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The CoML Pilot Project MAR-ECO: Goals, Status, and significance for ICES.

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Abstract

The Mid-Atlantic ridge and adjacent waters are targeted in an international ecosystem study under the Census of Marine Life programme. This pilot project shall gather new knowledge on biodiversity, distribution patterns, and ecological processes, and the overriding aim is "to describe and understand the patterns of distribution, abundance and trophic relationships of the organisms inhabiting the mid-oceanic North Atlantic, and identify and model ecological processes that cause variability in these patterns". Fish, crustaceans, cephalopods, and gelatinous plankton and nekton have the highest priority in the study, but there will also be some focus on epibenthos and top predators such as seabirds and cetaceans.

A major challenge of the project is to overcome observation difficulties at large depths and in rugged terrain. A central aim is thus to utilise modern remote sensing technology (acoustics, optics) using advanced instrument carriers (e.g., towed vehicles, ROVs, AUVs etc.).

The project will work on the Mid-Atlantic Ridge and in adjacent waters from the Azores to Iceland, both by surveying large areas by acoustics and mid-water trawling, and by focusing on selected sub-areas for intensive sampling and observation by traditional and novel methods and technology. Overlapping with the field seasons 2003-2005, the period 2004-2008 will be an analytical phase, including also submission of data to OBIS.

The project will provide significant new information on exploited resources and biodiversity of immediate value to ICES, OSPAR and other advisory authorities. Examples are new data on habitat use, distribution patterns, life history strategies, and population genetics of deep-sea fishes exploited by ICES member states.

Keywords: Mid-Atlantic Ridge, biodiversity, distribution, macrofauna
The website http://mar-eco.no/ is the main source of updates, contact information, and documents relevant to the project.

Introduction and Background

Despite the wide distribution and extensive area of mid-ocean ridges (e.g. Garrison 1993), relatively few previous investigations have been dedicated to the study of the animal communities inhabiting these vast areas of the world ocean. Ridges may have characteristic faunas, but they may also significantly influence the processes such as intercontinental migration and dispersion affecting slope and shelf biota. Compared with the continental shelf and coastal environments, the ecosystems of the mid-oceanic ridges are poorly known and exploratory activity will provide new knowledge on both previously described and undescribed species. However, providing well-documented new information on how mid-oceanic ridge communities are structured and sustained is a challenging task.

The MAR-ECO project **(http://www.mar-eco.no/)**, that aims to study the mobile macrofaunal communities associated with the Mid-Atlantic Ridge between Iceland and the Azores, has recently been established as an international ecosystem study under the Census of Marine Life programme (CoML **,** **http://www.coml.org)**. The overriding goal is ***to describe and understand the patterns of distribution, abundance and trophic relationships of the organisms inhabiting the mid-oceanic North Atlantic, and identify and model ecological processes that cause variability in these patterns.*** The study will focus on pelagic and benthic macrofauna, and utilise innovative methods and up-to-date technology to map distributions, analyse community structure, study life histories, and model trophic relationships.

The Mid-Atlantic Ridge (MAR) is the spreading zone between the Eurasian and American plate (Fig. 1) is a part of a world-wide system of oceanic ridges. As a result of volcanic and tectonic processes, the ridge is continually being formed as the two plates spread at a rate of about 2 cm/yr. Between Iceland and the Azores the ridge extends over 1500 nautical miles, and it is characterised by a rough bottom topography comprising underwater mountain chains, a central rift valley, recent volcanic terrain, fracture zones, and seamounts. The MAR has an important influence on the deep-water circulation of the North Atlantic, partly separating deep waters of the eastern and western basins.

Globally the mid-ocean ridge systems represent major features of all oceans. In terms of surface area, the ridge habitats are vast compared with the shelf and slope habitats where most marine biological research has been focused to date. Hitherto many deep-sea biologists have avoided ridge areas because of cost of surveys and difficulties in using existing sampling equipment that would be readily damaged or lost. The exception is the exploration of chemosynthetic ecosystems, e.g. hydrothermal vents which has attracted considerable research effort (e.g. Van Dover, 2000; see also the Inter Ridge home page **http://triton.ori.u-tokyo.ac.jp/~intridge/**). A number of expeditions have been devoted to such systems around the world, but very few on the northern part of the MAR. Vent fields represent, however, a very minor fraction of the ridge area and the influence of chemosynthetic production on the overall biological production along the ridges is probably small.

Most previous deep-sea studies have been conducted either just off the continental slopes or in oceanic basins, and the understanding of the significance and influence of

the mid-ocean ridges on composition and distribution of pelagic and benthic fauna is still negligible.

The knowledge of certain very abundant and sometimes very widely distributed taxa such as cephalopods and gelatinous plankton organisms is particularly incomplete. These groups are difficult to sample, and traditionally their significance in pelagic ecosystems has been underrated. In oceanic systems such animals are very characteristic (Angel, 1997), and there is evidence that these groups play major roles in the food-webs of the ecosystems near the ridges and in frontal zones associated with the major circulation features. Thus, the potential for new significant discoveries is particularly great for these groups.

The mid-oceanic ridges have slowly become fishing areas of an international fleet of trawlers and longliners, and many of the species targeted have life histories that make them particularly vulnerable to overfishing. Pelagic fisheries of the open ocean have been targeting tuna, swordfish and sharks that tend to be found near fronts, eddies and islands. Whales also occur in such areas. The significance of mid-ocean ridge ecosystems for long-range migrants such as whales and large epipelagic fishes (e.g., tunas and billfishes) is not clear.

Traditional demersal fisheries have been conducted on the MAR within the Azorean and Icelandic EEZs, for many decades by Iceland (Magnusson and Magnusson, 1995), Russia and vessels from other eastern European nations (Troyanovsky and Lisovsky, 1995). Many nations have carried out exploratory fishing in the 1990s, including the Faroes (Thomsen 1998), Norway (Hareide *et al.* 1993; Langedal and Hareide, 1997), and Spain (Iglesias and Muñoz, 2001). The reported landings from the area remain, however, relatively small and variable, and few vessels find the ridge fisheries profitable.

Fisheries investigations have yielded valuable information on the distribution and abundance of fish, but have mainly considered species of commercial interest. Consequently, the exploratory fishing efforts of the past three decades have only to a limited degree enhanced our knowledge of the MAR ecosystems, communities, and the processes that structure and sustain the ridge communities. Few studies have aimed at providing basic taxonomical or ecological understanding.

Overall, the quantity and quality of the available information on ridge communities and their relation with adjacent basin communities and the slope faunas remains unsatisfactory. New technology and international collaboration makes a dedicated effort along the Mid-Atlantic Ridge feasible, and timely, although still challenging. In view of the global distribution of ridges, such efforts will provide information of great global interest.

MAR-ECO tasks

Some basic <u>overall</u> questions to be addressed by MAR-ECO are:

a) *Are the MAR communities extensions of the communities inhabiting the North Atlantic continental slope regions?*

b) *Is the MAR a barrier between the pelagic fauna of the east and west North Atlantic basins? Is there a difference in species occurrence either side of the MAR?*
c) *Do circulation features, such as the north Atlantic Current and north Atlantic Drift, act as barriers between the northern and southern fauna? In the region of the north Atlantic Current, what is the effect of eastward drift and import of material from the west?*
d) *What is the significance of individual seamounts within the ridge system?*
e) *Is the trophic structure of the northern mid-Atlantic ecosystem similar to that on the slope regions of the eastern and western sides of the Atlantic?*

A major challenge of the project is to overcome observation difficulties in distant waters at large depths and in rugged terrain. A central aim is thus to utilise modern remote sensing technology (acoustics, optics) using advanced instrument carriers (e.g. towed vehicles, ROVs, AUVs etc.), in addition to more traditional samplers and observation methods. The application and testing of new approaches, techniques and equipment is intrinsic to the MAR-ECO, and technological advances made in the deep-sea area may prove very useful also in shelf waters. The focus provided by an international multi-disciplinary project in a challenging environment, such as the deep-sea, is a great motivation for technological innovation on many fronts.

The Science Plan (available on the website ***http://www.mar-eco.no/***) presents the three central tasks of MAR-ECO and a compilation of hypotheses and suggestions resulting from discussions during and after an initial workshop held in Bergen, Norway, 12-13 February 2001:

Task 1: Mapping of species composition and distribution patterns.
Theme 1: Identity and distribution patterns of macrofauna.
The traditional classification of the pelagic fauna into epipelagic, mesopelagic, bathypelagic, abyssopelagic and benthopelagic communities is generally accepted. However, along the mid-ocean ridge the complicated topography and the effects on the circulation system and production of seamounts and the passage of mesoscale eddies may modify the picture substantially. Many pelagic and benthopelagic animals tend to aggregate in very limited areas. Study of behaviour, integrity and the dynamics of such aggregations will be undertaken in selected geographic areas. Characterisation of the physical environment of the faunal aggregations, focusing specifically on current patterns or frontal processes that may advect and concentrate pelagic prey organisms, is an essential component of the project.

Theme 2: Population genetics and dispersion studies.
Some species found on the mid-oceanic ridges are associated with relatively isolated seamounts, but the same species may also occur along the continental slopes of the North Atlantic basin. It is of great importance from both a scientific and management point of view to know whether the populations along the mid-oceanic ridges are really isolated from others, and if not, how dispersion occurs. Unique insights into these questions will be obtained from studies of population genetics undertaken in collaboration with, and for comparison with, other projects working on the continental slope.

Task 2: Identification of trophic interrelationships and modelling of food web patterns

The deep water fauna along and adjacent to the mid-oceanic ridges must somehow survive on the generally very limited local surface production and on advective concentration of phyto- and zooplankton. Two processes may be assumed to be particularly significant for the distribution and production of pelagic and demersal fauna on the mid-oceanic ridges and seamounts: vertical migration by epi-, meso- and bathypelagic organisms facilitates transfer of biomass and energy from the surface layer to deeper layers, and the current pattern around the seamounts may import and concentrate food. The oceanic macrofauna ultimately depends either on collecting the food near the surface or waiting for food particles to sink or migrate to a depth where they can be captured. The mesopelagic nekton has adopted the first strategy and performs extensive diel vertical migrations. Benthic and benthopelagic animals rely more on utilising food supply from above through sedimentation and migration. The project will analyse how the ridge system affects the processes of energy and material transport in the vertical dimension. To determine the trophic relationships among the demersal and pelagic animals is a central task for MAR-ECO.

Task 3: Analyses of life history strategies

The dependence on energy supplied from above or by advection probably limits turnover and production within the ridge community. Fauna inhabiting the mid-oceanic habitats must therefore have developed life history traits and ecology adapted to this limited production. It is often assumed that many of these deep oceanic species grow slowly, have very long life-spans, high ages at maturation, low fecundity and limited mobility. Major efforts will be made to test these assumptions through new investigations of growth and life history traits and systematic comparison of the diversity of these traits between related taxa from different habitats (the better known fauna of the continental slope). Quantification of these life history traits is critical to establishing the relationship between *biomass* and *production* in the ridge ecosystem.

Organisation and schedule

An International Steering Group has been established to organise and oversee the planning, financing, and implementation of the pilot project (Table 1). Norway has taken on the secretarial duties for the project, and the responsible institution will be the Institute of Marine Research (IMR) in collaboration with the University of Bergen.

The planning phase of MAR-ECO (2001 –2003) has been initiated and a formal organisational structure has been set up. A planning grant from the A. P. Sloan Foundation enables the International Steering Group to stimulate the network of experts to formulate component projects. The working titles and outlines of 14 MAR-ECO studies have been formulated, and are available at the website: http://mar-eco.no/ . The field phase is planned for 2003-2005, and a new Norwegian research vessel (*G.O. Sars)* will be at the disposal of the project activities, and may form a central focus of international multi-vessel operations. The field work is to be followed by analysis and synthesis of the data (2004-2008). Data will be incorporation in the CoML project: Ocean Biogeographic Information Systems (OBIS) and the completion of the project and a final synthesis is scheduled for 2008. It is anticipated,

however, that extensive material will be available for examination and further analyses also after this final year.

Societal benefits of MAR-ECO

A major overriding aim of MAR-ECO is to provide society with well-founded knowledge of patterns and processes of the mid-oceanic ridge ecosystem. The ridge system is a global feature found in all oceans, but surprisingly few focused studies have been conducted in ridge systems. New knowledge thus has a great value in itself, providing humanity with a greater understanding of the environment shared by all. The MAR-ECO vision is that, following the 2001-2008 project period, the identity, distribution patterns, food-webs, and life history patterns of the macrofaunal communities of the northern Mid-Atlantic Ridge and its flanks will be understood and well known both to the scientific community and the interested public.

New information is also required by governments and international bodies to design and implement environment and fishery management plans for mid-oceanic systems. The entire MAR-ECO area lies within the ICES Area (primarily Sub-areas X and XII), and enhanced knowledge on habitats, biodiversity and fishery resources would benefit the advisory process and outcome.

In a recent quality status report issued by OSPAR (the Oslo-Paris Commission) (OSPAR, 2000), a comprehensive review of information on the ecosystems of the oceanic north Atlantic was presented. A number of issues were raised that called for greater research effort, and with regard to biological data the following list of "uncertainties" was provided:

- Basic systematic information about the majority of benthic taxa, especially the smaller organisms;
- The importance of gelatinous organisms in pelagic ecosystems, mainly because the cannot be adequately sampled;
- The role of microorganisms in food webs and many aspects of biogeochemical cycling;
- The zoogeographical patterns and distributions of many keystone species and communities;
- The life cycles of many keystone species;
- The structure and dynamics of most deep-water food webs;
- The biological pathways for contaminants in deep ocean ecosystems;
- The natural variability against which contemporary changes in biological systems can be assessed;
- How long-term cycles in the physical environment affect midwater and seabed communities and processes;
- The links between biodiversity, productivity and other ecological processes;
- The impact of removing top predators, such as fish, from the oceanic ecosystems; and
- How to distinguish between natural variation and anthropogenically-generated change.

Many of these issues raised by OSPAR will be addressed by MAR-ECO.

Assessing the status of fish populations is never easy but it is particularly difficult for deep-sea stocks. This issue has been adressed repeatedly by the ICES ACFM and is a major concern of the ICES Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). One of the major problems is the quality of the data available. Data on the age structure of catches and stocks is normally a basic necessity for assessing fish populations, but age determination is difficult with many species of deep-sea fish. Even accurate species identification can be difficult and may be lacking. This is particularly true for deep-sea sharks. Our understanding of the biology and ecology of deep-sea fish is still far from complete. Knowledge of their basic biology such as migration, stock identity, recruitment, growth, feeding, maturation, and reproductive capacity of most deep-sea species still lags considerably behind that of shelf species. All of these factors affect the quality of stock assessments, and restrict our ability to evaluate the impacts of fishing on the deep-sea ecosystem.

MAR-ECO will provide new data on habitats, communities, and population biology. Of particular and immediate relevance to the assessment of deep-sea fish resources will be the studies of population genetics and life history strategies. An already initiated component project collects samples of a range of commercially exploited species, e.g. black scabbardfish, roundnose grenadier and alfonsino, from reference localities around the North Atlantic. Together with samples from the Mid-Atlantics Ridge, this new material will form the basis for DNA-based stock identity studies. In the life history project studies of growth, natural mortality, and reproductive biology will provide new information of value for the assessments of vulnerability to exploitation.

It is important that research effort of widely scattered resources and oceanic habitats are well integrated and can be carried out on a relevant oceanic scale and by international teams. It is the ambition of MAR-ECO to satisfy these needs. At present the research effort on deep-sea resources and ecosystems is too limited.

ICES will benefit from MAR-ECO when advice is formulated regarding habitats, communities and stocks as requested by NEAFC, the EU and national governments.

Literature

Angel, M.V. (1997). Pelagic biodiversity. In: R.F.G. Ormond, J.D. Gage, and M.V. Angel (eds.). Marine biodiversity: patterns and processes. Cambridge University Press, Cambridge, U.K. 449 p.

Garrison, T. (1993). *Oceanography: An invitation to Marine Science.* Wadsworth, Belmont, California.

Hareide, N.-R., Skarboevik, E., Kjerstad, M., Shibanov, V., Vinnichenko, V. and Gorchinsky, K. (1993). Forsoeksfiske etter orange roughy paa Den midt-atlantiske rygg med fabrikktraalaren m/t Ramoen 1. september – 8. oktober 1993. Report, Moere Research, Aalesund, Norway and PINRO, Murmansk, Russia. 80 p.+appendices. (in Norwegian).

Iglesias, S. and Muñoz, P. D. 2001. Spanish investigations on deep-sea resources in northern Mid-Atlantic Ridge and adjacent areas. Working Document presented to the Workshop on the CoML pilot project "Patterns and processes of the ecosystems of the northern Mid-Atlantic, Bergen 12-13 February 2001. 7 p.

Langedal, G. and Hareide, N.-R. 1997. Rapport fra forsoeksfiske paa Reykjanesryggen/Midt-atlanterhavsryggen med M/S Skarheim juli 1997. Report, Norwegian Directorate of Fisheries and Moere Research, 58 p. (in Norwegian).

Magnusson, J.V. and Magnusson, J. 1995. The distribution, relative abundance and the biology of the deep-sea fishes of the Icelandic slope and Reykjanes ridge. p. 161-200 in: Hopper, A.G. Deep-water fisheries of the North-Atlantic Oceanic Slope. NATO ASI Series, Series E. Applied Sciences, vol. 296, 420 p.

OSPAR Commission. 2000. Quality Status Report 2000, Region V- Wider Atlantic. OSPAR Commission, London. 110 p + xiii pp.

Thomsen, B. 1998. Faroese quest of orange roughy in the North Atlantic. ICES C.M. 1998/O:31.

Troyanovsky, F.M. and Lisovsky, S.F. (1995). Russian (USSR) fisheries research in deep waters (below 500 m) in the North Atlantic. p. 357-366 in: Hopper, A.G. *Deep-water fisheries of the North-Atlantic Oceanic Slope*. NATO ASI Series, Series E. Applied Sciences, vol. 296, 420 p.

Van Dover, C.L. (2000). The Ecology of Deep-Sea Hydrothermal vents. Princeton University Press. 424 pp.

Table 1. The current International Steering Group of MAR-ECO.

Dr. Odd Aksel Bergstad, IMR, Norway (chair)
Prof. Peter Boyle, Univ. Aberdeen, UK
Dr. Olafur S. Astthorsson, MRI, Iceland
Dr. Ricardo S. Santos, Univ. Azores, Portugal
Dr. Uwe Piatkowski, Univ. Kiel, Germany
Dr. Michael Vecchione, NOAA, NMFS, USA
Dr. E.M. Burreson, Virginia Institute of Marine Science (VIMS), USA
Prof. Ulf Båmstedt, University of Bergen, Norway
Dr Pascal Lorance, IFREMER, France

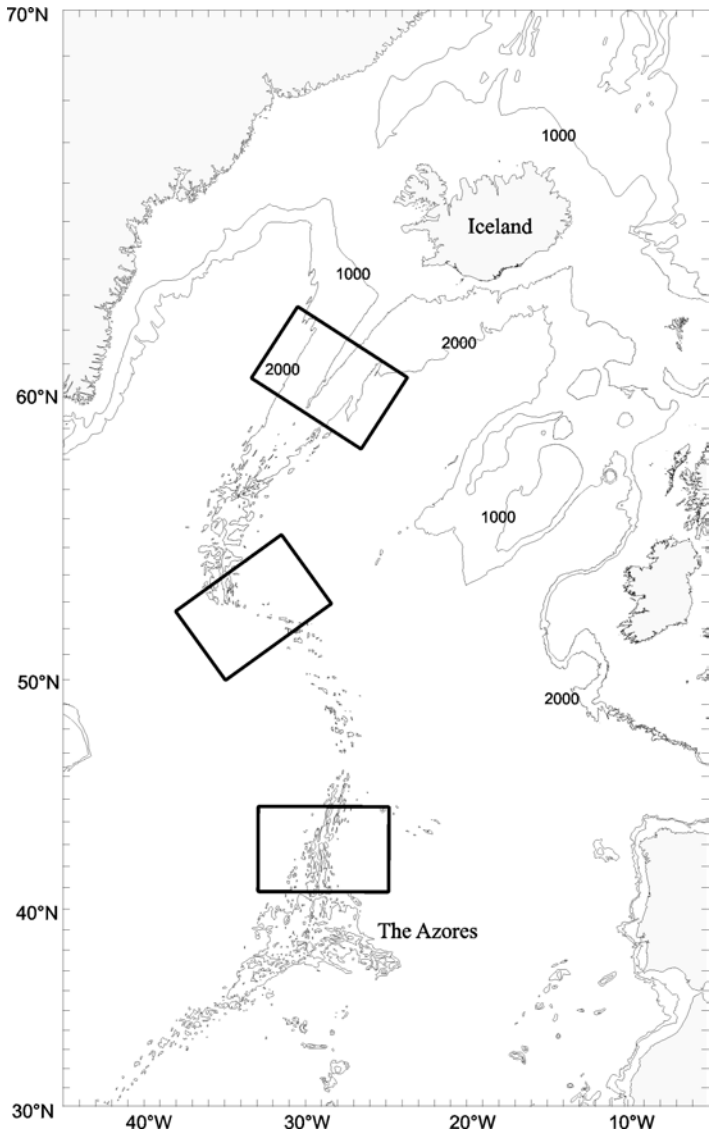

Figure 1. The North Atlantic Ocean, and the Mid-Atlantic Ridge. Sub-areas selected for detailed studies.