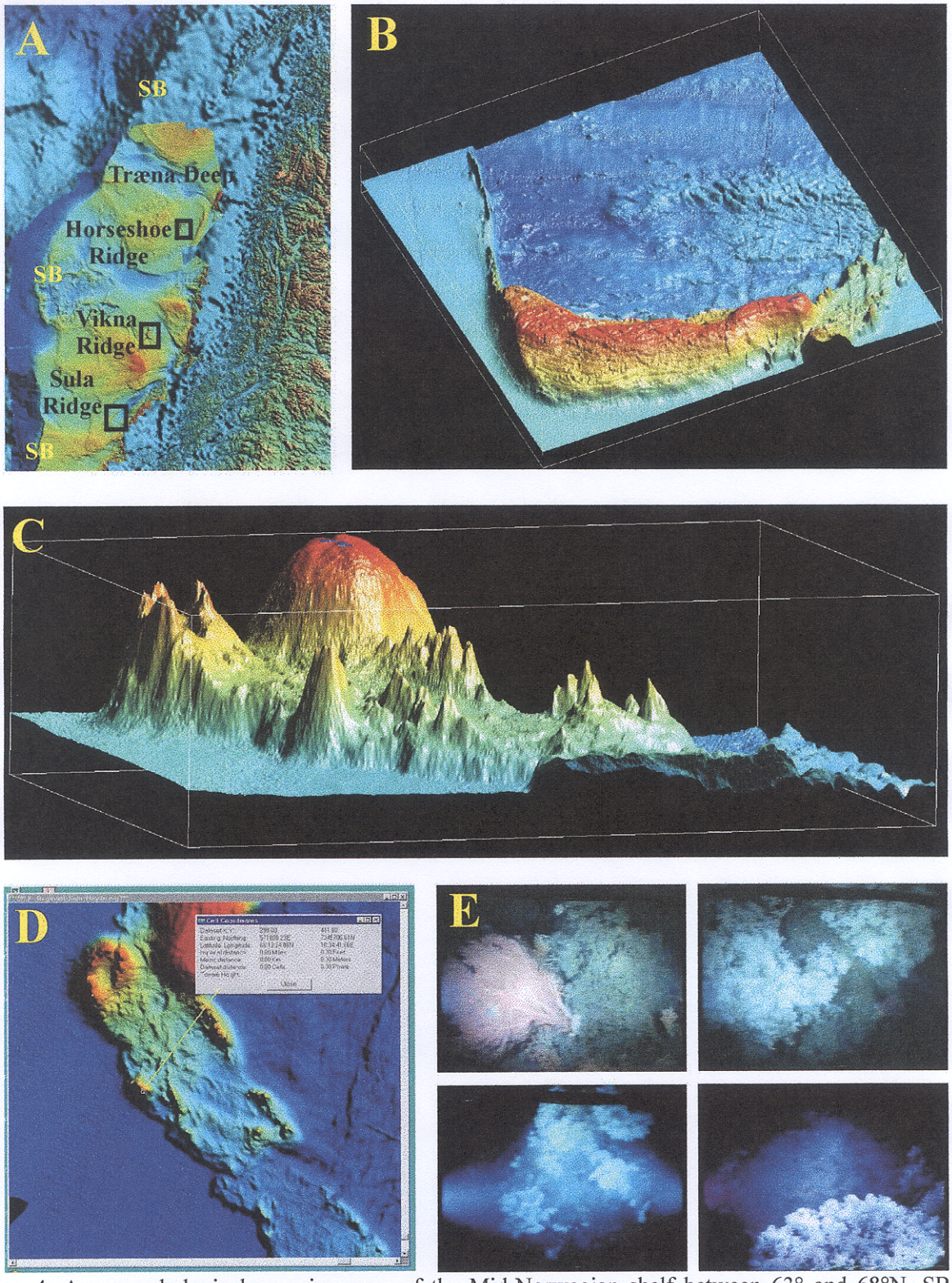

Figure 4. **A** – morphological overview map of the Mid-Norwegian shelf between 63° and 68°N. SB – shelf break at 400-500 m water depth. **B** – 3-dimensional view of the Horseshoe Ridge – a 100 m high and 10 km wide moraine ridge at 300 m water depth. **C** – low angle 3D-view, enhancing the coral reefs on the southern flank of the ridge (far right in **B**). **D** – screen dump from ErMapper (the image processing system used) showing the coordinates of one of potential coral mounds. **E** – video photographs from the location in **D** of corals, verifying the interpretations from the detailed bathymetry.

The bathymetric investigations were supplemented with data from video and still photographic, side-scan sonar and sediment-grab investigations of the sea floor (for details see Fosså *et al.*[7]).

From the investigations in 1998 and 1999 at the Sula and Vikna Ridges and from ancillary observations mostly from fishermen, it was reported by Fosså *et al.*[8] that the condition of ***Lophelia pertusa*** coral reefs was significantly influenced by fisheries bottom trawling. Acknowledging the limitations of the methodologies they applied, these authors approximated that between 1500 and 2000 km^2 within the EEZ of Norway can be characterized by coral reefs; one-third to one-half of this coral-reef habitat may already be damaged or significantly affected by bottom trawling. These investigations led to series of actions by Fosså and colleagues involving public outreach and education campaigns to inform the fishermen, general public and legislators about the importance of the coral-reef ecosystems as important habitats contributing to the biodiversity in Norwegian waters. This work culminated in legislation which now forbids any seabed-disturbing activities at the Sula and Vikna Ridges (Fosså in preparation' for a description of actions leading to legislation).

Notably, after learning to recognize the characteristic features of ***Lophelia*** coral reefs from bathymetric images collected at Sula, the Geological Survey of Norway noted that the seabed features at Horse Shoe Ridge (Fig. 4 A-D) were similar to those at the Sula Ridge and possibly were due to the presence of uncharted coral reefs. This area is not frequented by fisheries bottom trawlers, and thus little was known about its seabed habitats. Field investigations in summer 2000 by IMR indeed confirmed that Horse Shoe Ridge is a setting for coral reefs (Fig. 4 D and E). Thus, a fundamental objective of bathymetric mapping within MAREANO, namely the rapid visualization of seabed features and classification of these to a habitat level, was achieved.

For more information on MAREANO contact:
Thomas Noji, Institute of Marine Research, thomas.noji@imr.no; or
Terje Thorsnes, Geological Survey of Norway, terje.thorsnes@ngu.no.

For more information specifically on investigations of ***Lophelia pertusa*** reefs contact:
Jan Helge Fosså, Institute of Marine Research, jan.helge.fossaa@imr.no.

For a color version of Figure 4 contact:
Thomas Noji, Institute of Marine Research, thomas.noji@imr.no.

Notes and References

[1] "Norges muligheter for verdiskaping innen havbruk", DKNVS (Vitenskapsselskapet) og NTVE (Vitenskapsakademiet) , Trondheim 1999.

[2] To be hosted by the Institute of Marine Research in Bergen, Norway from 30 January to 01 February 2001; contact person is Thomas Noji at IMR.

[3] Lanters R., Skjoldal H.R., Noji T.T., Daan N., Offringa H., van Gool S. (1999). Ecological Quality Objectives (EcoQOs) for the North Sea. A Work Document for the 5th International Conference on the Protection of the North Seas, Scheveningen, The Netherlands, l-3 September 1999.

[4] Greene H.G., Yoklavich M.M., Sullivan D., Cailliet G.M. (1995). A geophysical approach to classifying marine benthic habitats: Monterey Bay as a model. In: Applications of side-scan sonar and laser-lien systems in fisheries research, Alaska Fish and Game Special Publication No, 9, pp. 15-30.

[5] Lindeboom H.J., de Groot S.J. eds (1998). IMPACT-II, The effects of different types of fisheries on the North Sea and Irish Sea Benthic Ecosystems, NIOZ Report 1998-1, Netherlands Institute for Sea Research, 404 pp.

[6] Kostylev V.E., Todd B.., Fader G.B.J., Courtney R.C., Cameron G.D.M., Pickrill R.A. (submitted). Benthic habitat mapping on the Scotian Shelf based on multibeam bathymetry, surficial geology and sea floor photographs. Marine Ecology Progress Series; Kostylev V.E. (2000). Brown's Bank scallop fishery. Contract report to GSC Atlantic. 18 pp.

[7] Fosså J.H., Mortensen P.B., Furevik D.M. *(2000). Lophelia* coral reefs along the Norwegian coast: distribution and condition [in Norwegian]. Fisken og Havet 2-2000, 94 pp.; Foss% J.H., Mortensen P.B., Furevik D.M. (submitted). The deep water coral *Lopheliapertusa* in Norwegian waters. Hydrobiologia.

[8] Same as 7

[9] Fosså J.H., Mortensen P.B., Furevik D.M., Moldeskred T. (in preparation). The protection of deep-water coral reefs in Norway: from documentation to legislation.