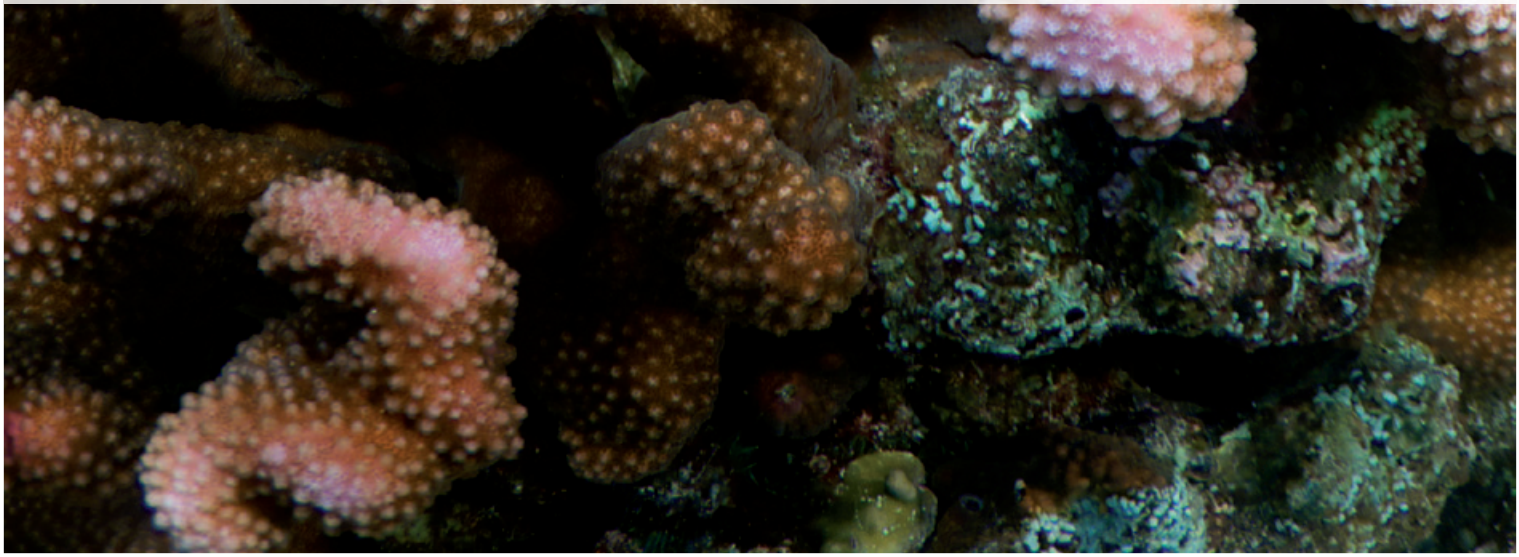
ESF EUROCORES Programme

Ecosystem Functioning and Biodiversity in the Deep Sea (EuroDEEP)

Final Report



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LESC covers the following scientific domains:

- Molecular Biosciences
- Microbiology
- Biological Chemistry
- Agriculture
- Plant and Animal Biology
- Ecology
- Climate Research
- Earth Sciences
- Glaciology
- Oceanography
- Meteorology

Cover picture:
Blue starfish, coral reef

Contents

Foreword

The EUROCORES Programme EuroDEEP on 'Ecosystem functioning and biodiversity in the deep sea' (EuroDEEP) was designed to explore further the deep-sea environment, describe in more detail the biological species and communities that inhabit it, and understand better the physical and geochemical processes that shape the environment in which these communities live. This will provide the foundation for the programme to describe, explain and predict variations of biodiversity within and between deep-sea habitats, their consequences for deep-sea ecosystem functioning, and the interactions of the deep sea with the global biosphere.

Beside the progress in understanding the deep sea environment, the Programme aims to develop sustainable management and conservation options for the marine resources that will benefit society as a whole.

EuroDEEP consisted of four Collaborative Research Projects from 2007 to 2011 covering quite different research areas on the deep sea ecosystem, and this enabled it to achieve a large and unprecedented set of results.

Significant progress has been made in understanding the biodiversity and ecosystem functioning in the southern European deep-sea environment, in monitoring the colonisation processes in chemosynthetic ecosystems, in characterising the microbial diversity in two hypersaline anoxic lakes in the Mediterranean area, and in studying the population connectivity in order to handle sustainable fisheries in the Deep Sea.

The successful Final EuroDEEP Conference, held in Reykjavik in connection with the 12th Deep Sea Biology Symposium (June 2010) gave the EuroDEEP scientific community a valuable chance to share the scientific results with a larger audience involved in marine sciences. This event also provided the basis to develop further, in collaboration with the European Science Foundation, a potential plan for future research priorities and activities in a larger framework, involving the marine and polar scientific communities.

This comprehensive report is aiming to highlight the major achievements of the four Collaborative Research Projects and the potential for future developments of research in a field which is of paramount importance, considering the increasing threat to marine ecosystems generated by climate changes and human presence.

My collaborators and I would like to thank the four Project Leaders and all the scientists involved in EuroDEEP for their high level contribution and commitment to this EUROCORES Programme.

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Head of Life, Earth, Environmental and Polar Sciences Unit
European Science Foundation

Dr Paola Campus
EuroDEEP Coordinator

Ms Anne-Sophie Gablin
EuroDEEP Administrator

1. Governing Bodies

1.1 Management Committee

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1.4 Funding Organisations

Belgium
Research Foundation Flanders (FWO)

France
National Centre for Scientific Research (CNRS)

France
French Research Institute for Exploitation of the Sea (Ifremer)

France
National Institute for Development (IRD)

Ireland
Irish Research Council for Sciences, Engineering and Technology (IRCSET)

Italy
National Research Council (CNR)

The Netherlands
Netherlands Organisation for Scientific Research (NWO)

Norway
The Research Council of Norway

Portugal
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EUROCORES Coordinator (2010-2011)

Ms Cindy Regnier
EUROCORES Administrator (2006-2008)

Ms Anne-Sophie Gablin
EUROCORES Administrator (2009-2011)

2.
Description of the EuroDEEP Programme

2.1 Rationale and Objectives

The deep sea is the largest environment on Earth. It contains important mineral and biological resources of interest for science, industry and society. It is a relatively continuous and highly interconnected environment composed of a wide variety of specific ecosystems, both pelagic and benthic, which sustain particular, and often unique, microbial and faunal communities with a vast yet largely unknown biodiversity. The deep sea is one of the least studied environments on the planet, where research is strongly linked to technological advances. More is known about the moon than about the deep sea. Exploration of the deep sea will continue to yield significant discoveries for decades to come.

Large-scale multidisciplinary studies are essential to understand how physical, geological and geochemical processes shape deep-sea habitats, control biological and biogeochemical processes, and determine their relationships with the global biosphere. Acquiring this knowledge is especially urgent in an ecosystem that, being largely unknown, is already under increasing anthropogenic pressure. Commercial exploitation of deep-sea fish stocks, minerals, oil and gas resources, or the use of the deep benthic areas for waste and CO_2 dumping, have been increasing steadily in the last decade. There is evidence of damage caused by some of these activities, resulting in significant biodiversity and habitat loss in ecosystems where recovery from disturbance may take decades.

Before the launch of EuroDEEP, no country in Europe had the human resources and access to large-scale facilities needed to undertake deep-sea research at the ecosystem level. A number of European-led initiatives were developed within the Census of Marine Life (CoML) Programme to identify research priorities and prepare scientific programmes on specific deep-sea topics. Relevant Projects falling in the CoML Programme are: ChEss (Chemosynthetic Ecosystem Science), working on biogeography of chemosynthetic ecosystems; MAR-ECO(Mid-Atlantic Ridge Ecosystem Project), studying the pelagic and benthic fauna of the northern Mid-Atlantic Ridge; CeDAMar (Census of Diversityof Abyssal Marine Life), assessing the biodiversity of abyssal plains; CoMargE (Continental Margin Ecosystem), investigating the diversity and distribution of fauna on continental margins; projects relevant to deep-sea research on seamounts and microbes are also part of CoML. Parallel EU initiatives related to different aspects of deep-sea research and monitoring were developed since early 2004, and generated an additional platform for networking among the deep-sea scientific communities: MOMAR/MOMAR-NET (Monitoring the Mid-Atlantic Ridge), EXOCET/D (EXtreme ecosystem studies in the deep OCEan: Technological Developments), ESONET (European Sea Floor Observatory Network), MARBEF (Marine Biodiversity and Ecosystem Functioning EU Network of Excellence) and HERMES (Hotspot Ecosystem Research on the Margins of European Seas). However, none of these initiatives, with the exception of HERMES, provided funding for new sampling and exploration of the deep-sea.

The objective of the EuroDEEP Programme has been to provide the necessary framework and funding for the development of top-quality deep-sea research at the European level in the global context of the Census of Marine Life, of the Scientific Committee on Oceanic Research (SCOR), and of the International Geosphere-Biosphere Programme (IGBP).

Scientific Goal

The focus of the EuroDEEP Programme has been to explore further the deep-sea environment, describe the biological species and communities that inhabit it, and better understand the physical and geochemical processes that shape the environment in which these communities live. The aim of this focus was to describe, explain and predict variations of biodiversity within and between deep-sea habitats, their consequences for deep-sea ecosystem functioning, and the interactions of the deep sea with the global biosphere. This will generate a solid platform to develop sustainable management and conservation options for the marine resources.

To reach this target, EuroDEEP focused on sharing of national large-scale resources, essential for deep-sea research: ships, Remotely Operated underwater Vehicles (ROVs), submersibles, Autonomous Underwater Vehicles (AUVs), deeptowed vehicles, deep-sea sampling equipment, new sensors, etc.), as well as coordinating the efforts amongst scientists and laboratories from the countries involved and linking with ongoing projects.

EuroDEEP catalysed excellent research on biodiversity in the deep sea, and on the mechanisms to generate it and maintain it by means of abiotic and biotic processes.

EuroDEEP focused as well on the role of the deep-sea in the biogeochemical processes affecting the global biosphere, bringing together taxonomists, microbiologists, ecologists, physical and chemical oceanographers and geologists.

Facts and Figures

Deadline for Applications: 29 May 2006

Funded Collaborative Research Projects (CRPs): Four consisting of 19 Individual Research Projects in 8 different countries, working in close collaboration with 10 Associated Partners from 6 different countries.

Duration of Programme: 2007-2011

Budget for research: 3,5 Million Euro

2.2 List of Projects

Biodiversity and ecosystem functioning in contrasting southern European deep-sea environments: from viruses to megafauna (BIOFUN)

Professor Francisco Sardà Amills (CRP Leader)
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Professor Carlo Heip
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Dr Serge Heussner
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Dr Elena Manini
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Professor John Patching
National University of Ireland, Galway, Ireland
Replaced as of 1st September 2010 by
Dr Gerard Fleming
National University of Ireland, Galway, Ireland

Professor Ann Vanreusel
Ghent University, Ghent, Belgium

Professor Roberto Danovaro*
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Dr Nikolaos Lampadariou*
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Professor Michael Türkay*
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*Associated Partners

Monitoring colonisation processes in chemosynthetic ecosystems (CHEMECO)

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Dr Marina Ribeiro da Cunha
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Professor Jean-Pierre Henriet*
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*Associated Partners

Unravelling population connectivity for sustainable fisheries in the Deep Sea (DEECON)

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Dr Stefano Mariani
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Dr Sergio Stefanni
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Dr Francis Neat*
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*Associated Partner

Microbial Diversity in the Deepest Hypersaline Anoxic Lakes (MIDDLE)

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TU Kaiserslautern, Kaiserslautern, Germany

*Associated Partners

2.3 EUROCORES Quality Assurance

2.3.1 Theme Selection

2.3.2 Project Selection

The peer review of the Collaborative Research Project proposals in a EUROCORES Programme like EuroDEEP is a multi-stage process, including the establishment of an **international and independent Review Panel** (RP). In response to an open Call for proposals, **outline proposals** of about 3 pages are submitted by a team of applicants (minimum 3 from 3 different countries). At that stage, the RP is responsible for the sifting of outline proposals prior to the invitation of full proposals. At the **full proposals stage**, each proposal is sent for **written external assessments** to at least 3 referees, including referees from outside Europe. Applicants are given an opportunity to reply to the anonymous referee reports.

Written referees' assessments and replies by applicants are then considered by the RP with scientific quality being the main selection criterion. The RP makes recommendations for funding of Collaborative Research Projects (CRPs), with prio ritisation, which ESF communicates to the EUROCORES Funding Organisations (EFOs).

As described in the previous section 2.1, after such an international peer review process, four Collaborative Research Projects (CRPs) were selected for EuroDEEP and launched in 2007.

2.3.3 Management Committee

At the time that the Call for Proposals is published, a Management Committee (MC) is established (see page 4 for the EuroDEEP MC).

- The MC has overall responsibility for the EUROCORES Programme within the guidelines of the EUROCORES Scheme;
- The MC can request expert advice from the EUROCORES Scientific Committee, Review Panel or any other *ad-hoc* advisory group;

- Members support the EUROCORES review process by nominating potential Review Panel and external expert referees on behalf of their funding organisation;
- Each MC member is responsible for liaising with their funding organisation, including supervision of the funding process for EUROCORES projects within their organisation;
- Members may attend all meetings of the EUROCORES Programme as observers.

2.3.4 Mid-Term and Final Reviews

Each EUROCORES Programme undergoes two comprehensive reviews to evaluate progress at the mid- and final- stages. The aim is to assess scientific cooperation and interactions among the investigators, and in the case of the mid-term review to:

- examine the merits of the EUROCORES Programme and its potential;

and for the final review to:

- examine the merits of the EUROCORES Programme and the lessons there are to be learned for potential follow-up initiatives.

They are assessed using the following criteria:

- Novelty/Originality: Most innovative/original scientific contribution of each CRP to the Programme and to the relevant field of research;
- Multidisciplinary Research: How each CRP is working towards (or achieving) multidisciplinary research;
- Collaborative Research: Results obtained within the CRP during this reporting period that would not have been achieved (or would have taken longer to achieve) in an individual project;
- European-added value: European dimension given to National funding (e.g: building up ERA; developing critical mass of expertise; addressing issues of scale and scope). For CRPs involving partners outside Europe: a clear example illustrating their added value to the Programme and their contribution to the relevant field of research in Europe;
- Relevance to the Call: Achievement most relevant to the Call.

As commented by the Review Panel Members on the occasion of the Final Evaluation of the Programme, EuroDEEP has proved a great success, showing a high degree of international cooperation and well-integrated research projects.

2.3.5 EUROCORES Acknowledgements

To promote the EUROCORES Programme and the national funding organisations who support it (and prior to 2008, the European Commission), all publications, posters, websites and other dissemination outputs are required to be clearly identified as being Programme-funded or co-funded. This is an important indicator for monitoring the outputs of the Programmes, particularly peer-reviewed publications.

For EuroDEEP the acknowledgement was:
The European Science Foundation (ESF) provides scientific coordination and support for networking activities of funded scientists currently through the EC FP6 Programme, under contract no. ERAS-CT-2003-980409. Research funding is provided by participating organisations. EuroDEEP *is managed by the Life, Earth and Environmental Sciences (LESC) Unit at the ESF.*

For other EUROCORES Programmes from 2009 onwards the acknowledgement is:
The aim of the European Collaborative Research (EUROCORES) Scheme is to enable researchers in different European countries to develop collaboration and scientific synergy in areas where European scale and scope are required to reach the critical mass necessary for top class science in a global context.

The scheme provides a flexible framework which allows national basic research funding and performing organisations to join forces to support excellent European research in and across all scientific areas.

Until the end of 2008, scientific coordination and networking is funded through the EC FP6 Programme, under contract no. ERAS-CT-2003-980409. As of 2009, the National Funding Organisations will provide the funding for the scientific coordination and networking in addition to the research funding.

3.
Highlights of the Collaborative Research Projects

3.1 Biodiversity and ecosystem functioning in contrasting southern European deep-sea environments: from viruses to megafauna (BIOFUN)

Principal Investigators:

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*Associated Partners

Funding Organisations:

Belgium: *Research Foundation Flanders (FWO)*
France: *National Centre for Scientific Research (CNRS)*
Ireland: *Irish Research Council for Sciences, Engineering and Technology (IRCSET)*
Italy: *National Research Council (CNR)*
Spain: *Ministry for Education and Science (MEC)*
The Netherlands: *Netherlands Organisation for Scientific Research (NWO)*

Scientific Background and Objectives

The bathyal and abyssal ecosystems are the largest habitats on Earth, covering over 60% of the Earth's surface. Yet, only a very small fraction of the deep sea has been explored to date, and the surface that has been physically sampled amounts to only a few hectares, or the equivalent of a few football fields. What little we know indicates that the deep oceans are characterized by biodiversity levels among the highest on the planet, much of which remains undescribed, especially in the case of small organisms and prokaryotes. It was therefore timely and critical, at the onset of EuroDEEP, to explore and investigate the diversity and functioning of deep-sea ecosystems, to explain the links between trophic structure and life cycles with diversity and distribution patterns.

The results obtained will provide the necessary baseline information for the assessment of

the natural and anthropogenic impact on deep-sea ecosystems and to propose management and conservation options.

The overall aim of BIOFUN was to characterise, under an ecosystem approach, two deep-sea habitats – the mid-slope and abyssal plain – including for the first time the analysis from viruses to megafauna, to understand the linkages between biodiversity patterns and ecosystem functioning in relation to environmental conditions. The study areas included the Galicia Bank in the Atlantic and the Mediterranean Sea, from west to east (Figure 1).

Field work

BIOFUN has had an intense field work programme (2007-2009), with 6 major cruises in the Atlantic (Galicia Bank) and across the Mediterranean Sea. All these cruises were multidisciplinary and sampled the geological, physical and biological (from viruses to megafauna) components of the seafloor at 1200, 2000 and 3000 m depth, as well as other extra depths depending on the cruise. It is worth highlighting the effort made in sampling simultaneously environmental, abiotic and biological parameters, allowing the study of the relationship between biological patterns and the environment. All cruises had participants from all or most BIOFUN partners, and the samples were taken using standardised methodologies.

Analysis phase

The analysis phase took place between 2009 and 2010. BIOFUN had a strong training component, with 5 postdocs, 9 PhD students and over 15 MsC students. The most important achievement of the BIOFUN project was that, for the first time, all life components inhabiting deep-sea ecosystems were considered together. This provided the first insight on the biodiversity patterns among life kingdoms, and represented a basis for future research developments in the deep sea.

Specific novel results

Some of the major results obtained during the BIOFUN project are found below. Initial results have been published or are in preparation for publication in over 36 papers, and the BIOFUN community had a strong presence in the major related Symposia, such as, amongst others, the 12th Deep Sea Biology Symposium (Iceland, 2010), Ocean Sciences (Portland 2010), Meiofauna Congress (Gent, 2010), Society of Microbiology meeting (2010), EGU (Vienna, 2011). The BIOFUN community is also preparing 4 synthesis papers in which all size components of the biota are integrated and analysed to assess how their community structure changes in relation to different measures of ecosystem functioning. This will be a final product of the project.

Abiotic characteristics

- Detailed information on downward particle fluxes, including organic matter, currents and hydrology in the open ocean of the NW Mediterranean Sea, in the area of deep-water formation. The results show that deep Mediterranean environments are occasionally exposed to extreme events.

Viruses

- Viruses appear to play a major role in global biogeochemical cycles, deep-sea metabolism and overall functioning of the deep sea. Viral variables have been related to the other benthic deep-sea domains for the first time.

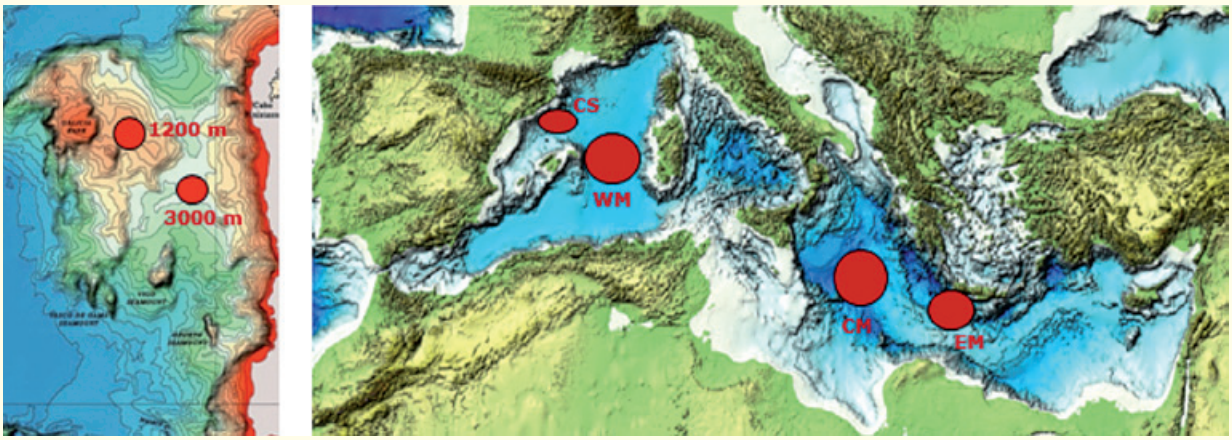

Figure 1.
BIOFUN study sites. **A**, Galicia Bank, NE Atlantic. **B**, Mediterranean: **CS**, Catalan slope; **WM**, Western Mediterranean; **CM**, Central Mediterranean, **EM**, Easter Mediterranean.

Figure 2.
Examples of studied fauna. **A**, Predatory nematode (*Sphaerolaimus*) swallowing another nematode (*Amphimonhystrella*) © Ellen Pape, UGENT. **B**, Deep Mediterranean crustacean decapods sample and **C**, Deep Mediterranean fish sample Eva Ramirez-Llodra © ICM-CSIC.

Figure 3.
Examples of marine litter collected in the deep Mediterranean. **A**, **B** and **C**, Western Mediterranean, 1200, 2000 and 3000 m respectively. **D** and **E**, Central Mediterranean at 1200 m. **F**, Ghost fishing from a net collected at 1200 m in the Central Mediterranean. © Eva Ramirez-Llodra, ICM-CSIC.

Bacteria

- Mid-water bacterial community structure is not strongly influenced by the oligotrophic gradient in the Mediterranean.
- Mid-water bacterial diversity decreases from surface to mid-water column and increases from mid-water column to the benthos.
- Ultramicrobacteria (0.1um-0.2um) are widely distributed in the Mediterranean.
- Unexpected and unique bacterial diversity on the southern Cretan margin.

Meiofauna (Figure 2)

- Development of modified fatty acid analysis techniques for deep-sea meiofauna which may occur at very low abundances.
- One of the first detailed investigations that includes experimental approaches and field observations on the relationship between nematode biodiversity and ecosystem functioning.
- Continuation of the time series sampling in the Ierapetra basin (E Med) to study temporal trends of metazoan meiofauna.

Macrofauna

- Small (<10 km) to large (> 100 km) spatial-scale variability in the distribution and biodiversity patterns of the macrobenthic community has been analysed.

Megafauna (Figure 2)

- Exploration of bathyal and abyssal areas for megafauna, showing a decrease in taxonomic groups from West to East in the Mediterranean and with depth, as well as a decrease in overall biomass along the longitudinal gradient.
- First detailed study of bathymetric and longitudinal distribution of deep Mediterranean non-crustacean megafauna invertebrates.

- Deployment of novel landers with video and geochemical sensors for the study of megafauna.
- Novel data on links between primary productivity and deep-sea fish, which compete with invertebrates for the same food sources.

Modelling

- Ecotrophic models for deep Atlantic and Mediterranean ecosystems (in development).

Marine litter and chemical contamination

(Figure 3)

- Pioneer data on chemical contamination in bathyal and abyssal Mediterranean megafauna (in progress).
- First quantification of basin-wide litter accumulation in the deep Mediterranean.

European added value

The international collaboration and critical mass of scientific expertise and funding provided by the Collaborative Research Project (CRP) was essential to achieve the objectives being addressed by BIOFUN. Sampling the deep sea requires the use of large infrastructures and state of the art technology (oceanographic vessels, deep-water sampling equipment such as trawls, corers, landers, etc), as well as human power, which can only be achieved through international collaboration. In the specific case of BIOFUN, the European collaboration resulted in joint cruises that allowed for a truly integrated ecosystem approach using standardized methods and a wide range of scientific expertise, equipment and methodologies available in the CRP, to study, for the first time, all biological components, from viruses to megafauna. An assessment of the deep-sea biodiversity and of the linkage between deep-sea biodiversity and ecosystem functioning is a prerequisite for planning the future management of deep-sea ecosystems. BIOFUN contributes to this and provides a comparative analysis of key Atlantic and Mediterranean areas, which by being investigated using exactly the same techniques and methodologies will allow the possible development of specific management strategies.

Selected Publications

Baldrighi, E.; S. Aliani, A. Conversi, E. Manini (in prep). From Micro to Macrofauna: an integrating study of different benthic communities and their response to environmental variables in the deep sea Ionian. Marine Ecology Progress Series.

Braeckman U, Provoost P, Gribsholt B, Van Gansbeke D, Middelburg JJ, Soetaert, K, Vincx M, Vanaverbeke J. (2010). Role of macrofauna functional traits and density in biogeochemical fluxes and bioturbation. Marine Ecology Progress Series 399: 173-186.

Danovaro R, Company JB, Corinaldesi C, D'Onghia G, Galil B, C. Gambi, A.J. Gooday, N. Lampadariou, G.M. Luna, C. Morigi, K. Olu, P. Polymenakou, E. Ramirez-Llodra, A. Sabbatini, F. Sardà, M. Sibuet, A. Tselepides 2010 Deep-Sea Biodiversity in the Mediterranean Sea: The Known, the Unknown, and the Unknowable. PLoS ONE 5(8): e11832. doi:10.1371/journal.pone.0011832.

Durrieu de Madron, X., Stabholz, M., Kerhervé, P., Heussner, S., Delsaut, N., Kunesch, S. Khirpounoff, A, Calafat, A., Canals, M., Puig, P & Testor, R. (in prep). Impact of open-sea convection on particulate fluxes and sediment dynamics in the deep basin of the Gulf of Lion.

Jeffreys, R.M., Lavaleye, M.S.S., Bergman, M.J.N., Duineveld, G.C.A., Witbaard, R. & Linley, T. (2010). Deep-sea macrourid fishes scavenge on plant material: evidence from in situ observations. Deep-Sea Research 57, 621-627.

Jeffreys, R.M., Lavaleye, M.S.S., Bergman, M.J.N., Duineveld, G.C.A. & Witbaard, R (2011). Do abyssal scavengers use phytodetritus as a food resource? Video and biochemical evidence from the Atlantic and MediterraneanDeep-Sea Research 58, 415-428.

Jeffreys, R.M., Lavaleye, M.S.S., Bergman, M.J.N., Duineveld, G.C.A. & Witbaard, R Linking deep-sea biodiversity to food quality: a molecular approach (submit to Plos one, 2011).

Jeffreys, R.M., Lavaleye, M.S.S., Bergman, M.J.N., Duineveld, G.C.A. & Witbaard, R (in prep). Using biomarkers to reveal differences in feeding and physiological strategies in deep-sea fish: a comparison between the Mediterranean and Atlantic (submit to MEPS, 2011)

Jeffreys, R.M., Lavaleye, M.S.S., Bergman, M.J.N., Duineveld, G.C.A. & Witbaard, R (in prep.) The trophic ecology of the megabenthic community at Galicia Bank (submit to MEPS, 2011).

Lampadariou N, Tselepides A, Hatziyanni E (2009) Deep-sea meiofaunal and foraminiferal communities along a gradient of primary productivity in the eastern Mediterranean Sea. Sci Mar 73:337-345.

Molari, M. and E. Manini (2012). Reliability

of CARD-FISH procedure for enumeration of archaea in deep-sea surficial sediments. Current Microbiololgy. DOI 10.1007/s00284-011-0056-5.
Pape E., Moodley L., Van Oevelen D., Vanreusel A. (in prep) The fate of dissolved organic substances in differently structured deep-sea benthic commuities.
Ramirez-Llodra, E., Company, J.B., Sardà, F. and Rotllant, G. (2010). "Megabenthic diversity patterns and community structure of the Blanes submarine canyon and adjacent slope in the Northwestern Mediterranean: a human overprint?" Marine Ecology 31: 167-182.
Sardà, F. and Company, J.B. (in review). The deep-sea recruitment of *Aristeus antennatus* (Risso, 1816, Crustacea: Decapoda): an euribathic species on the Mediterranean Sea. Marine biology.
Schneider, M. & Stefanni, S. (in prep.). First record of the Atlantic soft pout *Melanostigma atlanticum* KOEFOED, 1952 (Actinopterygii, Zoarcidae) from deep-waters of the Eastern Mediterranean Basin.
Soetaert, K, & van Oevelen D (2009). Modeling Food Web Interactions in Benthic Deep-Sea Ecosystems, A Practical Guide. Oceanography: 22 (1): 128-143.
Stefanni, S. & Schneider, M. (in prep.). On the occurrence and biology of the rare deep-water shark *Somniosus* (*Rhinoscymnus*) *rostratus* (Risso, 1826) (Elasmobranchii, Somniosidae) in the Levantine Basin, Eastern Mediterranean.
Tecchio S, Ramírez-Llodra E, Sardà F, Company JB (2011) Biodiversity of deep-sea demersal megafauna on western and central Mediterranean basins. Scientia Marina 75(2):341-350.
Tecchio S, Ramírez-Llodra E, Sardà F, Company JB, Palomera I, Mechó A, Pedrosa-Pàmies R, Sanchez-Vidal A (2011) Drivers of deep Mediterranean megabenthos communities along longitudinal and bathymetric gradients. Mar Ecol Prog Ser., 439: 181–192.
Zeppilli D., Danovaro R. Cosmopolitanism and biogeography of the genus *Manganonema* Bussau, 1993 (Nematoda: Monhysterida) in the deep-sea ecosystems. Animals 1: 291-305.

3.2 Monitoring colonisation processes in chemosynthetic ecosystems (CHEMECO)

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*Associated Partners

Funding Organisations

France: *National Centre for Scientific Research (CNRS); French Research Institute for Exploitation of the Sea (Ifremer); National Institute for Development (IRD)*
Portugal: *Foundation for Science and Technology (FCT)*

Scientific Background and Objectives

The main objective of this Collaborative Research Project (CRP) was to realise a multidisciplinary study of colonisation processes at several sites distributed in the European waters, from the Mediterranean Sea to the Atlantic Ocean and North Sea. The specific interest of CHEMECO relied in the first place on the establishment of pioneer microbial communities, on the recruitment of metazoan larvae, on the development of symbioses, and on their importance in the biodiversity and tropic structure of newly-established communities. A second aspect of this project was to assess the impact of metazoan colonisation on chemical exchanges and biogeochemical processes. CHEMECO proposed to address these aims through a unique combination of site surveys, replication of colonisation experiments, comparison of natural and experimental

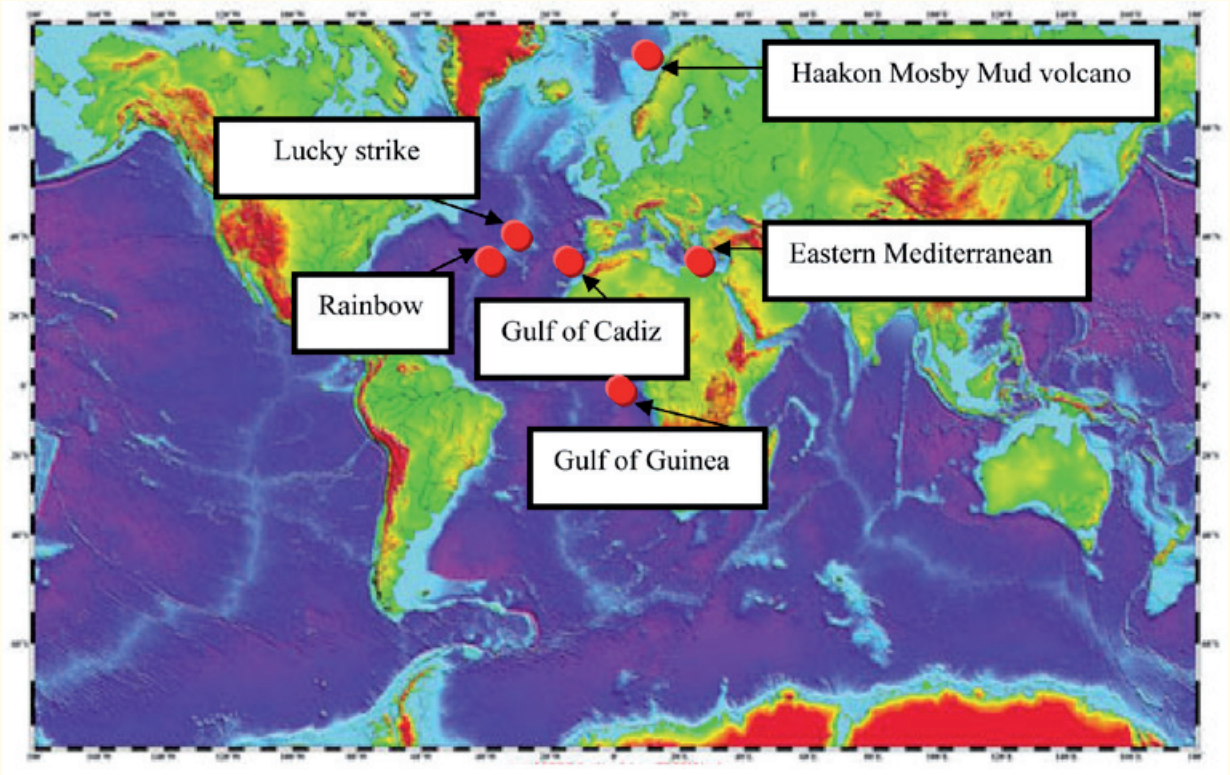

Figure 4. CHEMECOLI experiences

organism assemblages, in situ chemical monitoring with microsensors, and reactive transport modeling. Similar colonisation devices hosting the same type of mineral and organic substrates were planned to be used in order to replicate long-term experiments at different sites. Local geological settings and ecological, chemical and biogeochemical patterns were also planned to be characterised.

CHEMECO focussed on a series of deep-sea chemosynthetic ecosystems, for which the different Principal Investigators (PIs) and Associated Partner (AP) of the CRP acquired an expertise in the previous years.

Field work

The main originality of the project lies in the experimental approach that was implemented, and which allowed a multi-site integrated study (Figure 4).

The CHEMECO community used a novel colonisation device named CHEMECOLI (Figure 5) for CHEMosynthetic Ecosystem COlonisation of Larval Invertebrates (Gaudron et al. 2010). This was placed in different seafloor areas hosting chemosynthetic ecosystems (hydrothermal vents and cold seeps) filled with different organic substrates to generate chemically reduced habitat for different period of time: 2 weeks, 1 year, 2 years and 3 years. Fifty one colonisation devices were deployed from 2006 to 2009 at depths ranging from 354 meters to 2300 meters deep, from the Eastern Mediterranean to the Norwegian Sea (Figure 4). After one year at 1700 meters deep in eastern Mediterranean, hydrogen sulphide was still being produced at micromolar level, and this was measured using electrochemical tools (Le Bris et Duperron, 2010) during the recovery of the device on board (Gaudron et al. 2010). The experiment involved a number of research groups that shared the substrates issued from the CHEMECOLI, with different expertise(Figure 6) to understand the biodiversity and ecosystem functioning of the deep-sea reducing habitats from microbiota (bacteria, micro-eukaryote, fungi) to the metazoan.

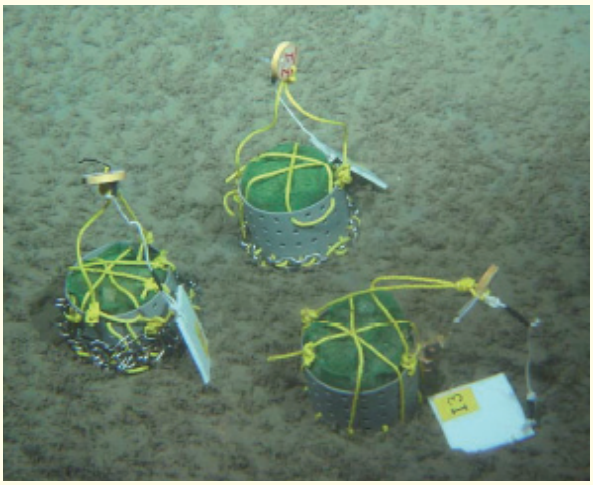

Figure 5. CHEMECOLIs in situ at Haakon Musby. © Vicking/Ifremer

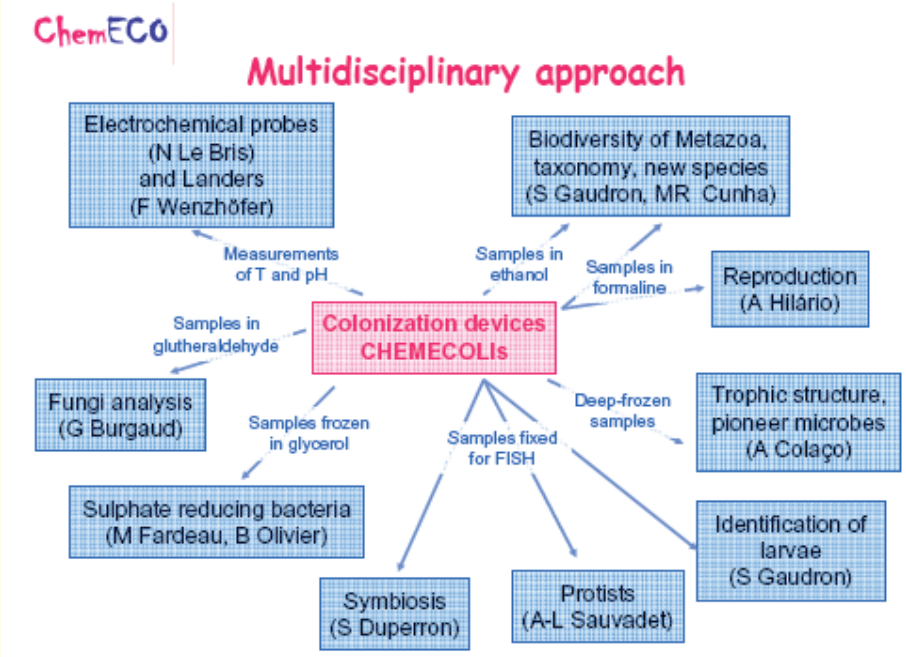

Figure 6.
The multidisciplinary approach

Specific novel results

Through this device, CHEMECO managed to collect metazoans ay young stages, including heterotrophic species with some species new to Science (Böggeman et al. in subm). The highest diversity was found within CHEMECOLI filled with organic substrates and deployed in the Mud Vulcanos of the Gulf of Cadiz, whatever the duration or the depth (Matos et al. in prep.). The Gulf of Cadiz seems to be a hotspot of marine biodiversity (Cunha, pers. communication). Interestingly symbiotic species such as Bivalvia (thyaririd, vesicomyid, solemyid, Bathymodiolid) and Polychaeta (siboglinid) (Brissac et al., 2010; Gaudron et al. 2010; Matos et al. in prep) were mainly recovered within CHEMECOLI harbouring organic substrates (mimicking reducing habitats). These metazoans have evolved in complex symbiotic relationships with chemosynthetic bacteria, often sulphur- or methane-oxidizers. Bacteria sustain at least part of their hosts' nutritional needs, while they benefit from shelter and access to their substrates. The small mytilid *Idas* sp. Med. (1 cm shell length on the picture Figure 7) was shown to harbour 6 bacterial symbionts in its gill tissue, based on investigation of specimens from the Eastern Mediterranean. During the Medeco cruise in the Eastern Mediterranean (2007), specimens of this species were sampled from various substrates including carbonates, tubeworms and wood deployments (Lorion et al., 2012). Very similar mussels occurred within CHEMECOLI in the Gulf of Cadiz, and naturally in the Gulf of Mexico, suggesting a highly versatile mussel species with the potential to adapt and disperse to various habitats and geographical locations (Duperron et al., 2010; Rodrigues et al., in preparation).

Some of the other highlights are the discovery of new anaerobic microorganisms involved in the reduction of sulfur compounds, and sulfate-reducing bacteria (SRB), in particular known as significant contributors to the oxidation of organic matter in marine environments. In this respect, enrichments from wood cubes issued from CHEMECOLI deployed for one year at 1700 meters deep in the Eastern Mediterranean have enabled the isolation of two novel strains of SRB: strain C1TLV30, considered as a novel bacterial species (*Desulfovibrio piezophilus*), having 96% similarity with *D. profundus*, a piezophilic hydrogenotrophic SRB isolated from deep-sea sediments, and strain C1TH30

Figure 7.
Alive chemosymbiotic species from eastern Mediterranean on board, recovered from cold seeps at 1700 meters deep. © Duperron&Gros

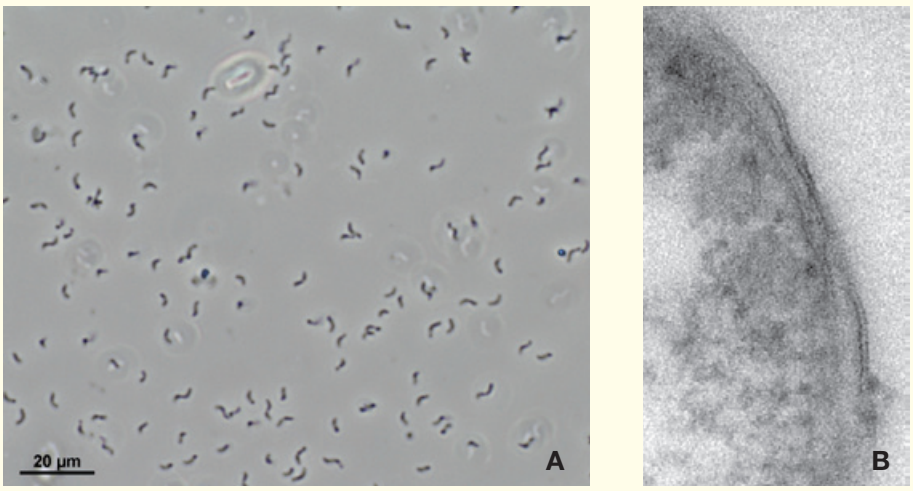

Figure 8.
A, Phase-contrast photomicrograph of cells of strain showing vibrio shaped bacterial cells. **B**, Ultrathin sections showing the Gram-negative type of cell wall of strain C1TLV30^{T}

having 99% similarity with *D. dechloracetivorans*, an acetoclastic SRB also isolated from marine environments (Khelaifia et al., accepted). Strain C1TLV30 was shown to be piezophilic, growing optimally at 10 Mpa and pressures up to 250 bars, and this strain shows unique changes in membrane lipids composition. Further enrichments from the wood cubes issued from CHEMECOLI from Mud Vulcano (Mercator) from the Gulf of Cadiz (354m depth) led to the isolation of two other SRB: strain B0109P2, having 98% similarity with *D. dechloracetivorans*, and strain B0109G, having 98% similarity with *D. marinisediminis*. Both isolates should also be considered as novel species of genus *Desulfovibrio* (Khelaifia et al., in prep). Isolation of hydrogenotrophic and acetoclastic *Desulfovibrio* strains from wood fall samples at different depths in the Mediterranean Sea and in the Atlantic Ocean suggest that these microorganisms should be considered of ecological significance in the decomposition of wood falls in deep marine environments.

The complete full picture of colonisation is not yet available as some partners are still studying microbes, protists and metazoans diversities using gene sequencing and pyrosequencing (454). However the CHEMECO group hopes, in the next year or two, to write a synthesis on colonisation when each partner will be happy with their own results. Ecological studies are a long process.

European added value

In the context of increasing costs for ship operation, sharing of ship-time has been highly valuable to enlarge the focus of the experimental approach. Through the international CHEMECO Collaborative Research Project, scientists have managed to conduct successfully several *in situ* experiments, benefitting from the French, German and Belgian cruises. These cruises permitted the study of a large area of European waters, from the Norwegian Sea to the Mediterranean via the Gulf of Cadiz. The Project has benefitted immensely from shared European infrastructures, including ships, deep submergence vehicles, taxonomy networks, and museum expertise.

The international, multidisciplinary character of CHEMECO is one of the assets of this CRP: researchers with different expertise (from geological and biological habitat mapping, to chemical flux measurements, submarine technology development, microbiology, molecular biology, zoology, trophodynamics) have been on cruises together and shared experiments. Back in the laboratory, the experts analysed their results separately, and the next step will be to put all these together in common multidisciplinary papers.

Selected Publications

Burgaud, G., Arzur, D., Durand, L., Cambon-Bonavita, M-A., Barbier, G. (2010). Marine culturable yeats in deep-sea hydrothermal vents: species richness and association with fauna. FEMS Microbiol Ecol 73: 121-133.

Brissac, T., Rodrigues, C.F., Gros, O., and Duperron, S. (2011) Characterization of bacterial symbioses in Myrtea sp. (Bivalvia: Lucinidae) and Thyasira sp. (Bivalvia: Thyasiridae) from a cold seep in the eastern Mediterranean. Mar. Ecol. 32: 198-210.

Böggemann, M., Bienhold, C., Gaudron, S.M. (2011). A new species of Glyceridae (Annelida: Polychaeta) recovered from organic substrates experiments in cold seeps from eastern Mediterranean, Marine Biodiversity journal, DOI 10.1007/s12526-011-0091-2.

Colaço et al. Trophic structure of colonization

modules at chemosynthetic environments: a comparative approach, in preparation.
Duperron, S. (2010) The diversity of deep-sea mussels and their bacterial symbioses (review). In Kiel (Ed.) The Vent and Seep Biota. Topics in Geobiology series, Springer, 33: 137-168 (peer-reviewed book chapter).
Gaudron, S.M., Demoyencourt E., Duperron S. (2012). Reproductive traits of the cold seep symbiotic mussel Idas modiolaeformis: from gametogenesis to larval dispersal. Biological Bulletin, in press.
Gaudron, S.M., Pailleret, M., Duperron, S, Pradillon, F., Gaill, F (2010). Colonization of symbiotic species and associated fauna into organic substrates deployed in deep-sea reducing habitats. Marine Environmental Research, 70: 1-12.
Khelaifia, S., Fardeau, M.L., Aussignargues, C., Garel, M., Tambourini, C., Cayol, J.L., Gaudron, S.M., Gaill, F., Ollivier, B. (2011) Desulfovibrio piezophilus sp. nov., a novel sulfate-reducing bacterium isolated from wood falls in Mediterranean Sea. Int. J. System. Evol. Microbiol, 11: 2706-2711.
Lartaud, F., Little, C.,T.S., de Rafelis, M., Bayon, G., Dyment, J., Ildefonse, B., Gressier, V., Fouquet, Y., Gaill, F., Le Bris, N. (2011). Fossil evidence for serpentinization fluids fueling chemosynthetic assemblages. Proceedings of the National Academy of Sciences of the United States of America, 108: 7698-7703.
Lorion, J., Halary, S., do Nascimento, J., Samadi, S., Couloux, A., and Duperron S. (2012). Evolutionary history of Idas sp. Med, (Bivalvia: Mytilidae), a cold seep mussel bearing multiple symbionts. Cah. Biol. Mar. 53: 77-87.
Matos, F., Hilario, A., Rodrigues, C.F., Cunha, M.R. Colonization of artificial substrates in chemosynthetic ecosystem, in preparation.
Nunes Jorge, A., Duperron, S. and Gaudron, S.M. Identification of marine bivalves recovered within CHEMECOLIs, in preparation.
Rodrigues, C.F., Duperron, S., and Gaudron, S.M. (2011) First documented record of a living solemyid in a pockmark of the Nile deep-sea fan (eastern Mediterranean Sea). Mar. Biodiv. Records, Vol. 4: e10.
Rodrigues, C.F., Duperron, S., Cunha, M.R., Gaudron, S.M. et al. Idas sp. Med. amphi-atlantic species? in preparation.

3.3 Unravelling population connectivity for sustainable fisheries in the Deep Sea (DEECON)

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Funding Organisations

Ireland: *Irish Research Council for Sciences, Engineering and Technology (IRCSET)*
Norway: *Research Council of Norway (NFR)*
Portugal: *Foundation for Science and Technology (FCT)*

Scientific Background and Objectives

Over-exploitation of traditional coastal stocks has resulted in the shift of commercial harvesting towards less-known, deep-sea living resources in many parts of the world.

The intensity at which deep sea harvesting is taking place, and the growing availability of relevant technologies, greatly exceed the pace at which scientists can reliably obtain estimates of basic biological parameters for the purpose of stock management and conservation. The resulting current lack of understanding of the biology of several new target species, along with the naturally slow growth rate and presumably low resilience of such populations, raise serious concerns about the long-term viability of fisheries, as well as the survival of species and communities. A key to managing fisheries and protecting ecosystems, lies in the understanding of the underlying demographic and life-history characteristics of deep sea species, such as their life-span, their growth and age at maturity, their reproductive potential, and their dispersal, migratory behaviour and spatial population structure.

DEECON aimed to apply the most modern methodologies for a multidisciplinary approach to unravel population structure and population connectivity in economically important deep-sea fish species,

using molecular genetic markers, otolith microchemistry, and oceanographic modelling within a common statistical modelling framework. Through the joining of individual strong research groups with a profound expertise within each field involved, the collaborative team represented a solid consortium with the unique opportunity to spearhead European research into new frontiers in the deep sea. Based on a well-balanced mix of proven technology and new approaches, DEECON acquired new fundamental biological knowledge to be used for developing scientifically sound management plans for one of the world's most valuable ecosystems.

The two most focal points of the research have been:

1. Detecting population structure and understanding processes and mechanisms behind such structures;
   and
2. Characterising biodiversity in deep sea communities.

The first point greatly benefits from the use of complementing methods, including otholith chemistry, oceanographic modeling and genetic analyses (both microsatellites and mtDNA), providing more robust information than any single method can provide alone. The study of the genus *Aphanopus* identifies two cryptic species with overlapping morphology, hence directly contributing to the second point, which will be addressed in broader terms in the near future, utilising the wealth of information on intra-specific biodiversity that is currently being developed within the CRP, as the individual projects complete the interdisciplinary synthesis. Further extension to include gene expression to study adaptation to the deep sea brought a new perspective and another level of multidisciplinarity for the project.

Specific novel results

The novelty of the research lies in the following points:

1. Understanding primary mechanisms behind population genetic structure in tusk (*Brosme brosme*) in NE Atlantic and the Roundnose Grenadier (*C. rupestris*).
2. Detecting absence of population genetic structure in the Orange Roughy at a larger geographic scale than hitherto recognised.
3. Developing novel genetic markers for several seep-sea species.
4. Uncovering strong patterns of spatial differentiation in otolith microchemistry in the Roundnose grenadier, complementing genetic results.
5. Transcriptome from 6 separate tissues of *Aphanopus carbo*, to explore gene expression associated with depth. This is the first transcriptome for a deep sea fish.

The very nature of DEECON entailed multidisciplinarity: researchers combined methodologies such as otholith chemistry and shape analysis, multi-locus genetic markers, and oceanographic and other computer modeling and simulations, in order to understand mechanisms of population connectivity in selected deep sea fishes. Oceanographers worked together with geneticists and marine ecologists to resolve common research issues, including characterizing dispersal and gene flow at various life history stages.

The phase of data integration will allow production of the most innovative interdisciplinary publications arising from the project.

Another important step will be linking gene expression to depth, as well as variation among populations from the deep-water environment.

European added value

DEECON research has been developed through promotion of work on a large geographic scale, interacting with scientific cruise leaders for samples, and developing new methods for investigating deep sea fish population structure. Given the vast geographic range covered by deep sea habitats and the transnational nature of the associated fisheries, it would have been impossible even to conceive a project like DEECON without keeping a Europe and ocean-wide perspective.

Results will be crucial to identify knowledge gaps and so make further progress in understanding demographic processes in the deep sea. Due to the heavy involvement of several partners in the ICES scientific community, it is expected that the results from DEECON will serve to provide better advice for future European and international management of these species, and provide guidelines for exploring population connectivity in a multi-species and multidisciplinary context.

Selected Publications

Cunha RL, Madeira C, Coscia I, Mariani S, STefanni S and Castilho R, (2012, in prep.) "Ancient mitochondrial DNA divergence in the deep-sea shark Centroselachus crepidater". To be submitted to: Molecular Phylogenetics & Evolution.

Helyar S, Sacchi C, Coughlan J & Mariani S (2009). Novel microsatellite loci for a deep sea fish (*Macrourus berglax*) and their amplification in other grenadiers (Gadiformes: Macrouridae). *Conservation Genetics Resources,* doi: 10.1007/s12686-009-9049-0.

Helyar S, Coscia I, Sala-Bozano M & Mariani S (2010). New microsatellite loci for the longnose velvet dogfish Centroselachus crepidater (Squaliformes: Somniosidae) and other deep sea sharks. *Conservation Genetics Resources.* DOI: 10.1007/s12686-010-9316-0.

Knutsen H, Marie Le Goff-Vitry, Fiani D, Hoelzel AR (2008). Isolation and characterization of microsatellite loci in a marine fish species, the roundnose grenadier (*Coryphanoides rupestris*). *Molecular Ecology Notes*, 8, 993-995.

Knutsen H, Catarino D, Sannæs H, Stefanni S (2009). Development of eleven microsatellite loci in the deep sea black scabbardfish (*Aphanopus carbo*). *Conservation Genetic Resources,* DOI 10.1007/s12686-009-9021-z.

Knutsen H, Jorde PE, Sannæs H, Hoelzel AR, Bergstad OA, Stefanni S, Johansen T and Stenseth NC (2009). Bathymetric barriers promoting genetic structure in the deepwater demersal fish tusk Brosme brosme. *Molecular Ecology,* 18, 3151-3162.

Knutsen H, Jorde PE, Bergstad OA, Skogen M. (2011). Population genetic structure in a deepwater fish Coryphaenoides rupestris: patterns and processes. *Marine Ecology Progress Series*, revised.

Longmore C., Fogarty K., Neat F., Brophy D., Trueman, C. & Mariani S. (2010). A comparison of otolith microchemistry and otolith shape analysis for the study of spatial variation in a deep-sea teleost, *Coryphaenoides rupestris*. Submitted to *Environmental Biology of Fishes*. DOI 10.1007/s10641-010-9674-1.

Longmore C, Trueman CN, Neat F, O'Gorman EJ, Milton JA & Mariani S (2011). Otolith geochemistry indicates life-long spatial population structuring in a deep sea fish, *Coryphaenoides rupestris*. *Marine Ecology Progress Series,* 435: 209-224.

Ring AK, Knutsen H and André C (2009). Development of ten microsatellite loci in the ling (*Molva molva*). *Molecular Ecology Resources, in press.*

Schneider M, Sannæs H, Jorde, PEJ and Knutsen H (2009). Isolation and characterisation of 11 microsatellite loci in the abbysal carapine grenadier *Coryphanoides carapipnus* (Actinoperygii, Macrouridae) and cross amplification in two other deep-sea macrourid species.*Conservation Genetics, DOI 10.1007/s10592-009-9838-8.*

Stefanni S, Bettencourt R, Knutsen H and Menezes G (2009). Rapid PCR-RFLP method for discrimination of the two Atlantic cryptic deep-sea species of scabbardfish. *Molecular Ecology Resources,* doi: 10.1111/j.1755-0998.2008.02470.

White T.A., Stefanni S., Stamford J. and Hoelzel A.R. (2009). Ocean basin panmixia in a long-lived, deep-sea fish with well defined habitat dependence and relatively low fecundity Molecular Ecology 18: 2563-2573.

3.4 Microbial Diversity in the Deepest Hypersaline Anoxic Lakes (MIDDLE)

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*Associated Partners

Funding Organisations

France: *National Centre for Scientific Research (CNRS)*
Italy: *National Research Council (CNR)*
The Netherlands: *Netherlands Organisation for Scientific Research (NWO)*

Scientific Background and Objectives

The main strategic objective of the MIDDLE project was to gain for the first time new fundamental knowledge in the field of Biology and Evolution of the Biosphere through the comprehensive investigation of a unique deep-sea extreme environment at different complexity levels, and application of this knowledge in biotechnology. The multidisciplinary character of the MIDDLE project manifested itself through the participation of various scientific groups specialising in several research areas: geochemistry and geophysics; biogeochemistry and microbial diversity; biochemistry and enzymology; biotechnology and environmental genomics; biophysics and structural biology of proteins.

Specific novel results

The main highlight of this Project consists of the fact that four Mediterranean Sea anoxic hypersaline deep-sea lakes (DHALs) were subjected for the first time to microbiological analyses during the activities of MIDDLE. Among these four lakes, two were discovered by the MIDDLE partners during the 2008 MIDDLE cruise.

Hypersaline anoxic lakes are considered to be the best analogues for evaluating potential habitats for life or preservation of life's signatures on icy planets, in particular and Jupiter's moon Europa. Martian depressions enriched in hydrous sulphate deposits, and a putative subsurface ocean of Europa, have been suggested to be similar to Mediterranean Sea anoxic hypersaline deep-sea lakes. Insights into survival strategies of pro- and eukaryotic microorganisms in such extreme environments will provide a basis for elucidating the biochemical capabilities that define the limits for cellular life and give new knowledge that can be applied for astrobiological studies. Moreover, the progress in studying the molecular phylogeny and ecology, structural biology, and biochemistry of DHALs will certainly bring new insights in the field of Biology and Evolution of Biosphere.

As an example, the study of the athalassohaline lakes Discovery and Kryos defined the limit of life, which is defined primarily limited not by water availability, but rather by chaotropicity of the ecosystem: the concept "*everything is everywhere*" does not cater for extremely harsh athalalassohaline environments.

European added value

Throughout the whole duration of the MIDDLE Project a tight collaboration between the partners was achieved. All the research partners and, in particular the German, Spanish and UK teams, were present during the three cruises organised by the Project Coordinator. The microarray reactome developed by the Spanish partner was firstly validated with samples collected from Atalante and Kryos brine lakes.

The MIDDLE strategy and work plan included four working packages, each of which was carried out in tight and active collaboration between all MIDDLE partners, highly experienced researchers at several European institutes.

The Mediterranean Sea deep-sea hypersaline anoxic lakes are the only examples of such extreme environments found in European waters (Italy/Greece). From this point of view, these lakes are much more easy accessible and "cost-effective" extreme environments for study by the European scientific community. Moreover, the discovery of the Mediterranean brine lakes' extreme environments and the life therein was achieved mainly, and for the first time, by European scientists. Europe already has a lead in extremophiles research and development, which can now be built on significantly by developing the novel area in deep-sea exploration originally proposed in MIDDLE Project.

Selected Publications

Alexander, E., Stock, A., Breiner, H.-W., Behnke, A., Bunge, J., Yakimov, M.M., Stoeck, T. Microbial eukaryotes in the hypersaline anoxic L'Atalante deep-sea basin (2009) *Environmental Microbiology*, 11 (2), pp. 360-381.

Borin S., Crotti E., Mapelli F., Tamagnini I., Corselli C., Daffonchio D. (2008) DNA is preserved and maintains transforming potential after contact with brines of the deep anoxic hypersaline lakes of the Eastern Mediterranean Sea. *Saline Systems* 4:10-17.

Borin, S., Brusetti, L., Mapelli, F., D'Auria, G., Brusa, T., Marzorati, M., Rizzi, A., Yakimov, M., Marty, D., De Lange, G.J., Van der Wielen, P., Bolhuis, H., McGenity, T.J., Polymenakou, N.P., Malinverno, E., Giuliano, L., Corselli, C. and Daffonchio, D. Sulfur cycling and methanogenesis primarily drive microbial colonization of the highly sulfidic Urania deep hypersaline basin (2009) *Proceedings of the National Academy of Sciences of the United States of America*, 106 (23), pp. 9151-9156.

Edgcomb, V., Orsi, W., Leslin, C., Epstein, S.S., Bunge, J., Jeon, S., Yakimov, M.M., Stoeck, T. Protistan community patterns within the

brine and halocline of deep hypersaline anoxic basins in the eastern Mediterranean Sea (2009) *Extremophiles*, 13 (1), pp. 151-167.

Gentile, G., DeLuca, M., Denaro, R., LaCono, V., Smedile, F., Scarfi, S., DeDomenico, E., DeDomenico, M. and Yakimov M.M. (2009). PCR-based detection of bioluminescent microbial populations in Thyrrenian Sea. Deep See Res part II 56: 763-767.

Grossi et al. (2010) *Hydrostatic pressure affects membrane and storage lipid compositions of the piezotolerant hydrocarbon-degrading Marinobacter aquaeolei strain #5*. Environm Microbiol 12(7): 2020-2033.

LaCono, V., Tamburini, C., Genovese, L., LaSpada, G., Denaro, R. and Yakimov M.M. (2009). Cultivation-independent assessment of the bathypelagic archaeal diversity of Tyrrhenian Sea: comparative study of rDNA and rRNA-derived libraries and influence of sample decompression. Deep See Res part II 56: 768-773.

La Cono et al. (2010) *Genomic signatures of fifth autotrophic carbon assimilation pathway in bathypelagic Crenarchaea.* Microb Bioetechnol 3(5): 595-606.

La Cono et al., (2011). Unveiling microbial life in new deep-sea hypersaline Lake Thetis. Part I: Prokaryotes and environmental settings. Environmental Microbiology 13(8):2250-2268.

Yakimov, M.M., LaCono, V. and Denaro R. (2009). A first insight into occurrence and expression of functional amoA and accA genes of autotrophic and ammonia-oxidizing bathypelagic Crenarchaeota of Tyrrhenian Sea. Deep See Res part II 56: 748-756.

Yakimov, M.M., La Cono, V., Denaro, R., D'Auria, G., Decembrini, F., Timmis, K.N., Golyshin, P.N., Giuliano, L. Primary producing prokaryotic communities of brine, interface and seawater above the halocline of deep anoxic lake L'Atalante, Eastern Mediterranean Sea (2007) *ISME Journal*, 1 (8), pp. 743-755.

Yakimov, M.M. et al. (2011). Contribution of crenarchaeal autotrophic ammonia oxidizers to the dark primary production in Tyrrhenian deep waters (Central Mediterranean Sea) ISME J 5(6):945-961.

4. Networking and Dissemination Activities

Networking and Dissemination activities are key characteristics of a EUROCORES Programme like EuroDEEP. Their aim is to encourage and facilitate scientific collaboration and diffusion across the Collaborative Research Projects (CRPs) within a given domain or, if appropriate, across different domains and programmes. These activities are flexible and can be tailored to the needs of a given programme.

Networking activities

These are collaborative activities bringing together scientists from EUROCORES Programmes and colleagues from other relevant programmes in order to discuss, plan and implement future collaboration and interaction.

Typical examples are:

- Working group meetings, seminars, workshops, symposia, conferences;
- Summer Schools (targeted for the members of the academia, the private sector, and governmental or non-governmental organisations);
- Training programmes and specialised courses (graduate-level and continuing-education)
- Short visits.

Dissemination activities

These are all the activities with the aim of raising awareness on and diffusing results of the EUROCORES Programme.

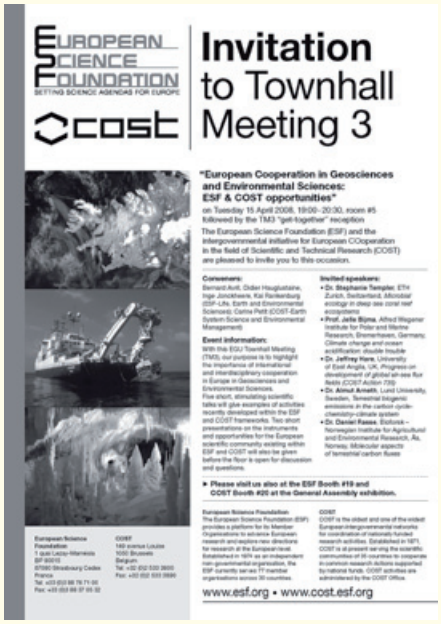
- Leaflets, posters, publications, books, exhibition booth or stand at a conference.
- Invited sessions at larger conferences (when the EUROCORES programme is not directly involved in the conference as a main or co-organiser of the event).
- Dissemination travel grants, to support active participation at conferences (organised outside the EUROCORES programme), while promoting the EUROCORES Scheme in general and disseminating the achievements of the Programme in particular.

This section provides an overview of the main networking and dissemination activities of the EuroDEEP Programme.

- **First annual EuroDEEP Conference**
  Taormina, Sicily, 26-29 November 2007

This first EuroDEEP Programme kick-off event has allowed a first gathering of all Project Leaders, Investigators, and (associated) Members involved in the EuroDEEP Programme to meet and present the respective aims, methods and approaches of the individual and collaborative research projects.

The meeting has offered a unique discussion opportunity through oral presentations from EuroDEEP Programme members, complemented by presentations of invited internationally renowned researchers. The meeting will provide a platform for leading scientists and young researchers in the field of deep-sea biodiversity science to interact. The meeting has as its main goal to foster the networking and collaboration links between the different countries and projects, and to discuss Programme level efforts with other ongoing (inter)national initiatives in deep-sea biodiversity research.



• **EGU General Assembly 2008**
13-18 April 2008, Vienna, Austria

EuroDEEP has co-funded the Session: BG6.4 Biogeochemical interactions in chemosynthetic deep-sea ecosystems: methods, tools and strategies, convened by Dr Nadine Le Bris, on Friday 18 April 2008.

Session description: The past decade has raised challenging issues about the nature of interactions linking the biotic and abiotic components of deep-sea hydrothermal environments and other chemosynthetic habitats (e.g.: methane seeps, massive organic inputs like whales' skeletons, wood falls, etc).

Among these are: the diversity and relative importance of microbial metabolisms in carbon fixation and mineralisation processes, the role of key-invertebrate species on biogeochemical transformations and fluxes.

Answers to these questions are required to appreciate the response of chemosynthetic ecosystems to environmental disturbance and their potential influence on the global biosphere.

This session focussed on new insights to these questions, including inter-disciplinary studies of biogeochemical and geobiological systems and advanced technological developments for the exploration, observation, experimentation and monitoring at relevant scales on the seafloor.

The EUROCORES Programme EuroDEEP and COST have organised a Townhall meeting entitled "European Cooperation in Geosciences and Environmental Sciences: ESF & COST opportunities" (TM3) Union 2008 General Assembly, on Tuesday 15 April 2008.

The purpose of this EGU Townhall Meeting (TM3) was to highlight the importance of international and interdisciplinary cooperation in Europe in Geosciences and Environmental Sciences. Five short, stimulating scientific talks have given examples of activities recently developed within the ESF and COST frameworks. Two short presentations on the instruments and opportunities for the European scientific community existing within ESF and COST were also given before the floor was open for discussion and questions.

• **Workshop on Microbial Metagenomics**
Giardini Naxos, Sicily, 19-22 May 2008

Scope of the workshop: Mining the new activities for biotechnological applications from marine diversity, and especially from marine extreme habitats through meta-, post- and comparative genomics had already been brought to a new technological level through past activities. Recent breakthrough in this field of research significantly improved our understanding of the new mechanisms of the functioning of marine microbial consortia, their contribution to global element cycling and possible impact of their activities on global climate patterns, and, not least, the genomic basis of niche specificities that allow microbes to thrive in the various marine environments.

The Workshop was designed to highlight several major objectives:

(i) the state-of-the-art facilities and expertise to sample unique and hardly accessible marine environments,
(ii) advanced technology for construction of metagenomic libraries,
(iii) modern sequencing, sequence annotation and the cutting-edge bioinformatics resources,
(iv) high-end activity screening technology,
(v) presentation of applied research in this field by the companies with solid market positions in biocatalysis, drug discovery and cosmetics production.

• **Second annual EuroDEEP Conference**
10 November 2008, Valencia, Spain

This annual meeting of the EuroDEEP community was organised back to back with the

• **World Conference on Marine Biology**
11-15 November 2008, Valencia, Spain

The EuroDEEP Programme was present at this conference through a EuroDEEP open session: Ecosystem Functioning and Biodiversity Science in the Deep Sea.

Convener: Jonckheere, I.

Co-conveners: Gaill, F., Ramirez, E., Yakimov, M., Stenseth, N.

The discovery of new types of ecosystem on mid-ocean ridges and continental margins have changed our vision of biodiversity in the deep-ocean and its links with the global biosphere. The energy supplies to these communities rely on methane- and sulfide-oxidizing microaerobes which are unique in their ability to satisfy their carbon and nitrogen needs from inorganic sources, under free-living forms or symbiotic association with invertebrates. Geologically-driven sources of such reduced compounds to the deep-seafloor (hydrothermal vents, methane seeps) are mostly ephemeral and discretely distributed, as are the massive organic inputs (whale carcasses, sunken woods) that harbour species closely related to vent and seep endemic taxa. These fragmented reducing habitats, however, markedly differ in their chemical/biogeochemical features and temporal dynamics.

The aim of the multi-disciplinary EuroDEEP Programme is to further explore and identify the deep-sea environment, to further describe the biological species and communities that inhabit it, and to better understand the physical and geochemical processes that shape the environment in which these communities live. The final Programme goal is to describe, explain and predict variations of biodiversity within and between deep-sea habitats, their consequences for deep-sea ecosystem functioning, and the interactions of the deep sea with the global biosphere.

This open session invited contributions addressing these research themes as a prerequisite for the sustainable use, and development of management and conservation of marine resources.

• ASLO 2009 Conference

25-30 January 2009, Nice, France

The EuroDEEP community was represented through session 32: From molecules to organisms: Chemoautotrophic pathways and mechanisms of energy transfer in extreme marine environments (http://www.aslo.org/meetings/nice2009/topical_sessions.html)

Organisers: Nadine Le Bris, IFREMER, nlebris@ifremer.fr; Michail Yakimov, Insitute for Coastal Marine Environment IAMC-CNR, michail.yakimov@iamc.cnr.it; Stefan Sievert, Woods Hole Oceanographic Institution, ssievert@whoi.edu

Extreme environments in the deep-sea, such as hydrothermal vents, hydrocarbon seeps, brine lakes or massive organic falls are characterised by steep chemical gradients at the interface between reducing fluids and seawater. Lower pH, and high concentration of toxic gases (e.g., H2S, CO2) and dissolved metals, constrain the ability of organisms to live at these interfaces. These environments however harbour some of the most productive marine communities. Chemolithoautotrophy and symbioses have been identified as key processes sustaining high biomass production in some particular contexts, but much remains to be known about the mechanisms of energy transfer from molecules to organisms in a wide range of oceanic settings, and their role in ocean biogeochemistry. The aim of this session is to bring together microbiology, biochemistry, geochemistry and symbiosis biology to provide a more comprehensive view of the diverse mechanisms sustaining high biological activity at redox chemical interfaces in the deep ocean. Availability of chemical substrates, diversity of pathways related to carbon fixation and energy generation, metabolic preferences of prokaryotes, adaptability of symbioses and their interactions with biogeochemical processes, as well as the potential large-scale impacts of these processes, were all considered.

- **Symposium of Aquatic Microbial Ecology (SAME 11)**
  30 August - 4 September 2009, Portorož, Slovenia

The National Institute of Biology, Marine Biology Station Piran organized the 11th Symposium on Aquatic Microbial Ecology in Piran, Slovenia, from August 30 to September 4, 2009. The role of microbes is still far from being fully understood and it is important to continue the tradition of previous SAME (Symposium on Aquatic Microbial Ecology) meetings in discussing the importance of novel microbial pathways in aquatic environments.

The symposium activities embraced different aspects of research in aquatic microbial ecology, offering opportunities to share information among ecologists, molecular biologists, biochemists, and all those in related areas. During this symposium a number of interesting presentations were made discussing recent progress in this field, also highlighting future trends and research directions in the field of aquatic microbial ecology. The programme consisted of ten sessions focused on Microbes in microbial biogeochemical cycles, Organic matter transformation, Sediment microbiology, Operational taxonomic units in microbial ecology, Climate change and aquatic microbes, Microbial interactions and communication, Viral Ecology and Modelling in aquatic microbial ecology.
More information at: http://www.mbss.org/same11/

- **Third annual EuroDEEP Conference**
  23 September 2009, Venice, Italy

Participants of the EuroDEEP final conference

- **Final EuroDEEP Conference**
  6 June 2010, Reykjavik, Iceland

- **12th Deep Sea Symposia**
  7-11 June 2010, University of Iceland, Reykjavik, Iceland

12 EuroDEEP PhD students and Postdocs from the 4 different EuroDEEP Collaborative Research Projects received a grant to attend this meeting.
More information about the symposia at:
http://12dsbs.hi.is/

- **Workshop on Challenges in the study of deep sea ecosystems' interconnectivity**
  8-10 September 2010, University of Aveiro, Portugal

This workshop brought together seventeen scientists from different areas of expertise. The aims of this workshop were to review the current knowledge and identify scientific problems and research limitations on the study of deep-sea ecosystems' connectivity, focusing on two main themes: reproductive biology and methodologies.

The multiplicity of concepts of connectivity was documented, and an important aspect of the workshop was to recognize that the working concept of connectivity must be clearly defined at the beginning of any and each study The presentations by the participants illustrated the assortment of available and developing methodologies to study deep-sea population connectivity. However, the following discussions emphasized the need for more fundamental knowledge on larval biology and reproduction in order to apply interdisciplinary approaches and reach a better understanding of this complex issue.

The three major outcomes of the workshop were 1) the identification of gaps in knowledge, 2) the establishment of collaborations between the workshop participants, their institutions, and other groups and 3) the identification of a specific site, the Strait of Gibraltar, to serve as a case study area for future collaborative proposals on connectivity between deep-sea ecosystems using multidisciplinary approaches. Additionally, a review of literature concerning population connectivity studies across the Gibraltar Strait was planned for publication.

5.
Outreach Activities

BIOFUN

- National Geographic Italia: Abissi Mediterranei- una nave italiana alla scoperta dei segreti delle profondità dei nostri mari. A presentation of part of CNR work: http://www.nationalgeographic.it/dalgiornale/2010/08/06/news/abissi_mediterranei-83021/
- NIOZ news February 2010: Diepzeevis eet ook vegetarisch
- http://www.nioz.nl/nioz_nl/2706c717bf987c01143e18dbb715a59b.php
- http://news.bbc.co.uk/earth/hi/earth_news/newsid_8547000/8547332.stm
- http://deepseanews.com/2010/03/spinach-popeye-and-fishy-pigeons/

TV appearance

- ARTE Documentary entitled "Des montagnes sous la mer" (director: Alix Francois Meier) featuring the Belgica cruise to the Galicia Bank in June 2008, broadcasted on ARTE March 9th 2009.
- Thalassa documentary on Mediterranean canyons, fisheries and litter accumulation in the deep-sea, with the participation from ICM-CSIC BIOFUN scientists and footage of García del Cid prior to the BIOFUN cruise in Nov. 2009. Shown in TV3 on 29/01/2010. http://www.tv3.cat/videos/2618659/El-golf-de-Lleo-un-reservori-depeixos
- Participation in a small itinerary exhibition on marine biodiversity where the new species of galatheid crab discovered during the BIOFUN cruise in June 2009 is featured (ICM-CSIC, Barcelona 2010).
- Deep-sea studies by NIOZ -including BIOFUN- were promoted by a contribution to an exhibition in the Museum for Education (MUSEON, the Hague, Oct-May 2009) and lander footage was used in a deep-sea exhibition in Genoa (Italy, 2010).
- Litter collected during a Mediterranean BIOFUN cruise was sent to the Plymouth Aquarium for a deep-sea exhibition being created in collaboration with the EU Project HERMIONE (2010).

CHEMECO

- Sylvie Gaudron: "Pour la Science nº392, June 2010: "les bois coulés, une autre source de vie des fonds marins".
- Aveiro. 17 June 2010 – Newspaper article "Mar profundo" (Deep-sea), "Laboração contínua, nº 169, Fábrica Centro Ciência Viva, Diário de Aveiro. General public, Portugal.
- The deep ocean: discovering an unknown world. 28 May 2010, Portalegre. *(seminar by A. Hilário aimed at high-school students and teachers).*
- Academia no Verão - Uma viagem ao fundo dos oceanos. 16 and 23 July 2010. Aveiro. *(seminar and practical activities, organised by MR Cunha, A Hilário, A. Ravara and L. Génio, aimed at high-school students and teachers).*
- "Impaciências" (Theme: Deep-sea) 15 May 2010 - Participation of MR Cunha as invited speaker in a public outreach activity in Fábrica, Centro de Ciência Viva ("Living Science Center), Aveiro, Portugal. General public, Portugal – UAveiro.
- " OÁSIS DO MAR PROFUNDO- Deep-Sea Oasis" 2010- lecture at the workshop

"Explorando o Oceano na Escola" (Exploring the Ocean in School) as part of the collaborative project "Ocean Exploration in the International Education Community" (EXPLORE) IMAR/DOP-UAz, Oceanoscópio - Ocean Technology Foundation (USA) and the National Oceanic and Atmospheric Administration (USA) (aimed at high school students and teachers).
- Oásis do Mar profundo. Encerramento das XV Olimpiadas do Ambiente. 8 de Maio 2010, Horta, Faial. (invited talk by A. Colaço, aimed at general public).

DEECON

- Newspaper Agderposten 24. Sept
- Azorean Newspaper publishes the article: "A final há 2 tipos de peixe-espada-preto nos Açores". *Tribuna das Ilhas* 2007, Ano 5 nº 284: 9
- Produced a science divulgative video (DVD) from the DEECON cruise in 2007
- CenSeam Newsletter VIII August 2007
- DEECON website: www.imr.no/deecon

MIDDLE

- *La Stampa* 01 Aprile 2009, Tutto Scienze, page 27
- *Into the Deep: Exploring the underlying possibilities. ESF MIDDLE Project International Innovation, May 2010, pages 41-43*
- MIDDLE website: http://csbg.cnb.csic.es/mamba/index.html

6.
Related ESF Activities

BIOFUN

BIOFUN and EuroDEEP have greatly strengthened collaborations between the partners, and a number of new initiatives have emerged from here:

- Joint PhD student between ICM-CSIC and UGENT on deep Mediterranean meiofauna in the framework of the new Spanish project DOS MARES. PhD funded.
- Joint PhD student between ICM-CSIC, HCMR and Uni. Aveiro to work on deep Mediterranean macrofauna from existing samples from BIOFUN and other national projects. PhD proposal under evaluation.
- Collaboration between ISMAR-CNR and the Plymouth Uni. (UK) regarding pteropod diversity and paleoceanography.
- Collaboration of NIOZ in the EU project CoralFISH in relation to the newly discovered short link between deep-sea fish and photic zone production.
- Participation of the NUIG partner in an Irish collaborative research project, contributing microbiological sampling and community structure analysis to a biodiscovery survey of deep-sea canyons in the Northeast Atlantic.

CHEMECO

The collaboration among members of CHEMECO CRP is continuing through the networking activities of a CNRS joint research group (GDRE DiWOOD in a second 4-year programme coordinated by N. Le Bris for CNRS). Cross-cooperation between partners of different CRPs will also expand through the development of research on submarine canyons, for which the CHEMECO has set the basis of a joint experimental approach led by CNRS and UPMC on the western Mediterranean coast.

DEECON

DEECON dealt with gene expression of deep sea organisms and provided the first transcriptome of a deep sea fish, *Aphanopus carbo*, comprising 6 transcriptomes (6 different tissues) sequenced in a single 454 run. This database is the first of its kind and it is expected that the collaborations established during the Eurocores programme will lead to inclusion of more deep sea organisms. It is still unknown what genes are involved in the adaptation to depth and their roles in relation to conspecific organisms from shallower waters.

Some of the researchers are also involved in new projects that include an extension of DEECON objectives. ReDEco, a project under the MarinERA programme funded by the EU FP6 ERA-NET Scheme, has a WP dedicated to connectivity between Mediterranean and adjacent Atlantic for selected deep sea species.

MIDDLE

The nucleus of the partners established during the current MIDDLE Project has submitted several scientific proposals, two of which were funded by the European Commission within FP7-KBBE call and ESF-EUROCORES Programme EEFG (Environmental and Evolutionary Functional Genomics), respectively.

7.
Conclusions

Reader: Because of the incomplete nature of some of the Final Reports and of the understandable delay in the completion of the 4 Collaborative Research Projects, due to inevitable ship programming difficulties, the Review Panel Members could make only a partial assessment of the EuroDEEP Programme.

Overall evaluation of the EuroDEEP programme based on scientific achievements

In general, the EuroDEEP Programme has proved a great success, showing a high degree of international cooperation and well-integrated research projects.

The reports from the different Collaborative Research Projects (CRPs) clearly highlight that the sharing of infrastructures (e.g. joint cruises), state-of-the art technology, and methodologies and interdisciplinary collaboration, enabled a broad scope of research that would not otherwise be possible. The great strength of the Programme is that it provided a framework in which this could happen.

The list of publications to date in top-class journals is impressive. Deep-Sea research on the scale undertaken here is not now possible for any single European country alone, given the high cost and demands on ship time. This is the real European added value to the Programme, as well as the collaboration between some of the best marine scientists in Europe on joint projects.

One weakness was that many excellent laboratories were unable to participate because of national funding policies. A particular weakness was approving projects that could not be carried out as originally planned because the proposed national contributions were not available. Deep-Sea research is an area of science that can really benefit from EUROCORES Programmes such as this. EuroDEEP has shown the benefits of such European collaboration.

Only after two years, when all the scientific results have been published, will it be possible to assess the full significance of the Programme.

Overall comments on the final project reports

The quality of the reports varied, with one of them being considered by the Review Panel as an example of best practice in showing the benefits of integrating science in an extremely ambitious and successful Collaborative Research Project.

It would be a good practice within the EUROCORES Programmes if Project Leaders would send a copy (preferably in electronic format) of every publication deriving from the Collaborative Research Project to the ESF office. This would be beneficial both for checking that ESF funding had been acknowledged, and to highlight the achievements in the period of research activities under each Collaborative Research Project.

Many of the questions on the Final Report form were not directly addressed or incompletely answered by some Project Leaders. This made it very difficult for the Review Panel to accurately assess some Collaborative Research Projects. In some instances the Review Panel believed that the achievements of individual CRPs were understated, resulting in a less positive assessment than would otherwise have been the case.

All EUROCORES Collaborative Research Projects should be able to demonstrate the sharing

of data and the integration of results obtained by different Collaborative Research Project partners. In some instances this was not done in EuroDEEP.

Recommendations

Project Leaders should be required to identify the five most significant publications resulting from their Collaborative Research Projects, and provide files in PDF format of these as part of the Collaborative Research Projects' Final Reports.

Review Panel Members should be invited to attend scientific meetings for discussions with Project Leaders, in order to focus them on the achievements and difficulties, if any, encountered in their Collaborative Research Projects. This would aid the overall assessments of the Collaborative Research Projects.

Careful consideration should be given to the aims and objectives of the Programme, in the phase of the Calls for Outline Proposals, to enable sufficient common ground for the Collaborative Research Projects to interact.

The sharing of data should be mandatory from the beginning of the Programme.

A plan for the dissemination of Collaborative Research Project results should be required at the Outline and Final Proposal stage, with particular reference to the largest possible audience. This should be done at Collaborative Research Project level and the appointed Scientific Committee should present a plan for disseminating the purpose and achievements of the overall Programme.

Since the complete results of the research in such Deep-Sea projects are normally available only two years after the end of the Programme, consideration should be given to freeze some funds to support a comprehensive action of dissemination and publication of the overall achievements within three years of completion of the Programme.

A plan for the integration and future development of research of the EuroDEEP community in a broader research area is strongly recommended.

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