

# **Patterns and Processes of the Ecosystems of the Northern Mid-Atlantic (MAR-ECO)**

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*MAR-ECO is led by an International Steering Group. Please see project website for current membership.*

<http://www.mar-eco.no>

## **1. LONG-TERM GOALS**

The overriding aim of the MAR-ECO project is to apply modern technology and platforms to describe and understand the patterns of distribution, abundance and trophic relationships of the organisms inhabiting the mid-oceanic North Atlantic, and further to identify and model ecological processes that cause variability in these patterns. The waters associated with the mid-Atlantic Ridge between Iceland and the Azores is the target area. The study aims to develop and demonstrate strategies and technology for use in other mid-ocean ridge areas and hence provide a basis for world-wide exploration of ridge-associated communities and ecosystems.

In an effort to expand into waters beyond the North Atlantic, efforts will be made to develop parallel efforts in the South Atlantic supported and managed by regional resources.

## **2. OBJECTIVES**

The greatest focus is on mesopelagic and benthopelagic macro- and megafauna (nekton and macrozooplankton), and their trophic relationships. Benthic fauna will be described in selected habitats, especially to facilitate analyses of food-web structure involving e.g. benthopelagic and benthic fishes.

Objective 1: Mapping of species composition and distribution patterns.

The most central activity will be the mapping of species distributions and species composition using both traditional and innovative methods, but analyses of population genetics and dispersion patterns will also be included. Therefore, two themes have been defined:

*Theme 1: Identity and distribution patterns.*

*Goals:*

- To determine a broad scale distribution of the pelagic and benthopelagic communities.
- To describe the benthic macrofauna in a limited number of typical habitats or along selected cross-ridge transects.
- To provide input data to food-web studies.

## *Theme 2: Population genetics and dispersion studies*

### *Goals:*

- To analyse spatial and temporal genetic structure of species. Methods include analysis of sequence variation, microsatellites, other types of sequence marker.
- Provide molecular phylogenetics and detection of cryptic species. This will be coupled with taxonomic studies.
- To use molecular methods for species identification. These are currently in development especially for systematically difficult groups.

## Objective 2: Identification of trophic interrelationships and modelling of food web patterns

In conjunction with analysing and mapping the characteristic faunal communities of the northern mid-Atlantic ecosystem a major subject deriving from field work will concentrate on investigating the trophic structure of the target area. One central question will be addressed: *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?*

### *Goals:*

- To study variations in the trophic structure of the northern mid-Atlantic ecosystem along an east-west gradient
- To study variations in the trophic structure from north to south
- To study the unique food web patterns of seamounts

## Objective 3: Analyses of life history strategies

Life history strategies are important in controlling the distribution and population structure of the species inhabiting the MAR and seamount regions. Available information on the large scale distribution patterns of deep water fishes indicate that some are found on both sides of the North Atlantic Ocean while others only occur on one side of the ocean and along the MAR. The same may also apply to some of the other less studied groups of pelagic animals.

### *Goals:*

- To study life history strategies of selected species of the fauna related to the MAR and seamounts.
- To reveal any relationships between large scale distribution patterns and life history strategies of demersal and pelagic species of the MAR and adjacent continental slopes.

## **3. APPROACH**

Working in mid-ocean waters and at great depths and rugged topography is technologically challenging and expensive. MAR-ECO's strategy has been to mobilize 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 mobilization is a continuous ongoing process. The approach has been to create a network of scientists that can satisfy the requirements throughout the project's planning, field and analysis phases by seeking to contribute primarily national resources to a co-ordinated international effort. Being a network effort dependant on many sources of resources, MAR-

ECO 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 is to sample and/or observe organisms of the size range from mm to tens of 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 is needed. In order to sample all relevant depths, the technologies need to function from surface waters to about 4500 m.

Thus when a ship is working for MAR-ECO, it will combine e.g. traditional sampling with nets with novel acoustical and optical instruments mounted on the hull, on cables, moorings or submersibles. Depending on the objectives, sampling will be continuous along the ship's track, or limited to certain locations where samplers, moorings or submersibles are deployed for a limited period of time. MAR-ECO used long-term acoustic moorings for the duration of the 8-week *G.O.Sars* cruise, and one of these moorings were in 2005 successfully recovered after being out for almost a full year.

The same strategy is likely to be needed of MAR-ECO efforts shall be developed in other waters, e.g. the South Atlantic.

#### **4. WORK COMPLETED**

##### *Cruises*

The major dedicated MAR-ECO cruise was the 8-week cruise on the Norwegian RV *G.O. Sars* 4 June-4 August 2004, and the 3-week operation of the chartered longliner MS *Loran* (reports a.o. profiles on [www.mar-eco.no](http://www.mar-eco.no)). The Icelandic RV *Arni Fridriksson* effort in June-July 2003 was a significant early contribution, actually a prolongation of a much longer ICES-coordinated Irminger Sea survey in which also the German and Russian vessels were participating. The 2003 effort on RV *Mstislav Keldysh* was short but included a series of dives with the manned submersibles *MIR-1* and *-2* in the Charlie-Gibbs Fracture Zone. Both in 2003 and 2004 several cruises served the EU 5th Framework project OASIS of which elements are seen as contributions to MAR-ECO. The most relevant elements were the studies on the Sedlo seamount north of the Azores. German, Portuguese and UK ships participate in this effort. RV *Delaware II* operated on the New England seamounts in 2002, 2003, 2004, and 2005 and collected important reference material from that area.

The only dedicated effort on the mid-Atlantic Ridge in 2005 was a short period of a July cruise on the German vessel RV *Walther Herwig*. This vessel conducted depth-stratified zooplankton sampling along two meridional transects, especially targeting ichthyoplankton, from the northern section of the MAR-ECO study area.

Recently, major additional ship-time commitments have been made by the United Kingdom and the USA for 2007-2009 (see pt 5 below).

##### *Onshore analyses*

Analyses of data and material from cruises in 2003, 2004, and 2005 began immediately after the cruises were finished. Sub-groups of scientists and students have focused on specific tasks associated

with each of the 10 component projects in which MAR-ECO is organised. The individual components have formulated concrete plans and distributed tasks among partners.

A first major task after the major MAR-ECO expedition on RV *G.O. Sars* and MS *Loran* in 2004 was to curate all samples. This has been accomplished by the Bergen Museum staff during the months after the cruise and is now near completion.

Many samples were not sorted to species on the ships, and a second main task has been to check identifications and sort unsorted samples. The majority of the fish, cephalopods and benthic invertebrates have now been identified, but much work is still needed on the extensive samples of zooplankton and micronekton. MAR-ECO and other funding agencies have sponsored many visiting scientists, several workshops, and samples have been sent to taxonomists for further examination. Such activities are listed in the text table below. The table does not include the extensive efforts being made by individual scientists and students.

Full project meetings were held 2-3 June 2005 in Lisbon and in Aberdeen 6-7 July 2006. The meetings comprised plenary presentations of results as well as sub-group sessions to discuss ongoing and future work.

*Table of MAR-ECO networking activities in the Summer-Autumn 2005-Summer 2006. DN1,PN1,Z1 etc. are acronyms for component projects dealing with demersal nekton, pelagic nekton, and zooplankton respectively*

Activity	Time	Organiser	Funding source (in addition to internal funding)
Z1. Sorting and identification of mesozoopl. in Moscow	April 05- November 05	Z1 team in Shirshov Inst.	Nordic Council of Ministers
MAR-ECO field phase workshop	2-3 June 05	OA Bergstad, T. Falkenhaus, IPIMAR	The Research Council of Norway, FCT, EU MARBEF, IPIMAR, IMAR, DOP.
DN3 Visit by Tina Molodtsova and Kiril Minin to Bergen to work on benthos collection	2 weeks in August 05	J. Kongsrud A. Gebruk	Norwegian Foreign Office Funds
MAR-ECO presentations and open-ship day on the island Godoy	September 05	O.R Godø, J.E. Dyb	
MAR-ECO exhibition, Horta, the Azores	September 05	DOP	DOP
MAR-ECO exhibition, "Deeper than the light", Natural History Museum, Kristiansand, Norway	September 05	Bergstad, Falkenhaus, Museum staff	
MARBEF RMP workshop, IMR, Bergen. "Strategies and methodologies for assessing the state of the biodiversity in open ocean pelagic sites"	October 05	A.Pierrot Bults, U. Piatkowski	EU MARBEF
O.A Bergstad visits MAR-ECO scientists in P. P. Shirshov Institute of Oceanology, Moscow	4 days November 05	OA Bergstad	IMR, Norway
Z1 taxonomy workshop on decapod shrimps, IMR, Norway	5-9 December 05	T. Falkenhaus	
PN3 Satellite telemetry workshop, Horta, the Azores	1 week in January 06	L. Nøttestad, DOP	

MARBEF RMP workshop, IFM-GEOMAR, Kiel "Integration of different methods to study patterns and changes in pelagic biodiversity in the open ocean along the mid-Atlantic Ridge"	27-29 March 2006	U. Piatkowski	EU MARBEF
Z2 workshop on ROV and UVP data, Villefranche-sur-Mer	1 week in April 06	M. Youngbluth,	
MAR-ECO annual project meeting, Aberdeen University, UK	6-7 July, 06	OA Bergstad, T. Falkenhaus, B. Wigham	Norwegian Foreign Office (Russian delegates)
Z1 workshop on zooplankton Multinet data, Faroe Islands	14-18 August, 06	E. Gaard	
PN1 workshop on cephalopod material, Bergen Museum, Norway	3 weeks in September 06	J. Kongsrud, E. Willassen, U. Piatkowski	
South Atlantic MAR-ECO workshop, Brazil	6-7 September 06	OA Bergstad, Angel Perez, CTTMar	

## 5. WORK PLANNED

The plans for the coming year (Autumn 2006 and Spring 2007) reflect the phase that MAR-ECO has reached. The challenge in future years is to combine early analyses of existing data and samples and publishing with a continued emphasis on new work at sea.

The US commitment of a vessel in 2007 and the UK commitments for 2007, 2008, and 2009 extend the field work beyond the original 2003-2005 field phase, but represents a significant opportunity for further studies. The cruises will be used for focused studies in and near the Charlie-Gibbs Fracture Zone. A particular focus is given to studies in association with the Sub-polar Front.

As taxonomical challenges are overcome and remaining samples are sorted, the MAR-ECO database is being revised and quality-controlled. Next steps will be several:

- 1) Further taxonomical and systematical analyses of many taxa. This can also include description of new species based on morphological and molecular analyses, range revisions of known species etc.
- 2) Studies of population genetics for certain target species using microsatellite DNA.
- 3) Studies of trophic patterns based on stomach content examination and DNA sequencing.
- 4) Analyses of distribution patterns and species assemblage structure.
- 5) Analyses of identity, behaviour and ranges of acoustic scattering layers.
- 6) Input of geo-referenced occurrence data to OBIS.

In parallel, sub-groups have already been working on datasets not directly utilizing the biological collection:

- 1) Further analyses of the observations from the underwater video profiler (UVP).
- 2) Re-examination of footage from benthic and pelagic dives by ROVs
- 3) Studies of demersal fish and invertebrate occurrence on photographs from baited benthic landers.
- 4) Analyses of physical and chemical datasets from CTDs, ADCPs and water samples.

Work on most of these elements is well advanced. Indeed, publications are being planned and written. Many papers have already been published and/or read at meetings worldwide (please see presentation archive), adding to the growing legacy of the project. MAR-ECO will in the coming year continue to support sub-groups meetings and short-term visits by scientists and students to collections and colleagues. The MAR-ECO policy is that partners should publish findings as soon as they see opportunities, but several components work according to agreed publication plans. During the next year, it is expected that the output of scientific talks, articles, notes and theses will be substantial within a range of fields from taxonomy and systematics to ecology and physical oceanography. Two special issues containing MAR-ECO results will be published in 2007 (Deep Sea Research II and Marine Biology Research).

Following satisfactory quality-control and re-checking of species identifications, occurrence and abundance data from the various cruises and gears will be made accessible to OBIS. It should be appreciated that the number of taxa is high and that the data are large and diverse, thus the preparatory phase is extensive.

Planning of field efforts in 2007-2009 began during the Aberdeen workshop in July 2006, and efforts are now underway to mobilize relevant technology. There will be a planning meeting from ECOMAR (UK effort) in Aberdeen in January 2007.

MAR-ECO held a meeting with potential partners from South America and southern Africa in Brazil 6-7 September. A full report is forthcoming, but the conclusion was that a regional steering group was formed that will produce a concept note/ science plan as basis of further efforts in the South Atlantic. The chair of the new steering group will meet in the MAR-ECO SG. It is the long-term goal that this initiative will lead to an expansion of MAR-ECO efforts southwards along the mid-Atlantic Ridge.

## 6. RESULTS

Technical advances were made during several of the cruises. MAR-ECO has demonstrated, especially on the *G.O.Sars* and *MS Loran* expedition, that many technologies can and should be combined on the same platforms in order to explore deep-sea communities and ecosystems efficiently. In the pelagic zone, successful application of sampling technology for efficient depth-stratified sampling with big and small multiple cod-end trawls and nets, controlled partly by acoustic instruments, was another breakthrough. The combination of advanced acoustic instruments (echosounders of several frequencies and configurations) with optical instruments and catch data from capture gears, will provide new insights into the pelagic animal communities and their distributions. Successful real-time bathymetry mapping using multibeam acoustics and mapping software was a further breakthrough and facilitated controlled deployment of ROVs, landers and double-warp bottom trawls to 3800m in rugged terrain which was very poorly mapped previously. Whales and birds have been mapped by traditional sighting surveys along cruise tracks, but attempts have also been made to tag large baleen whales by satellite transmitters. Again, combination of sightings, tagging data, and data from e.g. samplers and acoustics will provide new insight into occurrence patterns and behaviour. This will surely be valuable technology for further ridge studies in other waters.

Results of MAR-ECO are emerging and many publications have already appeared. At the project meetings in Lisbon and Aberdeen numerous scientific contributions and progress reports were

presented, either orally or as posters. Many of these will result in formal publications in the special issues mentioned above or elsewhere. Highlights were reported previously, and the project is now in a consolidation phase where preliminary results are being quality-assured and published. Twenty-nine papers are likely to be submitted to the *Deep-Sea Research II* issue, and 10 in *Marine Biology Research*. In addition, the project has co-sponsored a Russian book on the biogeography of North Atlantic seamounts.

## **7. IMPACT AND APPLICATIONS**

### **a. Ocean Observing Systems**

MAR-ECO has developed and utilized battery-powered hydroacoustic and photographic landers/moorings that may become useful as technologies for future ocean observing systems. The instruments used by MAR-ECO can operate for weeks or months.

### **b. Marine Ecosystem-based Resource Management (Delete this section if there are none)**

Ecosystem-based resource management can only be achieved if the structure and processes of the systems are known and understood. Mid-ocean systems have not been extensively studied, thus MAR-ECO gathers useful basic information that will benefit future advisory processes and management.

Data from MAR-ECO are already in demand, e.g. new data on the occurrence of corals on mid-Atlantic Ridge hills and the existence of impacts of fishing gear. Some information has already been provided to ICES and used as partial basis for advice to e.g. the Northeast Atlantic Fisheries Commission and the Oslo-Paris Commission.

### **c. Capacity Building and Training**

MAR-ECO has managed to involve about 120 scientists, students and engineers from 16 countries in the exploration of a mid-ocean ecosystem. All of these will share knowledge and competence and enhance their individual competences. Juniors will learn from experiences of the seniors, and this is especially significant in research areas such as taxonomy and systematics where recruitment has been poor in later years.

MAR-ECO has students in several countries and research areas spanning for hydroacoustics, GIS, taxonomy of many taxa, trophic ecology, and physiology. The population of student is growing steadily, and many of these recruits will add significant capacity to future ecosystem research.

MAR-ECO communicates with schoolchildren in several countries and thereby contributes to raising the interest in ocean research and the challenges of building new knowledge through science.

## **8. GEOGRAPHIC EXPANSION**

MAR-ECO has targeted the mid-ocean North Atlantic between Iceland and the Azores, but has associated activities in the neighbouring ocean basins and on selected seamounts.

At the moment there are no concrete spin-off projects, but the International Steering Group (SG) is considering ways to expand into other waters. This will have to happen as a result of other scientific teams adopting MAR-ECO strategies and technologies in their geographical areas.

The most natural area to select for expansion is the South Atlantic, and the SG held a meeting with prospective South Atlantic partners in Brazil 6-7 September 2006. A separate report will be worked out from this meeting and published on [www.mar-eco.no](http://www.mar-eco.no).

## 9. RELATED EFFORTS

### a. Links to Other CoML Projects

Project Name	Cross-Over Person(s)	Nature of Relationship
ChEss	Gebruk, Santos, Billett	Common members of SG, collaboration on PO. Joint proposals. Sharing of expertise.
CeDaMar		Collaboration on PO
CMarZ	Bucklin, Falkenhaus, Melle	Sharing of samples and taxonomic expertise
CenSeam	Uiblein, Menezes a.o.	Formalised liaison arrangement. Collaboration on expansion project in South Atlantic
GoMA	Vecchione a.o.	Sharing of comparative data from seamounts
ArcOD	Gebruk	Common member of SG
TOPP		Common interest in technology for tagging and mapping, but no active contact

### b. Partnerships

MAR-ECO depends on support from and collaboration with a multitude of funding agencies, and any list of “partnerships” would be both incomplete and quickly outdated. Apart from the support from the A.P. Sloan Foundation that benefits the entire network, the support for most of the research (salaries, ship-time, running costs) come from national agencies such as ministries and research councils, or private sponsors (see [www.mar-eco.no](http://www.mar-eco.no)). This results from applications submitted by MAR-ECO scientists and sub-groups, supported by the SG.

The list below only includes a couple of EU projects where MAR-ECO has special relationships.

Organization Name	Point-of-Contact	Nature of Relationship
The EU project MARBEF	Several MAR-ECO scientists	Personal memberships and project funding through RMPs
The EU project OASIS	Bernd Christiansen	Sharing of data

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## 10. EDUCATION & OUTREACH

Tightly integrated with the scientific efforts, MAR-ECO has an extensive education and outreach activity directed at schools, media and the general public. A lot is web-based, but emphasis is also placed on direct contacts between scientists and the public at meetings, conferences, science fairs and “open ship” events when ships are in port (e.g. two such events were organized in 2004 in Horta and Aberdeen). A strategy in the current phase of the project is to ask scientists and institutions working on particular sub-projects to write short popular articles that can be used both on the website, as backgrounders for schools, and in the media. Of special interest is a website series called “Student of the month” where MAR-ECO students present their work and findings in a popular manner.

Media attention reached a climax in the weeks after the *G.O. Sars* expedition in 2004 when worldwide coverage was achieved following a press release and conference in Bergen, but has continued to be high, with project personnel having to respond to requests from a wide range of media outlets in their countries and internationally. Photographs and video clips remain in high demand.

The PO activity was greatly stimulated by receiving the 2004 Norwegian Research Council Award for Excellence in Science Dissemination, and the 2004 Institute of Marine Research Price for Public Dissemination. MAR-ECO is currently nominated by the Norwegian Research Council for the EU Descartes Prize for Science Communication.

The school network in Europe, co-ordinated by France, received a COMMENIUS status and had a planning meeting in Horta, the Azores in 2004 and further reciprocal visits. The network utilizes backgrounders on the project website, and run their own projects. The UK school has been very active and has been awarded MAR-ECO certificates for their efforts. Teachers and classes have been meeting for reciprocal visits. The Norwegian Research Council has profiled the project several times in its popular magazine for children, lastly also on a widely distributed poster displaying science achievements in the period 1905-2005.

The 60 min TV documentary “Havlandet” by NRK, shown initially on Christmas day in Norway, is currently being distributed internationally. The project has also responded positively to the CoML request for input to the major film production by Jacques Perrin. MAR-ECO continues to pursue the idea of a popular well-illustrated book.

An exhibition on deep ocean science is already installed at the Bergen Museum. From October 2004 to February 2005 the MAR-ECO artist Ørnulf Opdahl exhibited paintings from his participation on RV *G.O.Sars* in the Henie-Onstad Art Centre in Oslo. In April-June 2005, the same paintings plus photographs by the British wildlife photographer David Shale (participant on the *G.O.Sars* 2004) were exhibited in the Nordic House in Iceland. Thereafter, the exhibit traveled to Horta in the Azores for display in August. Following the exhibition efforts in Reykjavik and Horta, a first comprehensive exhibition of art, technology and science was shown in Kristiansand, Norway during the National Science Week in September 2005. A smaller version was also shown in Kragero, Norway, later in the year. This initiated the planning of the larger traveling exhibit called “*Deeper than Light*” which is currently under construction at the Bergen Museum based on two major grants from the University.

In parallel, efforts have been developed to produce the following:

- A book/catalogue on deep-sea studies to follow the exhibition. This is a collaboration between ChESS, CoMarge and MAR-ECO (the DESEO group)
- An interactive touch screen presentation has been developed by a group of MS students in Grimstad, Norway.
- The artist Ørnulf Opdahl is producing further artwork for the “Deeper than Light” exhibition.
- Led by Nina Svane Mickelsen, a deep-sea computer game is being designed at the University of Bergen. Nina has been awarded a doctoral scholarship for 4 years.
- Prof. Peter Boyle approaches international publishers with plans for a popular book on MAR-ECO.

### *Future efforts*

MAR-ECO will maintain the PO activity along the same lines as previously. The top priority is to keep the website dynamic, serving the public and school network. Fostering and co-ordination of contributions from scientists and students are major tasks that require day-to-day attention.

Particular priority PO projects are:

- 1) The traveling exhibition “Deeper than light”, and exhibition catalogue.

The exhibition will be on display in March-April 2007 in Bergen, then travel to other venues in Europe and elsewhere. It is critical that commitments from venues are secured by the end of 2006. *It is the hope that the CoML will provide significant assistance in achieving commitments from exhibition venues.*

The imminent priority is a preview of first elements of the exhibition in Genova in October 2006. MAR-ECO has been selected as one of three Norwegian contributions funded by the Norwegian Research Council.

- 2) Popular book.

A book project is under development and a concrete proposal from former member Prof. Peter Boyle who has been considered favourably by the MAR-ECO Steering Group. The book will be illustrated by paintings, photographs and drawings of high quality; provided by project personnel, Opdahl, Shale, and the late Thorolv Rasmussen (illustrator during the 1910 RV *Michael Sars* expedition, ref. the book “The Depths of the Oceans”). *Critical shortcoming is that at present no commercial publishers have made commitment to the book idea, and MAR-ECO would welcome any assistance from the CoML E&O team.*