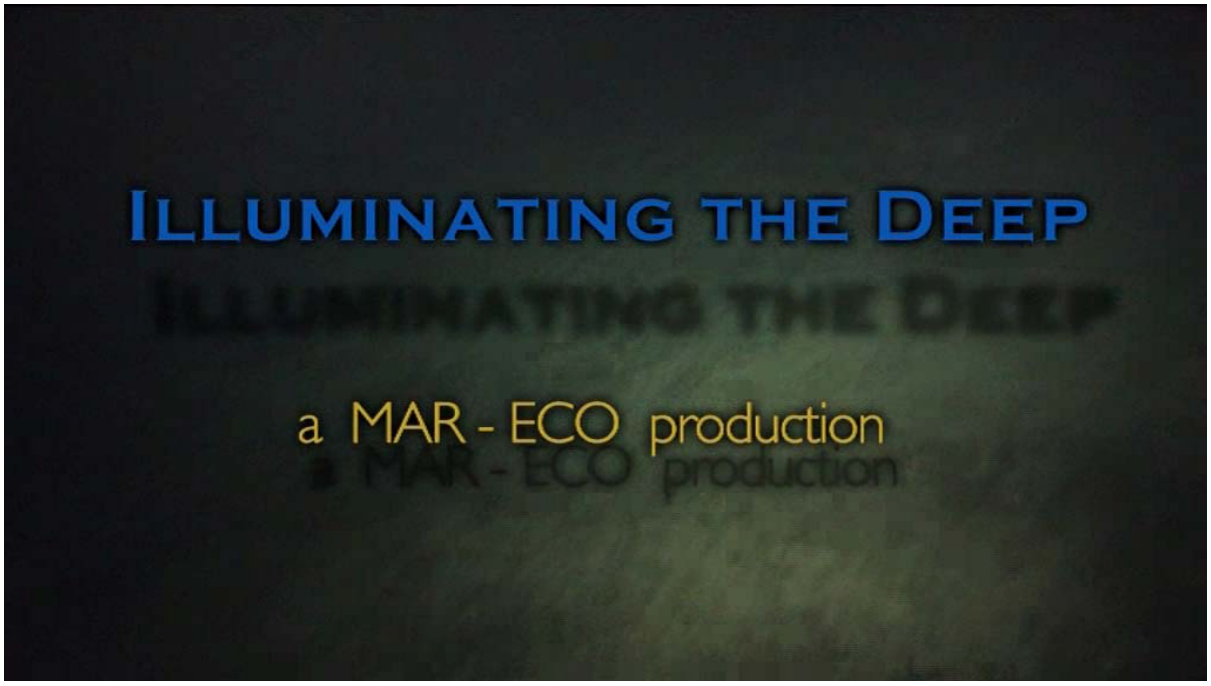


Chapter 1, Introduction
Over 70% of the earth's surface is ocean. Much of this environment is relatively unknown and unexplored. It is far from land, the waters are deep. Access is expensive and dangerous. Expanding global fishery efforts have shown that the waters around oceanic ridges are more fruitful than those of the open ocean. Scientists around the world are concerned about learning about these unexplored ridge and sea mount environments, before they are lost forever.

Marsh Youngbluth (plankton ecologist, Harbor Branch Oceanographic Institution):
It's like going into space. Instead of outer space it's what's been called Inner Space.

Peter Rask Møller (fish taxonomist, Vertebrate Department, Zoological Museum, University of Copenhagen):
And that's why I call it an extreme environment.

Marsh Youngbluth:
What is below the surface is a deep, dark, hyperbaric world. And many people never ever have a chance to see it.

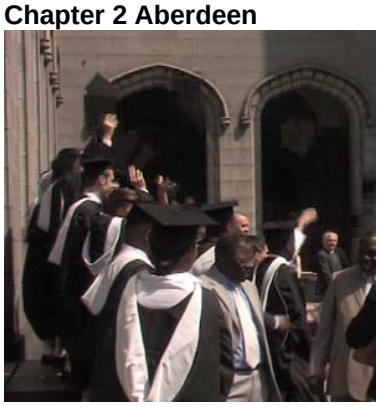
Amy Heger (MAR-ECO PhD-student, deep-sea bioluminescence):
There's so much that we don't know, you are always going to find something exciting.

Annelies C. Pierrot-Bults (zooplankton, chaetognath taxonomy, Institute for Biodiversity and Ecosystem Dynamics, Zoological Museum, University of Amsterdam):
If you want to know what is really going on in the ocean you first need to know what is there.

MAR-ECO is one of the projects within the Census of Marine Life global initiative. The project began in 2001. Since that time there have been a number of international cruise efforts to the project area. The largest was a 2-month expedition in the summer of 2004 aboard the newly-built Norwegian research vessel the GOSars.

The aim of MAR-ECO is to learn more about the ecosystems living in the relatively unexplored waters over the northern mid-Atlantic Ridge. It is a pilot project that aims to demonstrate how effective multi-disciplinary use of new, innovative technology and methodologies could be employed to study other ocean ridge and sea mount areas.

Chapter 2 Aberdeen



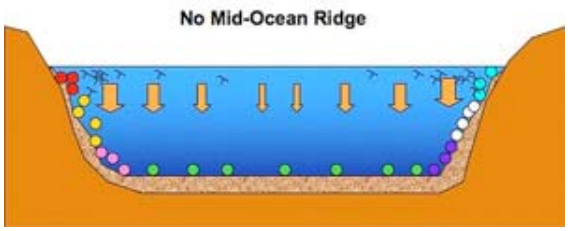
Around 50 MAR-ECO scientists and participants gathered at the University of Aberdeen for the 2006 annual meeting. They participated in tree days of intense meetings going over results thus far and planning future collaborative activities.

This year's annual meeting was hosted by researchers from the University of Aberdeen working at Oceanlab. Oceanlab is a deep sea research institute specialising in the development of deep water landers that conduct research on the sea floor.

But what is MAR-ECO about …

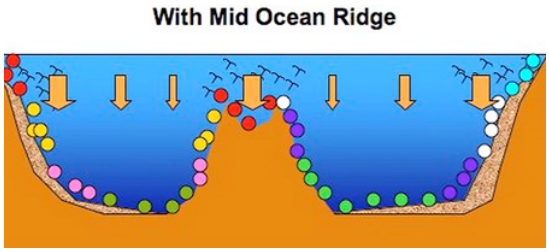
Chapter 3 MAR-ECO

Monty Priede (deep-sea fish ecology and behaviour, Oceanlab, University of Aberdeen):
The basic scientific questions are what are the effects of the presence of a ridge in the mid ocean



Tracey Sutton (mesopelagic fish, trophic ecology, Harbor Branch Oceanographic Institution):
The point is that most of the ocean is fairly structureless so the only structure is the fluid properties of the water itself. But there are places where the deep pelagic meets with topography.

Monty Priede:
So if we have a hypothetical ocean with no ridge, with a succession of species as you go deeper and a general high level of production near the coast and as you go toward the middle of the ocean things get more and more oligotrophic.



The movement of organic matter to the ocean floor the pelagic-benthic flux decreases toward the middle of the ocean. But what we hypothesize is that if you have a mid-ocean ridge you will have a sort of biological hot spot which has two functions. One is possible as a stepping stone for species traversing the ocean. The other is that for some species the ridge may act as a barrier to dispersion.

Chapter 4 GOSars

Summer 2004 Mar-Eco scientists went to sea aboard the new Norwegian research vessel, the GOSars. Their goal was to explore the waters over the northern mid-Atlantic Ridge.

These waters have not really been explored for nearly 100 years. Advances in technology will make it possible to learn a great deal of new information about this deep-sea, mid-ocean environment.

Peter Boyle, (cephalopods) Professor emeritus, Department of Zoology, University of Aberdeen:
The technology is hugely important in a modern expedition and justifies in all senses why it is still necessary to go and explore these environments again. The expeditions that were done 100 years ago are no longer sufficient to describe the animals that we have. The new tools that are available reveal so much more information. All of these tools have essentially put man in the deep sea in a way that never in the past has been possible and allow man essentially to ignore, if you like, some of the biological hostility of the deep sea environment. We do not have to personally survive the pressure, the cold, the dark: instrumentation can do it for us.

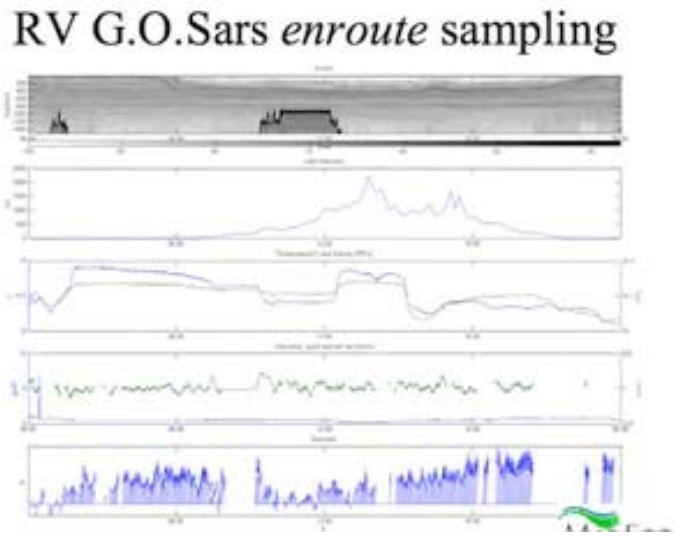
Filipe Porteiro (fish biology, mesopelagics, Department of Oceanography and Fisheries, University of the Azores):
Everything was very interesting and I was quite excited to be a member of the nice scientific crew. I worked quite a lot identifying fish. Every eight hours we had eight-hour shifts. I think the most important this was this collaboration in this multi-disciplinary group that was observing the inner ocean in a different perspective.

Fifty-five multi-disciplinary experts from 13 different countries set sail aboard the GOSars expedition. In addition there were 4 more researchers aboard the Norwegian long-liner that accompanied the GOSars during the second leg of the expedition.

Filipe Porteiro: I think that this complexity was observed in different ways. This allows us to re-construct the puzzle and to get a unified picture of that environment.

The aim was to examine the interaction of the ocean wildlife with the ridge's geological structure.

Chapter 5, Data
With so many scientists and so much equipment effective data management was a critical challenge to address. MAR-ECO scientists knew they needed to discuss effective data management strategies before embarking on the cruise.



Thomas de Lange Wenneck, (Nowegian Marine Data Centre, Institute of Marine Research, Bergen):
We had good planning meetings before the cruise. We had long discussions about how to register data, what kind of data we wanted to record and how we wanted to use them.

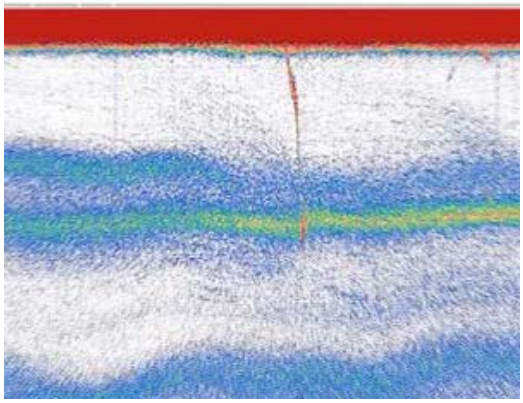
The GOSars was able to record a vast

array of information underway.

Thomas de Lange Wenneck: The GOSars Cruise Log system recorded data every minute: the position of the boat, the direction it was headed, the depth where the boat was … So we had quite detailed information about where we were every minute of the two/months cruise.

Data recorded included weather information such as temperature, wind, light, satellite information, acoustic information recorded at different frequencies, (fade out narrator, fade in Thomas)

Chapter 6 Results (acoustic)



The amazing quietness of the GOSars and advances in technology made it possible for MAR-ECO scientists to collect acoustic data down to 3000m. This is the deepest this technology has ever been used.

The acoustic data revealed details such as a whale diving to feed. This is the first time such data has been recorded.

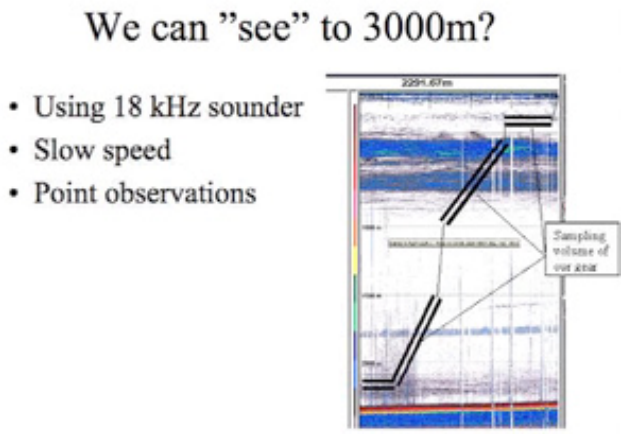
The cruise had two legs: one down to the Azores, the other returning north. It employed a huge arsenal of sampling gear from nets designed to collect smaller zooplankton, to huge trawling nets.

The cruise strategy involved employing several different sampling gear simultaneously. In addition, because existing maps of this area were not detailed enough, MAR-ECO scientists needed to first make their own maps of the bottom using multi-echo sounders.

According to Odd Aksel Bergstad, the project leader, it was truly remarkable how so many different scientists were able to collaborate together effectively to accomplish so much in such a little window of time.

Chapter 7 Acoustic detail

The GO Sars was designed to be able to under take continuous acoustic analysis of the waters beneath the ship. Five different frequencies are used to build up a detailed picture.



Anders Thorsen (fish reproduction, Institute of Marine Research, Bergen):
For the lower frequencies, the advantage is that it can go very deep into the water column all the way down to 1500m without the signals being so much disturbed by noise. While the disadvantage is that the resolution becomes coarser so you may not observe very small animals. At very high frequencies like the 200 is very good for zooplankton, for example, which are very small. But the problem is that the wavelength is so short that it cannot go as deep as the 18 kilohertz. So all together you get a more complete picture of what is in the water column.

Chapter 8, More results (sampling strategies, submersibles)

Researchers use different sampling approaches.

Tone Falkenhaug (zooplankton ecology, Institute of Marine Research, Flødeviken)

When you go out in an area that has not been sampled very much before you really do not know what you are going to find. You can have different strategic approaches. One is the standardized way of doing things. You can write up maps afterwards, compare similar sampling depths and different stations and so on. The other strategy is a more opportunistic sampling strategy where you actually sample at different depths and at different stations depending on what you see in the acoustic registrations.

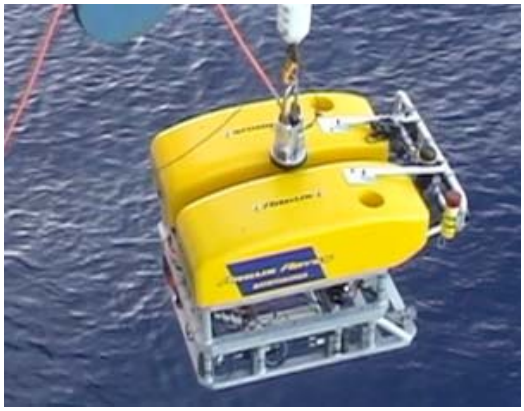
Scientists use different gear to study different kinds of organisms.

Tracey Sutton:
The problem when you use really big gear is that it goes out open and it fishes the whole time so you do not know when and where you caught individual things. Fishes, and organisms in general, the bigger they are the better they can swim. Swimming speed is really a function of how large an animal is. They can sense or 'hear' a net coming in the same manner that they find their prey; they are always 'listening', especially in the deep sea where it is dark.

Ideally what you want to do is you want to use a large piece of equipment that surrounds the group of fishes or squids or whatever. It is called herding gear, where you kind of surround the fish by using a large-mouth net with big mesh. If the fish knew they could just swim through it they would, but they hear it coming so they keep bunching in the middle and keep swimming. Eventually they just get tired and the net overtakes them. That is how the large, commercial-sized gear works.

What we did on the GOSars was we used a kind of combination of techniques. We used very large pelagic trawls but we had an opening and closing mechanism that was placed in the back of the net, so that in essence we had three separate nets attached to a net with a large mouth. We could open and close each of those cod-end nets to get a discrete sample but still use a large net.

We can combine acoustical techniques now with our net sampling. It is just another way to not be fishing in the blind. It is like using a flashlight instead of just groping in the dark.



The GOSars was also equipped to handle submersibles.

Marsh Youngbluth:
The average depth of the ocean is 4000m. Most of the vehicles that are around can go to 1000m, some to 2000m and a few to 6000m. But there are less than six of these in the world.

These submersibles are able to capture samples using robot arms, but they are also able to film video and still material of deep sea creatures in their native environment.

Chapter 9, MIR, marine snow

MAR-ECO was extremely fortunate in being able to piggy-back scientific dives aboard the Russian MIR manned submersibles from the RV Akademic Mistislav Keldysh (June 2003) in the Charlie-Gibbs Fracture Zone. The Keldish was on an eco-tourism expedition to the Titanic! These were the first ever manned explorations of this area. Mike Vecchione explains how they decided to quantify the digital observations they made.

Mike Vecchione (cephalopod taxonomy, NOAA, Smithsonian National Museum of Natural History)

What we did was we divided the video tapes from the dives up into one-minute segments. We accepted a one-minute segment as acceptable transect segment if the sub maintained a constant altitude above the bottom that allowed reasonable visibility of the bottom and if the sub maintained a constant speed along the bottom during that one minute.

Researchers were amazed at the amount of marine snow that was present in these deep dark waters. Marine snow is organic sediment that has drifted down from the surface layers.

Chapter 10 Museums

It is exciting to be able to go out and collect deep sea organisms. But that is just the first step. In order to be of value to the scientific community the material needs to be identified and documented.

Annelies C. Pierrot-Bults:
You need more people actually. That is the bottleneck. We need more people who are experts and who can do this.

The GOSars material is curated and stored at Bergen Museum in Norway.

Peter Rask Møller:
They really took care of the material in a very good way at Bergen Museum. All the fish are still there. This is really important, especially compared to other projects where they may just identify everything on board and then throw it away. There is no chance, then to check. That is what we can do now using both DNA and morphology. On the GOSars cruise they both kept the fish and tissue samples. The collection will be really valuable for a long time in the future also. It is not just for a few years; it will be really valuable for future projects in 50 years, 100 years maybe.

Annelies Pierrot-Bults explains that university museums, such as Bergen Museum, are really valuable because they are not only responsible for exhibitions but they also conduct important research and maintain extensive scientific collections.

Annelies C. Pierrot-Bults:
For research you need another attitude. With research, the collections need to be accessible. People need to be able to handle the collections, to get into them, to get the animals out and use them for their research, have students in and also that they can handle the specimens. You need a really dedicated research team within a museum to really do something with it. We do not collect because of collections; we collect to do research. What is important now can be not considered important in ten years time and then in fifty years time it is considered really important that you have this information.

Right now everybody is talking about global change and climate change. How can you document climate change and what it does to animals in the ocean if you do not have any collections from fifty years ago, so you can go back and see what happened then.

Chapter 11 More results – modeling and identifying new species

Even the best equipment today gives us a picture of life in the deep sea that is incomplete. Scientists use data sets to build models that can help to complete our understanding of deep-sea populations.

Mikko Heino (fish population biology, Institute of Marine Research, Bergen):
This is a study very much ‘in progress’ including some results from this

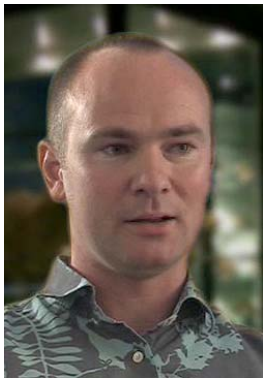
morning! This is what I would like to call a classic or typical fish-length distribution. We have a long right tail. It is truncated here on the left, most likely because of catchability.

I think that it is clear that these length distributions must carry some information about species' life history. It must be possible to extract that information somehow. Actually size is often the only individual variable we have recorded for many individuals.

and sometimes models even work!

Mikko Heino:
I was happy to see that the model actually produced the results I was expecting.

Identifying new species is challenging. The popular press often portrays DNA and genetic analyses as being a kind of magic tool that can provide instant answers. Fish taxonomist Petter Møller explains that DNA tests are just one of the tools used in systematics.

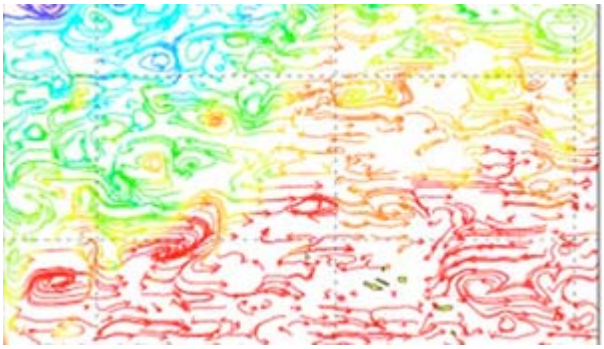


Peter Møller:
To decide whether something is a new genus or a new family or a new species I would base my decision on morphology. It is obviously a good idea to support this with genetic work. I use molecular DNA markers to study mainly the relationships between species, genera and even families in some cases [he works with classifying a group of fish called Ophidiiforms].

Rus Hoelzel explains the purpose of his genetic work within MAR-ECO.

Alan Rushworth Hoelzel (genetics, Department of Biological Sciences, University of Durham):
It is mostly about determining the extent to which the mid-Atlantic Ridge and the sub-Polar Front are acting as barriers to gene flow or influencing it in some way the patterns of genetic diversity across the north Atlantic.

Chapter 12 Eddies



Mid ocean waters are not uniform aquatic environments. Currents, differences in temperature or salinity and proximity to land forms create different environment in the sea.

One of the interesting features that MAR-ECO scientists were able to study is the presence of huge eddies in the waters near the Charlie-Gibbs Fracture Zone in the turbulent waters of the sub-polar front.

Henrik Søiland (physical oceanography, Institute of Marine Research, Bergen):
So an eddy is kind of an entrapment of water that moves biological material along with it. The eddy size was about 100km in diameter. That is a typical size for what we call a meso-scale eddy. We could clearly see the properties of the eddy anomaly down to 1000m.

As a physical oceanographer Heinrik's work was very important for the biologists aboard the GOSars.

Henrik Søiland:
It is very interesting to see what impact the physical oceanography has on the biology. At the Institute of Marine Research we have a long tradition of always studying the physical oceanography in connection with the biological observations so that you have the background information that fish and the zooplankton experience. These organisms aggregate where there are favourable physical conditions.

Chapter 13 Taxonomy
In addition to the physical data, taxonomic data is vital. Taxonomy is the 'alphabet' of biology.

Odd Aksel Bergstad:
We are very grateful to the taxonomists who have been working hard to identify all the species from the MAR-ECO collection so that we can actually start analyzing some of the patterns of distributions and also to try to speculate on the factors influencing these distributions.

Taxonomists have to be detectives in order to understand the clues given them by limited amounts of biological material. Fish taxonomist Franz Uiblein explains.

Franz Uiblein (ichthyology, Institute of Marine Research, Bergen):
It is a sort of Sherlock Holmes story that I am going to tell you. We have much less species than previously believed that is for sure, but how many: one, two or four species? We will now look a little bit at the material we collected from MAR-ECO from both the *GOSars* and the *MS Loran*. There are three main [morphological] characters that are important. The next step is to include more [morphological] characters. It gets a little difficult to show that graphically, when you include four or five characters on one graph, but it is possible. You have to do a multi-variant analysis. That is how it works in systematics. In this case, then, we have two species. We just have to give them names now.

Chapter 14 Gelatinous zooplankton
Although most of the samples collected were fish, other kinds of organisms were collected as well.

Thanks to MAR-ECO Bergen Museum now has one of the largest deep-sea cephlapod collections in the world.

However, many soft-bodied organisms such as cephalopods, holothurians and zooplankton are not easy to collect with traditional methods. In underwater videos they are beautiful and graceful. On deck, they are just an amorphous lump of jelly.

Uwe Piatkowski (cephalopod and zooplankton biology, Leibniz-Institut fur Meereswissenschaften, Forschungsbereich Marine Okologie, University of Kiel):
One of our major problems when we catch these animals is that they are pretty much damaged. Identification is thus pretty tough sometimes.

Andrey Gebruk (hydrothermal vent ecology, holothurians, Russian Academy of Sciences, P.P. Shirshov Institute of Oceanology):
Of course you cannot get them in trawls. They are absolutely fragile and delicate. Nothing would be left in the trawl. You can only observe them and watch them [using underwater photography].

Annelies C. Pierrot-Bults:
You cannot catch them in nets; that is why you use [underwater] video.

Marsh Youngbluth:
Now we have digital photography and we can get excellent pictures [of these fragile organisms].

Chapter 15 More results – overall findings
Despite the challenges and the masses of material to be identified and documented, already - just two years after the GOSars cruise – the work is nearly complete. MAR-ECO scientists are beginning to publish some results.

Alan Rushworth Hoelzel:
We are already finding interesting things.

Nikki King (PhD student, deep-sea fish ecology, Oceanlab, University of Aberdeen):
The main findings [that our group has found] are that there is this layering of scavenging fishes.

Marsh Youngbluth:
The facts about mid-water processes are that we know very little. But it looks like in a lot of places that inter-faces are really important for gelatinous zooplankton, and I think for most of the animals in the ocean. They are layered and the layers depend on where there are fronts or where there are thermoclines [temperature changes] or where pictoclines [pressure changes]: where there is some sort of discontinuity. That is where the hot spots are.

The results show relatively low biodiversity in the waters north of the sub-polar front, but high biomass of the species that are present, while the southern waters show the opposite, with high biodiversity, but relatively low biomass of individual species.

The idea that the sub-Polar Front is a critical area is reinforced by data from virtually all the organisms studied.

Tone Falkenhaug:
For me it was very surprising to see the situation around the sub-Polar Front in the Charlie Gibbs Fracture Zone area where there was a very high abundance of zooplankton and high abundance of chlorophyll. This seems to be a very hot spot.

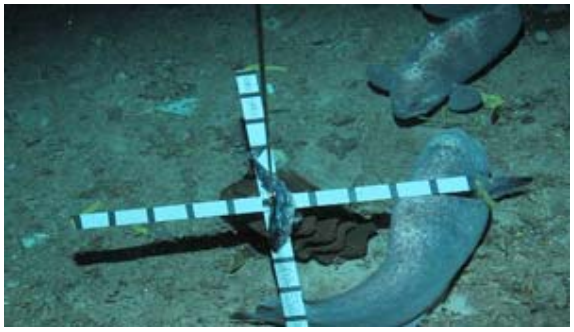
Filippe explains that MAR-ECO scientists were unusually efficient at identifying and documenting the cruise material.

Filipe Porteiro: During the *GOSars* cruise we collected more than 60 000 specimens. We identified some of the fish on board during the cruise, but we have also held several workshops after the cruise to identify the fish. Now we have more or less 97% of the fish identified. Some are appending and soon we hope to have identified all of them.

This is very unusual. Normally the material is collected and stands in jars for several years waiting for somebody else to go there and to identify [the specimens].

In some cases MAR/ECO researchers were able to learn more about the life history of some organisms. Andrey Dolgov explains.

Andrey Dolgov (fish biology trophic ecology, Polar Research Institute of Marine Fisheries and Oceanography):
I hope that we found the spawning grounds of *Rouleina attrita* in one or two of the trawls.



With so many exciting finds it is hard to pay tribute to them all. Monty Pried from the University of Aberdeen has established a research station that builds landers that can be sent to the sea floor. Monty explains what the landers revealed during the GOSars cruise.

Monty Priede:
I guess on the mid-Atlantic Ridge there were two interesting things really. One is that the mid-Atlantic

Ridge is made up to two ridges. There is a sort of central valley that we like to think of as a mystery valley and we wondered what lived down there so we launched a lander into the central valley wondering what we would find. The floor of the valley is covered with very fine white silt, very, very clean.

We found lots and lots of grenadier fish there. A surprising thing was that the sharks that we see living up on either side of this central valley do not take short cuts through the centre of the valley. It was interesting to reveal what lives in this hidden valley in the middle of the ridge.

The other interesting thing was what lives on the tops of the ridge. On the top of the ridge we saw these large wolf-fish; one metre long wolf-fish, which we have never seen before anywhere else. They seem to live on the summit of the ridge. The interesting thing was that we actually photographed a pair of them. According to the books they pair for life and go together male and female and guard a nest full of eggs. It was nice to grab an image of this ugly couple living on top of the mid-Atlantic Ridge.

The ecosystem of the deep sea involved more than just fish. Cephalopods, gelatinous zooplankton, crustaceans and other organisms are believed to play major predator and prey roles.

Uwe Piatkowski:
These are very important predators and they are very important prey for many of the big animals such as fishes, sea-birds and whales we encountered during the cruises.

Paal Mortensen specializes in deep sea corals.

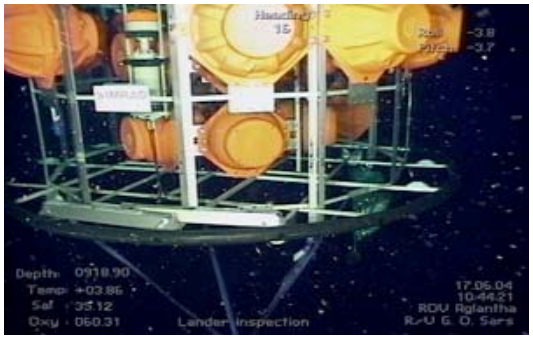
Paal Buhl Mortensen (epibenthos, cold-water corals, Institute of Marine Research, Bergen):
The largest [coral] colony [we saw] was approximately half a metre across. That is not very big, indicating that these sites are not favourite sites for these types of coral reef-forming species.

Marsh Youngbluth is a gelatinous zooplankton or jellyfish specialist.

Marsh Youngbluth:
[Gelatinous zooplankton] are ambush predators; they just sit there and wait for something to swim in -like a curtain of death and doom.

A bigger concern is that they make take over fisheries if in fact we over-fish a given region.

However, it is hard to get evidence about the role these soft-bodied organisms play in the marine ecosystem. They are damaged in nets and they are digested quickly and may not make it to the surface in the stomachs of their predators.



Chapter 16 Kongsberg
Kongsberg gave 3 acoustic devices to the project. These were placed on the bottom and recorded acoustic data from the waters above. One of these was equipped with extra batteries and allowed to remain on site for a whole year providing valuable seasonal acoustic data.

Chapter 17 Publications
MAR-ECO has been able to facilitate the publication of

invaluable Russian data about north Atlantic fisheries.

Three major publications relating to MAR-ECO are planned for the year ahead. Both Deep Sea Research II and Marine Biology Research are planning special issues based on MAR/ECO results.

John Gordon (fish ecology, Scottish Association for Marine Science):
There will be a special volume of Deep Sea Research II, which is a journal that specializes in reports of scientific meetings and reports of projects. What this special issue is about is bringing everything together – a synthesis of the results. You get the oceanographers and the fish people and the zooplankton people producing synthetic papers that bring all the various facets of the project together.

Andrey Gebruk:
We just think that it is a good idea to have a results in one special issue; a recently organized Nordic journal, Marine Biology Research. The issue focuses on MAR-ECO results in benthic studies.

In addition a monograph is being published.

Andrey Gebruk:
The Biogeography of north Atlantic Sea-mounts: MAR-ECO is actually focused on studies of sea-mounts because the mid-Atlantic Ridge is a chain of sea-mounts. Sea-mount biogeography is very relevant to the biogeography of the mid-Atlantic Ridge. One of the key questions in MAR-ECO is biogeography and distributional patterns along the mid-Atlantic Ridge.

Chapter 18 Collaborating
Getting to the middle of the Atlantic Ocean and conducting deep sea research demands tremendous resources.

Peter Boyle:
I think that [MAR-eco] is very exciting and interesting activity and one really that single governments and single organisations usually cannot entertain.

Participants in MAR-ECO said that there were many advantages to working in a large international project. They highlighted the benefits of multi-disciplinary approaches and being part of an international team of experts.

Tracey Sutton
For me the most exciting thing on this cruise was this combination of scientists from all over the world, all specialists in their field; we had a common theme [goal]. We were all trying to answer a bigger question rather than just focusing on our one field. To have a larger group together in one platform to go out into a totally unknown place with this team and to feel like you are part of a great question was very exciting.

Peter Møller:
I think actually that it was maybe my first time to be part of a big international project. Many things are easier than when I have worked before on smaller projects that I have defined myself. You can sometimes get a little disappointed that no one really cares about [what you are doing], nobody really pays attention. Here, there is a whole group of colleagues that are interested in your progress – everybody needs the results and you feel like a big family in some ways.

Tom Bech Letessier (MAR-ECO BSc-student):
I certainly found it very stimulating to meet people from all over Europe and the world as well.

Paal Buhl Mortensen:
It is a great advantage to have a group of experts from different fields that can collaborate and enhance knowledge about a single topic. It works better than separate scientists could do alone. Often you do not know the questions to ask, so you will definitely not get an answer. But if you have another expert there you can have the right question. Of course, the questions you have can better be answered if there are more brains to think about the question. It is a synergetic effect of bringing people together.

Marsh Youngbluth:
What we need are more scientists, and more people interested in the deep ocean. MAR-ECO was a way to start that. It was a way to encourage a lot of research in various areas of the world, not just along the mid-Atlantic Ridge. I think that that was the point of the programme; to get a number of spin-offs so that the rest of the world would gain an appreciation [of the deep sea].

Annelies C. Pierrot-Bults:
If I had an unlimited budget I would like to make base-line documentation about certain spots in the ocean, like in the middle of a big water mass. Then you would know exactly what all is there; all the species, everything. It is a lot of work to do that, to make an all inventory station. Then you can monitor. For monitoring you have to find a kind of species that you can use for monitoring because you do not have time and resources to monitor everything. You should not even try [to monitor everything] because it is not feasible. Making good base-line documentation about sites is really important even though it is difficult. MAR-ECO went a long way towards doing this from the very small animals down to the big ones. [In MAR-ECO] we have achieved a lot of things.

Peter Boyle:
Of course, when we recognize that it is individuals that both generate and drive the science, here MAR-ECO has obviously been extremely fortunate that Odd Aksel Bergstad from IMR was involved from the beginning in the formulation of the process. He has been able to devote his time to seeing it through to its conclusion and follow-through. I think that it speaks very highly of his skill and powers of communication with a very diverse group of people that he was able to manage so successfully to keep the scientific group motivated, to keep them literally all in the same ship, both at sea and on land, working in the same direction. I am sure that all the participants will wish him well in seeing the whole programme through to its conclusion.

Chapter 19 Students

MAR-ECO has also emphasised cross-generational training of students, the scientists of the future. The project has supported a number of students in a number of different countries.

Amy Heger:
It has been amazing because I have always had an interest in bio-luminescence and for me to find a PhD dealing with this phenomenon was just incredible. I took the chance and it has been a fantastic journey.

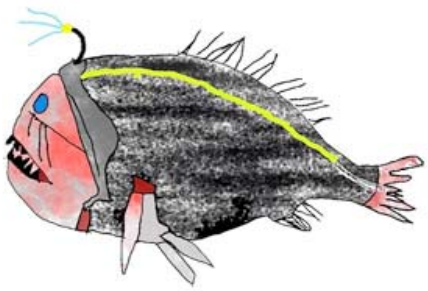
Nikki King:
I think that being a PhD student involved in this project from the early stages has actually given a really strong foothold in the deep-sea scientific community. You are obviously getting to network with a lot of scientists who are older, therefore more established and therefore more credible. You get to know these people on a personal level because you are associated with them. You also get a big data

set. You go through the stages of collecting the data and working it up to the final paper stage and publication. It has been really good.

Anders Opdal:
As a student being involved in such a large project as the MAR-ECO Project, was very rewarding for me. I got access to a whole lot of data in a very big database, from which I could extract a lot of information – almost too much information!

Tom Bech Letessier:
I actually graduated yesterday! I had my graduation ball on Tuesday and I did the actual graduation ceremony yesterday. You have caught me at a very busy time of my life! [In MAR-ECO] you have so much access to so many people who are the top in their field. Obviously it can be a bit daunting at first, but they are also very including and they want you to do well.

Chapter 20 Public Outreach (Education and Outreach)
The MAR-ECO Project is not only responsible for high quality internationally important research, it also is firmly committed to involving the general public in the research process. Education and Outreach have been important dimensions of MAR-ECO from the project's beginning. In 2004 the project's leader, Odd Aksel Bergstad, was awarded the Norwegian Research Council's Prize for outstanding contributions to research communication and public outreach.



School Project
Nikki King received an award for her outstanding work with the MAR-ECO school network.

Ingvar Byrkjedal (vertebrate curator, Bergen Museum, Norway):
We have to tell the world about our nice findings and our nice stories; not only to our colleagues but to all the rest of the world. A natural place to start is with the younger generation and that is what Nikki has been doing. If I am not mistaken, her presentation now has to do with an award-winning project that she undertook with schools.

Nikki King:
This is the MAR-ECO schools' network. I was quite surprised to find out that we actually have links with schools in Indonesia and Chile.

The school pupils initially came to visit the GOSars when it came in to dock in Aberdeen. Then we decided that it would be quite good to have a Thursday lunch-time session devoted to MAR-ECO. This was optional and the students that were interested could come along and work with me and Jenny Gallacher on little projects and link back with MAR-ECO.

We started with posters; colourful, bright posters aimed at different age groups. This went on for four months. Then we did another project that was a local environment project comparing the north-east of Scotland marine environment with those of the other network schools: the Lofoten islands in Norway and the Azores.

Jo Hoyer is a member of the MAR-ECO Public Outreach team.

Jo Høyer (Information Director, Institute of Marine Research, Norway):
It is not only telling the MAR-ECO story to scientists, but to the next generation [of scientists] and to society [in general].

Chapter 21 Deeper than Light
To actively share the exciting discoveries in the deep sea with the general public, MAR-ECO and the Bergen Museum are producing an international travelling exhibition entitled, "Deeper than Light".

Jo Høyer:
This is not an “information” exhibition, it is an “experiencing” exhibition. [Visitors will] experience the deep: the fascination of the deep, the conditions [there], deep-sea life, … [and how] this affects people.

Chapter 22 Maretind

Nina Svane-Mikkelsen (PhD-student, University of Bergen, Norway):
I will just tell you a little bit about Maretind. It is part of my PhD at the Information, Science and media Studies at the University of Bergen.

Members of Nina’s team are working with MAR-ECO scientists so that the behaviours of the deep-sea creatures and the physical features of the deep-sea environment in the computer game are based in scientific fact.

Fishery Impact

One of the driving reasons for undertaking exploratory expeditions such as MAR-ECO is the need to document the status quo of marine resources so that sustainable fisheries can be established in the deep sea.

Paal Buhl Mortensen:
My personal opinion about fisheries in these areas is that one should have in mind that the fish species that are being targeted are long-lived and slow-growing, as is also the habitat they are swimming around. That means that any impact is very long-lasting; it will take a long time to recover, both for the fish stocks and the habitat.

Also the areas out there are not very well mapped. We do not know how unique they are, how big they are and we do not know what is there. What is clear to me with such little knowledge about fish is that these fish stocks should be very well studied before there is any fishing allowed to take place. But that is a very different question than what I am studying; the benthic communities.

Chapter 24 Future activities

The success of MAR-ECO thus far, and especially of the GOSars cruise is resulting in some exciting new endeavours. Scientists aboard the GOSars were, for the most part, only able to take a snapshot of the deep-sea communities at a particular moment in time. It was not possible to undertake comparison studies.

Tone Falkenhaug:
This was just a brief mapping of the area. Later [future] cruises will go into the area and will do exactly that kind of [comparison] investigations where you can compare day and night differences and also if there are changes between different years.

Beginning next summer, two other national efforts are going to mount expeditions that will include MAR-ECO scientists. They will return to the Charlie Gibbs Fracture Zone and the area of the sub-Polar Front.

Monty Priede:

I am delighted that we actually got funding for a UK contribution to MAR-ECO, which will be known as ECOMAR (ecology of the mid-Atlantic Ridge). We have got two million pounds worth of funding for expeditions over a period of three years – in three successive summers, 2007, 2008 and 2009.

It means that we will be able to leave instrumentation on the [sea] floor between cruises to make long-term measurements of water flow, delivery of organic matter to the sea-floor and the [Norwegian Institute of Marine Research's] long-term sonar experiment will also be deployed from the James Cook.

Mike Vecchione:
The US has just taken delivery of a new fisheries research ship – a 63m long, acoustically quiet trawler, named the *Bigelow*. I have booked time on the *Bigelow* for about a year from now [summer 2007]. The actual dates have not been set firmly in the schedule yet but it looks like it is going to be from early June until early July [2007].

My concept of the operation is to take the *Bigelow* out to assess inter-annual variability in the MAR-ECO area. I want to focus on the Charlie Gibbs Fracture Zone. What I want to do is to take her out and to re-occupy some of the same stations that the *GOSars* did.

Chapter 25 MAR-ECO, a CoML pilot project
MAR-ECO is well on its way to fulfilling its obligations as a Census of Marine Life pilot project. It has developed and tested new technologies and strategies for conducting a multi-dimensional deep-sea expedition. This knowledge can now be applied to other areas, such as the other frontal zones crossing the mid-Atlantic Ridge. MAR-ECO leaders participated in an international meeting of science leaders from countries nearer to the southern portion of the ridge. They are interested in documenting the ecosystems that live there.

Chapter 26 conclusion
One of MAR-ECO's youngest researchers reflects on the importance of marine biological research.

Tom Bech Letessier:
I think that just as electronics and computers have been the major [development] of this century, I think that marine biology is going to be more important in the next [century]. We are depleting resources and we need to combat under-development and poor fishery management.

Peter Boyle:
From an extremely unknown, unexplored area …

Marsh Youngbluth:
What is below the surface is in a deep, dark, hyperbaric world …

Peter Møller:
That is why I call it an extreme environment …

Amy Heger:
There is so much that we do not know about the deep oceans, there is so much to discover; you are always going to find something exciting. So go for it!!