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Towards improved understanding of the diversity and abundance patterns of the mid-ocean ridge macro- and megafauna

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Abstract

Mid-ocean ridges are vast features of all oceans but their fauna and ecological significance remain poorly understood. Ridge studies in recent decades were understandably biased in favour of the newly discovered chemosynthetic ecosystems. Investigations of photosynthesis-based systems and communities associated with ridges were scattered and few despite their much larger scale and significance for ocean productivity patterns and biogeography and for the management of human activities on the high seas. This knowledge gap was recognised by the Census of Marine Life (CoML) programme and led to the initiation of a dedicated field project on non-chemosynthetic systems and communities of a mid-ocean ridge.

The present collection of articles highlights results from the project 'Patterns and Processes of the Ecosystems of the northern Mid-Atlantic' (MAR-ECO), the CoML field project that aims to explore the diversity and distribution patterns of photosynthesis-based communities of mid-ocean ridges by a range of classical and new technologies and methods. In 2003–2005, comprehensive investigations were conducted on pelagic and epibenthic macro- and megafauna of the Mid-Atlantic Ridge between Iceland and the Azores. Several research vessels participated in the first field phase of the project, but the majority of the results were from a 2-month international expedition on the Norwegian vessels R.V. *G.O. Sars* and the chartered fishing vessel M.S. *Loran* in 2004. This introduction explains the background and goals of MAR-ECO,

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summarizes the strategies and sampling efforts, and briefly introduces future plans as the project enters a second field phase in 2007–2009.

Keywords: Mid-ocean; Biodiversity; Communities; Photosynthetic; MAR-ECO

1. Introduction

The idea for a comprehensive biodiversity study in waters associated with the mid-Atlantic Ridge in the North Atlantic emerged in the late 1990s, but reached a mature and operational stage in 2001 when a transatlantic consortium of scientists wrote a science plan for the Census of Marine Life (CoML) project named Patterns and Processes of the Ecosystem of the Northern mid-Atlantic, acronymed MAR-ECO. The history and first years of the project were described in two main papers, written prior to the initial field phase in 2003–2005, the first by Bergstad and Godø (2003) and the second by Bergstad and Falkenhaug (2005). The work at sea generated major new biotic and abiotic datasets and collections, and the scientific network of scientists and numerous students conducted substantial analyses in the subsequent years. Several papers were published early (e.g., Holland et al., 2005; Sanamyan and Sanamyan, 2005; Vinogradov, 2005; King et al., 2006; Fock and John, 2006; Fossen and Bergstad, 2006; Priede et al., 2006; Vecchione and Young, 2006; Young et al., 2006a, b), including a monograph on the biogeography of seamount biota (Mironov et al., 2006), and many oral presentations were read in scientific fora. The present collection of papers constitutes the first major comprehensive, although by no means exhaustive, presentation of scientific results from MAR-ECO's first field phase. The papers span taxonomical ranges and ecological zones from the pelagic to the benthic, and from the seamounts to abyssal depth. There are detailed descriptions of observation technology using various capture gears, acoustic, optics, and both vessel-based and independent platforms.

This introductory paper explains the motivation, background and objectives of MAR-ECO as a contribution to deep-ocean pelagic and ridge science, under the framework of the CoML programme.

2. Motivation and aims

The motivation for MAR-ECO was twofold. Firstly, the curiosity-driven scientific challenge of exploring the fauna and distribution patterns in a major area and habitat that had not been investigated satisfactorily with new tools and methods. Key questions, such as "What is the significance of mid-ocean ridges, as comparatively shallow structures in the middle of the deep oligotrophic ocean, for the distribution and production of biota?", demanded answers. Secondly, the urgent need to derive data and information useful for managing the ridge biota, including fisheries resources and vulnerable benthic communities. This latter motivation was reflected in the participation in the project by academic and fisheries institutions from several nations.

The overriding objectives formulated in the original science plan, worked out on the basis of an idea stage workshop (see www.mar-eco.no/sci), were admittedly ambitious, i.e. "to describe and understand the patterns of distribution, abundance and trophic relationships of the organisms inhabiting the mid-oceanic Norm Atlantic, and identify and model ecological processes that cause variability in these patterns". The project has reached some of the goals, primarily the descriptive elements that dominate the results presented in tins issue, and further work in the coming years will be needed to study and model trophic relationships and processes underlying distribution and abundance patterns.

MAR-ECO is partially hypothesis-driven, partly purely descriptive, the latter due to the lack of basic information to even raise testable hypotheses. Patterns of abundance and species composition were assumed to be influenced by topography, depth, and the occurrence of different watermasses or hydrographical features, especially the Sub-Polar Front that divides the relevant section of the Mid-Atlantic Ridge into almost equal northern and southern sectors (i.e. essentially cool and warm) (Søiland et al., 2008, and references therein). There was also interest in exploring whether western and eastern slopes had different species composition and how these compared with patterns on similar continental slopes in the North Atlantic Ocean. A key question was how pelagic biota and abundance patterns were influenced by topographic features,

and this was studied for phytoplankton, zooplankton, and nekton, including whales and seabirds.

3. Strategy and structure of project

MAR-ECO is being carried out by an international network of scientists, students and technicians, and the participants have had access to common funds and material. The network members take part in various field or analysis activities depending on interest, and ability to make commitments of time and other resources. MAR-ECO therefore should be regarded as a network effort, not a project funded in advance for a certain period with a specified personnel and other firmly committed resources. During the planning phase 2001–2003, the Steering Group aimed to secure resources and personnel for the subsequent field and analysis phases by approaching public and private sector funding agencies and a range of sponsors.

The overall project was structured into 10 contributory projects, each with individual hypotheses, goals and personnel. The contributory projects specified tasks to be accomplished and wrote plans for the post-cruise handling of data and material. The components were grouped into three main areas by target ecological components: plankton, pelagic nekton, and demersal nekton (including epibenthic megafauna), but there are obvious linkages among these.

Working in mid-ocean waters and at great depths over rugged topography is technologically challenging and expensive. MAR-ECO's strategy was to mobilise relevant experts, instruments and ships from several countries in order to achieve a satisfactory competence and capacity to meet the challenges at an acceptable cost. This mobilisation is a continuous ongoing process, and the project has to tune activities to the availability of personnel, technologies, ship-time commitments and funds.

Using a range of technologies on the same platform provides more comprehensive results and enhances the potential for new discoveries. The aim was to sample and/or observe organisms of the size range from millimetres to metres (e.g. small zooplankters to whales); hence, a range of samplers adapted to collect this kind of information in the most accurate and efficient way was needed. In order to sample all relevant depths, the technologies would ideally need to function from surface waters to about 4500 m.

4. The field campaigns 2003–2005

The ship-time commitments realized in the initial field phase are listed in Table 1. Also included are planned cruises in the second field phase starting in 2007. Reports from most of the listed cruises were posted on www.mar-eco.no/sci or on www.rrz.uni-hamburg.de/OASIS.

The initial commitment, crucial for the initiation of the project and forming a backbone of the entire effort, was the Norwegian offer of the R.V. *G.O. Sars* for a 2-month campaign in 2004. This led, however, to an early commitment by Iceland for extending their 2003 Irminger Sea redfish survey onto the Mid-Atlantic Ridge (Reykjanes Ridge) so as to sample an area of interest to MAR-ECO. Russian and German contributions to the same redfish survey also were modified so that at least reference material and data of value to the project were collected. Similar reference materials were collected on New England seamounts by the USA and by the EU Fifth Framework project OASIS on East Atlantic Seamounts (Sedlo and Seine).

A short but more spectacular effort in 2003 was the joint US–Russian submersible cruise on the R.V. *Akademik Mstislav Keldysh*. This was accomplished with funding from the NOAA Ocean Exploration Office and A.P. Sloan Foundation, and provided the rare opportunity to dive with the manned submersibles MIR-1 and MIR-2 in the Charlie–Gibbs Fracture Zone, to depths and areas never before visited by man. This issue contains one paper resulting from that effort (Felley et al., 2008); other papers were published previously (Vinogradov, 2005; Sanamyan and Sanamyan, 2005; Holland et al., 2005).

In 2004, the project had its main international and multidisciplinary effort with the expedition in June–July on the R.V. *G.O. Sars* and the chartered fishing vessel M.S. *Loran*, involving a scientific party of 75 scientists and technicians from 13 countries. The strategies and roles played by the two vessels are described by Wenneck et al. (2008) and Fossen et al. (2008) and will not be repeated here. While other cruises sampled only subareas of the study area, the 2004 expedition investigated the entire segment. Only the northern Reykjanes Ridge was not sampled extensively due to the Icelandic vessel's efforts in that area the previous year.

The efforts of R.V. *G.O. Sars* and M.S. *Loran* generated extensive collections of fish as well as

Table 1
Ship-time partly or fully committed to MAR-ECO, 2003–2009

Year	Country	Ship/vehicle	Duration	PI and responsible institution
2003	Iceland	R.V. *Arni Fridriksson*	2 weeks (as element of Irminger Sea survey)	T. Sigurdsson, MRI, Reykjavik
2003	Germany	R.V. *Walther Herwig*	1–2 days (opportunistic trawling during passage of MAR)	E. Behtke, Institut für Seefischerei, Hamburg
2003	Germany	R.V. *Poseidon*	2 weeks EU 5FP OASIS project cruise	B. Christiansen. University of Hamburg
2003	Germany	R.V. *Meteor*	4 weeks EU 5FP OASIS project cruise	B. Christiansen, University of Hamburg
2003	Portugal	R.V. *Archipelago*	Three 2-week cruises, longlining at Sedlo and Seine seamounts, OASIS project	R. Santos, University of Azores
2003	Russia	R.V. *Smolensk*	1–2 weeks (as element of Irminger Sea survey)	A. Pedchenko, PINRO Murmansk
2003	Russia/ USA	R.V. *Ak.Mstislav Keldysh*	1.5 weeks (MIR dives, C-G Fracture Zone)	M. Vecchione, NOAA NMFS
2003	USA	R.V. *Delaware II*	2 weeks, New England seamounts, collection of reference material	M. Vecchione, NMFS, NOAA
2004	USA	R.V. *Delaware II*	2 weeks, New England seamounts, collection of reference material	M. Vecchione, NMFS, NOAA
2004	Norway	R.V. *G.O. Sars*	4 days (Norw. fjords). Technology trials	Godø, IMR
2004	Norway	R.V. *G.O. Sars*	8 weeks (entire area)	Bergstad & Godø, IMR and University of Bergen
2004	Portugal	R.V. *Archipelago*	Three 2-week cruises, longlining at Sedlo and Seine seamounts, OASIS project	R. Santos, University of Azores
2004	Norway	*Chartered longliner* M.S. *Loran*	22 days	J.-E. Dyb, IMR, Moere Research, US NMFS
2005	USA	R.V. *Delaware II*	2 weeks, New England seamounts, collection of reference material	M. Vecchione, NMFS, NOAA
2005	Germany	R.V. *Walther Herwig*	4 weeks	H.C. John, University Hamburg
2005	USA	R.V. *Delaware II*	2 weeks, New England seamounts, collection of reference material	M. Vecchione, NMFS, NOAA
2007	UK	R.R.S. *James Cook*	4 weeks	I.G. Priede, UK Consortium
2008	UK	N.E.R.C. ship		I.G. Priede, UK Consortium
2009	UK	N.E.R.C. ship		I.G. Priede, UK Consortium

invertebrates. Bergen Museum functions as a permanent repository for these collections.

In 2005, there were no dedicated MAR-ECO cruises, but an interesting series of cross-ridge samples of fish larvae and eggs were collected on the German R.V. *Walther Herwig* as a courtesy contribution to the project.

In both 2004 and 2005, OASIS project cruises were conducted, and also US NOAA cruises related to the CoML project GoMA (Gulf of Maine Project). These provided reference data from seamounts on either side of the Mid-Atlantic Ridge.

So the field efforts were extensive, at least in terms of number of cruises and people involved, but in relation to the size of the study area both along and across the Ridge (area the size of northern Europe), the sampling in 2003–2005 at most constituted only a good start. We had access to a range of modem technologies, but not all items initially on our wish list. The papers in this issue and others published elsewhere hopefully document that valuable new results were obtained, despite inadequacies and lack of sufficient ship-time.

5. The future

Lead times in proposals to national funding agencies led to late approvals of certain project activities, and partners in several countries applied for cruises but failed. In 2006, the UK consortium were successful, however, initiating a second field phase of MAR-ECO in the years 2007–2009 when UK vessels will conduct process orientated studies in and near the Sub-Polar Front about halfway between Iceland and the Azores. A US ship also may sail to the same area that was shown in several papers in this issue to be particularly interesting, marking a transition between a northern and southern faunal province and also itself constituting a sub-area of apparent concentration of macrofauna

and presumably high production levels. As a result of these ship-time commitments, and perhaps others, MAR-ECO has been extended to 2010 when a final report will be issued as an element of the overall CoML end report, including information from both field phases.

The question of expansion into other waters and ridge areas on a global scale has been on the agenda in MAR-ECO and CoML since the start of the efforts, and with this series of papers and others we hope to have paved the way for similar studies elsewhere. In the autumn of 2006, an interim MAR-ECO steering group was formed in the South Atlantic, bringing together relevant expertise from both sides of that ocean area. The biodiversity of the Mid-Atlantic Ridge in that area has hardly been investigated and hopefully the next few years will see commitments of resources to new comparative efforts in these waters. But the global mid-ocean ridge system winds for 60,000 km around the globe, and we have essentially just begun the exploration of the first few minor segments of this exciting feature of the biosphere.

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