EUROPEAN COMMISSION

Community research

EurOCEAN 2004

# Proceedings of the EurOCEAN 2004

# European Conference on Marine Science & Ocean Technology

**Celebrating European Marine Science**
**Building the European Research Area**
**Communicating Marine Science**

## Galway, Ireland
## 10–13 May 2004

SEVENTH FRAMEWORK PROGRAMME

Marine Institute

Marine Board

Proceedings of the EurOCEAN 2004
European Conference on Marine Science & Ocean Technology

Proceedings of the

# EurOCEAN 2004

## European Conference on
## Marine Science & Ocean Technology

**Celebrating European Marine Science**

**Building the European Research Area**

**Communicating Marine Science**

**Galway, Ireland**
**10–13 May 2004**

Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Communities, 2007

ISBN 92-894-7727-X



*Printed in Italy*

PRINTED ON WHITE CHLORINE-FREE PAPER

Proceedings of the

# EurOCEAN 2004

## European Conference on Marine Science & Ocean Technology

**Celebrating European Marine Science**

**Building the European Research Area**

**Communicating Marine Science**

**Galway, Ireland**
**10–13 May 2004**

*Edited by:*

**Witold Cieślikiewicz, Niamh Connolly, Gilles Ollier & Geoffrey O'Sullivan**

# Conference Conveners

## Thematic Session 1

*"The Role of Ecosystem and Biodiversity Research in the Conservation of Natural Reserves and Marine Resources."*

**Piia Tuomisto** (DG Research)

## Thematic Session 2

*"Forecasting and Transport Research in Support of the Security of the Maritime Environment."*

**Alan Edwards** (DG Research)

## Plenary Session 1

*"FP6 ERA—European Research Area."*

**Cathy Eccles** (DG Research)

## Thematic Session 3

*"Natural and Anthropogenic Impacts on Coastal Ecosystems."*

**Christos Fragakis** and **Hartmut Barth** (DG Research)

## Thematic Session 4

*"Exploration of the European Ocean Margin and Deap-sea Resources and Ecosystems."*

**Luis Fariña Busto** (DG Research)

## Plenary Session 2

*"The Contribution of the Young Generations to the Future of the European Marine Research Area: Marie Curie Fellowships in the Domain of Marine Sciences."*

**Olga Lage** (DG Research)

# EurOCEAN 2004

**10–13 May 2004. Galway, Ireland**

## PREFACE

The EurOCEAN 2004 Conference marked the 10$^{th}$ Anniversary and 5$^{th}$ Conference in the very successful series of EurOCEAN / MAST Days Conferences which started in Brussels in 1994. EurOCEAN 2004 brought together over 550 marine researchers, policy makers and private sector representatives to share information and views on a range of marine research issues, to celebrate the contribution that European marine science and technology makes to our understanding of marine ecosystem functioning and its contribution to future economic and social developments in Europe. During the conference, over the three day period, participants listened and responded to presentations from 25 leading European researchers covering topics ranging from Ocean Margins Research to Integrated Coastal Zone Management. EurOCEAN 2004 provided an essential networking opportunity, a critical ingredient of modern research, which was facilitated by ten Ancillary Meetings, extended coffee breaks and an exciting social agenda.

EurOCEAN 2004 coincided with the accession on 1$^{st}$ May 2004 of ten new Member States to the Union. To mark this historic event, a special exhibition describing the Marine Research Programmes / Priorities of the New Coastal Member States: Cyprus, Estonia, Latvia, Lithuania, Malta, Poland and Slovenia and including Bulgaria, Romania and Turkey was organised and much appreciated by all.

Oceans are a largely under-explored domain on Earth. They inspire our curiosity and awe with their sheer size and power, but also their beauty and fragility. They cover two thirds of our planet and yet in many cases are represented as almost blank areas on our maps. They offer the huge potential of under-exploited resources, economic activities and well-being of the citizens. Yet, some of the oceans' ecosystems have been degraded significantly over the last hundred years or so, particularly through unsustainable and destructive forms of exploitation and the serious pollution of coastal waters. Oceans are also a fundamental component of the European and global climate systems. The Gulf Stream is considered the driver of Europe's moderate climate. Changes in ocean currents and other dynamics are an indicator of global climate change. Thus, oceans need to be investigated, but also to be used responsibly.

The Conference took place as many marine research projects funded under the European Commission 5th Framework Programme (FP5) were coming to an end and at about the mid term of the European Commission 6th Framework Programme (FP6), which supports large integrated efforts towards a European Research Area. It provided a forum to report on major FP5 and FP6 projects in marine science and technology and to prepare efficient planning of the contribution of the marine science community to the 7th Framework Programme of Community Research.

The EurOCEAN 2004 Conference was organised at a time when major Earth Observation and Monitoring initiatives relevant to marine research in which Europe is heavily involved, and in particular to operational oceanography, such as the GEOSS (Global Earth Observation System of Systems), GMES (Global Monitoring for Environment and Security), and INSPIRE

(Infrastructure for Spatial Information in Europe) were gaining momentum. Indeed operational oceanography including its relevant activities of systematic and long-term routine measurements of the oceans together with coastal zones and atmosphere, and their rapid interpretation and dissemination implies accessing a global set of oceanographic data that could be facilitated through the GEOSS, delivering services for the monitoring of the marine environment through GMES, and benefiting from a better data policy through INSPIRE. Many of the discussions which took place at the conference were situated at the crossroads of the above three initiatives and the conference helped the community of the operational oceanographers to clarify their involvement with respect to these initiatives.

The outputs of the EurOCEAN 2004 Conference were threefold and included:

1. An excellent opportunity for networking and communication.
2. The EurOCEAN 2004 Conference Proceedings, which provides an assessment of the FP5 & FP6 marine research projects.
3. The Galway Declaration—a distillation of the views and consensus of the Conference, and a prominent political statement agreed by the participants of the conference on the future of Marine S&T in Europe.

The **Galway Declaration**[1] calls on the European Commission and the Member States to recognise:

- the crucial role of the oceans in climate, carbon cycle and life on earth;
- the major contribution maritime industries can make to the achievement of the objectives outlined in the Lisbon Agenda;
- the essential role of marine science and technology in generating the knowledge needed to fuel this economic achievement in harmony with the environment;
- the critical role the European Research Area / 7th Framework Programme must play in supporting world class excellence in marine science & technology.

The EurOCEAN 2004 Conference, and in particular the Galway Declaration, provided foundations to those elements of a future European Maritime Policy that relate to marine science and technology. This is reflected in the Maritime Policy Green Paper published by the European Commission in June 2006 in which marine research has been identified as a key element of the future Maritime Policy. The Commission recognises that an all-encompassing maritime policy should be supported by excellence in marine scientific research, technology and innovation.

Quality research, and in particular marine research, is a foundation that supports competitiveness and sustainable development in line with the three pillars of the Lisbon Agenda (Economic, Social, and Environmental). It is a pre-condition for a knowledge driven economy and a major contribution to developing robust and sustainable solutions to complex problems. The European research efforts contribute to the development of educational horizons, new skills and to the creation of high value-added knowledge-based jobs. All these aspects are considered as paramount for the development and implementation of the European Maritime Policy. It is also an opportunity to demonstrate the benefits for EU citizens arising from European research, as well as further enhancing the articulation of the European Research Area.

These EurOCEAN 2004 Conference Proceedings represent an excellent review of the state of the art in the marine research domain. The Commission proposal for the 7th Framework Programme of Community Research points out specifically marine research activities under the Environment theme.

All conference participants, keynote speakers, and session raporteurs are to be thanked for their contribution during the Conference, as well as for their patience during the subsequent editing process. The EurOCEAN 2004 Conference, and in particular the Galway Declaration, provides

[1] For full text of Galway Declaration see Annex 1

vision and a solid foundation for going forward into the 21st century and establishing a European Marine Research Area which can be seen as a major component of the European Research Area.

Gilles Ollier
Policy Officer ‘Earth Observation’
European Commission, Directorate General for Research

## Table of Contents

# PART 1

## PAPERS FROM THEMATIC AND PLENARY SESSIONS

**SESSION** **OPENING KEYNOTE SPEECH**

**TITLE** **COMMUNICATING SCIENCE**

**AUTHOR(S)** ***CLIVE COOKSON***

Science Editor, Financial Times, 1 Southwark Bridge, London SE1 9HL, UK.
Tel: +44 20 7873 4950
Email: clive.cookson@ft.com

## SUMMARY

Scientists are coming to realise how important it is to communicate their work to the public through the media and to engage with the public on controversial issues. This presentation gives an insider's view of the way journalists work. Why, for example, are certain stories picked up by the media, while others never get started? Where does science news come from and what makes a "good story". The Myers and Worms paper published in Nature last year provides a good case study of the way a marine science story can provide positive coverage for marine science in the mass media.

## DISCUSSION

The amount of coverage given to marine science in the mass media has increased substantially since the 1980s. To give a rough measure I used the Lexis-Nexis news database to count the number of articles containing the phrase "marine science" in the world's main English-language newspapers for each calendar year from 1989 to 2003. (If you search for articles about oceanography, you get very similar results.). The coverage more or less doubled during the 1990s, with a particular steep increase during the first half of the decade – it is possible that the peak in 1995 was related to the Brent Spar controversy that year, but I have not done the detailed analysis to prove that point.

Of course, more does not necessarily mean better. But my impression over 20 years in science journalism is that the quality of science coverage has improved – not so much because journalists have got better as because science-based organisations and individual researchers have become better in their approach to the media. By 'better', I mean more open, responsive to journalists and proactive in their public relations policy. But there is still room for improvement.

To help bridge the gap between science and the media, let's look first at what scientists and journalists have in common as individuals. We are all :

•Curious

•Analytical

•Skeptical

•Delight in discovery

•Competitive

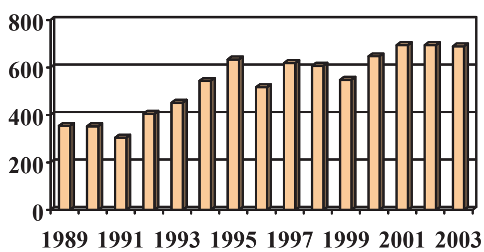
•Motivated

•Free-thinking

•Self-critical.

But we have nothing in common when it comes to reporting results. In the scientific word you start with the detailed evidence. Journalists – and most other people - start with the conclusion, then go on to broad facts and then (maybe) down to the details.

**Marine Science Stories in English Language Newspapers**



Most scientists do not understand the operating constraints on science journalists in the mass media. The challenge uppermost in the journalist's mind is often not so much to get the scientific truth across to the reader or viewer as to sell the story to the news editor or whichever other internal gatekeeper the newspaper, magazine or TV programme employs. The media always has a vast oversupply of potential stories, even at slack periods like the Christmas/New Year lull or the August 'silly season'. If your story is not sensational enough, they will ignore it - 'spike' it in journalists' jargon.

I myself would rather read a serious science story than anything about the entertainment business or the Royal family or most things about politics, but news editors have different values, even on serious newspapers, and a scare story about a Frankenstein salmon, for example, may tune in better with those values than a measured attempt to communicate the real risks and benefits of fish genetic engineering. Remember that the mass media are about entertainment as much as information.

So if I pick up what I believe is a good story for the FT, I normally negotiate with the appropriate newsdesk (the UK desk, world news, financial and so on) before I even think of writing it. If it is really important I may go straight to the overall news editor who controls what appears on the front page. A similar process applies to the longer, in-depth articles known as features, when you run things through with the appropriate features editor. As the writer, I agree a word count, the outline of the piece and its delivery time. The point is to avoid writing for the spike – something that happens very frequently on papers like the Daily Mail where the science correspondent often writes four stories a day, only one of which actually appears in the paper. On the FT most of the pieces that are written do appear, though they may be cut substantially during the editing process (and, by the way, the writer is not usually consulted about the cutting, unless the story is unusually sensitive, or about the headline that appears above the piece).

The process by which some stories are picked up and run in the media, while others never get started, is quite chancy, even capricious. Coverage will depend on how many other stories are around on the day, and who happens to be on duty among the writing and editing staff. When I am away there are usually fewer science stories in the FT.

Where do the stories come from? Science journalists' sources fall into five broad categories:

Firstly, there are **press releases and official announcements**.

These arrive in gigantic quantities by mail, fax and email. On a typical day I'll get maybe 70 press releases and publicity materials such as corporate magazines - a pile of paper about half a metre high when they're all printed out. I am afraid that the vast majority go straight into the 40 gallon oil drums used to accumulate waste paper at the FT.

Secondly, **Personal contacts by letter, phone or mail** can give the best stories of all -- those sought-after scoops and exclusives. But we have to beware of the false exclusive: all too often, a PR person rings up and says: "You can have this story all to yourself if you agree to run it prominently in the FT", when in fact it's so obscure that no one else will want it.

Thirdly, **Visits to press conferences, scientific meetings, academic and industrial laboratories** etc. will usually produce a worthwhile story. With modern communications technology, it would be possible to work as a reporter without leaving the office, but I think it is essential to get out at least once a week to meet people and see their working conditions.

Fourthly, there are the **Academic journals**. Original papers in Nature, Science and so on are a vital source of news for science and medical journalists. The journals normally give us access to their most interesting papers a few days ahead of publication, on an embargoed basis, to provide time to prepare stories. Two web-based services are important sources of embargoed information for registered science journalists: one is AlphaGalileo, based in the UK and focused on Europe, and the other is Eurekalert, which is run by the American Association for the Advancement of Science.

Finally there is the source that we like least but which we are often forced to use: **following up something from another paper or magazine, or radio or television.**

Once a story starts in one newspaper, it may well develop what journalists call ‘legs’ and run in many others. (Incidentally the advent of computer databases has made it much easier to follow up stories than it used to be in the old days of paper cuttings but it means that an error in one newspaper is more likely to be imitated elsewhere unless you get it corrected in the database.)

Non-journalists often ask me what attracts media attention - what makes a ‘good story’. Unfortunately this is extremely hard to define for outsiders. You can list some attractive ingredients: sex; intrigue; corruption; death and disease; bizarre events; genuine scientific breakthroughs. If someone doesn’t want you to publish the story, that adds a frisson of excitement. Above all, a good story is unexpected. One test is “guess what, darling!” – is the story interesting enough to tell your wife or husband or boyfriend or girlfriend about over supper?

I cannot over-emphasise the vast number of science stories that I could write, compared to my time and the space available for them in the paper. Given unlimited time and resources, I could write thousands more pieces than I actually do. And the longer I do the job, the longer grows my list of subjects to cover in the future.

A specific example of how well marine science can be communicated, if sufficient effort and resources are put in, is the paper by Ransome Myers and Boris Worm that Nature published (and put on its cover) on 15 May 2003. This was one of the biggest marine science stories of the year, as far as the mass media were concerned.

Here are some of the ingredients that made it work :

- There was a well thought through programme to reach out to the media, coordinated by SeaWeb a wonderful organisation based in Washington DC, which has done a lot to raise public awareness in North America of the oceans and the life in them.
- The paper appeared in a leading journal – and on the cover.
- The scientists were committed to communications and willing to put in a great deal of time talking and getting their message across.
- The research results were striking and the message relatively simple.
- The findings had policy implications.
- And finally, lady luck was on side – there were no big competing news stories at the time.

The outcome was excellent worldwide media coverage, including – the ultimate measure of success – cartoons as well as articles.

In conclusion, what journalists are looking for from scientists includes:

- A story that is compelling – or at least interesting.
- Access both to the scientists who did the research and to others who can put the work in context.
- Responsiveness. If you get a call from a journalist on a daily paper with an immediate deadline, make an effort to return it quickly.
- Ability to answer the “so what?” question.
- Good sound bites for broadcasters and metaphors for the print media.
- A willingness to guide journalists to other people with different perspectives.

## ACKNOWLEDGEMENT

I am grateful to the staff of SeaWeb, particularly Nancy Baron, for passing on their insights into communicating marine science.

**SESSION** **THEME 1: THE ROLE OF ECOSYSTEM AND BIODIVERSITY RESEARCH IN THE CONSERVATION OF NATURAL RESERVES AND MARINE RESOURCES**

**TITLE** **SESSION REPORT**

**RAPPORTEUR** ***DR. JOHN JOYCE***

Fisheries Science Services, Marine Institute
John.joyce@marine.ie

**SUMMARY**

Thematic Session 1 brought together 4 keynote speakers addressing: fisheries science (Gabriella Bianchi, FAO, Rome), the ecosystem approach to fisheries management (Chris Frid, University of Newcastle-on-Tyne, UK), marine biotechnology (Adrianna Ianora, Stazione Zoologica A. Dohrn, Naples, Italy) and marine biodiversity (Carlo Heip, NIOO-CEME, The Netherlands).

**INTRODUCTION**

In opening the first Thematic Session, the chair, Professor Mario Ruivo (Chairman of the Portuguese Committee for the IOC), reiterated the importance of the effective communication of marine science, to inform not only the public, but also those in positions to influence the research priorities, policies and budgets under which marine science operates.

## The Ecosystem Approach to Fisheries Management: An Integration of Science and Socio-Economics towards Sound Policy and Management Decision-making

Dr Bianchi stated that, while knowledge-based management is the most effective way to manage the ocean's resources in a sustainable way, scientific information must be combined with practical considerations.

Implementation of an *ecosystem approach* to fisheries management puts great emphasis on consultation and communication with stakeholders. It identifies roles, objectives and the close relationship between management targets and the science required to underpin them.

The main challenges for science in the development and future application of a truly ecosystem approach to fisheries management were identified as:

- **Consideration of Several Different Timescales** - Science based ecosystem approaches need long-term timescales that are not typical of working fisheries.
- **Reconciling Private Sector Research with the Public Good** - How is it possible to reconcile privately funded research with the public good and long term perspectives?
- **Lack of Communication and Linkages Between Stakeholders** – This includes the need for increased communication to enhance understanding of the challenges related to dealing with uncertainty, complexity, and different timescales.

## The Science Needed to Underpin Ecosystem-based Fisheries Management in European Seas

Professor Chris Frid profiled how an ecosystem approach could be applied to fisheries management. Fisheries are vitally important industries for nutrition, health and economics. And yet, society cannot manage the ecosystem or the climate that influences fisheries. All that society can manage is the human activity within the system.

Moving forward, the scientific community needs *to make the scientific advice stronger and more applicable to ecosystems and their inherent resources*. It is widely recognised that there is too much fishing effort at present and that this effort needs to be reduced. Other measures such as *closed areas and technical conservation measures* need to be taken into account.

Science needs to underpin this approach in **two areas**:

- **The Science Educator's Role** – scientists need to inform the widest possible constituency about the choices to be faced. Realistic assessments have to be made as to what is possible and what is not.
- **Provision of Clear Management Advice** - an ecosystem approach requires access to knowledge derived from a far wider range of sciences than conventional approaches would use. The scientific community needs to develop better predictive regimes to inform society as to what might happen to a given ecosystem, using simulations and models.

Policy makers need to know about habitat quality and marine protected areas and how they should be geographically spaced and linked, to respond to biological dynamics.

## Marine Biotechnology and Biodiversity

Adrianna Ianora described some of the opportunities that marine biotechnology offers.

## Opportunities

- European waters - containing a wide range of species and habitats – represent a vast reservoir of biological material;
- The scientific community must develop the technology improvements necessary to facilitate discovery and analysis;
- The scientific community has the opportunity to enhance its knowledge, and to educate the public, marine industries, policy makers and the financiers of research as to the vital importance of biodiversity and an ecosystem approach to fisheries management;
- This dissemination and application of knowledge, both in the European and global contexts, will lead to improved application of this knowledge for the public good.

## Challenges

- Reducing the loss of biodiversity – as a result of pollution, overfishing, invasive species and climate change;
- Addressing collapsing fish stocks as a result of overfishing;
- Ignorance of the consequences of reducing biodiversity and habitat destruction;
- Incompatibility of the time scales required by scientific methods and the immediate problems of fishing industries;
- Communicating to decision makers the difficulties scientists face in dealing both with and predicting uncertainty;
- Conflicting uses by society for the marine resources, for example between fishing industries, conservation interests, marine extraction and waste disposal requirements, etc.

## Marine Biodiversity – What it is and What the Problems Are

Professor Carlo Heip explained that marine biodiversity is poorly understood and largely unexplored. Marine biodiversity is under threat from a range of human activities; for example, the introduction of invading species through ballast water causes coastal ecosystems to become homogenised globally, ultimately reducing biodiversity.

Fisheries and the overexploitation of top predators is also a major threat to biodiversity. Biodiversity is important – it holds the key to many vital marine processes and possibly to biological resources of relevance to the pharmaceutical and bioprospecting industries. The reduction in biodiversity has ethical implications. Society cannot ignore the effects human activities have upon biodiversity.

## DISCUSSION

### Future Research and FP7

The future marine R&D priorities should address the need to:

- Introduce 'Marine Science' issues on the FP7 agenda;
- Mobilise interdisciplinary research;
- Fully understand ecological processes, particularly in support of the ecosystem approach to fisheries;
- Map and catalogue living resources;
- Perfect techniques for synthesising and mass-producing marine biochemicals;
- Communicate scientific developments and successes to decision makers as well as the general public;
- Raise awareness of the importance of 'The Sea' within the European Commission, Parliament and Member States' Governments and agencies.

### Application of the Ecosystem Approach to Fisheries Management

The only thing society can endeavour to manage is human activity. In the first instance, the scientific community needs to demonstrate links between problems and develop instruments to discriminate between climate and other anthropogenic effects on the ecosystem.

Secondly, in relation to the application of an ecosystem approach to commercial aquaculture, it was noted that the dependence on the use of fish protein to culture high value fish (such as salmon, trout, cod and flatfish) was unsustainable. If this link between aquaculture and fisheries could be broken, conservation of wild fish resources would be enhanced.

### Biotechnology

The opportunities for the next ten years in marine applications of biotechnology are promising. Microalgae are already mass-produced for a number of industrial processes, and it may be possible to apply mass-production to new discoveries from the sea. Scientists must be allowed time to discover the properties of these new biomolecules before mass-production can be developed.

### Communication and Research

The ecosystem approach to fisheries management is a prime example of how communication between scientists and society needs to be improved. Specific questions that need to be addressed include: How can the research community best communicate its scientific knowledge for the public good? How do scientists perceive that ecosystems should develop in the future?

## CONCLUSION

Regarding management of marine ecosystems, the traditional approach of studying single impacts in isolation appears to be too blunt an instrument to fully understand the delicate balances and interlocking webs of biological dependence that make up life in the sea. Until scientists and society can understand the full impact of anthropogenic effects on complex ecosystems in a truly holistic way, society risks losing the benefits such systems have to offer in terms of biodiscovery, food production and the maintenance of life on this planet.

Knowledge is the key to enhanced management; the scientific community must take responsibility and communicate with a range of stakeholders, including decision makers, politicians, other scientists and the general public, to inform them of how vitally important the problem of ecosystem management and biodiversity loss is for all society.

## KEY POINTS THEMATIC SESSION 1
## ECOSYSTEMS FUNCTIONING AND BIODIVERSITY

- The ecosystem approach to marine resource management needs to be considered in a long-term-perspective, particularly with regard to fisheries management;
- The research community needs to improve communication to inform the widest possible constituency about the choices to be faced in adopting the ecosystem approach;
- The research community needs *to make its scientific advice stronger and more applicable to real ecosystems*, allowing scientific information to be combined with practical considerations, resulting in the *provision of clear management advice*;
- Marine biodiversity - poorly understood and largely unexplored - is under threat from a range of human activities including the introduction of invading species, resource exploitation, climate change etc;
- The overexploitation of top predators is a major threat to biodiversity; there is a need to reduce fishing effort, and to implement Marine Protected Areas;
- European waters contain a wide range of species and habitats; a vast reservoir of biological material exists which may be of relevance to the pharmaceutical industry;
- Scientists must be allowed time to discover the properties of these new biomolecules before mass-production can be developed;
- Marine science is trans- and inter- disciplinary and must be considered as such in FP7;
- Future marine R&D priorities should address the need to:
    - Mobilise inter-disciplinary research.
    - Fully understand ecological processes, particularly in support of the ecosystem approach to fisheries.
    - Map and catalogue living resources.
    - Perfect techniques for synthesising and mass-producing marine biochemicals.
    - Communicate scientific developments and successes to decision makers as well as the general public.
- Raise awareness of the importance of ‘The Sea’ within the European Commission, Parliament and Member states.

**SESSION** **THEME 1: THE ROLE OF ECOSYSTEM AND BIODIVERSITY RESEARCH IN THE CONSERVATION OF NATURAL RESERVES AND MARINE RESOURCES**

**TITLE** **THE ROLE OF FISHERY SCIENCE IN FISHERIES MANAGEMENT: LESSONS FROM THE PAST AND PERSPECTIVES FOR THE FUTURE**

**AUTHORS(S)** ***GABRIELLA BIANCHI***

Food and Agriculture Organization of the United Nations, Rome, Italy.
Tel: +39 0657053094, Fax +39 0657053020
E-mail: Gabriella.bianchi@fao.org

## SUMMARY

The ecosystem approach to resources management is a necessary outcome of our times, a manifestation of intellectual and societal progress. It is based on the increasing understanding of the world around us, a growing environmental awareness and lessons learned from fisheries management of the last 50 years or so. From this has come an awareness of the need for management systems to be broader in scope in order to encompass the key interactions between fisheries, the resources they target and the wider ecosystems in which they operate. This is occurring in parallel with the recognition across all fields of natural resource management that it must be prudent, transparent and democratic. The new challenges brought by the ecosystem approach to fisheries management will be presented in relation to a revised role of science under the new paradigm.

## INTRODUCTION

Past fisheries management failures, the emerging new paradigm of the ecosystem approach to fisheries management and the introduction of the precautionary approach to resources management, compound with a changing relationship between science and society, challenge fisheries science practitioners in many ways. In particular, the relevance and scope of research carried out as part of natural resources management are being questioned, mainly in relation to the costs involved, the benefits received and the ability of science to meet the new challenges brought by the ecsosystem approach to fisheries management.

## The role of science in policy-making

There is not much disagreement that knowledge-based management is the most appropriate approach to natural resources management in modern societies. However, experience shows that the way it has been implemented so far has not been too successful. There is a rich literature and numerous reviews on the role that science has played in fisheries management in the last 50 years (e.g. Garcia 2004), during which the role of fishery science has been periodically questioned following major stock collapses and now in relation to broadened objectives as represented by ecosystem management. In the international debate, the perception of the relative importance of science in the success and failure of fisheries management has been quite different. Already in the early 70s, John Gulland warned on the erroneous belief that complete scientific understanding was necessary for effective management (Gulland, 1971). He saw the willingness of fisheries administrations to take action as the key element for successful management. Furthermore, decisions had to be taken before complete and precise scientific answers could be provided. In fact, fisheries could develop and overexploit resources at a much faster pacerequired by scientific assessments to provide advice. Ludwig et al. (1993) also attribute limited value to science in relation to natural resources management and indicate that better ecological understanding is not the solution towards a better performance of management.

Based on a review of past experiences, Garcia (2004) concludes that there is no apparent correlation between the amount of science produced and the performance of management systems. In fact, some of the most dramatic collapses in fish stocks have taken place in some of the best-studied regions of the world. There seems to be a wide consensus today that main causes of fisheries management failures are not due to inadequate fisheries science, but to the condition of free and open access found in many fisheries, the inadequacy of enforcement systems, the weakness of decision making vis-à-vis pressure from the industrial sector often because of overcapitalization and overcapacity, poor transparency in decision-making, poor communication with stakeholders, just to mention a few. A few important conclusions emerge from past experiences:

1. Science is a necessary but non-sufficient condition for successful resources management. One of the consequences is that the huge investment made in fisheries science is often nullified because of poor management
2. The recognition of the wider limitations in management systems lead to the need for an expanded scope of fishery research, from being mainly biological to also include social, economic and policy-oriented disciplines
3. Decisions have to be taken also under conditions of limited scientific knowledge (consistent with the precautionary approach)

## The Ecosystem Approach to Fisheries (EAF) (FAO, 2003)

The ecosystem approach to resources management has developed from an increasing understanding of the world around us, an increasing environmental awareness and the need for management systems to be transparent and democratic, not only for the stakeholders that are part of a given sector but for society at large. The first of these items could be defined as “knowledge maturation”, i.e. a greater awareness of the importance of the interactions among fishery resources and the ecosystems within which they exist (environmental effects on fishery resources and effects of fishing on non-target species and habitats, on ecosystem structure and functioning, including biodiversity). The other important element is the recognition of the wide range of societal objectives for the values of fishery resources and marine ecosystems within the context of sustainable development and the need for management systems to reflect this to a greater extent as compared to what has been the case so far. Because of the above, the number of stakeholders increases to include non-fisheries practitioners and future generations (intergenerational equity). Many of the ideas embodied in the ecosystem approach to fisheries (as described in FAO, 2003) have developed during a long period of time and can be related to the development of an international environmental awareness (Weber, 2002) as reflected by the Convention on Biological Diversity (1992), representing the culmination of earlier processes such as the “United Nations Conference on the Human Environment” held in Stockholm in 1972. In the marine domain, the United Nations Conference on the Law of the Sea (1982) with the institution of the Exclusive Economic Zones (EEZs), the 1995 FAO Code of Conduct for Responsible Fisheries, and the Reyakjavik Declaration of Responsible Fisheries in the Ecosystem (2001).

As a follow-up to the processes above, FAO has developed guidelines that provide a framework for implementing the ecosystem approach to fisheries (FAO, 2003). The FAO definition of EAF is as follows: *“EAF balances diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries.”*

The above vision implies important challenges, in addition to those identified through 50 year experience of traditional fisheries management referred to above (here with traditional we mean the research-based management paradigm), related to the scope of research, the way research is funded and the institutional arrangements.

## KNOWLEDGE BASE FOR EAF

The FAO guidelines (FAO, 2003) underline the importance of implementing the ecosystem approach incrementally, and that this should build on existing management practices and scientific advice. Therefore, sustainable management of target species is still a very relevant objective. However, although necessary, this becomes insufficient to meet the needs for ecosystem sustainability (Hall and Mainprize, 2004). The guidelines also offer a first checklist of needed research, including 5 main areas (modified from FAO, 2003): 1) Ecosystem and fishery impact assessments; 2) Socio-economic assessments; 3) Assessment of management measures; 4) Assessing and improving the management process; 5)Monitoring and assessments, including development of simple appraisal methods (indicators).

What seems to be important in planning research relevant in the context of EAF is the following:

- Where costs for research cannot be increased, a process of reprioritization should be undertaken by research and management institutions
- In this process, it is important to make sure that there is a close link between clearly stated management objectives and the research needed
- More effort should be put into recognition of uncertainty and how to deal with it

The complexity and the uncertainty related to ecosystem models will increase. Uncertainty is due both to limitations in the current scientific tools but also to the nature of complex systems. Some of the uncertainty can be reduced by further scientific enquiry but some is inherent to the systems themselves (**indeterminacy)**. Uncertainty can be reduced as a result of scientific understanding although the costs of science may become too high. Degnbol (2002) warns on the danger of falling in the cost/complexity trap, i.e. by extending the presently adopted 'hard predictability' model to ecosystem-based management given the amount of the resources required dedicated to research in marine ecosystem processes, while the ability to predict behaviour of complex systems is limited. Figure 1 shows how increasing investment in research can reduce uncertainty but only to a certain point and where we want to be is not situation 1 (high uncertainty-low costs) not in situation 3 (increasing research costs dramatically without achieving a significant reduction in uncertainty).

This area of uncertainty is difficult to deal with, both from a theoretical viewpoint and because of the high costs. There are two main developments that can be adopted. One recognizes the science to underpin the ecosystem approach as part of the realm of what has been defined as "post-normal science" (Funtowicz and Ravetz 1995), defined as the science that provides information to a policy process and is characterised by great uncertainty, value conflicts, high stakes and urgency of decisions. This approach establishes the limitations of the answers that can be provided by science and provide an alternative decision making process based on negotiation with stakeholders and characterised by being fully transparent.

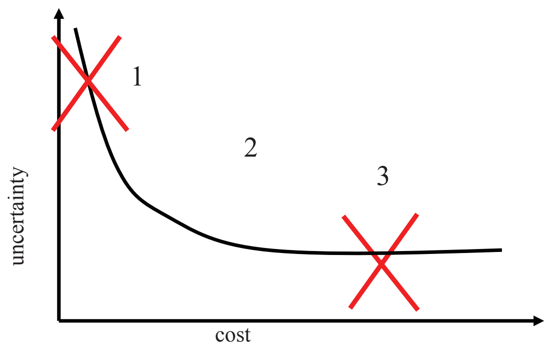



Figure 1. Relationship between uncertainty and costs of research to reduce uncertainty

Another approach, also based on the realization that hard predictability is an impossible goal, particularly when moving to the ecosystem level, is the development and use of indicators. Ecosystem indicators, with the related reference values, and clearly linked to stated operational objectives, are seen as a most useful tool in the implementation of EAF. The recently held

SCOR/IOC International Symposium on Quantitative Ecosystem Indicators for Fisheries Management (Paris, 2004) provided a useful overview of the progress made in developing ecosystem indicators, including: i) environmental indicators, ii) diversity and species indicators, iii) community and trophic indicators and spatial indicators. This symposium is a major milestone but work needs to be done in order to consolidate the results presented, tease out those indicators that have the appropriate properties in terms of usefulness for fisheries management and to continue develop indicators in those areas that are not yet well covered.

**Need to consider several time scales**

The effects of fishing and climate on the ecosystem often develop over decadal time periods. Ecosystem approaches require long time scales and objectives that are not compatible with the short-term objectives that have been typical of fisheries management so far. There is a need for fisheries management to expand its objectives also in time and include considerations of ecosystem sustainability that imply longer time scales. Based on present understanding, key ecosystem parameters should be identified and sampling schemes developed in order to monitor and assess their status.

**The way scientific objectives are set and how science is funded**

Nowotny et al. (2001) provide a clear account of the changing relationship between science and society in the course of the post-industrial period and how science has been ‘put into context’ (contextualisation). Applied science dominates, and the amount of funding coming from the private sector is also increasing. This development should be monitored in order to avoid a situation where research priorities and direction are dictated by market forces and not by long-term, strategic objectives as those implied in the ecosystem approach to fisheries management. As it was noted earlier, long-term impacts on the ecosystem require a research strategy of long-term nature that does not belong to the short-term perspectives that characterize the private sector. It is important therefore to strike a good balance between short-term vs long term objectives, private vs government funding and responsibility.

**Institutional arrangements**

A holistic approach to management, such the ecosystem approach, implies the existence of sectoral linkages and present institutional arrangements do not seem to be adequate. These are different from country to country but are often based on traditional sectorial subdivision of responsibilities. This means that institutional structure and processes may have to be revised and/or institutional collaboration will have to be strengthened, as for example between ministries and between research institutions. This process will also require a clarification of respective roles and duties.

Another aspect is related to the capability of research and management institutions to develop in response to crises and emerging new paradigms. Present arrangements for provision of scientific advice are based on the existence of educated mangers, policy makers and fishing industry that have learnt and understand basic scientific principles. Furthermore, legislation has been shaped under the existing scientific paradigm. Under the conditions of a changing paradigm, the capability of institutions to change is inhibited by existing legal and organizational frameworks. There is therefore also a need to revise the institutional frameworks.

## CONCLUSIONS

One main message based on past experiences is that precautionary management decisions have to be taken also when science cannot provide precise answers. On the other hand, science can greatly contribute to the establishment of efficient management systems assuming that the system is able/willing to put into practice the scientific advice and provided that the scope of science is well tuned in relation to clearly stated management objectives. Main new challenges for science are related to increasing complexity and uncertainty, need to consider several time and space scales, and the need to revise present institutional arrangements.

## REFERENCES

Brundtland, G.H. 1997. The scientific underpinning of policy. Science, 277: 457.

Degnbol, P. 2002. The ecosystem approach and fisheries management institutions: the noble art of addressing complexity and uncertainty with all onboard and on a budget. IIFET paper 171.11p

FAO. 2003. The ecosystem approach to fisheries. FAO Technical guidelines for Responsible Fisheries. No. 4, Suppl. 2. 112 p.

Funtowicz, S.O. and Ravetz, J. 1995. Risk management, uncertainty and post-normal science. In: Reinertsen, H. and Haaland, H. 1995. Sustainable fish farming. Proceedings of the first international symposium on sustainable fish farming. Oslo, Norway, 28-31 August 1994. p261-270.

Garcia (2004). Fishery science and decision making: dire straights to sustainability. Paper prepared for the World Conference on the Scientific and Technical Bases for the Sustainability of Fisheries. Miami. 26-30 November 2001. Rosenstiel School of Marine and Atmospheric Science.

Nowotny, H., Scott, P., and M. Gibbons (2001). Re-thinking science. Knowledge and the public in an age of uncertainty. Polity Press and Blackwell.

Weber, J. (2002). Economic and social issues in sustainable development. In: World Summit for Sustainable Development. What is at stake? The contribution of scientists to the debate. 201 pp.

**SESSION** **THEME 1: THE ROLE OF ECOSYSTEM AND BIODIVERSITY RESEARCH IN THE CONSERVATION OF NATURAL RESERVES AND MARINE RESOURCES**

**TITLE** **THE SCIENCE NEEDED TO UNDERPIN ECOSYSTEM-BASED MANAGEMENT OF EUROPEAN SEAS**

**AUTHOR(S)** ***CHRIS FRID***

Dove Marine Laboratory, School of Marine Science & Technology,
Univ.y of Newcastle upon Tyne, Cullercoats, North Shields, NE30 4PZ, UK.
Tel +44 (0)191 252 4850 Fax +44 (0)191 252 1054
e-mail: c.l.j.frid@ncl.ac.uk

## SUMMARY

Adoption of the Convention on Biological Diversity and the Bergen Declaration has led to a shift to management policies aimed at implementing ecosystem-based management. This is resulting in new science needs and challenges for the science community. Science has, to a large extent, successfully identified pollution impacts and the need for management of water quality. Fisheries have been the subject of science based management for over 100 years with the objectives focussed on the fish stocks. Ecosystem based management requires the recognition that human activities frequently impact on many aspects of the ecosystem other than the targets. This paper considers how we are beginning to address these in fisheries management and what challenges remain for the science community in supporting a move to an ecosystem-based approach.

## INTRODUCTION

The ‘ecosystem approach’ to environmental management seeks to manage human activities with regard to the full range of impacts on the ecosystem, both the direct and indirect effects. As fishing is generally regarded as the most pervasive human impact on the marine environment recent changes in its management serve as a useful case study. This paper considers the measures introduced in the NE Atlantic region to limit the ecosystem effects of fishing, what the key outstanding issues are and then to consider what the science needs are to allow the full adoption of ecosystem based management of fisheries.

### Fishing and the ecosystem

Fishing activities influence marine ecosystems in a number of ways. These include: (i) direct removal of target species, (ii) direct changes in size structure of target populations, (iii) alteration in non-target populations of fish and benthos [1-3], (iv) alterations in the physical environment [4-8], (v) alterations in the chemical environment [9], (vi) food chain effects such as trophic cascades [10] and (vii) altered predation pressure [11]. It is impossible to harvest a species without (i), and as in most cases harvesting will be selective (ii). In an ideal world we would probably wish to take our catch of target fish at a sustainable level and with minimum effects on (ii) to (vi). This then is the challenge of ecosystem based fisheries management.

## Existing ecosystem measures in fisheries management

A number of existing measures can be regarded as addressing ecosystem considerations. These include interactions between species, fisheries effects on the supply of food for predators, and the additional fishing mortality of non-target species.

Interactions between species are accounted for by the use of a multispecies version of the Virtual Population Analysis (MSVPA) models used for predicting fish stock size and hence catch limits. The MSVPA has its origins in a multi-compartment production model of the North Sea model.

Experience and analysis of the performance of MSVPA has shown it to be quite robust to changes in input parameters. Most importantly, it was found that the long-term predictions arising from a multi-species approach differed significantly from single species predictions.

One example of an ecosystem level management scheme that has been implemented to protect predators is for the sandeel fishery off the east coast of Scotland and NE England. A number of internationally important seabird colonies occur in this area. While these birds range far and wide and take a variety of prey outside the breeding season, sandeels are a very important component of the diet of adults and young during breeding. At this time the birds' foraging is also restricted to sites relatively close to the breeding grounds. While the evidence of a fishery – seabird interaction is only circumstantial, it was sufficient to prompt a precautionary response. Industrial fishing in the 'sandeel box' (which covers the inshore area from eastern Scotland down to NE England) is closed if the breeding success of kittiwakes in the nearby colonies falls below 0.5 chicks per pair for 3 successive years. The fishery does not reopen until breeding success has been above 0.7 for 3 consecutive years. Thus management of this fishery is based on an ecosystem objective (seabird population health), is precautionary (the link is not yet proven), and uses kittiwake breeding success as a biological indicator of the ecosystem effects of the fishery [12].

Fisheries scientists have long been concerned about the impact of discarding of undersize fish (for example fishery discards in the North Sea were estimated to be 262,000 tonnes of roundfish, 299,300 tonnes of flatfish, 15,000 tonnes of elasmobranchs and 149,700 tonnes of benthic invertebrates per year [13]), The recent growth in environmental awareness has also highlighted issues concerning the bycatch of charismatic species such as birds and cetaceans. For example, a number of porpoises and dolphins, are taken as bycatch in mid-water trawls and a variety of set nets. In the Danish gillnet fisheries in the North Sea estimates of cetacean bycatch range from 3887 in 2001, to 7366 in 1994 [14]. The management objective is to keep mortality below 1.7% for cetacean populations. The use of pingers, which help cetaceans avoid the nets, was made mandatory by the EU in the Celtic Sea, English Channel and North Sea in 2003.

## Ecosystem considerations for which management measures have yet to be developed

### Sensitive habitats

The Oslo-Paris Commission (OSPAR) provides the international regulatory framework for a number of human impacts in the NE Atlantic, although it does not have competency over fisheries management. OSPAR is, however, the lead body for the application of the UN Convention on Biological Diversity in the marine environment in the region, and as such is developing management measures to ensure BDC goals are met. It is in the process of identifying habitats that are sensitive to various human impacts, including fishing. This categorisation obviously requires consideration of the different metiers and then a consideration of appropriate management measures [15, 16].

### Recognising ecological dependence

An example of ecological dependence is the failure of capelin recruitment in the Norwegian-Barents Sea between 1984 and 1985, a period when the biomass of an alternate forage fish, the herring, was also very low [16]. This led to the starvation of many species that fed on pelagic fish including cod, seals and sea birds. Capelin in the Norwegian-Barents Sea is now managed with a target escapement strategy. Thus taking account of the need to ensure a food supply for the cod and other predators.

### Genetic diversity

Genetic diversity is the product of thousands of years of evolution, yet irreplaceable losses can occur very quickly [17, 18]. This diversity is important for the long-term ability of a species to adapt to extrinsic factors such as pollution or climate change, and loss of populations (extirpation) most likely equates to a loss of adaptive variation. Yet, management units are often discordant with population structure. For example, in the blue whiting, *Micromesistius* *poutassou*, the main oceanic distribution is considered to represent a single stock and is managed accordingly. However, population genetic studies have indicated that partially separated stocks exist in the Mediterranean and in the Northeast Atlantic [19]. ICES has suggested four general measures to mitigate against the loss of genetic diversity [20]. These have yet to be implemented in fisheries management regimes.

## DISCUSSION: CHALLENGES TO PRODUCING ECOSYSTEM BASED FISHERIES ADVICE

There would seem to be two sorts of barrier to the production of ecosystem based advice. Firstly a deficiency in our science and secondly methodological impediments to using the science as a basis for management.

At present our ability to protect sensitive habitats is limited by a lack of knowledge on habitat distributions, we simply do not know the full extent or location of many seafloor habitats. Under the CBD all habitats have equal value and so we are spared the need to place values on or to characterise the functions of each habitat. However, we also need to develop the science to allow us to assess the scale of each protected area, the total area to protect regionally and the means of ensure an appropriate level of connection between protected areas. While theoretical and field studies, mainly in the tropics, on MPAs have advanced our understanding much needs to be done before they can be made operational in European Seas. We similarly need a series of linked protected areas to maintain genetic diversity, however, this is hampered by the lack of knowledge on the genetics of marine organisms, both target and non-target. Similarly, if we are to understand the consequences of the massive food web changes that fishing induces and are to develop a predictive capability for indirect as well as direct effects then we need both better knowledge of food webs and non-trophic ecological linkages and better, modelling, tools to assess the system response to management actions. Given the high number of generally weak links and the strong non-linearity of many these are major challenges.

In all these areas we are seeking to develop better predictive capabilities while recognising that our data will always be limited and so our predictions will include an element of uncertainty. While we strive to provide formal estimates of the degree and consequences of this, we must also develop ways, within the management process of dealing with it. Meteorology and the use of short and medium term weather forecasts provides an illustration of the difficulties of trying to base operational decisions on predictions made for complex non-linear systems.

There is no doubt that one area where the science community has failed managers in the past is communication and education. The science advice to managers has often been poorly expressed and accompanied by various caveats whose aim has been to protect the reputation of the scientist. The managers then find themselves caught between weak advice and pressure from interest groups. These often fail to understand the nature of the system and constraints on the advice and certainly the public, who become motivated in the debate, do. We thus have managers facing public pressure and lobby groups armed with weak advice. It is natural therefore that they often have responded more to the pressure than to the advice, using uncertainty to justify management measures that are at odds with the core advice. The solution to this is education. The public and stakeholders need to understand the consequences of alternative courses of action – you cannot have your fish and eat it – and managers need to produce clearer less ambiguous advice and explicitly framed as options.

## CONCLUSIONS

ICES has been asked on many occasions what is the single most effective step we can take to reduce the effects of fishing on the ecosystem. The answer is a simple one: reduce effort now and forever. This is the only measure that will afford any protection to genetic resources and habitat features. If we restrict the total fishing opportunities, we limit expansion into areas now unfished or rarely fished. Reducing effort will, of course, also provide benefits to exploited stocks and species suffering incidental mortality. Unfortunately there has been scientific advice for effort reductions, to preserve the stocks, for decades with a conspicuous lack of success.

There are those that believe the protection of the ecosystem will provide the incentive politicians and managers need to enact the necessary controls.

While effort reduction may be the single most effective measure, it will not on its own provide full protection to all ecosystem attributes in need of protection. Closed areas, whether complete or merely restricting certain metiers, are the only protection for habitat features, and even then we must still understand the necessary scale and spatial distribution required to provide protection. Similarly, while reducing effort will reduce our selective pressure on the gene pool, it will not remove it, and although approaches, such as gear substitutions, have a clear role to play in protecting habitat features or by reducing bycatch/incidental mortality, it will not address the genetic effects of fisheries.

The ecosystem approach is inherently participatory and stakeholders must be involved both for democratic governance but pragmatically to gain acceptance of the outcome. Science has to fulfil an educator's role in informing the stakeholders so that the management objectives set are achievable and arrived at after due consideration of the options/alternatives. The science needs of an ecosystem approach are much broader than those of fisheries science. This will mean some reallocation of resources if the advice is to come from the best source!

## Acknowledgements

The ideas and perspectives presented here are the authors own and do not reflect the views of any other organisation. I would like to acknowledge the role of the ICES Working Group on the Ecosystem Effects of Fishing Activities whose lively and authoritative membership has contributed greatly to the intellectual development of an ecosystem approach to fisheries management in Europe.

## References

Tuck ID, et al. 1998 *Marine Ecology-Progress Series* **162** 227-42.

Rumohr H and P Krost 1991 *Helgoländer Meeresuntersuchungen* **33** 340-5.

Camphuysen CJ, et al. 1995 *Consumption of discards in the North Sea. Final report EC DG XIV research contract BIOECO/93/10* Netherlands Institute for Sea Research, Texel. NIOZ Rapport 1995 - 5.

Auster PJ, et al. 1995 *Marine Ecology Progress Series* **127** 77-85.

Churchill JH 1989 *Continental Shelf Research* **9** 841-64.

Riemann B and E Hoffmann 1991 *Marine Ecological Progress Series* **69** 171-8.

Messieh S 1991 Oceanography and Marine Biology: Annual Review **16** 229-311.

Schwinghamer P, et al. 1996 Canadian Journal of Fisheries and Aquatic Science **53** 288-96.

ICES 1998 Report of the Working Group on the Ecosystem Effects of Fishing Activities ICES, Copenhagen. ICES CM 1998/ACFM/ACME:1 Ref.:E.

Carpenter SR, et al. 1985 *BioScience* **35** 634-9.

Frid CLJ, et al. 1999 *Ambio* **28** 578-82.

ICES 1999 Report of the study group on effects of sandeel fishing ICES, Copenhagen. CM 1999/ACFM:19.

Garthe S, et al. 1996 *Marine Ecology-Progress Series* **136** 1-11.

Vinther M and F Larsen, 2002. Updated estimates of harbour porpoise by-catch in the Danish bottom set gillnet fishery. Paper presented to the Scientific Committee of the International Whaling Commission, Shimonoseki. International Whaling Commission SC/54/SM31. 10pp.

ICES 2002 Report of the Working Group on the Ecosystem Effects of Fishing Activities ICES, Copenhagen. ICES CM 2002/ACE:03.

ICES 2003 Report of the Working Group on the Ecosystem Effects of Fishing Activities ICES, Copenhagen. ICES CM 2003/ACE:03.

Nielsen EE and E Kenchington 2001 *Fish and Fisheries* **2** 328-43.

Kenchington E 2003. The effects of fishing on species and genetic diversity In Sinclair M and G Valdimarson (Eds.)*Responsible fisheries in the marine ecosystem,* CAB International.

Giaever M and J Stien 1998 *Journal of Fish Biology* **52** 782-95.

ICES 2002 Report of the ICES Advisory Committee on the Ecosystem ICES, Copenhagen. ICES CRR 254.

**SESSION** **THEME 1: THE ROLE OF ECOSYSTEM AND BIODIVERSITY RESEARCH IN THE CONSERVATION OF NATURAL RESERVES AND MARINE RESOURCES**

**TITLE** **MARINE BIOTECHNOLOGY AND BIODIVERSITY: USE OF MARINE ORGANISMS AS SOURCES OF PHARMACEUTICALS AND OTHER BIOLOGICALLY ACTIVE COMPOUNDS**

**AUTHOR(S)** ***ADRIANNA IANORA***

Ecophysiology Laboratory, Stazione Zoologica A. Dohrn
Villa Comunale 80121, Naples, Italy.
e-mail: ianora@szn.it

## SUMMARY

Biotechnology is providing novel solutions to biological problems that have challenged scientists for decades. This rapidly expanding discipline, which has its foundations in many fields, including biology, biochemistry and molecular biology, is receiving increasing attention from the mass media due to many recent breakthroughs in genetic engineering, plant and animal tissue culture, and immunology. Since the early 1980's there has also been a rapid increase in the applications of modern biotechnological techniques in the marine sciences. The focus in this field has been, for example, to improve productivity in aquaculture, to identify new bioactive compounds for applications in medicine and the chemical industry, and to develop bioremediation strategies for applications in the world's coastal oceans. The aim of this paper is to focus on the ecological function and pharmacological applications of natural products originating from marine organisms. Many of these compounds are unique and have no terrestrial counterparts due to the demanding and competitive nature of the marine environment. Understanding the mechanism of action and natural function of these compounds can provide new insights into the molecular and cellular processes regulating basic physiological and ecological processes at sea, and can provide a basis for finding new applications for marine natural products. It can also help scientists develop new strategies for the correct management of these potentially important marine resources for the future.

## INTRODUCTION: SO WHAT IS BIOTECHNOLOGY?

As a general definition, biotechnology can be considered a technology that deciphers and uses biological information for generating various kinds of useful products. Therefore, biotechnology is not a science *per se* but rather a name given to a set of techniques and tools for copying individual substances or processes. In other words, *biotechnology is a science of transformation*. Biotechnology is nothing new and applications of it have existed for thousands of years. Babylonians were already drinking beer by 600 B.C. and Egyptians were baking leavened bread by the year 4000 B.C. To give a more marine example of biotechnology in the past, in ancient Rome togas were dyed royal purple or biblical-blue that were considered imperial symbols. The dyes were obtained from fresh glands of the rock murex, *Thais haemostoma*. Glands of the female rock murex yielded the colour royal purple whereas those of the male produced biblical-blue. The father of modern biotechnology is considered Louis Pasteur who was the first to demonstrate the fermentative capabilities of microorganisms in the 1860s. The new biotechnological revolution, however, occurred over a century later, in the late 1970s – early 1980s, when scientists learned to genetically manipulate plants and animals beyond traditional breeding practices. It is these recent breakthroughs that have catapulted biotechnology into the prominent position that it holds today.

Perhaps one of the most dramatic examples of biotechnological applications in the marine sciences is in the field of pharmacology. The literature describes a wealth of compounds from the sea which act on the cardiovascular and nervous systems, and which have anticarcinogenic or antibiotic activity. Palytoxin is the most toxic naturally occurring organic substance known and was used by the natives of Maui to tip their spears as a defensive mechanism against invaders from the island of Hawaii. Originally produced by zooanthids (*Palythoa* species), palytoxin can be sequestered by predatory fish such as the filefish *Alutera* and eventually cause paralysis in humans that consume this fish. Tetrodotoxin is produced by the pufferfish *Tetraodon sp.* and several species of arrow-worms that use this venom to paralyse their victims and enhance the likelihood of successful prey capture. The compound specifically inhibits Na+ permeability across nerve membranes, and is at least one order of magnitude more lethal than the venom of the black widow spider. Tedrodotoxin poisoning still occurs in many Asian countries, especially in Japan, due to consumption of certain species of pufferfish that are considered a food delicacy. Clinical symptoms of tedrodotoxin intoxication include numbness, paralysis, and in some instances death. The “zombie” state described in the Voodoo religion has been attributed to this toxin in potions derived from the pufferfish. The conotoxins are a class of small peptides extracted from highly toxic snails of the Indo-Pacific that have been shown to elicit strong neurotoxic effects by binding to an array of as yet unknown pharmacological receptors. In the 500 known species of cone snails, each has a venom that is distinct from any other venom. Pharmaceutical companies are now exploring the selectivity and potency of these toxins to develop new drugs for the treatment of chronic pain, epilepsy and other disorders.

In the decade from 1977 to 1987, approximately 2500 new metabolites were reported from a wide variety of marine organisms (Ireland et al. 1993). More than 90% of these have been isolated from four major groups of marine organisms, the seaweeds, sponges, coelenterates and echinoderms. This has mainly been due to the abundance and ease of collection of these larger organisms. However, at present, the percentage of novel compounds isolated from marine microbes and microorganisms is growing at an impressive rate due to new technologies for growing large biomasses of these smaller organisms. The subject of the following discussion deals with the secondary metabolites produced by the marine phytoplankton, small unicellular plants that constitute a relatively new and untapped source of natural products, and that are presently being mass cultivated for a number of biotechnological applications.

## DISCUSSION

Of the various groups that comprise the phytoplankton, diatoms, with over 1600 recognised species, constitute one of the major components in both freshwater and marine environments. Until recently, diatoms were mainly exploited for their high content of polyunsaturated fatty acids, and particularly elevated levels of 20- and 22-carbon ω-3 fatty acids (most commonly, eicosapentaenoic and docodahexenoic acids). These two acids are generally believed to be the components of fish and fish oils which are responsible for the health benefits of elevated levels of these oils in the diet. Since neither of the two acids is synthesized by mammalians, they must be obtained from plant sources. This has created an increasing demand for these acids as integrators in the diet. Examples of such dietary integrators are some milk products enriched with ω-3, or pharmaceutical products containing high levels of fish oil ω-3 in the form of daily tablets for human consumption.

Other possibly important applications for natural products originating from diatoms regard the production of compounds with neurotoxic activity. Diatoms were not known to produce secondary metabolites with such activity, but in 1987 there was an unprecedented episode of human shellfish poisoning that caused three human deaths and 107 cases of gastrointestinal and neurological problems due to consumption of mussels from Prince Edward Island in Canada. The causative agent responsible for these disorders was domoic acid produced by the diatom *Pseudo-nitzscia australis*. The toxicity of domoic acid is due to the fact that it mimics the excitatory activity of the neurotransmitter L-glutamic acid inducing destructive neuronal depolarisation and successive degeneration of the hippocampus of the brain. In severe cases of this pathology, known as amnesic shellfish poisoning, victims also show permanent loss of recent memory. Due to its capability to mimic L-glutamic acid, domoic acid shows very strong insecticidal activity more potent than other synthetic insecticides. The advantage in this case is that it is also a natural product and therefore presumably causes less damage to the environment.

Another class of interesting molecules that have recently been isolated from marine diatoms are those that induce abortions or congenital malformations in the animals that ingest them. The aldehydes responsible for these effects have been isolated and the same compounds have also been shown to have strong antiproliferative effects on human adenocarcinoma cells (Miralto et al. 1999). There is the possibility, therefore, that diatoms are also important sources for novel anticarcinogenic drugs.

Dinoflagellates are another major constituent of the phytoplankton. They are of interest to biotechnologists because several species of this group produce potent neurotoxins. Filter-feeding organisms such as bivalves and shellfish that feed upon toxic dinoflagellates can concentrate these toxins to high levels in their tissues. Typically, the shellfish themselves are only marginally affected but a single clam can sometimes accumulate enough toxin to kill a human being. These toxins can make their way up the marine food chain and are responsible for massive fish kills, both wild and farmed, as well as the deaths of many aquatic birds and mammals, including whales and sea lions. In humans, consumption of shellfish containing high levels of toxins can induce at least four types of pathologies: paralytic, neurotoxic, diarrhetic and amnesic shellfish poisoning. Records of human poisoning by at least two of these syndromes dates back to hundreds of years. However, the discovery and characterization of the molecules responsible for this biological activity are quite recent.

Okadaic acid, for example, was the first toxin isolated from a marine dinoflagellate even though it had previously been found in the sponge *Halichondria okadai* Kadota. The toxin was identified from a Tahitian strain of the dinoflagellate *Prorocentrum lima* and a derivative of this toxin, dinophystoxin, was later isolated from temperate species of the dinoflagellate genus *Dinophysis*. Both okadaic and dinophystoxin are associated with episodes of diarrhetic shellfish poisoning in humans. Apart from this acute effect, chronic exposure may promote cancer since both compounds inhibit serine/threonine phosphatase enzymes during cell cycle progression. Recent research also points towards effects upon testosterone levels in mammals.

The brevetoxins are a family of 9 compounds that are sodium channel activators. They cause repetitive de-polarization of nerve membranes with an increase in the influx of sodium ions that ultimately deplete cellular reserves of acetylcholine at the synapses. Another group of toxins, the saxotoxins, include at least a dozen compounds that cause the opposite effect to the brevetoxins. They bind to the sodium channels and specifically block sodium permeability of the nerve membrane, ultimately causing paralysis and respiratory failure in humans. The differences in structure of the various saxitoxins alter the rates at which they bind to and depart from the binding site on the sodium channel. Due to public concern, there has been a great deal of effort in recent years to develop new technologies to detect and control toxic algal blooms. For example, species or strain specific molecular probes are now being developed to detect and quantify toxic dinoflagellate and diatom species *in situ*. There is also the attempt to identify new bioactive compounds that specifically arrest the growth of toxic phytoplankton cells. Active extracts of blood serum from the horseshoe crab *Limulus*, for example, have been shown to cause abnormal growth of the diatom *Thalassiosira pseudonana* and possible applications of this type may also apply to toxic dinoflagellate species in the future.

Table 1. Some examples of how marine organisms can offer a huge potential in the search for new drugs in this century.

| Species | Possible field of medical usage |
| --- | --- |
| Cone snails | pain/ central nervous system |
| Bryozoans | anti-cancer, anti-viral, anti-inflammatory |
| Corals | anti-cancer, bone injuries, anti-inflammatory |
| Sponges | anti-malarial, anti-cancer, anti-viral |
| Dinoflagellates | anti-viral, anticoagulant, anti-cancer |
| Diatoms | anti-cancer, anti-bacterial |

## CONCLUSIONS

Aside from their biotechnological applications, many natural products play fundamental roles as defences against predators, competitors and pathogens, and are therefore essential for driving ecosystem functionality and maintaining ecosystem biodiversity. Chemical diversity among species is at the basis of ecological specialization, and can promote evolution and maintenance of biodiversity through resource and habitat partitioning. Research in the field of chemical ecology is growing at an impressive rate, not only to disclose the biological function of natural products, but also to find new biotechnological applications for these potentially important resources in our day-to-day lives. The assumption is that if we can understand the function of these compounds, and how they can alter biodiversity at the genetic, species and ecosystem level, we can better manage and protect them, and ultimately underpin the processes that are at the basis of ecosystem functionality.

One of the many challenges of the recently constituted network of excellence MARBEF (Marine Biodiversity and Ecosystem Functioning) will be to better understand what environmental factors trigger increased production of these compounds, so as to develop novel and ecologically relevant methodologies to apply to studies of allelopathy, antipredation, anifouling, antimicrobial, and other possible functions of secondary metabolites. It is hoped that the training and mobility of young scientists in this field will not only serve as a basis for finding new applications for marine natural products, but also for the development of new strategies for the correct management of these potentially important natural resources in the future. Since most research programmes do not allow for this type of exchange programme, the network participants will benefit from the possibilities offered by MARBEF.

## REFERENCES

Ireland, CM, BR Copp, MP Foster, LA McDonald, DC Radisky and JC Swersey, 1993. Biomedical potential of marine natural products. In: DH Attaway and OR Zaborsky (eds) Marine Biotechnology Volume 1: Pharmaceutical and Bioactive Natural Products. Plenum Press, New York, pp. 1-39.

Miralto, A, G Barone, G Romano, SA Poulet, A Ianora, GL Russo, I buttino, G Mazzarella, M Laabir, M Cabrini and MG Giacobbe. (1999). The insidious effect of diatoms on copepod reproduction. Nature 402: 173-176.

**SESSION** **THEME 1: THE ROLE OF ECOSYSTEM AND BIODIVERSITY RESEARCH IN THE CONSERVATION OF NATURAL RESERVES AND MARINE RESOURCES**

**TITLE** **MARINE BIODIVERSITY - WHAT IS IT AND WHAT ARE THE PROBLEMS?**

**AUTHOR(S)** ***CARLO HEIP***

Centre for Estuarine and Marine Ecology, Netherlands Institute of Ecology,
POB 140, 4400 AC Yerseke, The Netherlands.
e-mail: c.heip@nioo.knaw.nl

## ABSTRACT

Important changes of marine biodiversity in coastal and open ocean ecosystems are increasingly being observed but their causes are not always clear and their significance for ecosystem functioning in general and human use of marine resources in particular needs better specification. The free use of the oceans and the perception that the oceans are immune to human impact are important obstacles for action. Locally, clear effects of overfishing, pollution, introduction of 'alien' species and of intensive aquaculture have been reported from many areas in the world, the mechanisms become known, and the socio-economic processes involved become understood. Globally, understanding the effects of climate change and changing biogeochemical cycles on marine biodiversity and vice versa still requires an important research effort, also because there are indications that already important and perhaps irreversible changes in oceanic food webs are taking place.

Biodiversity is essentially the richness of life on earth: the species that are inhabit the earth, the genetic material they contain and the habitats in which they live. Millions of species of plants, animals and microbes populate our planet and owe their existence to evolutionary processes occurring in environments as different as the polar ice fields and the tropical rain forest. In the oceans conditions may appear to be more uniform and constant than on land, and they probably are, but the oceanic environment is unique, oceanic life is unique and life has originated in the oceans and has evolved there over a much longer time period than on land, creating a diversity of life forms that is far greater than on land.

Marine biodiversity is however very poorly known. Species diversity may be underestimated by one and perhaps two orders of magnitude and in terms of microbiota we are just scratching the surface of what exists. A few hundred thousand species of marine plants and animals have been scientifically described and only a few thousand marine bacteria and archaea. This compares poorly to the millions of species described from land. On the other hand, because life originated in the seas, the diversity at higher taxonomic level is much higher in the oceans, and this probably means that also genetic diversity is much higher. If millions of marine species remain to be described, the taxonomist's task may seem impossible but the probability of many exciting and important discoveries in the future is very high.

Marine habitats as well are hardly explored. Even shallow coastal habitats are at least as diverse as terrestrial habitats. In shallow waters we have a variety of sediment types, of rocky shores with kelp forests and deep coral reefs, we have small hydrothermal features and of course the coral reefs, seagrass fields and mangrove forests in warmer waters. Also the water column is much more finely layered than thought only a few years ago. The deeper sea floor, when going from the ocean margins to the deep sea, has yielded one surprise after the other after the hydrothermal vents were discovered in 1979. Still our observational tools only allow for a very limited understanding of the fine scaled patterns existing on the ocean floor and the total surface of deep sea floor that is physically sampled is about the size of a football field.

Because marine biodiversity is so poorly known it is not easy to answer the question what value the goods and services have that are provided by it, what value they may have in the future and whether the use and exploitation of these goods and services is sustainable. It is clear that the economic importance of the oceans is enormous and that much of it is linked to biodiversity. Food, through fisheries and aquaculture, is the most obvious economic resource, but there is exploitation of sand and gravel and $CaCO_3$ deposits such as maerl, exploitation of sponges, of corals for ornamental purposes, of oil and gas and perhaps gas hydrates in the future, and habitat for the worldwide tourism economy which is worth billions of €'s. There is also increasingly the exploration for and the exploitation of chemical products, anti-cancer drugs, pharmaceuticals and so on.

It is difficult to estimate the changes of biodiversity which are due to direct human impact, but most evidence suggests that coastal marine species are under heavy pressure in large areas of the globe due to at least five major problems.

- Overexploitation of resources
- Pollution and eutrophication
- Introduction of 'exotic/alien' species
- Habitat destruction (reefs, sand and gravel exploitation, mangroves)
- Global climate change

All of these require serious attention. Fisheries and aquaculture put heavy pressure on a number of species. Both demersal and pelagic fish species have undergone major changes in abundance and population structure, even in the vast areas of the open ocean. Aquaculture puts an additional pressure on fish stocks as the most valued species are often fed on other fish species and as genetic diversity erodes. The continued effects of pollution and eutrophication through excess nutrients are well documented for a number of places in the world, especially near industrial areas and where agricultural activities are high. The introduction of exotic species, where humans serve as a vector, is accelerating enormously, mainly due to transport in ballast water and the physical removal of biogeographical barriers. This threatens to change biological communities and lower the global marine gene pool, as successful species tend to be the same in different places.

Habitats as well are being changed and destructed by a number of human activities, such as dredging and sand and gravel exploitation, deep-sea mining and oil and gas exploitation, and fisheries with activities such as bottom trawling, the blasting of reefs and the clearing of mangroves. Perhaps most alarming is the rapid deterioration of coral reefs worldwide which seems to be due to a combination of factors including rising water temperatures and increasing phosphate concentrations. Deep-water corals also occur in Europe and are increasingly subject to destruction by fisheries activities.

Loss of marine biodiversity has been documented extensively for larger vertebrate and a few invertebrate species which are directly exploited by man. One of the most spectacular examples is the loss of diversity in pelagic fish due to the long line fisheries of a number of nations. This has recently been documented extensively by Myers and Worm. Marine turtles worldwide but also in Europe have undergone dramatic declines. Marine birds are the most important victims of accidental oil spills, such as recently from the Erika in Brittany in 1999 and the Prestige off Spain in 2003. Marine mammals, such as the monk seal, the harbour porpoise and some dolphin species, have disappeared from some areas but on the other side there are examples of spectacular recoveries after protection of sea lions, sea otters and some whale species.

Only a few marine species have gone completely extinct as far as we know. Still, the threat is there and protection of marine species and conservation of marine areas are on the political agenda since many years. In many EU countries coastal marine reserves exist that protect high diversity areas and may serve as reserves from which other areas can be repopulated. Fisheries are regulated by establishing quota for individual species based on a virtual population analysis based on abundance and size. Because basic statistics exist for a number of fish populations, the long-term trends of biodiversity of pelagic and demersal fish are known for a number of areas. The spectacular decline of large pelagic fish species due to the long-line fishing of a number of countries has been mentioned. In general the average trophic level as well as the average size of exploited fish populations has decreased over the last decades. This is the concept of fishing down the food chain. Since top predators are removed, the structure of the food chain has changed as well. Smaller species tend to increase in number putting more grazing pressure on the zooplankton which in turn releases the phytoplankton. Such changes may therefore increase primary production and the capacity of the oceans to absorb excess $CO_2$, but this is very speculative.

One reason why it is so difficult to clearly establish the reason for changes in biodiversity is that besides changes in food webs due to direct human exploitation, there are also long term changes that are probably due to climatic factors. One of the best known examples are the changes in distribution of copepod species in the Atlantic Ocean as described in the work of Gregory Beaugrand and his colleagues from SAHFOS. Over the last decades there has been a gradual shift in distributions from south to north. This shift may have had direct consequences for the fisheries as there appears to be a correlation between the abundance of copepods and that of gadoid fish.

**In conclusion:** the economic value of the goods provided by marine biodiversity is enormous. Although there are local changes in many areas in the world, some of which may be attributed to human activities, there is no widespread extinction to be feared as on land. The only activity that is changing marine biodiversity on the global level is fisheries. Fisheries are changing the marine food webs by removing top predators and increasingly by catching long-lived species down to a size below the threshold at which the population crashes. For many of these species recovery is extremely low or impossible.

Besides removing valuable resources, these activities also change the marine food web and thereby invoke the question whether the functioning of the marine ecosystem is endangered. Again, this question is very difficult to answer. The economic value of biodiversity lies in the insurance it provides against the loss of ecological services, including life support services. One should also consider hidden costs because most functions of marine biodiversity are unknown. Probably less than 5 % of marine bacteria are known. The innumerable and ecologically important benthic and planktonic protists may comprise at least 34 phyla and 83 classes. Textbook examples of bacteria deemed important in biogeochemical cycles concern species not even present in the marine environment and completely new functions and biogeochemical cycles are therefore expected.

To calculate the cost and profit of services provided by marine biodiversity one should distinguish between the value organisms have for individuals and for society. Private value corresponds to properties of organisms which make them of direct use in satisfying production or consumption needs. This value informs the decisions taken by individual resource users and is generally given by the market price. Social value corresponds to the direct and indirect services provided by organisms to all members of society. It includes all effects which are external to the individual resource user decisions. The open oceans are the common property of mankind and decisions on marine biodiversity can only be based on social value.

In general the effects of species on ecosystem functioning can be of three kinds:

- Species are redundant, only minimal biodiversity is needed to maintain ecosystem functioning.
- All species are important (Rivet Hypothesis), when species disappear functionality is damaged.
- Idiosyncratic hypothesis: species are important, but some are more important than others.

Empirical data suggest, and recent theory shows, that biodiversity can act as an “insurance” for ecosystem functioning against environmental changes. Species that appear functionally redundant in the short term may be complementary in the long term because of different responses to environmental variations.

Let us now consider the services provided by marine biodiversity. These include regulation of climate, storing and cycling of nutrients, absorbing and detoxifying pollutants and regulation of the biogeochemical cycles in general. Marine organisms play crucial roles in many biogeochemical processes that sustain the biosphere. The carbon and nitrogen cycles are dominated by ocean processes and by micro-organisms in the oceans and the interplay between natural processes and human activities is becoming increasingly important. Two examples of major processes involving carbon and nitrogen are primary production and nitrogen fixation. A limited number of species account to a large extent for the magnitude of these processes and the characteristics of such species as shaped by natural selection may be important to understand global change. Twenty years ago the major carbon fixers in the oceans had not been discovered yet. Cyanobacteria of the genera Prochlorococcus and Synechococcus, organisms of around 1 µm large, are now known to be responsible for as much as 30 % of all global primary production. It is not clear how human activity can impact the biodiversity of micro-organisms in the open oceans and what the consequences are. One example of an interaction is the limitation of primary production by iron in large parts of the world's oceans, limitation that can be changed by direct (fertilization) or indirect (climate change) human action. Another possible effect is that the increased uptake of $CO_2$ will lead to a lowering of pH. This may have important consequences for organisms such as Emiliania, which, besides being photosynthetic are also important calcifiers.

When this simple picture that the goods in the oceans are provided by macro-organisms and the services by micro-organisms holds, it is clear that the food web should be a central point of attention and research to explain what the consequences of human activities are. Only in a multidisciplinary approach can we hope to understand what the interactions between species and biogeochemical cycles really mean in terms of global change. This requires more directed efforts of exploration, description and experimentation as well as a modelling framework that can only be put together by a new scientific network.

**SESSION** **THEME 2: FORECASTING AND TRANSPORT RESEARCH IN SUPPORT OF THE SECURITY OF THE MARITIME ENVIRONMENT**

**TITLE** **SESSION REPORT**

**RAPPORTEUR** ***GEORGE ZODIATIS***

Oceanography Centre (DFMR), University of Cyprus.
email : gzodiac@ucy.ac.cy

## SUMMARY

This session on forecasting and transport research in support of the security of the marine environment was organised around four keynote presentations. Peter Ryder (EuroGOOS) described “Developments in Operational Oceanographic and Meteorological Services for the Maritime Environment”. Konstanze Reichert outlined how the German SME OceanWaveS GmbH carries out research in support of the security of the maritime environment. Nils Telle of the Norwegian Ship Owners’ Association described European marine transport research supporting the ocean environment, while Tim Wilkins of INTERTANKO (UK) spoke about tanker transport and the ocean environment.

## INTRODUCTION

One of the permanent risks regarding a maritime transport incident in the European seas is associated with the heavy traffic of all types of vessels. It is estimated that more than 200,000 vessels pass annually through the Mediterranean Sea. A similar situation can be found in other sea regions surrounding Europe. Such dense maritime transport activity imposes on coastal countries the need for operational forecasts and efforts to prepare an operational response in the event of an incident.

## DISCUSSION

The Barcelona Convention for the Protection of the Mediterranean Sea against Pollution, the Marine Pollution Emergency Response and Support System (MPERSS), the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) administered by the International Maritime Organization (IMO), the Global Maritime Distress and Safety System (GMDSS) and other international, sub-regional and local agencies, manifest the necessity for the implementation of operational applications to improve the information that is needed for taking actions in response to major maritime incidents, and in general to support the security of the maritime environment.

The primary procedure recommended for responding to maritime incidents, which will assist the local and regional decision makers to take appropriate actions, includes the application of operational forecasting models to provide predictions of the marine environment. Until recently, the most significant marine services, in terms of safety at sea, were provided by the meteorological weather forecasting agencies, in the form of wind, waves, storm surges and sea-ice forecasts.

In recent years, several international initiatives, such as GOOS, EuroGOOS, MedGOOS, BOOS and recently GMES, MOON, plus research projects such as MFSPP, MFSTEP, MAMA, MERSEA, EuroROSE etc., have promoted the development and establishment of operational oceanographic observing and forecasting systems and the relevant networks around Europe. Within the framework of these activities several pre-operational oceanographic observing and forecasting systems are active in Europe at present on global, regional, sub- regional and coastal scales: e.g. MERCATOR, FOAM, TOPAZ, MFSTEP, POSEIDON, CYCOFOS, etc.

The effective exchange and dissemination of observational and forecasting products to end-users is recognized as playing a crucial role in the operational response to maritime incidents. The use of the forecasting products for certain derived applications has proved to assist the security of maritime transport in cases of oil spill incidents.

There are two main research directions that support security in the maritime environment:

## 1. The Application of Statistical Analyses of the Ocean and Atmosphere (Physical, Biological and Chemical), Coupled with Near-real-time (NRT) Oceanographic and Meteorological Forecasts

The influence of sea-state on maritime transport and coastal and offshore structures plays a crucial role in increasing the safety and protection of the maritime environment. Wave and current monitoring systems, such as the WaMoS and HF radar systems, are valuable new tools in monitoring and reporting on sea-state, as demonstrated in the EuroROSE and MaxWave Projects. This new knowledge gained about sea state must be implemented into ship and offshore design criteria.

The oceans are generally considered as being seriously under-surveyed. Questions related to where best to invest for improvement in in situ and remotely sensed oceanographic observations, assimilation methods or hydrodynamic models, still remain. It is not yet possible to reliably forecast high-impact weather events. Neither is it clear how to meet the wide range of disparate needs for services in both a comprehensive and economical way.

In view of the above, there is a requirement to improve and to extend observing and forecasting systems on global, regional and coastal scales. The development of operational oceanographic forecasts requires an engagement in collaborative experiments that build upon existing operational and pre-operational capabilities, e.g. THORpex (for improved weather observing systems and forecasts), MERSEA (integrated project on operational oceanography) and similar EuroGOOS initiatives in coastal zones, etc. This should lead to the establishment of a European oceanographic observing and forecasting capacity, which builds upon, develops and exploits the GMES initiative. In addition, there is a need to address identified deficiencies, use international standards and design in interoperability and finally to commit to an oceanographic and forecasting research programme in FP7, closely-coupled to GMES and GEOSS

## 2. The Improvement of the Design, Construction and Operation of Maritime Transport

The improvement of the design, construction and particularly the *operation* of maritime transport will enhance safety at sea.

Despite the fact that 99.98% of the oil transported by tankers arrives safely at its destination, the regulations on the *operation* of maritime transport are largely developed in the aftermath of accidents, such as those of “Exxon Valdez”, “Erica”, and recently the “Prestige”.

The tanker industry is convinced that the most efficient way to minimize accidents is to design and construct safer vessels, taking into consideration not only advances in technology, but also the increasing knowledge of the environmental effects from shipping. Today, all of the newly delivered tankers have double hulls. Furthermore, the tanker industry, jointly with the shipyard industries and the classification societies, wishes to raise the minimum standards in the design, construction and operation of tankers.

Within these efforts, several conventions related to ballast water discharge, anti-fouling, operational oily waste and garbage discharges are implemented by the shipping industry; these protocols are regrettably not supported by many flag and port states.

The major directions in research related to maritime transport can be summarized as follows:

- Apply new technologies for on-board treatment of ballast water to avoid distribution of harmful organisms;
- Apply new technologies for the further reduction of gaseous and particulate emissions from maritime engines;
- Promote the education and training of seafarers in marine environment matters.
- Use alternative fuels, especially natural gas;
- Use improved double hulls by developing energy-absorbing structures;
- Establish Vessel Traffic Management and Information Systems in Europe (VTMIS);
- Develop contingency plans for ships in distress and incidents in European seas.

## Operational Forecasting and Maritime Transport

### Common Concerns - Risk Management

The areas of common concern to both operational forecasting and maritime transport include, for example, how to:

- Handle uncertainty in forecasts;
- Advise on sea-state extremes;
- Introduce technical solutions and procedures which minimise risk rather, than taking a purely precautionary stance.

**Possible Solutions Include:**

- Trial probabilistic forecasts with professional end-users who are managing risk;
- Characterize extreme events in a probability distribution format / table and educate users on how to use them;
- Encourage a "*risk based management approach*" in legislation and operations.

## CONCLUSION

The main conclusions and main messages that emerged from this Session identified the need to:

- Engage in experiments that build upon existing operational and pre-operational capabilities;
- Develop and implement incentive schemes to make European "green shipping" profitable;
- Integrate the sea-state and weather forecasts into the decision support systems for ship design and operation.

## Key Points Thematic Session 2:
## Maritime Forecasting And Transport

For Europeans seas, which support heavy vessel traffic; there is a need to promote the education and training of seafarers in marine environmental matters;

### Forecasting

- Forecasts (models, pre-operational oceanographic observing and forecasting systems, statistical analyses of the ocean and the atmosphere etc.) are needed to prepare operational responses in the event of a polluting incident in Europeans seas;
- A European oceanographic observing and forecasting capacity should be established, which builds upon the GMES initiative.
- An oceanographic and forecasting research programme should be secured within FP7, closely-coupled to GMES and GEOSS;
- Effective exchange and dissemination of observational and forecasting products to end-users is recognized as playing a crucial role in the operational response to maritime incidents;
- Researchers must engage in experiments that build upon existing operational and pre-operational oceanographic capabilities;

### Possible Solutions to Integrated Forecasting with Transport Include:

- Trial probabilistic forecasts with professional end-users who are managing risk;
- Characterize extreme events in a probability distribution format / table and educate users on how to use them;
- Encourage a "*risk based management approach*" in legislation and operations, rather than adopting a purely precautionary stance.

### Maritime Transport - Research Priorities Include Efforts to Improve the Design, Construction and Operation of Maritime Vessels

- New technologies for on-board treatment of ballast water to avoid distribution of harmful organisms;
- New technologies for the further reduction of gaseous and particulate emissions from maritime engines;
- Use alternative fuels, especially natural gas;
- Use improved double hulls by developing energy-absorbing structures;
- Establish Vessel Traffic, Management and Information Systems in Europe (VTMIS);
- Develop contingency plans for ships in distress and incidents in European seas;
- Develop and implement incentive schemes to make European "green shipping" profitable;
- Integrate the sea-state and weather forecasts into the decision support systems for ship design and operation.

**SESSION** **THEME 2: FORECASTING AND TRANSPORT RESEARCH IN SUPPORT OF THE SECURITY OF THE MARITIME ENVIRONMENT**

**TITLE** **DEVELOPMENTS IN OPERATIONAL OCEANOGRAPHIC AND METEOROLOGICAL SERVICES FOR THE MARITIME ENVIRONMENT**

**AUTHOR(S)** ***PETER RYDER***

Chairman, EUROGOOS, 8 Sherring Close, Bracknell, Berks, RG42 2LD, UK.
Tel: +44(0)1344 423380 Fax: +44(0)1344 421796
Email: pryder@eisuk.fsnet.co.uk

## SUMMARY

Operational meteorological and oceanographic information services depend upon observations of the relevant features of the environment, which are used both to characterise the domains of interest and to initialise numerical models operating in near real time to forecast the evolution of significant, high-impact features within them. It is clear that the oceans are radically under-sampled for these purposes and the structure of high-impact weather events is often inadequately described to forecast their development, particularly over the oceans. This creates a strong incentive to identify and then maximise the availability of key data, to make the best possible use of them, particularly through data assimilation by numerical dynamical models and to ensure that the models adequately represent all the important processes taking place in the domain of interest. A research strategy to help decide where future invest should take place is suggested. Because the main problem is to determine the optimum combination of investment in models, assimilation models and observing systems, the strategy has to make maximum collective use of and build upon currently available operational and near operational facilities in these areas.

## INTRODUCTION

Environmental information services about the oceanographic and atmospheric domains are required so that we can survive and prosper within them in a sustainable manner. We continually manage risk in this process on the basis of available information. We design structures and procedures to survive extremes efficiently and back up their use with advisory services which allow us to deal with day to day events. Environmental data are required to catalogue the spatial distribution of means, standard deviations, seasonal fluctuations and the like. We prepare specific forecasts out to the limits of predictability, which we are continually trying to extend to increase the time for mitigating action. Suspected climate change is a very significant challenge to this approach, primarily by casting into doubt the representivity of the body of environmental information gathered over many years and the suitability of the structures we have built on the assumption of stationarity.

In recent years as the desire and need for us to treat the environment in a sustainable manner has required an increased focus on the pressures we place on the environment in our attempts to ‘survive and prosper’. These often have biological and chemical consequences so the need to monitor and predict these, in response to the pressures, has grown.

Any attempt to manage risk has to deal with uncertainty. There is a growing appreciation of the value of probabilistic forecasts and of the capability to generate them in an objective manner. However, much remains to be done to develop effective services of this kind.

## DISCUSSION

**Current practice** with respect to both the land and marine environments is to capture environmental data so as to resolve important structures and properties, and process them to create the archives from which statistical information, assessments and nowcasts can be prepared. Numerical models initialised by such data in near real time are used to generate predictions of the future state of the atmospheric and oceanic domains. Increasingly sophisticated data assimilation methods are being used for this initialisation, to extract the maximum value from available data and the power of models to represent processes properly and fully. Such methods are used routinely in operational meteorology and semi operationally and in research mode in predicting oceanographic evolution.

Available computing power is also enabling ensembles of atmospheric models to be run in near real time. By initialising individual members of the ensemble with realistically different observations the sensitivity of particular outcomes to inputs can be explored and the probability of those outcomes estimated.

### Current capabilities

There has been substantial investment in operational and research satellites carrying passive sensors (radiometers & imagers) at visible, infrared and microwave wavelengths in geostationary and sun-synchronous orbits. There are active space-based remote sensors (altimeters, scatterometers, SAR) in polar orbits too. In combination these provide valuable data about the physical (and by implication biological) properties of the land, ice and sea surface and the 3D distribution of temperature, humidity, wind and cloud. Such methods are also able to characterize the distribution of trace gases in the atmosphere and offer the only realistic hope of resolving ocean eddies ( ~ few 10km)

Ground-based remote sensing systems in the form of profilers, lidars and weather and Doppler radars provide useful data over land and coastal HF radars are able to monitor near shore currents and wave structure. Upper air & surface *in situ* met observations are obtained from networks of land stations, ships-of-opportunity, aircraft-of-opportunity and moored buoys. Operational surface and sub-surface *in situ* oceanographic measurements are obtained from ships-of-opportunity, moored buoys, sea floor landers, profiling buoys & coastal sea level sites. Increasingly biological and chemical measurements are being made from ships of opportunities, such as ferries, moored buoys and landers as well as research vessels.

Atmospheric modelling & data assimilation are operational on the local (10km), regional (20km) and global (50km) scales. Boundary conditions for the sub global models are imported from the larger scale. Forecast atmospheric surface fields are vital drivers of ocean models. Eddies in the atmosphere (depressions) have a characteristic scale of 100s of km but vigorous systems and convective storms have important structure on a scale of 10s of km.

Ocean models that are almost eddy-resolving (10km) are semi-operational on the ocean, regional and basin scales. ~4 km resolution models are being developed, particularly for ecosystem modelling. Ocean data assimilation is in use and is the subject of very active research. The Global Ocean Data Assimilation Experiment (GODAE) represents a concerted effort to develop capabilities in this area.

### Current performance

It is evident that the oceans are seriously undersampled. Candidate technologies are available, see papers in Dahlin et al (2003), and their usefulness has been demonstrated in the GMES MerSea Strand 1 project, see http://www.nersc.no/~mersea for example. The GAMBLE project, http://www.altimetrie.net has shown the utility of altimeters for sampling sea surface topography and wave properties but coverage is woefully sparse to resolve many important features and seems set to become worse. Wide swath instruments such as scatterometers and radiometers are able to discern surface features to an adequate even tantalising extent, but subsurface physical, chemical and biological sampling is limited to a few locations and depths, see http://www.cefas.co.uk/monitoring for example. The sea floor is almost unobserved http://www.abdn.ac.uk/ecosystem/esonet/. The Argo project represents a substantial international effort to monitor subsurface temperature and salinity for modelling purposes, but even when it reaches its design goal of 3000 floats the probability of finding one float in any area of 100km2 x100km2 is ~10%; at present 1/3 of the target has been reached – see http://www.coriolis.eu.org

The atmosphere above the oceans is also inadequately observed, although again great technical ingenuity is shown and costs are minimised by extensive use of platforms of opportunity. Satellite monitoring particularly of temperature and humidity profiles, but also through wind fields derived from cloud motion, has made a major contribution but cloud limits the use of infrared for the former. The use of the microwave spectrum helps in this regard but vertical resolution suffers. Active satellite based sensors, in particular wide swath scatterometers and altimeters, also contribute by enabling useful measurement of wave height and surface wind.

Notwithstanding these investments it remains to be seen whether it proves possible to provide predictions of the properties of the oceans and the ecosystems within them with useful lead times. Furthermore, it is clear that high impact weather is **not** being forecast to the desired accuracy and it remains uncertain why this is so.

It is also the case that notwithstanding the theoretical benefits of probabilistic forecasting and the ability to produce such services based on them, much remains to be done to persuade potential beneficiaries of their value. Finally, as demonstrated within the thematic and crosscutting studies carried out to inform the design of GMES, and despite substantial past investment, there continue to be major impediments to the provision of effective and efficient information services to inform the development and implementation of environmental and security policy. These are not peculiar to the atmospheric and ocean domains, and crucially concern the joint use of environmental and socioeconomic data, the difficulties will have to be overcome if the strategic goal of the European Union to become the most competitive and dynamic knowledge-based economy in the world by 2010 is to be achieved .

## Suggested research strategy

The deficiencies discussed above all relate to the provision of information services, for which there are substantial existing infrastructures and past investment. Whilst it may be possible to isolate and research specific issues in an offline mode, the major issues concern the optimum **joint, collective** use and enhancement of individual components of the data capture, information creation and service delivery process. Such problems must be faced by coupling the research activity to the continuing operational service provision.

### APPLICATION OF THE STRATEGY

It is recommended that:

1. European scientists participate fully in the 10-year THORpex Global Atmospheric Research Programme whose objectives are to to accelerate improvements in short-range (up to 3 days) and medium-range (3 to 10 day) deterministic and probabilistic predictions and warnings of high-impact weather over the Northern Hemisphere. The European contribution is being managed by EUCOS and already includes one major field experiment over the North Atlantic to establish the feasibility and impact of adapting the observing system where the impact of additional data is judged to be high in the prevailing circumstances – see http://www.wmo.int/thorpex
2. The development of operational oceanographic capability in observing, modelling and assimilation on the global, regional and local scales within Europe be built around the MerSea IP initiative, which aims to capitalise on most of the existing semi-operational ocean modelling capability in Europe and 'develop a single high-resolution global ocean forecasting system shared by European partners together with a coordinated network of regional systems for European waters which will provide the platform required for coastal

forecasting systems' – see http://www.ifremer.fr/merseaip. Integration of additional research and development efforts supporting these goals should take place under the auspices of EuroGOOS.

3. Probabilistic prediction methods be developed & tested in a localised service targeted upon a discrete well informed user community. This will require:
   - A committed (probably) professional user community
   - Testing and training in production and delivery
   - Training in the use of products
4. The GMES initiative be used to further develop & test collaborative, comprehensive information services relating to the atmosphere & oceans on a European/regional scale which
   - Recognise wide range of data/information required
   - Use international standards
   - Design in interoperability for multiple use

## REFERENCES

The above has benefited, inter alia, from papers presented at the 3rd International Conference on EuroGOOS, held in Athens, Greece during 3-6 December 2002. The Proceedings are reported in: Dahlin, H., Flemming N.C., Nittis, K. And Pettersson S.E. (Eds), (2003) 'Building the European Capacity in Operational Oceanography', Elsevier Oceanography Series, 69.

**SESSION** **THEME 2: FORECASTING AND TRANSPORT RESEARCH IN SUPPORT OF THE SECURITY OF THE MARITIME ENVIRONMENT**

**TITLE** **RESEARCH IN SUPPORT OF THE SECURITY OF THE MARITIME ENVIRONMENT - INCLUDING THE SPECIFIC INVOLVEMENT OF AN SME**

**AUTHOR(S)** ***KONSTANZE REICHERT***

OceanWaveS GmbH, Munstermannskamp 1,D-21335 Lüneburg, Germany.

**ABSTRACT**

In the perspective of the Global Ocean Observing System (GOOS) an important goal is to develop operational tools for those in charge of safety and regulation for coastal marine operations and constructions, as well as for the protection of the marine environment.

Two research projects, **EuroROSE** and **MaxWave** carried out within the last 5 years, dealing with current and wave measurements and their forecast will be presented. For both activities the aspect of applied research, the end user involvement and the dissemination approach will be highlighted. For the company both projects had a strong impact on the research and marketing aspect of the radar based wave monitoring system **WaMoS II**.

**INTRODUCTION**

## WaMoS II

For surveying the ocean wave field WaMoS II, an operational wave monitoring system based on a common marine X-Band can be used. Mounted on a ship, oil rig or onshore it is a proven instrument that measures the wave energy its directions and heights as well as the surface currents. The system consists of conventional navigational X-band radar, a high speed video digitising and storage device and a standard PC. The analogue radar video signal is read out and transferred to the PC for storage and further real time processing. The data can be accessed either directly, via removable media, or on-line via modem/telephone or Internet.

Fig. 1: Systematic drawing of WaMoS II system components.

The measurement is based on the backscatter of microwaves from the ocean surface that is visible as 'sea clutter' on the nautical radar. From that observable sea clutter an analysis is carried through to deduce the unambiguous directional wave spectrum and the surface currents. Sea state parameters such as wave heights, periods, wave lengths, wave directions and the surface currents are estimated by a straight forward analysis.

## EuroROSE

The main objective of the FP4 project EuroROSE was the development of a transportable methodology for monitoring and forecasting winds, waves, water level and currents in limited areas (typical extent 40 by 40 km), such as coastal and port approach areas. Both by using ground based radars (HF and X-Band), in situ sensors and numerical models. The aim was to combine real time area covering measurements with numerical models to provide a best forecast and now cast for areas of interest, such as dangerous harbour entrances. The capabilities of area covering radar measurements as well as data assimilation methods were investigated. The overall system was demonstrated in Norway, where currents provide navigation difficulties and in Northern Spain, where the waves are the major concerns of harbour and ship operators.


Fig.2: Diagram illustrating the basic approach of FP4 project EuroROSE

## MaxWave

In the FP5 project MaxWave properties of and forecasting abilities for low frequency wave fields, extreme individual waves and wave groups were investigated for both deep and shallow waters. The research was triggered by the fact, that within the last years a high number of large ships had been lost. The causes of accidents are in many cases believed to be 'rogue waves'. These are individual waves of exceptional wave height or abnormal shape. Therefore new design criteria considering the impact of rogue waves on ships and offshore constructions are needed. The innovative aspect to reach theses goals was to combine new oceanographic knowledge and ocean wave data resources with new approaches to vessels, marine construction, design and operation. The project addressed the needs of coastal engineers and port designers/operators in terms of influence and impacts of extreme waves. An important aspect was to develop a quality-based metocean information product for the benefit of both high sea and coastal zone operating industry and authorities.

Fig. 3: Ship bow in heavy seas

## Approach

The methodology applied in EuroROSE was a combination of area covering remote sensed data and high resolution numerical forecast models including data assimilation, co-ordinated with the Vessel Traffic Services at ports and coastal monitoring centres. The system developed was tested in two field experiments, and was also validated from the scientific point of view.

In Norway the area in front of the passage south of Fedje was observed by two WERA HF radars sited at Fedje and Lyngøy, and by two

WaMoS II radars sited at Hellisoy and Nordoy. The two important reasons for selecting this passage for the measurements were:

- This passage is more dangerous for the tankers, because it is only about 1 km wide and some shallow areas due to rocks (-14 m) are nearby.
- Oceanographic features like eddies traveling along the coast from the south to the north, high current speeds up to 4 knots 5 to 6 miles off Fedje force tankers to reduce speed when they approach the passages, as they are sometimes drifted off track.

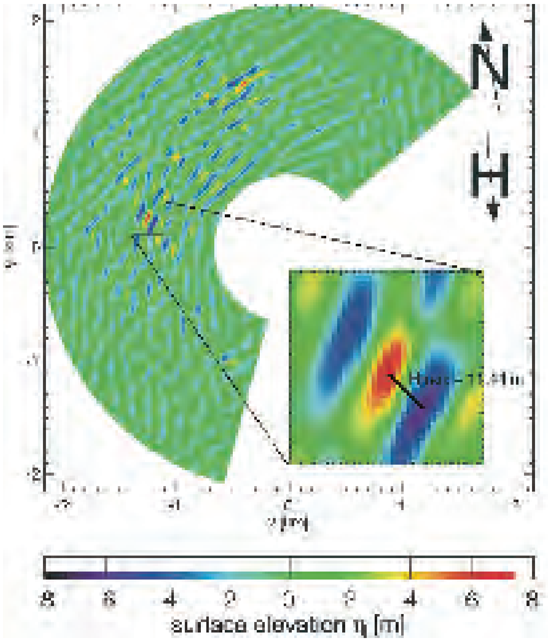



Fig. 4: Results from FP5 project MaxWave: Individual waves calculated from X-band radar images.

The experiments in the end user environment helped to promote the potential of ground based radars for harbour safety purposes. As a partner of such a big consortium it was possible to develop new software to investigate coastal effects on waves and currents for WaMoS II. EuroROSE supported the technical acceptance of a new measuring technique within the operational community. The contacts that were established during the project, especially the demonstration phase could be usefully exploited by the commercial partners.

MaxWave had the goal to confirm the existence of rogue waves and their risk of encounter and to implement the new findings in ship design. For this highly interdisciplinary approach, existing measurements and hindcast modelling were used to better understand the shape and impacts of extreme waves in relation with ship/offshore accidents. Statistics of abnormal waves were documented by in situ measurements with conventional wave sensors. For the remote sensing techniques used in MaxWave, X-band radar and SAR, new algorithms for the estimation of single wave events were developed. These developments have a strong impact on use of X-Band radars for regular wave measurements on board of ships.

MaxWave has created and still creates a lot of public awareness about the potential impact of waves on ships and offshore structures. Both projects presented here combined research in oceanographic features and transferred it into application. By this, safety aspects in ship and offshore design as well as operation could be addressed. From the market response in the commercial sector, it becomes clear that the findings of both projects, EuroROSE and MaxWave are of high relevance for the end users.

## Conclusions

The combined interdisciplinary research, academia, industry and end users can have a huge potential on the market acceptance and commercial development of SMEs. The X-Band radar based wave monitoring system WaMoS II benefited from the application in several projects. The success of such an approach is strongly depended on the personal commitment of the participants. A premise to reach the agreed project aims was respect for the different attitudes and approaches related to the variance of backgrounds of all partners.

**SESSION** **THEME 2: FORECASTING AND TRANSPORT RESEARCH IN SUPPORT OF THE SECURITY OF THE MARITIME ENVIRONMENT**

**TITLE** **EUROPEAN MARINE TRANSPORT RESEARCH SUPPORTING THE OCEAN ENVIRONMENT**

**AUTHOR(S)** ***NILS TELLE***

Norwegian Shipowners Association,
Postboks 1452 Vika, 0116 Oslo, Norway.

## INTRODUCTION

This presentation is primarily based on the experiences gained and results achieved when working with the EU-sponsored (FP4) thematic network TRESHIP - "Technologies for Reduced Environmental Impact from Ships", which was finalised in 2003. In TRESHIP where I was co-ordinator, we considered pollution from ships in a lifecycle perspective. In such a perspective, pollution from ships can be separated in three different parts: (a) Pollution when building ships (b) Pollution from ships in operation (c) Pollution related to scrapping of ships.

TRESHIP has dealt with emissions to air and releases to sea, i.e. emissions of CO2, NOx, SOx, CFC and releases of oil, ballast water and TBT. The thematic network did not discuss blackwater, graywater and sewage.

Operation of ships is what most people think of when talking about maritime pollution. The politicians and public at large will notably relate this to oil pollution of the sea following severe accidents, like the disasters due to grounding the grounding of Exxon Valdez, Tory Canyon, Amoco Cadiz or the sinking of Erika and Prestige.

The rest of this presentation will concentrate on ships in operation and on emissions to the atmosphere of $CO_2$, NOx, SOx and releases of oil to the sea.

## MARINE POLLUTION

### Facts and figures

First I will make a brief statement: More than 99.8 % of all oil transported by ships arrive safely at its destination. Total releases of oil to the sea amounts to 2.4 million tons annually. 24 % or 0,57 million tons of this originates from shipping. 0.12 tons or 5 % are releases from accidents with ships. This is the average, there might be variations from year to year.

Of the total emissions to the atmosphere 2 % of $CO_2$ comes from shipping, 5-7 % of total SOx emissions comes from ships and 10-13 % of NOx emissions comes from ships. Emissions of Volatile Organic Compounds (VOC) amounts to 1.7 - 1.8 million tons a year associated with handling and transportation of crude oil and oil products. This is about 3 times the amount of oil spill from shipping and corresponds to 0.1 - 0.15 % of all oil transported. It is estimated that shipping contributes to 5-10 % of the acid rain (NOx and SOx) in coastal areas, perhaps even more in coastal zones with heavy traffic such as the English Channel.

Marine bunker oil is in many ways to be considered a waste product from the oil refineries, and as such it contributes to solving a global waste problem. This should be kept in mind when comparing emissions of harmful substances from ships to air with other transport forms and land-based industries.

### Shipping versus other transport means

Emissions to air per ton transported with ships are much lower than emissions per ton from any other means of transport.

This comparison does not render full justice to other transport means. In many cases transport by trucks can not be replaced by ships and vice versa.

TRESHIP made a comparison of emissions of $CO_2$, NOx and SOx when a certain quantity of fish was transported from a coastal town in Norway to its destination on the European continent. This study showed that the emissions were lower for $CO_2$ and NOx when maritime transport was one of the links in the transport chain than when the cargo was transported by truck all the way. The SOx emissions, however, were higher for transport including a maritime link.

Taking into account that the trucks travel through built-up areas and the ship travels far from populated areas, maritime transport is by far more environmental friendly. The comparison did not include noise, vibration and distribution of dust.

## POTENTIAL FOR IMPROVEMENT

Shipping is by far the most environment-friendly means of transport there is. Shipping is looked upon as a mature industry, but TRESHIP points to a number of areas where there is an interesting potential for improvement or reduction of both releases to sea and emissions to atmosphere.

**Reduction of oil spills**

Nearly all tankers delivered today have double hulls. This represents an improvement compared to tankers with single hulls. TRESHIP has recommended further R&D to improve the construction of double hulls by developing new energy-absorbing structures. For low-energy collision and grounding this might be interesting, but for high-energy collision and grounding the potential for reducing the releases to sea is marginal.

**Atmospheric pollution**

It is both economic and environmental friendly to reduce ship resistance and thereby reduce the propulsion power. This can be achieved through improved hull forms, better propulsion devices, improved engines and reduced friction by developing better surface treatment or antifouling paints.

Ships, maritime prime movers and propellers are considered mature technologies, but there is still a potential for improvement. Alternative propulsion systems have been tested, and some of them seem quite promising. The gain might be in the order of some 5 %. But we foresee no major improvements in the near future.

Diesel engines have been and for many years to come will be the dominating prime mover. NOx emissions can be reduced by more than 60 %, but that will lead to increased $CO_2$ emissions and increased costs.

There are technologies available for reducing SOx emissions. The most efficient way to reduce the SOx emissions is to lower the sulphur content in the bunker oil. IMO has accepted a sulphur cap of 4.5 % or 1.5 % higher than what is the average sulphur content in fuel oil to day. The European Commission is currently preparing measures to lower the Sulphur-cap both for sailing in EU waters and for port stays.

Gas-fuelled diesel engines are interesting. The emissions will be substancially lower, this relates both to emissions of soot and particulates, of SOx, NOx and of COx. The efficiency is slightly lower, but the gap between the ordinary diesel engine and the gas-fuelled one is closing. Storage of the gas might be a bigger problem.

**Alternative engine systems**

Gas turbines and fuel cells are promising both as auxiliary engines and prime movers. Together with a number of European companies we have been studying maritime application for fuel cells. Safety and reliability have been vital questions, but the most important question at this stage is the economic and environmental potential for fuel cells in ships. A road map for future research in this interesting field will also be drawn.

### R&D NEEDS REPORT

Our R&D Needs Report indicates a number of ideas to reduce the environmental impact from ships. Most of the proposals plan to develop new and improved technology, but the most interesting proposals do not suggest to develop and implement new technology. The most promising suggestions seem to be:

- Establish the basis for legislation and incentive schemes that can stimulate a reduction of environmental impact and simultaneously contribute to make “green shipping” profitable.
- Develop and demonstrate vessel traffic and management and information systems in Europe and thereby contribute to increase multi-modal transport and reduce land based transport.
- Develop and demonstrate contingency and intervention systems for European waters.
- Improved education and training for maritime personnel.

To improve the technology is certainly important, but as mentioned, the potential to reduce the emissions and environmental impact from transport is higher by implementing the proposals mentioned above.

### EU-FUNDED R&D TO REDUCE ENVIRONMENTAL IMPACT FROM SHIPPING

Some of the proposals mentioned in TRESHIP’s Final Report coincides with the priorities in the report “The Maritime Industry R&D Master Plan” as issued by the “R&D Strategic Planning Group” of the “European Maritime Industries Forum”.

It will be too time-consuming to mention all these projects, so I will only mention the projects that might represent major technological achievements, sorted in two groups

- New technology and technology shift
- Integrated transport solutions or door-to-door transport

The European Commission has been very positive in sponsoring these projects. Everybody realises that investments in these projects can hardly be expected to show return on investments for many years. In such cases it is an essential condition that the European Commission and/or the national authorities are willing to share the economic risks with the industry in the development of the technology or in testing of new opportunities.

## New technology

- Martob. This project deals with the treatment of ballast water on board ships to avoid distribution of harmful organic substances. The project has succeeded in developing and testing new methods for treatment of the ballast water. The methods have not been tested in full-scale onboard commercial ships, but the industry has expressed interest for installing the equipment.
- FC Ship. The purpose of the project is to evaluate the economic and ecologic effect of installing fuel cell technology on board ships. The results so far are quite promising. The environmental effect is clear, with an interesting potential for further improvements. The economic effect is more uncertain, at least with the present technological status. But the project group has decided to apply for support for further R&D and pilot projects. We judge this as absolutely necessary and it is an essential condition to have a demonstrator on board a commercial ship.
- Hercules. The objective is to develop new technologies to drastically reduce gaseous and particulate emissions from marine engines and simultaneously increase efficiency. The project has just started and it is too early to present concrete results.

## Integrated transport solutions

- D2D. The purpose of the project is to develop and demonstrate systems to manage and control multimodal transport solutions – Supply Chain Management SCM. The project has developed a SCM for control and guiding of integrated transport solutions. The system has been demonstrated in commercial transport chains and it is now ready for use by the industry.

- Searoutes. The objective is to improve forecasting of sea-state and sea-weather, including near real-time data from high resolution and high precision altimeter satellites. The forecasts shall be integrated into advanced decision support systems for ship captains and ship management conserned with routing performance of ships.

The European Commission has also sponsored a number of other projects re. Integrated Transport Solutions. These projects have started recently and it is too early to expect concrete results.

## CONCLUDING REMARKS

Shipping is an often underrated industry and means of transport. In volume terms some 90% of Europe's external trade and over 40% of the internal longer haul transport is carried by ships. Shipping is also the most environmental-friendly means of transport there is. But that does not mean that we can allow ourselves to rest on our laurels. There is an interesting potential for improvements, both for reduction of releases to sea and emissions to air.

The oceans have had and will in the future have major importance for our environment. Everybody should feel responsible for protecting the oceans, especially we who have our work so closely tied to the seas. The shipping industry has taken responsibility and is prepared to do so and play an active part also in the future.

Environmental protection in shipping has so far been driven by governmental regulations, and new rules have normally been introduced almost emotionally after major accidents. The shipping companies have had to comply with these rules.

Shipping companies, as all companies involved in international business, are working in tough international competition. It is a challenge to balance between cost-effective operation and safe, environmental-friendly operation. Too little action and the company may not be complying with rules and regulations. Too much action and the company may loose its competitiveness.

A healthy maritime industry requires equal terms and fair competition. This means that all rules and regulations implemented to reduce environmental impact from shipping must be internationally accepted and governed, if not the competition will suffer and those not complying might gain a competitive advantage.

The primary driving force in all industries is economy. An interesting new trend is stricter requirements from our customers who more and more often have environmental-friendly operation as one of the conditions for their suppliers. So far we have not experienced that the customers are willing to pay extra for quality, but we have seen that substandard operators have been excluded from the "shortlists" or "list of preferred suppliers". The quality operators welcome this development!

To develop and implement new rules continuously is not necessarily the right way ahead. The "stick" could be replaced by the "carrot" and financial benefits should be introduced. Investing in environment-friendly equipment should be profitable and environmental-friendly operation should be a competitive advantage. We therefore recommend a totally new international regime for reducing the environmental impact from shipping.

However, we must also bring about a change from the current position of compliance with prescriptive and reactive regulations to a state of proactive and self-motivated improvements in all aspects, relevant to the environment and safe ship operation.

It is not only a question of technology. We are also talking about the organisational culture in the companies. For better protection of the environment, the current dominating "Compliance culture" should be replaced by a "Safety culture" and the responsible in this case is only the shipping company.

**SESSION** **THEME 2: FORECASTING AND TRANSPORT RESEARCH IN SUPPORT OF THE SECURITY OF THE MARITIME ENVIRONMENT**

**TITLE** **TANKER TRANSPORT AND OCEAN ENVIRONMENT**

**AUTHOR(S)** ***TIM WILKINS***

Intertanko London, St Clare House, 30-33 Minories, London EC3N 1DD, United Kingdom.

**SUMMARY**

With an increasing demand for energy resources and products around the world coupled with an increase in the sources of energy production, the tanker industry has had to enhance its ability to maintain this expanding supply network. But maintaining this vital service is not without its risk.

While conscious of the public concern relating to oil transportation, the tanker industry has been confronting the challenge of making a continual improvement of its environmental performance. INTERTANKO presents an overview of the principal environmental concerns relating to oil transportation by tanker, as well as of the solutions in place, both mandatory and voluntary.

## INTRODUCTION

It may come as a surprise to most people to learn that the shipping industry is changing. In fact, it is unlikely that the general public had even considered the notion unless explicitly asked of them. It may even shock the more astute among the general public to learn that the tanker sector is at the forefront of the change in terms of technical and operational advances. Advances which are rooted in a need to improve performance in terms of safety at sea and environmental protection.

### Market Demand

International shipping is becoming increasingly complex and more rigorously regulated. In turn, the demands on the tanker industry are growing, with an ever increasing demand for energy and an increasing desire for consumer satisfaction, i.e. the 'right here, right now' lifestyle.

There is a direct correlation between oil demand and sea trade, with an increase in demand of about 1.5 million barrels per day (bpd), per year over the last decade. To demonstrate that this trend is set to continue, the International Energy Agency (IEA) predicts an increase of 1.65 million bpd in 2004.

### Public Demand – Zero Tolerance

While demand for oil increases the general public becomes more demanding in terms of its zero tolerance approach to oil and chemical spills. As a consequence, regulations prompted by accidents are invariably stringent and involve considerable, unplanned costs for tanker owners. The primary dangers of such instant, prescriptive solutions are that they can introduce ambiguities and stifle innovation in the drive for safer, more efficient tankers.

Regardless of the improvements made by the tanker sector over the last decade, significant individual events have changed the course of the tanker industry. The introduction of the double-hull in North America following the *Exxon Valdez* spill in 1989 and now in Europe and across the rest of the world following the *Erika* and *Prestige* incidents in 1999 and 2002 respectively, has introduced new challenges for tanker operators, builders and equipment suppliers. An increasing complexity in the double hull structure, coupled with a larger steel work surface area which will require coating and corrosion protection is just one example of the considerations which have to be borne in mind when implementing new regulations.

## Forward Thinking, Practical Solutions

The tanker industry believes that the best way forward to prevent further accidents and "knee-jerk" reactions following an accident is to design and build safer ships, taking into consideration the continuing advances in technology, and increasing knowledge and understanding of the environmental effects from shipping. Coupled with this is the need to maintain maintenance standards throughout the lifetime of the vessel. This of course requires the pooling of knowledge and experiences, and the sharing of solutions by the operators, combined with expert assessments from the scientific and research community as to the potential problems of the future.

The voluntary solutions being implemented by the industry are extensively researched and tested, with the risk and subsequent costs absorbed by the individual owner (as opposed to the industry as a whole) and / or yard which is carrying out the trial. Prescriptive legislation on the other hand, may not receive the extensive and practical research required and as such rarely addresses the true source of the problem. Such requirements can therefore be impractical and ineffectual when implemented.

The knowledge and know-how of the industry, and the development of new legislation, rarely comes together in practice. Much of this is due to a, some might say justifiable, lack of trust toward the industry by the regulator, meaning political as opposed to scientific influence may take precedence during regulatory development.

To overcome this lack of trust and continue its work in seeking practical solutions to upcoming operational problems and those caused directly and indirectly by ill-conceived legislation, the industry must produce solutions that are well researched, workable and effective. Only by effectively presenting such work will the regulators and their governments begin to accept the complexities and demands placed on the tanker industry.

The following examples are given as a demonstration of the industry's lead on key safety and environmental issues:

TRIPARTITE - The tanker sector, together with the ship building yards and the classification societies have recently joined forces in an attempt to increase design, build and construction standards for new ships. Problems such as access to ballast tanks for surveys, and increased corrosion rates in crude oil cargo tanks has lead to extensive ongoing research by these bodies to avoid major repair costs and potentially catastrophic incidents during a tanker's operational life.

CRUCOGSA – INTERTANKO co-funded an industry project to ascertain the physical behaviour of crude oil during transportation, discharging and tank washing. A key finding was the quantity of VOC released from the cargo during transportation. Up to 7 million tonnes of VOC is emitted every year from the transportation of crude oil in tankers.

VOCON – As a direct consequence of the above study and its finding with regards to VOC emissions, a second project was commissioned by INTERTANKO in which an operational solution to the problem was found. The VOCON Procedure will reduce VOC emissions by up to 80% and so reducing air pollution and cargo loss. Since the completion of the project a number of marine manufacturers have designed equipment (automated pressure valves) to automate the process and improve its efficiency.

INTERTANKO and fellow industry bodies have also been extensively involved in various European and IMO related projects, acting as the industry reference and resource on technical and environmental matters.

## Identifying Issues

Although accidental spills often provoke the greatest efforts from politicians and regulators, it is on the operational level where most safety and environmental concerns are being identified by the industry. The following table gives an overview of some of the issues being dealt with by the tanker industry; the legislative requirements; the latest in technological and operational developments, and; the eventual aims and objectives from the industry perspective.

| Issue | Legislation | State of the Art | Aims |
|---|---|---|---|
| **Invasive Species in Ballast Water** | International Convention requiring specific treatment standard of discharge water covering organisms ranging in size from 10microns and upwards, including certain human pathogens. | Thermal, de-oxygenation, UV, biocide, filtration and separation are main methodologies for treatment. Few able to treat to legislative standard, those that can are unable to treat at desired volume so as not to impede normal ship operations. Ship board trials limited. | Elimination of ballast problem, 100% treatment standard, and eventual elimination of invasive species from other ship sources, e.g. hull fouling and chain locker.<br>Technology should be reliable, effective and suitable for ship board use. |
| **Anti-fouling Systems** | International Convention banning application (2003) and use (2008) of organotin based antifouling systems. | Tin-free systems still being developed, some uncertainty within the market as to effectiveness and environmental soundness of alternatives. | Short term: Soundness of TBT alternatives.<br>Long term: Effective biocide free systems available for larger, slower vessels which dock less frequently. |
| **Operational Discharges (Oily Waste)** | MARPOL Convention Annex I (International) – regulates discharge rates and quantities from all ship types (i.e. cargo and engine room waste oils) | Oily water separators, incinerators and oil discharge monitoring equipment.<br>Shore side reception facilities. | Zero discharge to sea and atmosphere. Minimise oil waste on board and ensure discharge ashore in all ports. |
| **Garbage** | MARPOL Convention Annex IV. Provides for incineration, separation and shore side collection. Biodegradable waste can be discharged at sea within certain rates and volumes. | Incinerators, compactors. Segregation management of materials. | Minimisation of waste at source. |
| **Air Emissions (Engine)** | MARPOL Convention Annex VI. Provides limits for SOx, NOx, CO2 and GHG's with requirements on engines, fuel and operation. | Low-sulphur fuels, albeit with limited availability. Exhaust gas scrubbing equipment.<br>Effective engine designs limiting NOx emissions. | Ready supply of low-sulphur fuels. Overall increase in fuel quality. |
| **Air Emissions (Cargo)** | MARPOL Convention Annex VI. Provides limits for VOC's and GHG's with requirements on engines, fuel and operation. | Specific operational means to reduce VOC's from crude oil cargoes by up to 80%. Vapour Return lines for crude oil loading and VOC release. | Limiting VOC discharge during loading and transportation. Widespread use of VOCON procedure. |
| **End of Life Vessels** | IMO Guidelines and Industry Code of Practice on Ship Recycling. | Green passport of Hazardous Materials on board. | Increase recyclability of ships, enhance health and safety management and waste treatment at recycling yards. |
| **Accidental Discharges of Oils and Chemicals** | MARPOL Annex I and II – specifying design criteria for oil and chemical tankers. | Protective location of fuel and cargo tanks. Increased tank segregation. Double hulls. | Use of probabilistic oil outflow methodology. |
| **Loss of Structural Integrity** | Industry Standards and MARPOL Convention<br>• Coating application and location (ballast and cargo tanks) | Goal based approach now being utilised with the IMO becoming more proactive in applying standards as opposed to industry interpretation and application. | Internationally applied minimum acceptable standards for new buildings.<br>Standardised and transparent maintenance and survey |

| Issue | Legislation | State of the Art | Aims |
| --- | --- | --- | --- |
| | • Corrosion margins<br>• Welding standards<br>• Scantling standards<br>• Steel standards<br>• Hull strength | | procedures. |
| **Propulsion Performance** | Emission requirements only (MARPOL Annex VI & Regional Legislation) | Use of redundancy in machinery systems based on risk assessment approach to tanker design. Twin engines, separate engine rooms, twin propeller shafts etc . | Further use of FSA and FMEA in engine and tanker design. |

The list is not exhaustive but provides an overview of some of the more pertinent issues. Further consideration should also be given to operations in extreme conditions, such as ice-class tankers, and navigational requirements, with specific reference to the rise in Particularly Sensitive Sea Areas (PSSAs), as designated by the IMO. The latter will see a host of new navigationally based protective measures imposed on shipping in areas deemed sensitive by way of ecological uniqueness and a high level of risk from shipping related pollution.

## KEY AREAS FOR CONSIDERATION

To rise to the challenge of safer seas and a cleaner marine environment the shipping industry needs to qualify the aspects in which it perceives are future areas of concern and liaise with all the other stakeholders in the maritime community to develop solutions that can be implemented effectively and without further detriment to other safety and environmental aspects of ship operation.

While ship operators and owners identify areas in need of further consideration on an independent basis, there is also the requirement for time and effort to be spent on identifying the overall effects of new legislation. In general, the ship operator benefits from experiencing first hand the manner in which legislation impacts other areas of safety and environmental performance on-board, with one requirement effecting an otherwise unrelated aspect of ship operation, sometimes creating new, previously unforeseen problems. This throws into light the potential use by regulators of risk assessment tools such as net environmental benefit analysis (NEBA) to assess the overall benefit and or impact of any prescribed regulation.

In some respects, an overall list of tanker safety and environmental issues, such as that given above, could be used by those developing legislation in an isolated area by way of a check list on the effects of the legislative solutions on other ship board operations.

As environmental management systems become more demanding and as the continuing upward trend for more environmentally sound transportation continues, it is likely that this method of measurement will be more extensively researched and utilised by the industry. The development of environmental performance models for individual ships may only be a few years away, allowing the operator and legislator to assess where the gaps lie and where improvements can be made to uphold this upward environmental trend.

Naturally this all comes at a price. At present the more advanced ship operator can find reward for more effective environmental management of his ships, however, there is still a need for greater recognition for this in order to sustain the current industry proactively. This recognition needs to come from regulators and charterers alike, but perhaps most importantly, the catalyst for this will be an increase in awareness and understanding from the general public.

**SESSION** **PLENARY 1: FP6 & THE EUROPEAN RESEARCH AREA**

**TITLE** **SESSION REPORT**

**AUTHOR(S)** ***JOHN MARKS***

European Science Foundation, Strasbourg, France.
e-Mail : jmarks@esf.org

## SUMMARY

The concept of the European Research Area (ERA) has been established as a platform to emphasise that a strong European research effort requires a concerted effort of EU funding through the Framework Programme, together with nationally funded research programmes. Only enhanced coordination and a real integration of research activities in Europe can overcome the fragmentation that currently characterises the European research effort. Marine science and technology are a perfect example of a domain where this integrated approach is developing and will bear fruit.

## INTRODUCTION

In opening the Session, Pierre Mathy (DG Research) highlighted changes in the position of marine science and technology in the context of political changes in the thinking about research and development in general at the European level. The role of the new instruments of FP6 in integrating science and scientists was illustrated in the presentation of Adelino Canario (University of the Algarve). José Rizo (DG Environment) showed the importance of close and early interaction between users and scientists in defining the research questions. The need for better coordination of Member State policies with those of the EC was argued by Rudy Herman (Science & Innovation Administration, Belgium), using the example of marine research infrastructures. Finally, Jean-François Minster (IFREMER) put marine science and technology in a global context, arguing that enhanced coordination of European efforts requires a global perspective, as the oceans ignore continental boundaries and marine research both requires and benefits from global co-operation.

## DISCUSSION

The Session yielded several forward-looking recommendations regarding the further strengthening of the European Marine Research Area, the further development of the marine research agenda and the conditions necessary for success.

## Challenges and Opportunities - The European Research Area (ERA)

### 6th Framework Programme (2000-2006)

Marine science and technology has benefited considerably from the successive EC funded research Framework Programmes (FPs). Previous FPs had specific dedicated marine programmes, such as Marine Science & Technology (MAST) and Fisheries & Aquaculture Research (FAR). In the approach chosen for FP6 there is however no dedicated marine science programme. While marine science clearly benefited from all FP6 instruments: the new instruments (Networks of Excellence and Integrated Projects), ERA-NET, as well as the traditional smaller sized projects (STREPs), there is little or no evidence of integration between the eight Priority Themes of FP6. A further concern is that funds allocated to environment related research decreased by 35% from FP5 to FP6. To reverse this trend in FP7 will require the presentation of convincing arguments from the scientific community and the Member States.

The European Research Area concept (adopted in 2000) marks the beginning of a more integrated approach to science and technology in Europe. As a result, FP6 not only addresses EC funded research, but also provides support for the co-ordination of national research. The Lisbon Summit (2000) set the objective that Europe should become "*the most competitive knowledge* *based economy in the world*" by 2010, and clearly identified R&D as an important instrument in this context. The Barcelona Council (2002) set a goal of 3% GDP for the spending on R&D, of which 2/3 should come from the private sector. For marine science and technology it is important that the Gothenburg Summit (2001) added the concept that all R&D should contribute to the sustainable development of the economy and underlined the responsibility for contributing to the research needs of the international environmental Conventions to which the EU has signed up. As a result, the 6th EU Environment Action Programme was adopted in 2002 to promote the integration of environmental concerns in all EU policies. This adds environmental considerations to the strengthening of European competitiveness. The World Summit on Environment and Development in Johannesburg (2002) further amplified the responsibilities of the industrialised countries regarding sustainable development. The greater emphasis on economic goals has nevertheless strongly shaped FP6, with less room for environment related research and fundamental science.

The marine science community has so far been rather successful in FP6, with three Networks of Excellence (NoEs) and five Integrated Projects (IPs) approved (at the time of this conference), in addition to several STREPs. Several projects address the science needs related to the EU fisheries policy, which is an important user of knowledge. As this policy is based on an ecosystem approach, the science involved is mainly basic research.

The research funding agencies have responded to the need for enhanced coordination by successfully proposing ERA-NETs in the field of Ocean Drilling (ECORD), coordination of Baltic Sea environmental research (BONUS) and recently the overarching MarinERA for co-ordination of national marine sciences programmes

## 7th Framework Programme (2007–2011)

Although only halfway through FP6, the development of the FP7 agenda has already begun. Under the Irish Presidency, the Research Ministers decided that basic science should receive increased support in FP7. Basic science is seen as a nursery ground for new ideas and is crucial for training the future generations of scientists. Meanwhile, the EC has proposed a doubling of the research budget for FP7. In a recent Communication, the Commission proposed six axes for the future research policy of the EU:

- *Collaboration*: continuation of the new and traditional FP6 instruments;
- *Technology platforms*: encourage public-private partnerships;
- *Competition in basic research*: bottom up, no themes, peer review processes under control of the scientific community;
- *Human resources development*: enhanced Marie Curie programmes;
- *Research infrastructure*: not only access, but also investment;
- *Enhanced coordination of national programmes*: ERA-NETs, access to Article 169 funding.

All six axes, individually and collectively, are important for creating a strong and effective European Marine Research Area. The marine research community is encouraged to develop ideas for the implementation of these axes from the marine perspective and to bring these to the attention of their National Authorities, particularly those involved in the development of FP7.

Given the new orientation of EC support for research, in arguing for more support for marine research from FP7, the following questions should guide the discussion:

- To which category of users is the topic of importance?
- Is the topic relevant to the public good?
- Should the topic be addressed at the European or at Member State level?

## Marine RTD Priorities

Though this Session focussed less on the identification of new priorities than did some of the other Sessions, the presentations identified examples of user requirements for new priorities and some new scientific challenges.

The main messages outlined include:

- The need to make connections between traditional marine disciplines and other disciplines, giving rise to innovative new science (e.g. marine genomics);
- The need to better address user requirements, (e.g. ecosystem approach in Fisheries Policy).
- The need to re-integrate "policy oriented" research (Priority 8) into the appropriate Priority Themes 1 - 7. For example, relevant policy research related to environment should be located in Priority 6.3. Global Change & Ecosystems.

There is a strong need for a stakeholder driven research agenda. Policies for the preservation, conservation and sustainable use of the marine environment require a scientifically based approach (i.e. the ecosystem approach). The ecosystem approach is defined as the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystems and their dynamics. An important component of the necessary knowledge relates to the development of suitable indicators for ecosystem health. Priority topics for research include the identification of ecological properties that are important to the structure or function of the ecosystem, or to the human uses of it. Because of the limited knowledge of ecosystems, the highly complex character of the processes involved and the limitations of the management systems, it is important to be able to deal with uncertainty and variability. This requires the development of risk assessment and of models through which future scenarios can be explored.

Genomics provides an example of a scientific domain which developed outside marine science and which is introducing important innovations into the marine science research agenda. Genomics is the large-scale analysis of genome architecture aimed at the discovery and identification of the function of many genes simultaneously. High throughput analysis technology and developments in bio-informatics have led to the mapping of the human genome and the genomes of several animal and plant species. Genomics is a potentially powerful tool to study the microbial diversity and functionality of model organisms. The emerging research domain of environmental genomics tries to understand the functional significance of genomic variation in natural communities. In metagenomics, entire ecosystems are treated as a single living organism. The application of genomics in samples from the Sargasso Sea has already given rise to the discovery of 148 previously unknown phylotypes and 1.2 million unknown genes.

In that context, the Marine Genomics Europe Network of Excellence, involving 44 partners in 16 countries and bringing together more than 300 researchers, was profiled as an example of an operational Network of Excellence. It is important that the marine genomics community establishes close links with the various other national and European genomics initiatives, in particular with the aim of sharing infrastructure.

Many of new discoveries in the Ocean frontier are of significant societal importance. The mapping of gas hydrates, for example, and the research necessary to assess their importance in terms of both risk (submarine landslides and subsidence) and as a new source of energy and pharmaceutical products can contribute safety at sea, diversification of energy supplies and new commercial opportunities.

Integrating marine science to address questions of global climate change and sustainable development is another priority. Examples of the research questions that are addressed in this context include the study of low frequency processes in climate variability and the mapping in sediments of palaeoclimate events associated with major changes in the ocean circulation during the last glacial period.

Several identified priorities have already been addressed in the Marine Board-ESF's Position Paper *Integrating Marine Science in Europe (2002)*. As a result of the recommendations of the EurOCEAN 2004 Conference, the Marine Board is in the process of up-dating this strategic document, particularly in the context of identifying priorities to be addressed within FP7.

## What is Needed to Make it Work?

This section is oriented towards a "future look" at the presentations and discussions of the first Plenary Session. Challenges include: What should be done to maximise the contribution of marine science to the needs of society and to the development of science itself? How will it be possible to strengthen the position of marine science and technology in FP7?

## Interaction with Stakeholders in Developing the Research Agenda

EC funding for research is traditionally mission oriented, designed towards supporting EU policies, enabling sustainable development and strengthening the competitiveness of the European private sector. A research agenda addressing these missions is best developed in dialogue with the potential end-users of the research results. This Session illustrated that such dialogue could lead to innovative science. The dialogue should start at the very initial stage of the development of the agenda. The scientific community should not be seen as just trying to sell its agenda to potential stakeholders!

From the presentation of José Rizo, and the discussion that followed, it became evident that in setting up this dialogue, it is important to take into account requirements and activities in related areas (e.g. supporting the implementation of the Water Framework Directive, the Common Fisheries Policy, etc).

The oceans are a rich source of resources, which, if exploited in a sustainable way, could benefit many sectors of society. This means that the design of a research agenda needs to involve 'non traditional' marine stakeholders, such as the pharmaceutical and energy sectors.

## The Role of SMEs

Marine science and technology benefits from collaboration with the private sector and involving SMEs in the development of advanced research equipment creates mutually beneficial opportunities. SME representatives emphasised that this potential was insufficiently realised at present. Other areas where SMEs could play a much greater role include the provision of specialist services. Examples given included the use and dissemination of data collected for research purposes (or operational monitoring) and in the development of engineering solutions, for example for integrated coastal zone management.

## Research Infrastructure

Rudy Herman reported that an estimated 50% of national funding for marine science goes to the development, construction and operation of marine research infrastructures. Very little support for marine research infrastructure is contributed from EU funds. There is a clear need to:

- Support a coherent and strategy-led approach to the common development of major research infrastructures in Europe;
- Facilitate multilateral initiatives leading to a better use and development of existing marine research infrastructures.

These issues are within the remit of the European Strategy Forum for Research Infrastructures (ESFRI), which established an Ad Hoc Working Group to address the situation in the marine sciences - Marine Infrastructures Working Group (MISG). The MISG addressed not only research vessels and other experimental or observation equipment, but also data and information. The MISG Report "European Strategy on Marine Infrastructure" was published by the Academy of Finland (2003) (ref. 6/03). The Working Group formulated four strategic visions for the coming decade:

1. European research vessels and associated marine equipment should constitute a coherent flexible facility that can effectively respond to a wide array of research needs.
2. European waters should be supplied by a network of buoys, profilers and sea bottom observation systems that provide long term coherent data for research and operational purposes.
3. Samples, data, analysis and other information retrieved by European marine scientists would benefit from networks of well-equipped marine centres, including online access to data calibration and quality control.
4. European marine research should be supported by an integrated and interactive web-based information system.

With regard to research vessels, the need for co-operation between smaller coastal research vessels is perhaps as important as for large ocean-going ships (for which collaborative schemes currently exist). A system, adapted for the regional scale, which allows for exchange of ship-time between countries should be developed. At the same time, standardisation of selected technical issues relating to coastal research vessels should be initiated.

With regard to data and information, the need for sustained archiving, ease of access and wide dissemination was emphasised. Ease of access is particularly important for the SMEs interested in developing services.

Addressing the problem of the funding of long-term time series observations of key variables was identified as urgent. The data obtained by long-term observations are of crucial importance to the identification of global change and serve also to monitor the effectiveness of mitigation measures. In this context the contribution to the marine component of the Global Earth Observation System of Systems (GEOSS) and the Global Monitoring for Environment & Security (GMES) initiative is essential for science, policy and economic exploitation. National governments and the EC should enable existing or new operational agencies to take responsibility for this. A major challenge will involve securing sustained funding of the monitoring systems from public and private sources.

## Mobility and Careers

As in other domains of science, many activities within marine research are people-limited rather than limited by the availability of infrastructure or funds. There is an urgent need to educate and support the next generation of marine researchers. This requires above all the creation of career perspectives for young researchers. For marine science, the traditional mono-disciplinary structure of universities' training and facilities imposes undesirable constraints.

With regard to mobility, and in relation to research facilities, there is a need to create a 'market' to link expertise with available facilities. This should be a component of the enhanced co-ordination of national programmes.

## Communication

Several of the presentations addressed the need for enhanced communication. To summarise:

- Scientific advice to policy makers should be clear, direct and relevant to the needs of the users. This requires an interactive process in which policy makers pose tractable questions, and scientists in turn put themselves in the position of the policy maker in trying to respond;
- The public shows a great interest in ocean issues, as is demonstrated by the success of aquaria and various media devoted to the sea. Outreach activities should become a systematic requirement in scientific projects.

## Partnerships and Co-ordination

Many players must contribute to the success of achieving a European Marine Research Area. The marine research community should strengthen, and where necessary develop, new partnerships, including:

- Enhanced co-ordination Between EC Programmes and National Programmes;
- Partnerships with the rest of the world: to fully include the overseas European territories, to develop partnerships with the US, Japan and others to address global marine science issues or to do research in the polar regions, to develop GEOSS, to participate in the international global change research programmes and to include the developing countries in the worldwide research efforts;
- Public-private partnerships for the development of technologies, for the exploitation of data and the provision of services.

Of course, enhanced partnership requires more co-ordination. There has been a rapid increase of the number of co-ordination instruments within FP6: including ERA-NETS, NoEs, IPs, ESFRI etc. The co-ordination efforts are seen as important tools, but they should be easy to handle and should not detract from the research effort. There is a clear need for rationalisation of instruments and approaches.

In general, it was agreed that more flexible instruments are needed to address the challenges identified above. These instruments should be suited to the goals to be achieved.

## CONCLUSION - ACT NOW!

Finally, the participants in the Session concluded that now is the time to influence the development of FP7. In order to make marine science a clearly identified element in FP7, it is necessary to communicate actively with the Member State National Authorities responsible for its development.

## KEY POINTS PLENARY SESSION 1
## FP6 AND THE EUROPEAN RESEARCH AREA (ERA)

- Enhanced co-ordination and integration of research activities in Europe is required to overcome the current level of duplication and fragmentation. Marine research is a perfect example of a domain where this integrated approach is developing;
- The need for better co-ordination of Member States' policies with those of the EC is particularly pertinent with regard to marine research infrastructures (to address standardization, co-operation etc.);
- Enhanced co-ordination of European efforts requires a global perspective, as the oceans ignore continental boundaries and marine research both requires and benefits from global co-operation;
- Communication, partnerships and education of marine researchers are of primary importance; there is a need to make connections between traditional marine disciplines and other disciplines, giving rise to innovative new science (e.g. marine genomics);
- Marine R&D priorities currently being addressed include:
    - ecosystem approach to marine resource management;
    - marine genomics;
    - mapping gas hydrates;
    - global climate change and sustainable development.
- There is a need to better address user requirements and societal needs (e.g. ecosystem approach in Fisheries Policy), to maximise the contribution of marine science to the needs of society and to the development of science itself; A common research agenda has to be established involving all stakeholders, particularly SMEs, this will require:
    - Interaction with stakeholders in developing the research agenda;
    - Involvement of SMEs;
    - Clear planning for marine infrastructure;
    - Clear career structure and enhanced mobility opportunities for researchers;
    - Enhanced communication;
    - Effective partnerships and co-ordination.
- Programme instruments developed for enhanced co-ordination are seen as important, but they should be easy to handle and should not detract from the research effort; there is a clear need for rationalisation of instruments and approaches.
- Marine scientists in Europe showed their collective capacity to build a coherent comprehensive vision of their key scientific, technological and infrastructure issues, expressed in the Marine Board position paper "*Integrating Marine Science in Europe*". The marine research community is encouraged to develop ideas for the implementation of the six thematic axes of FP7 and to bring these to the attention of their National Authorities.

**SESSION** PLENARY 1: FP6 & THE EUROPEAN RESEARCH AREA

**TITLE** **ERA AND FP6 MARINE RESEARCH IN EUROPE**

**AUTHOR(S)** **PIERRE MATHY**

European Commission, Directorate General for Research

Head of Unit I4 'Management of Natural Resources'

## SUMMARY

With the launching of FP6 in 2002 the Commission acknowledged that the issue of fragmentation of research in Europe can only be addressed by introducing new instruments enabling better integration of the research efforts in order to build a real European Research Area. The novelty of FP6 has been then the introduction of what is known now as the 'New Instruments', mainly Integrated Projects (IPs), Network of Excellence (NoEs) and ERA-Nets. With the ERA-NETs and the set of NoEs and IPs covering several key research marine domains, the European Marine Research Area becomes a reality and can be seen as a major contribution to the European Research Area.

## INTRODUCTION

The paper reviews the history of marine sciences in the European Framework Programmes, then reports on the state of implementation of the current Framework programme and indicates what the European Research System could be beyond Framework Programme 6, leaving open for discussion the place that marine sciences and technologies could play within this future System.

## DISCUSSION

Historically, European Community Research goes back to the 1957 EURATOM Treaty. Five successive Framework Programmes took place between 1984 and 2001. Three important steps can be highlighted in the course of this process:

- The first was the adoption, in 1987, of the European Single Act, when science and technology became a Community responsibility.
- The second was when the Treaty of the European Union was adopted in 1993 because with this Treaty, the role of research and Technological Development was acknowledged in the EU, in particular, for fostering economic competitiveness within the context of sustainable development.
- And the third step was the launching, in 2000, of the concept of a European Area for Research and Innovation, followed by the 6th Framework Programme in 2002, to facilitate the implementation of this concept.

From 1984 to 2004, marine sciences and technologies both contributed to and benefited from the successive Framework Programmes. They benefited initially from the MAST and FAIR programmes, then from several key actions in FP5, in particular Key Action 3 "Sustainable Marine Ecosystems", which is still going on, and now, from the implementation of Framework Programme 6 New Instruments.

These successive programmes contributed to the networking of European research potential and led to improving its efficiency and competitiveness, not only in Europe but also on a global scale. In parallel to the development of the European research strategy, progress was made in relation to the development of a European Environmental Policy. Sustainable Development was enshrined in the Treaty of Amsterdam in 1997, with the principle that environmental protection must be integrated into all European policies and activities. In 2002, the 6th Community Environment Action Programme was adopted to promote the integration of environmental concerns in all Community policies and to contribute towards the achievement of sustainable development. Within this 6th Environment Action Programme, 4 priority areas have been identified, including Nature and Biodiversity and Sustainable Use of Natural Resources.

The implementation of the 6th Environmental Action Programme implies the development of several thematic strategies, including one for the protection and conservation of the marine environment "to promote sustainable use of the seas and conserve marine ecosystems". The importance of this strategy was strengthened by the outcome of the World Summit on Sustainable Development, where marine ecosystems, oceans and sea resources have been subject to commitments by the participants, including the European Union. The reason to mention these political developments and commitments, both at a European and international scale, is that a research agenda is attached to them, which should be taken up by the future EU research system at some scale of implementation, either on a national or Community scale.

Coming back to FP5, Key Action 3 "Sustainable Marine Ecosystems" covered a broad range of topics. The many posters in the EUROCEAN 2004 exhibition illustrated how these topics are handled and which kind of deliverables are expected from the individual projects. However, in Europe the production of new knowledge and services is hampered to a very large extent by a structural fragmentation of the research potential which leads to unnecessary duplication of work and scattered research initiatives. This is the reason why, in FP5, the Commission pushed forward the idea of clustering research projects, and for Key Action 3, this led to the setting-up of several clusters with well-known acronyms. The rationale for these clusters was already very similar to the one which presided over the design of FP6, that is to say: the development of synergies between research actors, the setting-up of the conditions for a better response to societal needs and policy-making requirements, and overall, the improvement of the competitiveness and the efficiency of the European RTD system. But the Commission acknowledged that the issue of fragmentation can be solved only partly with this clustering approach and this is one of the reasons why the concept of the European Research Area was developed and implemented in particular through the 6th Framework Programme.

The ERA objectives are not to be separated from the broader political objective of the European Union to become the most competitive economy in the world. This ambitious objective set up at the Lisbon Council in 2000 has implications for the European Research System and this has constantly been repeated by Europe's political leaders, until the Commission pleaded for a serious increase in EU global expenditure on research. This was at the Barcelona Council in 2002. The need to overcome fragmentation is at the heart of the ERA concept. This issue can only be resolved through a better co-ordination and beyond that through a real integration of research activities in Europe.

The novelty of FP6 has been the introduction of what is known as the 'New Instruments', mainly Integrated Projects (IPs), Network of Excellence (NoEs) and ERA-Nets. At the mid-term stage of the Framework Programme's implementation, several NoEs and IPs have already been selected in the field of marine science and technology. Among those selected early on are the MARBEF and MARINE GENOMICS EUROPE projects. More recently the NoE EUR-OCEANS, the IPs HERMES, CARBOCEAN and MODELKEY have been selected and are being currently negotiated.

A number of Specific Targeted Research Projects (STREPs) have also been selected, covering a broad range of issues, including some projects of direct relevance to the EU Fisheries Policy, which, is an important end-user of knowledge, in particular with the progressive development of the so-called 'Ecosystem Approach'.

Several ERA-NETs have also been selected. These projects will play a key role in integrating national or major research programmes, either on a topical basis, such as ECORD, the European Consortium for Ocean drilling, which has already nested itself in the International Ocean Drilling Programme IODP as an integrated European Initiative, or on a regional basis, such as BONUS which aims at integrating the Baltic Sea Science Networks through the networking of relevant Funding Agencies. MARIN-ERA, the last project selected and still to be negotiated will aim at co-ordinating national and regional programmes in Europe on a broader basis. With the ERA-NETs and the set of NoEs and IPs, the European Marine Research Area becomes a reality.

A field where progress has still to be achieved is that of Marine Research Infrastructures. During the past two years, the European Strategy Forum for Research Infrastructures, set-up to advise the European Union on how to co-ordinate development and facilitate access to research infrastructures, has promoted the development of a European strategy, through its WG on Marine Infrastructures. The Marine Research Community and the national funding agencies should seriously consider this issue and use the opportunities offered by EU Framework Programmes to develop and start implementing an integrated research infrastructure strategy. This goes hand in hand with integration of the human potential and the development of integrated research projects, NoEs and programmes.

Within Framework Programme 6 two more calls for proposals will be published within the Thematic Priority “Global Change and Ecosystems”. As far as Call 3 is concerned, the contribution of marine sciences and technologies will again be sought in the form of New Instruments. The Commission will also call for STREPs in two scientific and technology fields relating to the Ocean. The detailed scientific content and the modalities of this 3rd call will be published following the same modalities as for the first two calls in the coming weeks.

A 4th call will be designed this year for publication in 2005. The S&T content of this call is still not known. This will depend in particular on the coverage of the Programme’s initial orientations, a coverage which depends also on the results of the first calls, taking account that Marine Sciences and Technologies are competing with many other research domains, within this Thematic Priority. The recent developments will also impact upon this 4th Call, in particular the GMES and GEO initiatives and the welcoming by the Member states of the Communication of the Commission on the Environment Technology Action Plan.

Beyond FP6, the Lisbon objective of improving growth and competitiveness, which includes the strategy for sustainable development set-up in Gothenburg in 2002, and also the many international and regional agreements to which the Union has subscribed, will drive the future environmental research agenda of the European Union, not only with regard to its science and technology content but also with regard to the instruments that will be used. The question is to know how to design a research system which takes fully into account this political agenda, building upon what has been done up to now and amplifying the developments of the ERA. A step further would be to design a system which would lead to the establishment of a real European Science and Technology Policy. And within the context of the EUROCEAN 2004 conference, the question is also to know how and why marine sciences and technologies could or should contribute to this process.

In order to answer these questions, recent developments have to be taken into consideration. The first development is the Commission Communication on an Environmental Technology Action Plan, issued in January 2004. This Action Plan is to foster the development of technologies aimed at reducing pressures on natural resources, improving the quality of life and stimulating economic growth. In a way this Action Plan allies the Lisbon objective of economic growth with the Gothenburg requirements for sustainable development. This will certainly impact upon the future EU research system in fields such as aquaculture, pollution prevention and mitigation.

The second development is the publication in February this year of a Communication by the Commission entitled “Building our Common Future”, which sets orientations for the political objectives of the European Union after 2006, and also for the financial perspectives of the Union after 2006. This communication re-affirms the Lisbon objective of competitiveness for growth and employment and the need for strengthening the European Research System in view of achieving this economic objective. Once again, the principle of Sustainable Development is re-affirmed in this Communication.

The communication contains also strong and explicit references to the sustainable management and protection of natural resources, a principle that has to be at the heart of future developments of important EU policies such as those for agriculture and rural development, fisheries and environment. It is obvious that a strategic research agenda should help further developments of these common policies and that important activities, also listed in this communication, such as the implementation of the EC Climate Change Programme, the thematic strategies and the development of a Biodiversity Action Plan should be considered when identifying the topical content of the future EU research and development system.

Finally, the very last development is the recent publication of another communication by the Commission, which is in line with the previous ones and provides orientations for future Research Policy in Europe. This communication will serve as a foundation for drafting a proposal by the Commission for the 7th Framework Programme in the coming months. Six axes, based on implementation instruments, not on research topics, but on implementation instruments, have been identified by the Commission for the future EU research system. Some of these axes are a continuation of what will have been set up within FP6: the consolidation of collaborative research, mainly through Integrated Projects and Networks of Excellence, the development of human resources and the co-ordination and opening of research programmes through ERA-NETs or other means are certainly to be maintained as a way of achieving some further steps on the path to European Research Policy development.

The Commission also suggests the development of new instruments. A novelty would be to encourage public/private partnerships at European level in innovative technology fields. This is the concept of a ‘Technology’ or ‘Technological Platform’ which is currently being developed, with the ambitious objective to gather all the stakeholders in a given technological area, including the research actors and the end-users, for designing technological development objectives and a related research agenda. These could be implemented later on through research initiatives to be funded from various funding sources, not only the Framework Programme since the idea is to go for a true partnership approach.

A second novelty will be the setting-up at European Union level, of a mechanism for funding basic research on a competitive basis. This mechanism would address research projects suggested by individual scientists or individual research teams. The only selection criterion will be scientific excellence and the selection will be done via a peer-review system.

And finally, the research infrastructure initiatives should be strengthened by mechanisms which would not only allow access to and the networking of infrastructures as in the past, but also the design and the funding in common of new infrastructures, mobilising resources not only from the Framework Programme but also from the other public or private funding bodies

## CONCLUSIONS

Assuming that science can be driven either by science itself, or by industrial requirements, or by the policy-making process, or by any other kind of users, the test to find out why a topic should be on the agenda of the future FP is to respond to three independent criteria:

- For which category of user(s) is the topic important?
- Is the topic in question relevant to Public Good?
- Should the topic be considered at Community level, for reasons such as its link to one or more Community policies, because of its dimension, which requires the putting together of huge resources, because of its geographical scale, or because if we consider it at Community level, there will be economy of scale, etc. In other words is there a Community added value?

If these questions receive convincing answers, then environmental research, in general, and marine sciences and technologies in particular, should receive adequate support in the next framework programme of community research. It will imply a proactive approach during the preparation of FP7 by the scientific community and the Member States’ authorities to demonstrate that this research needs to be carried out in a European framework and that European competitiveness will be improved by doing so.

**SESSION** PLENARY 1: FP6 & THE EUROPEAN RESEARCH AREA

**TITLE** FP6 NOE MARINE GENOMICS MANAGEMENT AND CO-ORDINATION

**AUTHOR(S)** *ADELINO V M CANÁRIO[1] AND CATHERINE BOYEN[2]*

[1]Centre of Marine Sciences, University of Algarve, Faro, Portugal
[2]Station Biologique, UMR 7139/CNRS-UPMC-GOEMAR, Roscoff, France

## SUMMARY

MARINE GENOMICS EUROPE (MGE) is a Network of Excellence devoted to the development, utilisation and spreading of high-throughput genomic approaches for the investigation of the biology of marine organisms and the functioning of ecosystems. For this purpose it incorporates and networks experts in genomics, proteomics, and bioinformatics from several Centres of Excellence with marine biologists who can make use of high-throughput genomics data. This involves the dedication and the development of common research infrastructures, both in genomics and in marine biology, and a common programme of research. The MGE research programme is broken down into Comparative, Functional and Environmental Genomics, three sections which structure more traditional themes which include microbial, algal, evolution development and diversity, and fish and shellfish nodes. This research can be applied to the management of marine resources (prediction of global changes in marine populations, conservation of biodiversity, fisheries management and improvement of cultivated species) and to gene mining for health and biotechnology. Activities are integrated under common strategies which allow the joint development of enabling technologies, the sharing of existing technical platforms, collectively gaining access to major European genomics centres, the regrouping under a common Bioinformatics Centre and the development of a web-based interface for communications within and outside the network. Spreading of knowledge is carried out through the organisation of workshops, courses directed at the scientific community as well as complementary dissemination activities targeting public, private and institutional communities.

## INTRODUCTION

Genomics is defined as the large-scale analysis of genome architecture, aimed at the discovery and study of many genes simultaneously. Conceptually it can be divided into Comparative, Functional and Environmental Genomics. Comparative Genomics essentially consists of examining whole genome structure, gene arrangement and rearrangement, with the aim of delineating the evolution of gene families, the molecular basis of adaptation (including the identification of genes potentially involved in niche adaptation) as well as the evolutionary relationships at various taxonomic levels in the Tree of Life. Functional Genomics comprises the development of genome-wide or gene-related experimental approaches to assess the biological and biochemical roles of open reading frames of unknown function and provides unprecedented insights into gene regulation. Environmental Genomics deals with the understanding of the functional significance of genomic variation, the basic unit of biodiversity, in natural biological communities. This includes the use of various genotyping approaches to delineate the structure of inter- and intra-specific biodiversity, as well as the Metagenomics approach, which treats entire ecosystems as a single living organism and involves the cloning and functional analysis of very large DNA fragments from uncultured organisms.

Marine organisms represent the largest and widest phylogenetic diversity on earth and as such they are a major challenge for molecular research teams, at a regional, national or international level. Using molecular approaches, marine biologists are now able to address key ecological questions with a level of resolution never attained by previous methods. For example, it is possible to use molecular probes directly on field samples, either to assess the level of genetic diversity of specific marine populations or to determine their nutritional regimes (prey identification). In fact genomic approaches are essential in marine biology since conventional genetic analyses are not accessible for most marine organisms, especially in microbial communities. In this respect, Environmental Genomics offers revolutionary analytical tools for tapping the vast, undiscovered genetic potential (including new functions) of the Oceans[1]. The availability of high-throughput, low-cost sequencing and the derived technologies also indicates that many marine biologists can now envision the day when the complete genome sequence of their model organism, or a proxy thereof, will be available in electronic databases, from which they will be able to investigate (and possibly exploit) the function of particular genes or groups of genes. Indeed, the genomes of several marine organisms - bacteria, Archaea, cyanobacteria, prochlorophytes, the diatom *Thalassiosira pseudonana* and the ascidian *Ciona intestinalis*, have already been completed, and many others, including vertebrates, are close to completion. In spite of this, the marine environment remains very little explored at the genomics level by European researchers.

It appears therefore it is a crucial time to launch a major effort to incorporate genomics into marine sciences, particularly into fundamental and applied marine biology. In this statement the term "genomics" is viewed in the widest sense, i.e., the development and use of a variety of gene-based technologies, including not only sequencing and genotyping but also transcriptomics and proteomics. Genomics high throughput approaches will considerably increase our knowledge of the biology of key organisms fundamental to the functioning of marine ecosystems. This is a prerequisite to understanding how these systems will react to predicted climate changes. Genome data will also be very useful for better husbandry of those marine species which are a source of food (e.g., salmon, oyster, shrimps and macroalgae) in order to promote better cultivation practices as well as to prevent economic losses resulting from disease. Finally, genome data on marine organisms will provide renewed access to marine biodiversity, which can then be tapped at the gene level for biotechnological applications.

## DISCUSSION

### MGE scientific structure

The MGE scientific structure is organized as a cross-fertilization between genomics approaches and components of the marine ecosystem (Figure 1). The vertical structure of MGE (Comparative, Functional and Environmental Genomics) addresses different levels of understanding relevant to marine biodiversity and ecosystem structure. Comparative genomics explores a limited but comprehensive number of model organisms that cover broad phylogenetic and ecological ranges. It will allow the determination of how fundamental cellular processes are conserved, in particular those relevant to the functioning of ecosystems (uptake of nutrients, cell growth, cell division, sexual reproduction, response to stress). Functional genomics focus on the detailed working of these key processes and should be directly applicable to areas such as process modelling (better parameterisation of elemental transfers) or management of ecosystems (e.g. development of biosensors). Finally, Environmental Genomics is concerned with the function of biodiversity, especially in microbial communities, and the structure of natural populations of marine organisms with respect to neutral markers and functionally adaptive genes.

The horizontal structure of MGE is defined by nodes (Microbes, Algae, Evolution Development and Diversity, and Fish and Shellfish) and covers the most essential players of the marine ecosystems from the base of the food web to the top, exploited species. MGE specific contribution is to provide new tools for the sustainable management of natural resources, including protection and exploitation of genetic resources. For example, the high-throughput genetic markers arising from genomic studies (such as single nucleotide polymorphisms) can be adopted as new tools, both for the monitoring and management of fisheries and the selection of improved genotypes in mariculture.

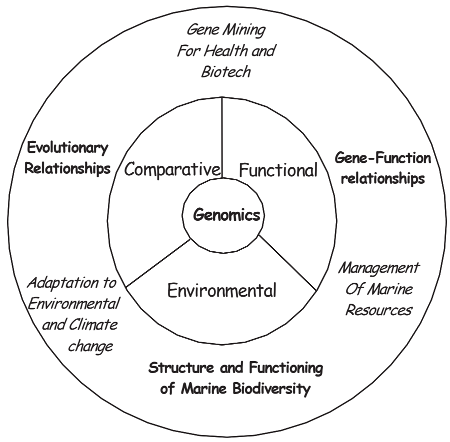



*Figure 1- Implementation and potential impact of genomics in marine science. Joint research activities appear in bold and applications in italics*

## MGE Management

The MGE Joint Programme of Activities is embedded in an overall management framework, helping in the leverage of integration and the decisive achievements in Jointly Executed Research (JER). In order to facilitate the decision making processes, in particular those relating to the adaptation of JER programmes and evolution of the network, a set of steering or advisory bodies has been put in place. The strategic and scientific management of MGE is ensured by the Scientific Steering Committee. This committee is in charge of the definition of the JER programmes and monitoring of the expected achievements. The implementation of research activities is under the responsibility of genomic sections (Technological Platforms, Bioinformatics Platform, Training and Education Council, Nodes). A Training and Education Council is in charge of the definition and implementation of training and teaching activities, inside and outside of the network. An advisory Intellectual Property Use and Dissemination Committee (IPUD) ensures that MGE develops a shared and harmonized approach to knowledge transfer and dissemination. Finally, an advisory Scientific Council includes external experts in marine biodiversity and ecosystems to help the network to identify new opportunities and to have an independent review of its achievements and future direction of science.

## MGE contribution to the ERA

Research on the biology of marine organisms has been for the last 150 years a field of excellence in Europe. Marine biologists have incorporated various technical and methodological revolutions linked to the advancement of physics, chemistry, biochemistry, molecular biology, statistics and computer sciences and this has ensured a continuous output of basic knowledge in the understanding of marine ecosystems and the management of marine resources. Several marine model organisms relevant to cell biology (cancer, apoptosis, ageing, etc.), neurobiology (giant axons in squid) and developmental biology have also contributed to the advancement of biomedical research. Compared to other fields, however, the community of marine biologists in Europe remains fragmented, with the results that European marine biologists have benefited less from the genomic revolution than researchers in other fields such as health, plant and animal sciences. It is also apparent that Europe is lagging behind the USA and Japan in the genomics of marine organisms. Of the more than 1.5 million Expressed Sequence Tags from eukaryotic marine organisms that have been released, less than 10% came from Europe. Similar conclusions can be drawn when looking at the marine prokaryotic and animal genome sequences. Today no individual European group in marine biodiversity and ecosystems research has the necessary critical mass, scientific expertise and technological resources to become a leading contributor at the global level. Thus, pooling of resources and objectives is required for Europe to overcome fragmentation and become a world force in the new and rapidly evolving "omics" sciences.

This situation affects European competitiveness for knowledge and technology transfer towards potential end-users, notably in the economy. For example, the exploitation of marine diversity in Europe for the discovery of new biotechnologies has also lagged behind the USA and Japan. In the USA, newly set up companies tap the metagenomic environmental libraries for the discovery of biomolecules useful in agricultural, pharmaceutical, chemical and industrial applications. Because so few (0.001-0.1%) marine micro-organisms have been cultured, genomic approaches are the method of choice for bioprospecting. The development of metagenomic approaches to studying the microbial component of marine communities in MGE not only provide unique insights into taxon diversity and ecosystem function but will also provide a rich source of biomolecules of social and commercial importance. However, a larger and concerted effort in this area is required at National and European level.

MGE will enable the European Research Communities in genomics and marine biodiversity to assemble around a shared pool of technological resources and a knowledge portfolio. It will also provide European researchers in marine biology with a unique network of novel scientific and technological resources as well as with a framework for the harmonisation of their own research. Hence, not only will MGE lead to a "a cross-fertilization" between the genomists and marine biologists, it will also result in a marked and long-lasting integration of the marine biology community.

By enforcing an improved coordination of research policies and major investments, MGE will directly contribute to reshaping the research capacities of marine biology across Europe. As the need for and the advantages of subsidiarity gradually become more and more obvious, the community of marine biologists in Europe will rely more and more on platforms, resource centres, and integrated activities. In particular, we envision that as marine genomics approaches are implemented, the various European research institutions which deal with the biology and ecology of key species and ecosystems, will need to discuss their policies collectively and to agree on the emergence of stronger nucleation points. In the long term, MGE should be able to convince these Institutions that there is a need for more complementarity and specialisation at the pan-European scale, involving, at the national level at least, the relocalisation of resources and staff.

## ACKNOWLEDGEMENTS

The contents of this abstract are largely taken from the Description of Work of the MGE Network of Excellence and therefore the authorship is extended to all those actively involved in setting it up. MGE has the financial support of the Commission of the European Union, Sixth Framework Programme, under priority 1.1.6, Sustainable Development, Global Change and Ecosystems (contract Nº GOCE – CT-2003-505403).

## REFERENCES

Venter, J. C. et al. Environmental genome shotgun sequencing of the Sargasso Sea. *Science* 304, 66-74 (2004).

**SESSION** **PLENARY 1: FP6 & THE EUROPEAN RESEARCH AREA**

**TITLE**

# EUROPEAN STRATEGY FOR THE PRESERVATION AND THE CONSERVATION OF THE MARINE ENVIRONMENT. KNOWLEDGE REQUIREMENTS

**AUTHOR(S)** ***JOSÉ RIZO***[1]

European Commission, DG Environment, Water and Marine Unit;
jose.rizo-martin@cec.eu.int

## SUMMARY

The European Commission has been requested to present, before May 2005, a proposal for a new Thematic Strategy for the protection and the conservation of the Marine Environment. This Strategy has to include an assessment of the current situation and the available instruments as well as proposals for the future. After the publication of a Communication (2002) setting the scene, the European Commission has launched an exercise that will lead to the formulation of the proposal for the Strategy. This exercise is not closed, although adopting the Ecosystem Approach appears to be one of the main elements of the Strategy. The implementation of such an approach cannot be done without important contributions from the Scientific Community. The Commission hopes that this contribution, already present, will continue and be strengthened in the future.

## INTRODUCTION

The 6th Environmental Action Programme of the Community[2] sees the conservation and the protection of the marine environment as a complex issue that requires a broad and multidimensional approach. It mandated the European Commission to consider the range of options and instruments required to assure such conservation, as well as to propose the necessary actions. In 2002, the Commission adopted the Communication Towards a strategy to protect and conserve the marine environment[3], which marks the first step in the preparation of the Strategy.

The Communication presents a first assessment of the adequacy of measures taken for the protection of the marine environment vis-à-vis the threats and pressures exerted on it. Although some significant improvements in the quality status of European seas have been realised, a large number of problems have yet to be fully addressed and major threats still persist and the situation requires new actions.The reasons for this include:

- The complex legal situation within and outside EU.
- The institutional and legal complexities of marine protection, since numerous bodies are involved with (partly) overlapping mandates and geographical scope.
- The existing gaps in knowledge and the weak link between research needs and research priorities.

[1] The views expressed are purely those of the writer and may not in any circumstances be regarded as stating an official position of the European Commission.

[2] DECISION No 1600/2002/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 July 2002 laying down the Sixth Community Environment Action Programme, *Official Journal L 242 , 10/09/2002 P. 0001 - 0015*

[3] COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT "Towards a strategy to protect and conserve the marine environment", COM(2002)539

## RECEPTION TO THE COMMISSION'S PROPOSAL. PREPARING THE STRATEGY

Although the approach, objectives and actions proposed were generally endorsed, the Council and the Parliament stressed some elements that the Marine Strategy should contain. In particular, the Strategy should:

- Be based in an integrated holistic policy approach, with a set of ambitious, clear and coherent objectives, quantitative and qualitative targets and timetables to be used as benchmarks to measure and evaluate progress;
- Develop guidance on the implementation of an ecosystem approach;
- Recognise the need of regional approach;
- Take account of all human activities that are having or could have an impact on the marine environment.

In addition, the reactions to the Communication showed considerable consensus that the Marine Strategy should cover not only Community waters. Particularly important was in this respect the endorsement of the exercise by Regional Conventions (OSPAR, HELCOM and Barcelona). As a result, the Marine Strategy is now intended to cover all European waters.

After the first round of institutional reactions, the Commission set up a number of groups to further elaborate on the issues of the Strategy, under the oversight of the Water Directors of Member States. These groups are open to the participation of representatives of EU Member States and Regional Marine Conventions as well as of experts from NGOs and from other concerned institutions. Their outcomes will be utilised by the Commission to prepare its proposals.

## WHAT THE STRATEGY IS LIKELY TO BE

Although the contents of the strategy are still under discussion, the elements that have been taken into consideration to date include.

1. First of all, the request to adopt an integrated and holistic view is to be met by using the Ecosystem Approach, which becomes a true cornerstone of the Strategy. The Commission is at present using the definition agreed in the Conference held in Koge in 2002, "the comprehensive integrated management of human activities based on best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of the marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity".
2. Secondly, two audiences are targeted, the European Union and all the countries bordering European Seas. In this respect, the challenge is two fold:
   - The Strategy should comprise an approach common to all areas, since Member States of the European Union are bordering all European sea areas and many common or transboundary problems require common solutions;
   - At the same time, it should recognise the need for regional specific approaches to address specific problems;
3. Thirdly, at present, the Commission considers proposing a legal instrument to introduce this new approach.

## THE ECOSYSTEM APPROACH, CORNERSTONE OF THE PROPOSED STRATEGY

The key element of the Strategy is the shift towards an integrated and comprehensive approach to the management of human activities affecting the marine environment. This approach is to be proposed for use by actors and sectors drawing goods or services provided by the marine environment. The EA emphasises the role of complex, dynamic ecosystems as critical natural capital assets whose functioning must be conserved.

A number of attempts have already taken place to implement integrated approaches into the management of activities taking place in specific ecosystems. Most advanced is the implementation in the fields of marine ecosystems, freshwaters and forestry. The adoption and the implementation of the EU Water Framework Directive has been of paramount importance. For marine ecosystems, various regional agreements have produced transboundary management concepts focussed mainly on the protection of species and habitats.

The choice of this approach leads to a formulation of the Strategy based in a Vision and Strategic Goals. The vision for the Marine Environment is that "*we and generations to come can enjoy biologically diverse oceans and seas that are clean, healthy and productive*". The Strategic Goals, common across all areas, all uses and all sectors being discussed at present are:

1. To protect and restore the function and structure of marine ecosystems in order to achieve good ecological status of natural systems.
2. To ensure that levels of contaminants and radionuclides in the environment do not give rise to significant impacts on or risks to human and ecosystem health.
3. To ensure sustainable use of all services and goods which have an impact on status of the marine environment.
4. To promote good environmental governance both within Europe and globally.

Although the guidance document to implement the approach is still being elaborated, some of its main elements are likely to include the:

- collection of ecological, socio-economic and institutional information,
- definition of goals and priorities, (including reference points),
- formulation of action plans to reach these goals,
- monitoring the results of the actions (including indicators),
- learning and integration of findings into the decision making process.

### UNCERTAINTY AND COMPLEXITY

The difficulties in applying integrated and holistic approaches to the management of human activities have been acknowledged many times and are due, in part, to the inherent uncertainties and complexities associated with the evolution of ecosystems.

It is a fact that knowledge about the ecosystem has limitations. In addition, the ability to measure processes that are associated with high variance may not be enough. Moreover, management systems are not precise. Learning to handle uncertainty and variance and how to take account of both in policy development and management is still required.

The Commission recognises the need to improve such knowledge, as well as the mismatch between the very abundant (but fragmented) knowledge available at present and the complexity of the situations to manage. Thus, the application of the precautionary approach is more needed than ever. More risk assessments are needed to underpin our decisions. Risk-Management has two important dimensions, the uncertainty and the time horizon. What, in a short time perspective, might pose a low risk might be very risky in the medium to long-term perspective. In this respect, more information about the long-term cumulative effects of human activities and pressures on the marine environment is therefore required. In this context, the knowledge about interactions and ecosystem structure and functions and the need to elaborate models able to explain past events and foresee or explore future scenarios should be underlined.

### KNOWLEDGE REQUIRED BY THE IMPLEMENTATION OF THE STRATEGY, SOME HINTS

## Monitoring and Assessment

It is not be possible to over-exaggerate the importance of assessment and monitoring activities in the successful implementation of an ecosystem approach. Firstly, by providing a sound scientific basis for identifying Ecosystem Objectives, selecting Indicators, and identifying reference

Points, and then, by allowing regular evaluations of the marine and measuring progress towards achievement of Ecosystem Objectives.

Once the suite of Ecosystem Objectives and their associated Indicators and Reference Points have been selected, it is through systematic monitoring and periodic assessment that feedback is received on how well the Objectives are being met. If implemented correctly, this approach should link closely with, and make fullest practical use of, existing and planned monitoring programs.

The importance of producing and making use of historic trends of ecosystem components is to be emphasised. Such data will be most effective when they are empirically based or, at least, based on theories for which there is broad consensus across the relevant scientific disciplines. A highly relevant topic is the development of appropriate indicators that, at the same time, describe the dynamic performance of ecosystems and are useful for managers. There are at present many sets and collections of indicators. The Strategy should contribute to cleaning and consolidating what already exists and, at the same time, pushing for new developments in this essential field.

### Scientific advice

The scientific advice must be clear, direct, and relevant to the needs of the entire governance processes. Policy-makers and managers must interact with scientists to pose tractable questions and requests for advice, in order for the scientific community to be able to address the questions asked, and provide answers that will actually be of help in the management process.

### Ecological regions

The Marine Strategy would be implemented at a regional scale, in eco-regions. Whereas some Ecological Objectives and actions could be the same in all areas or at all geographical scales, other ecological objectives would apply at other scales. Selection of eco-regions should take into account bio geographic (i.e. composition of faunal communities and patterns of primary production) and oceanographic features (depths, tidal and ocean currents, temperature or degree of seasonal stratification), as well as existing political, social, economic and management divisions. Definition of eco-regions should also take account of the links between the marine and terrestrial environment, including patterns of land use and distribution and density of human populations.

### Research

Basic knowledge is needed to support the implementation of the Ecosystem Approach. For instance, more research on the following elements would be helpful.

- Ecosystem Objectives: how to set, support and achieve them, in a scientifically consistent way.
- Indicators: how to construct effective indicators reflecting the Ecosystem Objectives.
- Limits: where to put them to prevent irreversible harm and, at the same time, support sustainable use.
- Impact of individual human activities for ecosystem components, structure and functions.
- Cumulative impacts of multiple activities, and the interactions of natural variation with consequences of human activities.
- Performing risk assessment and preparing scenarios.
- Mitigation measures and their effectiveness.

## CONCLUSION

The Commission would like the Strategy to give a new emphasis to marine environmental research. The implementation of the Strategy will require Member States to make use of currently existing knowledge or to produce new knowledge. In fact, there has been Community funded research in a number of fields covering elements likely to be put forward by the Strategy. In the future, all European means, either national or those funded by the Community, will be required to pay greater attention to the knowledge about the marine environment if the Strategy is to be successfully implemented. The Commission trusts that the Community action plays an important role in this implementation.

**SESSION** **PLENARY 1: FP6 & THE EUROPEAN RESEARCH AREA**

**TITLE** **MARINE RESEARCH INFRASTRUCTURES - NEED FOR A BETTER CO-ORDINATION.**

**AUTHOR(S)** ***RUDY HERMAN***

Science and Innovation Administration, Boudewijnlaan 30, B-1000 Brussels, Belgium.
Tel: +32 2 553 6001, Fax: +32 2 553 5981,
E-mail: rudy.herman@wim.vlaanderen.be

## SUMMARY

Europe has sizeable marine and coastal resources which are observed, studied and monitored by means of a variety of sophisticated and expensive marine research infrastructures. The optimal use of, and access to these research facilities are a prerequisite to a successful European Research Strategy. The Commission's European Research Area (ERA) initiative is stimulating Members States to join efforts and to contribute also - often in a regional context - to the establishment of a European Marine Research Area, EMRA. This will underpin the networking and help to identify and plan co-ordination for future needs.

## INTRODUCTION

The member states and the successive commissioners, responsible for Research and Technological development, addressed an increasing attention to research infrastructures in general in the preparation of the frame work programmes. The fact is that the larger infrastructures are very expensive in development and in maintenance for individual member states. This resulted in the establishment of the European Strategy Forum for Research Infrastructures (ESFRI) in order to improve the co-ordination of a better use and access of research infrastructure in general.

For the Marine sciences in particular, most of the member states spend approximately 50 % of their funds on the development, the construction and the operation of marine research infrastructures.

The main result of the EU marine RTD-activities is the stronger and still growing co-operation of the Marine Science Community in a larger framework. Only a very small part of the EU RTD-funding went to Marine Research Infrastructures. Another very positive outcome is that Marine Science Institutes have been active to organise themselves: e.g. the Marine Board of ESF, EUROGOOS, EFARO, EVRO, and several initiatives at Regional Sea level.

In April 2003 an ad hoc Working Group on Marine Research Infrastructure (MRI) was appointed by the ESFRI. The Working Group reported on the 'hot topics' with regard to MRI that need to be addressed in order to improve the current situation, and thus provide material conditions for the development of the marine science within the European Marine Research Area.

## DISCUSSION

### A European Strategy on Marine Infrastructure

The MRI- working group, composed by members mandated by the Member States, looked into the existing and planned larger marine research infrastructures together with possible needs in research infrastructures, taking into account the already formulated recommendation from major conferences organised by the commission in the last years (Strasbourg 2000, Hamburg 2000) and the effort made by specific working groups (e.g. ESF/Marine Board, 2002).

The MRI-working group fully supports and endorses the recommendations contained in the ESF-Marine Board Report "Implementing Marine Science in Europe" (2002). This ESF-MB report has the full potential to act as a framework to build on a European Marine/Ocean Research Policy.

The Working Group's result is reported in 'A European Strategy on Marine Infrastructure' (Anon., 2003) wherein four strategic visions for the coming decade are formulated with respect to:

- European research vessels and associated marine equipment;
- An European network of buoys, profilers and sea bottom observation systems;
- Networks of well equipped marine centres, including on-line access to data, calibration and quality control procedures;
- A European integrated and interactive information system.

Furthermore the MRI-working group recommended the establishment of an overarching co-ordination structure. This platform will contribute to the establishment of the EMRA.

Additionally to the MRI Working Group work an e-conference was organised to collect the views of different stakeholders: Policy oriented (Science managers), Operators (ships & other platforms) and infrastructure users (scientific communities, services in charge with monitoring).

## The electronic conference

The introduction of the new funding instruments 'Integrated Project' (IP) and 'Network of Excellence' (NoE) in FP6 is characterised by the stronger networking of very performing institutes. Several member states adapted their science policy by pooling highly qualified institutes and sometimes new possibilities were offered. The problem is that one has to invest in very large infrastructures, and that these may not always meet the requirements or expectations of the marine science community.

The e-conference (26 - 30 April 2004) was a co-operation between the Flanders Marine Institute and Science Policy Administration with the collaboration of EurOcean, ESF/Marine Board and IOC/UNESCO (Herman et al., 2004). Three topics have been considered:

1. Bottom up approach: what does the Marine Scientific Community expects from optimising MRI and perspectives related to new developments; Input into the decision making process; improving co-ordination and collaboration, with a view to optimise the use.
2. Rationalisation of information. Optimise by integration of information and avoid duplication. Several NoE and ERA-nets have similar work packages. Some of the deliverables need action beyond the competence and possibilities of the single activity. Need for a single platform with is integrating information, data and services.
3. New technologies: What could be expected from new technologies + their needs for information, data management and products & services?

The scientific community recognizes that the **new instruments** within FP6, such as '**Networks of Excellence**' and **ERA-NET**s (Marbef, Marine Genomics Europe, Bonus, MarinERA), will play an essential role in developing infrastructures and infrastructure standards. The funding of these new developments may come from pooling existing nationally funded infrastructures to obtain a minimal critical mass - also at an operational scale - and the joining of funds from Member states and the EU for new infrastructures and their operation and use, including education and training. When there is enough political will to bring together these different financial resources, an improved planning of the development and use of MRI at mid- to long-term scales could be secured. '*Get the bottom-up right and good top-down will follow*' (Keith Hiscock, MRI e-conference 2004) is a valid statement, since knowing and involving the key players who can contribute their experience and knowledge to the development of infrastructures makes that it will work and become a de facto standard.

Special attention was given to **small research vessels** (RV's). These are generally considered to be very important and specific infrastructure facilities in marine science. The larger ocean going RV's are subject to different collaboration schemes between several member states (Anon.2003). The role and the importance of coastal research vessels in Europe are not very visible, although their number is 90+. The need for co-operation between smaller coastal research vessels is as high as that for large ocean going ships. A system - preferably adapted for the regional scale - that allows for "exchange" of ship time between countries would increase mobility, co-operation and the use of facilities.

The suggestion to standardise selected technical issues of the coastal sea RV's facilities as one of the objectives of EU marine research development plans was well received. An initial step towards the standardisation of these coastal RV's is to identify how, when and where they operate. Standardisation of RV's would be beneficial for scientists but necessitates a clear unambiguous definition. At least, research and other data generated using small RV's should be comparable.

Another important issue is the use of **coastal stations** as bases for long term observing and monitoring activities and networking in Europe. These stations are very cost effective in carrying out specific types of research, and they constitute a perfect basis for establishing links with local stakeholders and for public awareness building. The latter aspect is very important, since communicating science to the public at large and to the classrooms becomes a challenging task. MRI can play an important role in making this communication more attractive, being a focal point in a participative approach, where new technologies, research, education and information interact.

One emerging new way to do science in the **deep sea** floor is to install long-term observatories equipped with multidisciplinary arrays of new (to be) developed sensors. These will furthermore have to be maintained on a regular basis. This calls for a programme of planning cruises and the use of large marine facilities.

A lot of attention was given to **taxonomy**-related issues, such as the lack of human resources (taxonomic expertise) and the need to apply the latest techniques for imaging and species categorisation to improve automatic species identifications. Analysis of taxonomical data will have to be automated too, although visual identification remains a very difficult and complex task.

## Need for a European focal point for information

Discussions on 'Rationalisation of information: Integration of information, data and services' revealed the need for a **single platform**. This requires a more complex architecture than an 'ocean portal' alone. The FP6 new funding instruments partly meet this requirement. Internet tools are very attractive, but even more important is to bring the people together. Several NoE's and ERA-NETs have highly similar work-packages. There is a need to avoid duplication and to optimise efforts by integration of information. Some of the deliverables need actions beyond the competence and possibilities of the single activity. The efforts that have been undertaken for a long time at national, European and international levels for the implementation of oceanographic data centres and the organisation of data exchange have to be acknowledged. But it is important to make a distinction between marine (or oceanographic) data centres and marine (or oceanographic) information centres.

The **management of information** has not been recognised as a priority until quite recently. Access to information on marine science and technology in Europe, particularly in the domains related to marine infrastructures and national programmes, should be facilitated. At this moment access to this information - when it exists - is difficult and dispersed. Standards are also missing. We would highly benefit from a European focal point for information, where end-users have easy access to coherent, reliable and updated information. In addition to this, information technology and information management is the appropriate approach to weave the links between the operators of the infrastructures and those developing the policy.

## The integration of development countries

Europe committed itself to be active in supporting sustainable development. For MRI, the Commission needs to work out specific measures to increase participation and to support the sharing of MRI when partners from third countries participate in projects. It is very important that more attention is to be given to the integration of development countries. In order to optimise the efforts, this should be done in close collaboration with ongoing initiatives in an international context (e.g. ESF, ICES, IOC, UNEP). Examples from such a multilateral co-operation are IOC's 'Training through Research' and the 'ODINAFRICA' programme (http://ioc.unesco.org/).

## CONCLUSIONS AND RECOMMENDATIONS

It is clear that the Commission's goal to establish the European Research Area is well received by the Member States and the scientific community at large. The Marine science community has already undertaken some important initiatives to build on the European Marine Research Area. The position paper "Integrating Marine Science in Europe" (ESF/MA, 2002) and the 'European Strategy on Marine Research Infrastructure' (Anon., 2003) may be considered as milestones in this respect.

It is essential, however, that further elaboration on the funding instruments - and in particular the 'ERA-NET' and 'Network of Excellence' concepts - is to be an integral part in the further development of a European Marine/Ocean Policy. Clear strategic goals and well defined criteria for each of the instruments must procure the solid ground to formulate priorities with respect to the development and use of Marine Research Infrastructure within the European Marine Science plan.

In order to improve the development and the use of Marine Research Infrastructures, the following may be considered for the next framework programmes (FP7 and beyond):

- Small research vessels are very important and specific infrastructure facilities in marine science. They could be operated by preference at a regional scale. Criteria to meet a number of technical standards need to be developed at a pan-EU scale.
- Coastal research stations can and should be revaluated.
- Issues related to long term monitoring (for coastal as well as for the deep ocean) should be dealt with: requirements for new technology, installation, maintenance, long term financing, data management and exchange.
- Integration of MRI in the communication strategy towards education and the public at large is recommended.
- Human resources are part of the marine 'infrastructures'. Attracting young scientists in marine science is essential.
- Better management of information is required for: 1) sharing knowledge and experience efficiently; 2) developing scientific dialog across countries and continents.
- Integration of information, data and services revealed the need for a single platform, overarching the initiatives within the new instruments

## ACKNOWLEDGEMENTS

I acknowledge the assistance of my MRI electronic conference colleagues Jan Mees and Laurent d'Ouzoville for discussing the issues addressed in this paper. Also I thank Ward Vanden Berghe and in particular the board manager Ward Appeltans and the MRI e-conference participants for their contributions.

## REFERENCES

Anon. (2001). Navigating the future: towards a Marine European Research Area. ESF Marine Board Position Paper, 3. European Science Foundation, MB: Strasbourg, France. ISBN 2-912049-21-10. 12 pp.

Anon. (2003). European strategy on marine research infrastructure. Publications of the Academy of Finland, 6/03. Academy of Finland: Helsinki, Finland. ISBN 951-715-455-0. 42 pp.

Boissonnas, J., Connolly, N., Mantoura, F., d'Ozouville, L., Marks, J., Minster, J.-F., Ruivo, M., Vallerga, S. (Ed.). (2002). Integrating marine science in Europe. ESF Marine Board Position Paper, 5. European Science Foundation, Marine Board: Strasbourg, France. ISBN 2-912049-35-0. 148 pp.

Herman, R., Mees, J., d'Ozouville, L. (eds) (2004). Electronic conference on 'Marine Research Infrastructures (MRI): The need for better Information and Co-ordination', 26-30 April 2004 - Final report. VLIZ Special Publication, 18. Flanders Marine Institute (VLIZ): Oostende, Belgium. iii + 20 pp.

SESSION PLENARY 1: FP6 & THE EUROPEAN RESEARCH AREA

# TITLE MARINE SCIENCES IN THE GLOBAL CONTEXT

AUTHOR(S) *JEAN-FRANÇOIS MINSTER*

Ifremer – Chairman of the Marine board
Tel : 33 (0)1 46482287, Fax : 33(0)146482248
E-mail: jminster@ifremer.fr

**THE ISSUE OF MARINE SCIENCE IN THE EUROPEAN CONTEXT IS DESCRIBED HERE BY SEVEN KEY MESSAGES.**

## Message 1: Marine sciences and technology have made very important progresses and discoveries in the recent years, in which European scientists actively contributed.

Every marine scientist has his preferred examples. Here are some:

- the mapping of major gas hydrate reservoirs and the assessment of their importance has been achieved ;
- major events of the changing ocean circulation during the last glacial period have been assessed;
- biotechnological products are now commercialised derived from molecules produced by marine bacteria;

## Message 2: Marine Sciences and technologies are a very lively discipline, as new visions and challenges have emerged.

Such are the role of picoplancton and bacteria in primary production, or the concept of the ecosystemic approach to fishery management…

## Message 3: European Marine Scientists have developed a collective capacity to build a coherent comprehensive vision of key scientific, technological and infrastructure issues.

The ESF Marine board position paper (Integrating Marine Science in Europe, November 2002) identifies the main drivers of Marine Sciences, new scientific issues on all major subjects, as well as on new technologies, marine infrastructures and observatories.

The fact that most ongoing marine science projects funded by the 6$^{th}$ framework program were described in this position paper demonstrates its quality.

## Message 4: Marine Sciences and technology are very open disciplines, which benefit from progresses in many other fields.

Examples are the dramatic evolution of life sciences, the continuous improvement of laboratory instruments, the explosion of information technologies, the continuous increase of computer capacities and the potential of numerical modelling. All these development are at the source of major evolution of marine sciences. Any future program should help increase the transfer of such new development to marine sciences.

## Message 5: Socio-economic activity linked to the ocean is essential to Europe. It requires knowledge, innovation, and continuously improved public policies.

It is to note that the added value of direct socio-economic activities at sea, excluding leisure, exceeds 70 billion Euros; that it is more than doubled by indirect activities; that, in many European countries, it is dynamic and growing faster than the gross European product. Research and technological development are at the origin of new activities, like marine biotechnologies, operational services or offshore renewable energy…

## Message 6: The public shows a great interest in ocean issues throughout Europe.

As an example, the European large aquarium drew together more that 4 million visitors each year. A recent poll among such visitors demonstrated a deep concern about marine resources and environmental issues, a demand for more information on scientific knowledge, and a request for improved education on the ocean at the school level. Outreach activities must systematically be included as one dimension of marine science projects.

## Message 7: The European dimension is key to Marine Sciences, socio-economic activities and maritime policies.

It is clear that the ocean ignores national boundaries, and that marine science issues require the assemblage of knowledge and tools beyond the reach of national programmes. It is worth remembering that the market for socio-economic activities at sea is essentially world-scale. Nearly all public policies dealing with the sea and presently handled at the European scale.

The 7$^{th}$ framework program is a unique opportunity to establish a marine initiative and help build the Marine Science European Research area.

**SESSION** **THEME 3: NATURAL AND ANTHROPOGENIC IMPACTS ON COASTAL ECOSYSTEMS**

**TITLE** **SESSION REPORT**

**RAPPORTEUR** ***YVONNE SHIELDS***

Marine Institute, Ireland

E-mail: Yvonne.Shields@marine.ie

## SUMMARY

This Session consisted of 4 presentations. Keynote speakers Laurence Mee (University of Plymouth, UK), Peter Herman (Netherlands Institute of Ecology) and Kerry Turner (University of East Anglia, UK) focussed on Integrated Coastal Zone Management. Teresa Pontes (INETI, Portugal) focussed on the ocean as a source of renewable energy.

## INTRODUCTION

Europe's coastal and associated marine regions support a diverse range of economic, social and cultural activities. Coastal zones are under heavy pressure from both land-based and maritime activities. Up to 85% of Europe's coast will experience moderate to high economic development in the near future; 25% of Europe's coastline is subject to erosion. Development pressures coupled with the dynamic aspects of the coastal zone and ubiquitous anthropogenic impacts, including global climate change, present a significant challenge to policy makers, planners and residents of coastal areas. Such pressures also present challenges to the research community in terms of integrating scientific, social, economic and technological issues that are required to implement an integrated coastal zone planning and management framework.

Over the past 10 years the EC has supported several ICZM related R&D projects, including those within the framework of the ELOISE (European Land-Ocean Interaction StudiEs) research projects cluster (funded through FP4, FP5 and FP6). The ELOISE projects cluster consists of research projects and assessments addressing land-ocean interactions at the European scale. Knowledge outcomes from the ELOISE projects ultimately contribute to the development of improved policies for coastal zone management. In addition, ICZM demonstration projects were supported via the LIFE and PHARE programmes.

## DISCUSSION

Arising from this body of research, the following specific operational, management and R&D challenges have been identified:

### Challenges:

1. At an **operational level**, there is a need to:

- Identify the management implications of the volume of existing data and information;
- Compile consistent and detailed databases at catchment level;
- Improve the spatial resolution of databases of coastal ecosystems;
- Link data archiving and predictive modelling with EC policy and Directive requirements (e.g. those of the Water Framework Directive WFD and the EU Marine Strategy);
- Apply atmospheric deposition models in an operational context and use these models to improve the evaluation of nutrient dynamics in coastal ecosystems;

- Develop regional indices of vulnerability across Europe.

2. At a **management** level, there is a need for:

- Recognition of the diversity of forms which contribute to the European coastal zone; there is no single European coastal zone;
- A thorough evaluation of the balance between different nutrient sources and processes to support the designation of sensitive areas;
- Enhanced understanding of how physical changes affect coastal dynamics.

3. In terms of **R&D priorities**, there is a need for:

- In-depth knowledge of the processes affecting carbon and nutrient dynamics, including the development of operational models for carbon and nutrient delivery to the coast; evaluate the consequences for coastal ecosystem functioning and biodiversity;
- Enhanced understanding of the structure and functioning of coastal food webs; develop predictive models for different food webs and anthropogenic impacts;
- Enhanced interdisciplinary research requiring unique methodologies to generate unique information; efforts to develop appropriate coupled models, incorporating not only physical, biogeochemical and biological aspects, but also ecological economics and social models;
- Research to predict trajectories for recovery and rehabilitation of habitats and ecosystems;
- Increased emphasis on developing technologies to harness renewable energy sources - for example wave and tidal energy - and to develop a better understanding of both the environmental impacts and the positive synergies and benefits that can arise from technology focused developments in the coastal zone.

To move forward, the Session identified a need to build on what has been achieved to date and to embrace new ideas and concepts that will enhance society's ability to address the particular and dynamic challenges of ICZM and sustainable development.

## CONCLUSIONS

Issues identified during the discussion included:

- The importance of addressing ICZM in an interdisciplinary context, recognising uncertainties and the linkage between social, economic and natural sciences, particularly to support policy development at the European level;
- Development of interdisciplinary research teams should be characterised by excellence and enhanced dialogue both within and between teams;
- The need for improved economic and social data, comparable across European countries;
- As part of the important contribution of ecological economics to ICZM, research is needed to evaluate the non-commercial role of marine resources in the European economy;
- Formal risk assessment is not feasible in the coastal environment. Increased use of foresights and scenario testing would offer insights into possible future environmental and socio-economic developments, contribute to reducing uncertainties and assist in policy development.
- If Europe is to support the development of technology driven sectors such as offshore wind and wave energy in coastal areas, more research will be required to identify sustainable development options. Potential synergies and environmental benefits remain unexplored;
- Finally, important points were raised by a contributor from the floor who asked: Is there a need to invent new policy development tools? How does the scientific community accommodate the need for institutional innovation and change?

In summary, to achieve successful ICZM, the EC, national governments, local agencies, industries and coastal communities must attempt to integrate the results of economic, social, environmental and technological research to adopt a more complete, valid and reliable framework and set of tools to support policy and decision making.

## EUROPEAN LIFESTYLES AND MARINE ECOSYSTEMS PROJECT

The recently started *European Lifestyles and Marine Ecosystems (ELME)* FP6 project was presented as an example of a project that will focus on large-scale issues. It will model the likely consequences to the marine environment of a number of plausible scenarios for European development in the next 20 to 30 years. A major aim of the project is to facilitate the development of a new capability for modelling across social, economic and ecological scales in Europe. This enhanced capability will improve the ability to support the integration of marine and coastal conservation into future EU policies. It will also assist with the identification of targeted research projects at the regional and local scale.

## KEY POINTS THEMATIC SESSION 3
## IMPACTS ON COASTAL ECOSYSTEMS

- The coastal zone is an area of intense use, subject to both maritime and land-based influences;
- ICZM research has to be addressed in an interdisciplinary manner to integrate scientific, social, economic and technological issues that are required to develop and implement an ICZM operational framework;
- In adopting an interdisciplinary approach, the ICZM research community should integrate their assessment of biogeochemical cycles, models, food webs, ecological economics etc. to ultimately develop a more reliable framework to support policy and decision making;

### Enhancement of ICZM research requires:

### Operational Support to Address

- Standardisation of databases; the identification and provision of integrated social, economic and ecological data;
- Development of coupled models, incorporating ecological economics, particularly in support of European policies and Directives;
- Development of regional indices of vulnerability;
- Improvement of ecological economics methodologies, adapted to coastal zone issues;

### Management Support to Address

- Uptake and use of knowledge of coastal dynamics, ecosystem functioning and recovery capacity etc:
- Scenario development and testing;

### R & D Priorities to Address

- The development of models for nutrient and carbon delivery to the coast; evaluate consequences for coastal system functioning and biodiversity;
- Structure and functioning of coastal food webs; predictive models for different food webs and anthropogenic impacts;
- Interdisciplinary efforts to develop appropriate coupled models;
- Modelling of habitat vulnerability and recovery potential;
- The evaluation of the non-commercial aspects of marine resources to the European economy;
- Development of foresight scenarios to assist the policy process;
- Development of technologies to harness offshore wind, wave and tidal energy.

**SESSION** **THEME 3: NATURAL AND ANTHROPOGENIC IMPACTS ON COASTAL ECOSYSTEMS**

**TITLE** **MARINE AND COASTAL CONSERVATION: AN ACHIEVABLE GOAL IN A NEW EUROPE?**

**AUTHOR(S)** ***LAURENCE MEE***

Marine and Coastal Policy Research Group, School of Earth, Ocean and Environmental Sciences, University of Plymouth, Plymouth, PL4 8AA, Devon, UK
Tel: +44 1752 233719, Fax: +44 1752 232406
E-mail: lmee@plymouth.ac.uk

**SUMMARY**

Rapid expansion of the European Union is fundamentally changing the macroeconomy, demography and governance of our society. The future state of the European marine environment is intrinsically linked to these changes but there has been little research to asses the linkages and predict changes. Stochastic modelling and scenario building offer possibilities to overcome this knowledge gap. A new FP6 project, European Lifestyles and Marine Ecosystems, is described that will explore these techniques on a Pan-European scale. The approach is exemplified for the Black Sea, currently recovering from massive eutrophication in the 1970s and 1980s. Unless accession of Danube Basin countries to the EU is accompanied by new agricultural practices, the return of the Black Sea's 'dead zone' is predicted.

**INTRODUCTION**

On 1 May 2004, the European Union underwent a huge expansion, embracing an additional ten countries; its area increased by a quarter, its population by a fifth and it will become the world's biggest trading block. With the incorporation of Romania and Bulgaria scheduled for 2007, the EU's population will rise to over half a billion people. The huge changes required to manage the new Union will affect the lifestyles of all of its inhabitants. New goals and methods for food production, new industrial standards, new freedoms of movement and revised measures for protecting the environment are among the changes that are already underway. With so many policy reforms however, it is easy to overlook the fact that they will share major responsibility for the Baltic, North Sea, NE Atlantic, Mediterranean and Black Sea. The integrity of marine and coastal ecosystems is inextricably linked with development on the land. Unfortunately, many of these linkages are poorly understood and, without a better knowledge base, there is a real danger that the prerogative for marine environmental protection will be inadequately addressed in the implementation of framework directives such as those for agriculture (the Common Agricultural Policy), industry (the Chemicals Policy), for waters (the Framework Water Directive) and for fisheries (the Common Fisheries Policy).

In developing new policies (such as the European Marine Strategy) for managing Europe's seas, there will be a need for information that bridges social and ecological scales. This requires multidisciplinary 'big picture' research that has previously been under-represented in support from funding Councils. The new Framework Six project *European Lifestyles and Marine Ecosystems*, described in this paper, will help to reduce this knowledge gap.

**DISCUSSION**

## The challenge to science of sustainable development

Though the term *Sustainable Development* (SD) has been championed as a basis of sound policymaking throughout the world, it has many contrasting definitions. Turner (1993), for example, has described it as "*the maximum development that can be achieved without running* *down the capital assets of a nation which are its resource base”*. This base encompasses man-made capital $K_m$, natural capital $K_n$, human capital $K_h$ and moral capital $K_c$. Though some specialists regard these forms of capital as interchangeable, this would imply that the partial loss of natural capital (habitats, wildlife, etc.) is an acceptable way of achieving growth in human and man-made capital, provided the total resource base remains constant. Those advocating “hard” sustainable development require each form of capital to remain constant, a goal that may be incompatible with growth in economies or population. The pathway chosen between these two very different interpretations of sustainability depends upon individual and collective values and worldviews and defies current scientific interpretation. Furthermore, as Ludwig et al (1993) have pointed out, many different interpretations of the past and predictions of the future are possible, based on historical information, since it is impossible to apply the scientific method by conducting controlled and replicable experiments on large-scale systems. Additionally, the response of systems to change is often non-linear, resulting in sudden or catastrophic change that is difficult to predict.

Equipped with this knowledge, scientists must approach the issue of sustainable development with some humility; data-hungry deterministic simulations and predictions used for natural resource management have suffered many failures. Sustainable development is best seen from an interdisciplinary and probabilistic perspective in which uncertainties are recognised and the linkage between social and natural sciences are an intrinsic part of research design. Research can examine a number of alternative hypotheses and predictions (expressed as empirical relationships and scenarios) and gradually reduce uncertainties.

The state of Europe’s marine environment depends on a chain of events in which the primary drivers are social and economic. For example, in order to inform policies to prevent overfishing, it is not enough to assess the short term maximum sustainable yields of individual fish stocks. Additional factors to be taken into account include ecosystem alterations through pollution, habitat loss and climate change, economic yield, price structure and subsidies, fishing community social structures, predominant attitudes and worldviews. Many of these factors are poorly studied and beyond the ‘comfort zone’ of specialists training in a single discipline. In some cases a system can be modelled as a whole but not as the sum of its individual components.

## The ELME approach

European Lifestyles and Marine Ecosystems (ELME) is a recently approved (1 January 2004) Framework Six project with the following overall objective: *Through improved understanding of the relationship between European lifestyles and the state of marine ecosystems, ELME will model the consequences of alternative scenarios for human development in post-accession Europe on the marine environment.* The project involves 27 institutions from 14 countries encompassing a wide range of specialities in natural and social science. It covers all of Europe’s regional seas (Baltic, North East Atlantic, Mediterranean, Black Sea) and focuses on four key issues:

- Habitat and species loss (as a result of physical destruction),
- Eutrophication,
- Chemical pollution, and
- Unsustainable extraction of living resources.

Initial priority region/issue combinations are shown in Figure 1. These are the result of a Delphi scoring exercise amongst a group of ELME participants and agree well

| | *Habitat loss* | *Eutrophication* | *Pollution* | *Unsustainable Fisheries* |
|---|---|---|---|---|
| **NE Atlantic** | 3 | 3 | 5 | 5 |
| **Baltic** | 2 | 5 | 4 | 4 |
| **Black Sea** | 4 | 5 | 2 | 4 |
| **Mediterranean** | 5 | 2 | 2 | 4 |

Priority: 5 = highest, 1 = lowest ◇ Selected for module 1

Fig 1: Ranking of issue/region combinations with independent analyses conducted in the framework of ELOISE (2004, in press).

The basic approach of ELME is (1) to study the immediate and deeper economic and social causes of the key problems on a catchment-wide scale (the relationship between socio-economic drivers, environmental pressures and state changes, following the DPSIR nomenclature), (2) to examine how social and economic drivers will change as a consequence of enlargement of the EU and other large scale policy processes, (3) to model the likely consequences to the marine environment of a number of plausible scenarios for European development in the next 2-3 decades. The overall methodology is described in Figure 2. The project is divided into six Task Teams (Work Packages) dealing with the four key issues, macro-economic and policy drivers, and overall modelling. During the current year, work is focussing on the priority region/issue combinations shown on Figure 1. The experienced gained and initial modelling results will then allow the Task Teams to extend coverage to all issue/region combinations and complete the 'big picture' analysis. Year three will be dedicated to scenario modelling and the analysis of regional and EU-wide policy implications. At every stage in the process, close contact is being maintained with the stakeholders – potential user groups of the information such as the regional seas commissions, the European Environment Agency and the Commission itself as well as leading non-governmental organisations. This is a two-way relationship as these stakeholder hold much of the information needed for ELME to complete its work and are the ultimate beneficiaries of the research.

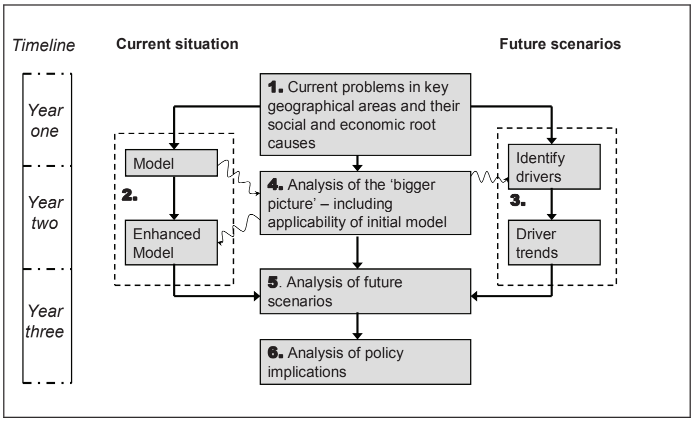



Figure 2: Overall methodology for ELME

## An example from the Black Sea

In the early 1970s, there was a catastrophic collapse of the huge benthic red algal (*Phyllophora sp*) ecosystem that dominated the NW shelf of the Black Sea. From the same time a hypoxic "dead zone" appeared on the shelf every summer with increasing area and duration. This caused massive mortality of benthic organisms, resulting in severe ecological and economic impacts. Both phenomena were consequences of eutrophication and, amongst other factors, this was related to increased application of fertilisers, particularly in the 11-

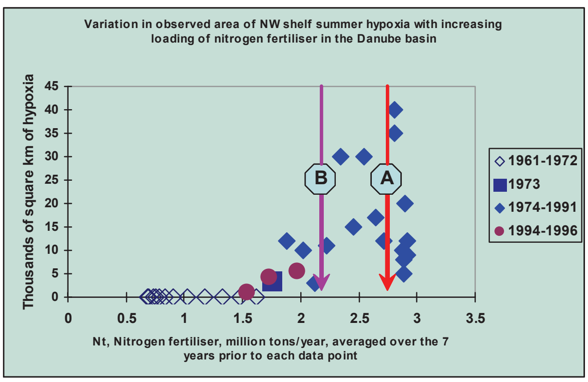



Figure 3: Relationship between hypoxia and fertiliser usage

country Danube basin during the 'green revolution' from the 1960s to the 1980s (Mee, 2001). A decade later, in the period from 1989-91, centrally planned economies collapsed in several of these countries, resulting in a prolonged period of economic chaos. This led to a sharp reduction in fertiliser applications (farmers had no capital to purchase them) and from 1996 (with one exception), the summer dead zone has disappeared - though the red algal beds have yet to recover. Of the 11 Danube countries, Austria and Germany are long-term EU Member States, four (Slovakia, Slovenia, Czech Rep., Hungary) joined on 1 May, 2004 and a further two (Bulgaria and Romania) will join in 2007. This will bring most of the agricultural production in the basin into the domain of EU legislation. Will this change favour continued recovery of the Black Sea?

To answer this question, historical information was gathered on fertiliser usage in the Basin, nutrient discharge from the Danube (data available since 1988), the scale of hypoxia and possible future scenarios for farming within the revised Common Agricultural Policy. There was a strong correlation ($R^2$ = 0.82) between total inorganic nitrogen discharge and the nitrogen fertiliser application, provided this is averaged for a seven year period prior to the year used for comparison. This makes sense, as some pathways for nitrogen to enter surface waters (e.g. via groundwater) are very slow. A plot of this smoothed fertiliser data against occasional measurement of the area of the 'dead zone' in summer, reveals a threshold for dead zone occurrence at about 1.7 M tons, corresponding to the situation in 1973 and 1996. Figure 3 shows the plot and the results of two tentative scenarios: Scenario A assumes equality in post accession fertiliser application rates in all states but with no net increase in total usage from 2001. Scenario B assumes a fixed maximum nitrogen surplus of 50 Kg/Ha (this is quite optimistic). Both scenarios would result in a return of the dead zone. If this is to be avoided, careful attention must be paid to reducing nitrogen surpluses by further improvements in agricultural practices.

## The research contribution to policy

The above example from work in progress shows the practical value of empirical modelling. The ELME project will provide an opportunity to explore such approaches more fully and to develop a new capability for modelling across social and ecological scales in Europe. Information from clear and transparent scenarios should facilitate the integration of marine and coastal conservation into future EC policies and Directives.

## REFERENCES

Ludwig, D., Hilborn, R., Walters, C. (1993) Uncertainty, Resource Exploitation, and Conservation: Lessons from History. Science 260:17, 36.

Turner, R.K. (1993). Sustainable environmental economics & management. Belhaven, London.

Mee, L.D. (2001) Eutrophication in the Black Sea and a basin-wide approach to its control. In: Von Bodungen, B. and K. Turner, (Eds.) Science and Integrated Coastal Management. Proc. Dahlem Workshop, 12-17 December 1999, Berlin. 71-94.

**SESSION** **THEME 3: NATURAL AND ANTHROPOGENIC IMPACTS IN COASTAL ECOSYSTEMS**

**TITLE** **BIOGEOCHEMICAL CYCLES AND THE MANAGEMENT OF COASTAL ECOSYSTEMS: A PERSPECTIVE FROM ELOISE RESEARCH**

**AUTHOR(S)** ***PETER M.J. HERMAN AND VINCENT ESCARAVAGE***

Netherlands Institute of Ecology (NIOO-KNAW), Centre for estuarine and marine ecology, p.o. box 140, 4400 AC Yerseke, The Netherlands
E-mail: p.herman@nioo.knaw.nl

## SUMMARY

In this presentation, we identify R&D efforts in order to improve our fundamental understanding of the ecological functioning of coastal ecosystems. On the one hand, more in-depth knowledge is needed of processes affecting carbon and nutrient dynamics, as well as on their relation with coastal food web structure and functioning. On the other hand, more knowledge of an interdisciplinary nature is needed to couple physical, biogeochemical and biological processes, and to develop appropriate coupled models. Finally, coupling of atmospheric deposition, river, estuary coastal and ocean models is needed for integrated assessment of scenarios. In order to make current knowledge operational, there is a large need in upscaling the often spatially scattered knowledge to assessments at the European level. Optimal strategies as to a) provide the necessary high-resolution databases and b) make predictions more process-based and less data-dependent have to be made. Operational models based on current state-of-the-art can be developed for nutrient and carbon delivery to the coast, and for the consequences of this input for coastal system functioning and biodiversity. Such models should provide the necessary regionalized indices of vulnerability to loading across Europe, as a basis for policy-making. Important management implications stressed in this review concern the (sub)regionalisation of nutrient emission rules. Physical conditions, background nutrient levels as well as organization of the food web have a profound influence on vulnerability of coastal systems. A second point concerns stoichiometry. There is not a single determining nutrient for the coastal ecosystems. Nutrient policies should take nutrient balances explicitly into consideration. Environmental policy should be integrated into agricultural, planning and economic policies, as well as in fisheries and aquaculture policies, and we largely have the tools to do so. Finally, physical changes in coastal ecosystems affect ecological functioning fundamentally, and much physical damage can only be solved at a European policy level.

## INTRODUCTION

Over the past years, the EU has supported many Research and Development projects in the framework of ELOISE (European Land Ocean Interaction StudiEs). The general purpose of this framework was to support high-quality research that could also support better policies for coastal management. Undoubtedly, with several hundreds of publications, the support of high-quality research has been extremely successful. It is impossible to even nearly summarize all the exciting research results obtained by ELOISE projects. In this presentation, we look at the resreacht from the coastal zone management perspective. What has ELOISE research contributed? We consider only management questions at a European level. Undoubtedly, many of the projects have also been very useful to assist in local management of specific areas. This contribution to society is often delivered by individual scientists, and is further reinforced through educational activities. However, policy at a European level deals with different questions, and we want to concentrate on those findings that could cause changes in these policies. As a second restriction, we focus on questions in the mid-range future. We will not address immediate problems, e.g. of the Water Framework Directive, although also here considerable contributions have been delivered. Finally, we concentrate on problems related to nutrient and carbon fluxes and their fate in coastal ecosystems. Even with these restrictions, the available material is overwhelming, and we necessarily present a rather idiosyncratic selection.

## DISCUSSION

### Nutrient inputs into the coastal zone

For atmospheric deposition, well-tuned mesoscale models are available, mostly validated on the North Sea region. The application of these models in an operational way (i.e. linked to meteorological models and to databases of emission sources) is well possible, as well as the use of the models to evaluate the relative importance of different sources. Further R&D efforts are needed to couple atmospheric deposition models to ecological models in the sea. Significant inputs are often related to short-term temporal and small spatial scales, and their effect depends strongly on the state of the ecological system (nutrient versus light limited). Management relevance of these efforts are in particular the designation of sensitive areas of emission (with respect to their effect of atmospheric nitrogen deposition at sea), as well as evaluation of different emission sources in this respect.

For transport of nutrients to the coastal zone from the watershed along the river continuum, two types of modeling have been used. Statistical modeling, combined with deterministic groundwater movement modeling, has been used to predict the changes of nutrient transport by larger rivers as a consequence of changed land use practices. It has been shown, among others in the RANR project, that reliable predictions of changed nutrient delivery are possible by this method, but it is very data-intensive and is, at least in principle, sensitive to changes in system functioning. Fully deterministic modeling has also been developed. The INCA project, for example, has made a generic model for N delivery by watersheds. The project has covered several hydrologically different watersheds in Europe, and developed a considerable validation base. Combined modeling of phosphorus, nitrogen, silicate and organic carbon forms is aimed at in the Riverstrahler model, used in several ELOISE projects. This model puts more emphasis on nutrient and carbon transformations within the river system, and attempts to be dependent on generally available statistics only to make it easily applicable to many rivers.

Major R&D efforts are still necessary to produce reliable and generic models for the (stoichiometrically coupled) transformations and delivery of nutrients and carbon by river systems, valid throughout Europe. Large variations in edaphic, hydrological and human-use related parameters are found across the continent, and it remains a major challenge to cope with this variability in a generic modeling. Also the biological transformations in riparian zones, headwaters and lowland rivers need to be better understood in order to improve model performance. A coupling of the dynamics of different nutrients and carbon in the models is absolutely necessary to 'feed' estuarine and coastal models with the correct input.

Apart from research needs, making models operational at a European scale is hampered by input data availability. The compilation of consistent and rather detailed databases per (sub)watershed is needed. This could in principle be achieved through the water framework directive.

Management implications of the current knowledge are diverse. Crucial points in nutrient emission policy, that can be evaluated using available tools, relate to the spatial distribution of the use and emission of nutrients. Spatial planning within watersheds (e.g. the conservation of riparian zones, the use of water storage basins) can strongly influence the nutrient emission to the rivers. Spatial planning between watersheds (depending on soil type, groundwater systems, inclination etc.) can also result in different output. The physical structure of headwaters and small rivers influences the intensity of the biological processes in the system. The distribution of nutrient use in agriculture (small-area-high-productivity versus large-area-low-productivity) influences the output of nutrients from watersheds. Purification of urban wastewaters can be weighed against measures taken in agriculture. This knowledge may lead to a more diversified and better targeted spending of efforts in reducing the risks of eutrophication, both in freshwater and coastal waters.

## Carbon and nutrient cycles in estuaries and coastal seas

The projects BIOGEST and EUROTROPH have studied carbon and nutrient cycles in estuaries and coastal zones (especially plumes). The emission of carbon dioxide and other greenhouse gases from estuarine waters in Europe is significant in comparison with anthropogenic emission. Estuaries, in general, are heterotrophic systems: respiration of allochtonous organic matter exceeds local primary production. The rest of the coastal system is generally autotrophic, and forms a source of organic matter to the ocean.

The difficulties in estimating and extrapolating carbon cycles of coastal systems have been demonstrated by the study of subsystems dominated by benthic primary production (seagrass, saltmarsh, mangrove, microphytobenthos). These subsystems, although occupying a small proportion of the surface of the coast, are responsible for a very high proportion of the total primary production. They have also been demonstrated to affect nitrogen cycles significantly, since uptake of nitrogen and storage in long-living tissue dominates (and eventually excludes) denitrification in 'vegetated' sediments. Because of the skewed area-productivity relation, database needs to produce reliable (global) upscaling of carbon (and nutrient) budgets are very large and currently not met, not even in Europe.

Not only in this example, it appeared that the 'classical' view on nitrogen dynamics in coastal systems was far too simplistic. Not only have new processes been discovered (e.g. anaerobic ammonium oxidation), but also the balance between different sources and processes (role of organic vs. inorganic nitrogen, denitrification versus uptake and storage, $N_2O$ production through nitrification and denitrification, nitrogen fixation and its regulation) has been shown to need re-adjustment. We currently lack models that incorporate these changed views on nutrient dynamics in coastal areas, and much research is still needed.

The importance of physical-biological coupling at different scales, ranging from the smallest turbulent eddies to entire coastal ecosystems, has been studied in the projects NTAP, PHASE, OAERRE. Physical mixing is a driving factor for interactions between planktonic organisms, for benthic-pelagic coupling and for coast-sea interactions. The latter is a key parameter determining the vulnerability of coastal ecosystems to eutrophication.

It is clear that, with respect to carbon and nutrient cycles, important R&D subjects remain open for further study and model development. Especially the link between the cycles of carbon and (different) nutrients, and the incorporation into models of recently acquired knowledge, is a major topic for research. This is needed for a better global upscaling of coastal processes, for a better prediction of changes due to anthropogenic stress, and for a better evaluation of vulnerability of coastal systems.

At an operational level, there appears to be a great need for better spatially resolved databases of European coastal systems. Much knowledge exists, but use of these data for upscaling carbon and nutrient budgets requires consistent databasing with high resolution.

For management, several implications can be indicated. On the long-term, the demonstrated capacity of large parts of the coastal zone to (net)absorb $CO_2$, and the dependence of this capacity on the existence of (often small-scale) habitats like kelp, reefs, saltmarshes etc. on the one hand, and on nutrient cycles on the other hand, is relevant for future scenarios of global change. The persistence of habitats with increasing sea level rise is of concern. On the shorter term, the large differences in vulnerability of coastal ecosystems can be the basis for a (sub)regional variability in nutrient emission rules. The debate on whether the same rules must apply everywhere has large economic and societal implications, but cannot be avoided given the high physical diversity of the European coastal zone.

## The ecological structure and food web in the coastal zone

Many studies in ELOISE have focused on the functioning of the coastal food web after nutrient enrichment. Some common themes in these studies are that food webs tend to respond rather linearly to (stoichiometrically balanced) nutrient additions on the short term, unless some complicating factors are available. The balance between the different macronutrients N, P and Si is an important conditional factor. Unbalances may shift the competition between major phytoplankton groups, changing the relative importance of the microbial versus the linear food chain. Other important factors are physical forcing, leading to different food web structures in physically different systems, and the time scales of biologically stored nutrients. Long time scales of storage in macrophytes may slow down recycling and thus phytoplankton production, but at high phytoplankton concentrations macrophytes may be competitively excluded. Similar positive feedbacks have been described for nutrient buffering in sediments. They lead to strongly non-linear behaviour of the ecosystem, and to the (still largely conceptual) definition of threshold loadings for system integrity and biodiversity.

R&D is needed concerning the influence of nutrient ratios, and the comparison of bottom-up versus top-down (e.g. fisheries, but also bird and fish predation) control of food webs. Predictive models for food web structure under different anthropogenic forcing are still far from complete or validated, and the same applies for fundamental understanding of physical-biological interactions.

Operationalisation of current knowledge is called for in restoration (and conservation) of macrophyte communities, and in the design of optimal harvesting strategies (e.g. of fish or shellfish) under different physical and anthropogenic influence.

Management implications are potentially large, although still uncertain. The importance of nutrient ratios should lead to a reconsideration of unbalanced emission reduction programmes. Over the past decade, reduction of phosphorus emission has been much more successful than that of nitrogen, thus potentially leading to more unbalance and qualitative changes in coastal communities. The importance of dams and other structures influencing sediment and silicate transfer to the coast equally deserves attention. Influence of anthropogenic changes in physical structures on the functioning of estuarine and coastal communities deserves more emphasis, as crucial decisions on ship traffic can only be taken at a European level (should there be maximum size for container ships, or should most European harbours continue to dredge their estuaries to deep-water canals?). Conservation and restoration management of coastal macrophyte communities should be framed in a better understanding of the relation between these communities and the nutrient regime in their environment.

**SESSION** **THEME 3: NATURAL AND ANTHROPOGENIC IMPACTS IN COASTAL ECOSYSTEMS**

**TITLE** **INTEGRATED COASTAL SCIENCE AND MANAGEMENT: CURRENT STATUS AND FUTURE PROSPECTS**

**AUTHOR(S)** ***R. KERRY TURNER***

Director, CSERGE and the Zuckerman Institute UEA, Norwich, UK
Eurocean Conference: Galway, 2004

## INTRODUCTION

Managing the rate of environmental change according to sustainability principles at any given place and time poses a number of formidable challenges for scientists, resource managers, politicians and other stakeholders. Three particular characteristics of coastal zones complicate the management task: the extreme variability present in coastal systems, the highly diverse nature of such systems, and their multi-functionality and consequent high economic value. Globalisation as a process has served to re-emphasise the importance of coastal zones as economic entities supporting livelihoods through flows of income derived from the in situ natural capital stock and trading networks. However, simultaneously coastal areas are socio-cultural places with specific historical conditions and symbolic significances (Turner *et al.* 2001).

### Integrated Environmental Assessment

Coastal zones are under heavy pressure from land-based activities located in river catchments, together with marine orientated factors and the ubiquitous impacts of climate change. Traditionally, both scientific research and governance have treated catchments and coasts as separate domains. However, it is increasingly recognised that they should in fact be treated as an integrated whole. But such an approach requires, among other things, a 'valid' and 'reliable' decision support system i.e. a toolbox of (natural and social science-based) methods and techniques encompassed by an analytical framework (Von Bodungen and Turner, 2001). An integrated environmental assessment system should comprise of three basic analytical stages: a scoping stage; modelling, data collection and monitoring stage; and an evaluation stage (Turner, 2004). In this paper the focus is placed on the first and second stages and the use of the DP-S-I-R (Driving Pressures-state changes-impacts-policy responses) scoping framework and so-called futures scenarios.

In order to help resolve some of the methodological issues involved in coastal management, the (DP-S-I-R) framework can initially be deployed. Its usefulness as a scoping device, when combined with scenarios, has already been proved on the basis of work undertaken in different European coastal-catchments. The aim should be to set out a more complete methodology for integrated coastal management, together with an appreciation of the practical problems and constraints faced as such methods are actually deployed.

The requirements of a practical coastal management support system will include: databases, indicators and monitoring measures, scenarios, models and evaluation methods and techniques and will all pose their own problems. There is an 'interface' problem, when science and scientific understanding merges (or not) into decisions making in the political arena. Questions posed by the policy process often need to be redefined before science can provide useful answers and some existing scientific knowledge is too specific to be of relevance to policymakers. Finally, it remains the case that there are some questions that science cannot yet answer. Policy targets and indicators then become very important but far from straightforward issues to address given the sustainability principles of:

- Economic and ecological efficiency (including the cost-benefit and polluter pays principles);

- Equity and fairness principle (including more inclusionary decision making and the subsidiarity principle);
- Precaution, given the inevitable uncertainties that persist in coastal science and policy domains; and
- Good governance.

To be judged an ultimate success, integrated coastal management as a process must unite government, civil communities, science and management and overcome or mitigate competing sectoral and public interests. It should interalia improve the quality of human communities who depend on coastal resources while maintaining the biological diversity and productivity of coastal-catchment ecosystems, and therefore the functioning of nature. Such a task can only be achieved incrementally over time and will be constantly challenged by complexity and uncertainty constraints. The future will always be shrouded by uncertainty and therefore accurate forecasting of coastal futures is not a feasible goal. However, it is possible to formulate scenarios, which can shed light on and offer insights into possible future environmental and socio-economic developments. The information generated by such 'future thinking' can assist the policy process in a more efficient and effective search for appropriate projects, programmes and policies.

The results of a scoping exercise for European coastal areas are reported in (Turner, 2004). It remains the case that 85% of Europe's coast face moderate to high risk from economic development – related pressures and some 25% of the coastline is subject to erosion. Given these erosional trends and flood risks, hard engineering sea defences have been the traditional response. But these defences also serve to reduce sediment input to the coastal system which intensifies erosion and the need for additional defences. Armouring the coastline in this way is essentially unsustainable on economic cost grounds alone.

## SCENARIOS AND COASTAL ZONE MANAGEMENT

A scenario can be defined as a coherent, internally consistent and plausible description of a possible future state of the world (Parry 2000). It needs to be emphasised that a scenario is not a forecast because it cannot assign probabilities to any particular outcome. Instead, scenarios portray images of how society and its supporting environment could look like given different sets of assumptions and consequent conditions. Scenarios typically contain qualitative storylines augmented by varying amounts of quantified data. They can be informed by relevant history but not conditioned by it, except in the case of so-called baseline or 'business as usual (BAU)' scenarios. The latter can be utilised as benchmarks against which to portray other possible states of the world and are completed with the aid of trend data. In practice, scenarios will combine a range of features depending on their real world application and the scale at which they are pitched. Scenarios are not precise future predictions but methods to aid decision makers in their efforts to cope with inevitable uncertainty. Scenarios may possess a variety of characteristics and can be deployed at different spatial scales and across different temporal scales (typically from 10 years to 100 years). They can be used to facilitate consensus, or negotiation, in situations where multiple competing stakeholder interests are at issue; or at least provide part of a more inclusionary process for decision-making. They can be focussed on particular policy objectives and/or instruments and provide sensitivity assessments. Finally, they can portray the consequences of policy and strategies that incorporate radically different worldviews in a more visionary way. In this context the 'alternative' visions are most often reflected against a baseline (BAU) trend scenario.

## EUROPEAN COASTAL FUTURES

The rapidly changing record of the last half century highlights the difficulties involved in forecasting the future decades ahead. But the underlying context for any 'futures' thinking for Europe must include an appreciation of the globalisation process and the implications of an expanding European Union and Single Market. Globalisation has brought a growing interdependence between financial markets and institutions, economies, culture, technology and politics and governance. So far, market forces and related social systems have become the increasingly dominant paradigm. For Europe, there is the additional dimension of change involving the potential inclusion of the countries of central and eastern Europe into the EU, together with their own internal transitions from centrally planned to market-based economies and societies.

There is no shortage of candidate scenarios to choose from but a hybrid approach which borrows from a set of scenarios previously formulated to investigate the impact of climate change technological advances and environmental consequences in a range of contexts (Parry 2000; Lorenzoni et al 2000, EEA, 2000) has much to recommend it. The aim is to fires provide a set of basic contextual narratives within which to set four somewhat more specific scenarios (UNEP 2002) with relevance for coastal-catchment areas across the European sub-regions (Western, Central and Eastern). The critical issues which need to be highlighted mirror the pressures, impacts and responses revealed through the DP-S-I-R framework.

The narrative contexts and the scenarios are framed by two orthogonal axes, representing characteristics grouped around the concepts of societal values and forms of governance. The values axis provides a spectrum from individualistic, self-interested, consumerist, market-based preferences through to collectivist, citizen-based communitarian preferences, often with a conservationist bias. The vertical axis spans levels of effective governance from local to global. The four quadrants are not sharply differentiated but rather are bounded by overlapping transitional zones not distinct boundaries. Change occurs as certain trends and characteristics become more or less dominant across the different spheres of modern life-government, business, social, cultural and environmental – see Figure 1.

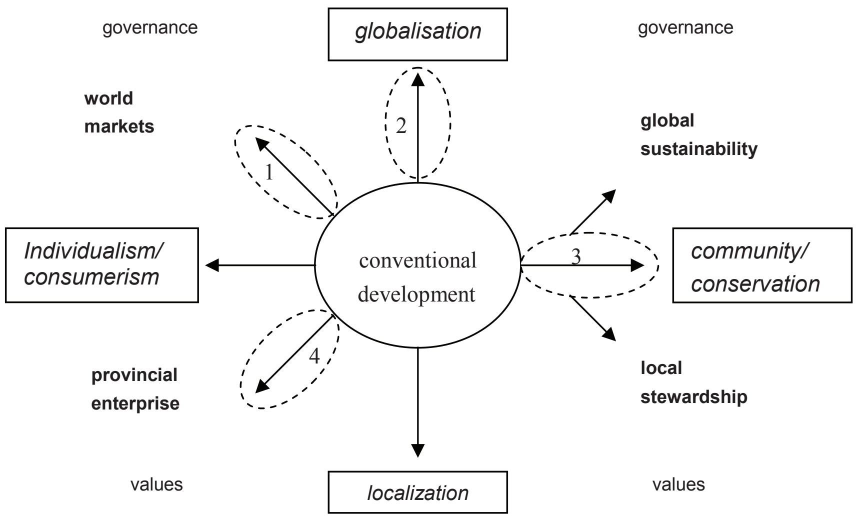



Fig. 1 Environmental Futures Scenarios (to 2080). NOTE: the four quadrants are separated by ‘zones of transition’ not distinct boundaries. Source: OST/DTI, Environment Futures, Foresight, OST London http://www.forsight.gov.uk/- see also Lorenzoni et al (2000; UNEP (2002).

Four main current drivers were considered to play a major role in shaping the present issues in across all Europe coastal areas: urbanisation, tourism, industry and harbour expansion, fishery and aquaculture. Those ubiquitous drivers affect especially habitat and composition of species and are a source of contamination processes and loss of amenities. Particular emphasis was placed on mass tourism, which is currently impacting the Black Sea and the Mediterranean Sea, moderately impacting the Baltic and the North Sea, and locally impacting the Atlantic coast.

From the economic point of view, fisheries loss due to over exploitation seems to be the trend throughout all basins. The current effects of other drivers (e.g. energy and agriculture sector) may also be relevant, but only more locally (at the sub-basin scale). The effects of climate change are not estimated to have caused very significant impacts over the past 30 years. The results of this assessment for the world markets, global sustainability and environmental stewardship for European coastal areas are reported in Turner (2004).

## REFERENCES


Von Bodungen B, Turner RK (2001) Science and integrated coastal management, Dehlem University Press, Berlin.

European Environment Agency (2000) Cloudy crystal balls: 'an assessment of recent European and global scenario studies and models', Env Issues Series No 17, EEA, Copenhagen.

European Environment Agency (2003) Europe's environment: the third assessment, Env Assessment Report No 10, EEA, Copenhagen.

Lorenzoni I, Jordan A, Hulme M, Turner RK, O'Riordan T (2000) A co-evolutionary approach to climate change impact assessment: Part I. Integrating socio-economic and climate change scenarios Global Env Change 10: 57-68.

Nunneri, C. *et al.* (2004) Group report: integrated assessment and future scenarios for the coast. In J. Vermaat *et al.* (eds.) Managing European Coasts: past, present and future, Springer, Berlin, forthcoming.

Office of Science & Technology (1999) Environmental futures. Report for the UK's National Technology Foresight Programme, DTI/Pub 4015/IK 399 NP, VRN 99647, London, UK.

Parry M (2000) Assessment of potential effects and adaptations for climate change in Europe: The Europe Acacia Project, Jackson Institute, University of East Anglia, Norwich.

Turner RK (2004) Integrated environmental assessment and coastal futures. In J. Vermaat et al. (eds.) Managing European Coasts: past, present and future, Springer, Berlin, forthcoming.

Turner RK, Bateman IJ Adger WN (2001) Economics of coastal and water resources: valuing environmental functions, Kluwer, Dodrecht.

UNEP (2002) Integrating environment and development: 1992-2002, UNEP, Nairobi.

**SESSION** **THEME 3: NATURAL AND ANTHROPOGENIC IMPACTS IN COASTAL ECOSYSTEMS**

**TITLE** **THE OCEAN: AN INEXHAUSTIBLE RENEWABLE ENERGY SOURCE**

**AUTHOR(S)** ***M. TERESA PONTES***

INETI, Lisbon, Portugal
Tel: +351 21 7127201, Fax: +351 21 7127195
E-mail:teresa.pontes@ineti.p

**SUMMARY**

In the last ten years the European Commission has provided a valuable contribution to the faster development of technologies to harness wave energy and marine currents energy. It has been found that about 200 TWh/y of electrical energy might be produced from these two renewable sources. These technologies are at a pre-commercial stage with several prototypes of wave energy and of marine currents being tested in the sea, and plans for construction of other prototypes exist. The diversity of systems still being developed indicates that a convergence for a winning technology has not occurred yet thus significant R&D effort is required until technologies will attain maturity. The priorities for R&D for the various types of devices are summarised.

**INTRODUCTION**

The oceans contain a huge energy resource with different origins. The most developed conversion technologies refer to tidal energy**,** which results from the gravitational fields of the moon and the sun; thermal energy (Ocean Thermal Energy Conversion or OTEC), resulting directly from solar radiation; marine currents**,** caused by thermal differences in addition to tidal effects; and ocean waves, generated by the action of the winds blowing over the ocean surface. The last two technologies are those that have deserved most attention in the last fifteen years showing better prospects to become competitive in the short- to medium-term.

This paper starts by an outline of the resource availability, the state-of-the-art of the technology including prototypes and environmental impacts for wave energy and tidal currents. Comprehensive review of these technologies and their status has been produced (e.g. Clément et al., 2002, FES, 2003) and priorities for R&D have been identified within the European Wave Energy Network and the Implementing Agreement of the International Energy Agency. These are summarised in this paper.

# WAVE ENERGY

## Resource

Waves are created by winds blowing over large areas of water, which in turn are generated by the differential heating of earth surface by the sun. Concentration occurs in both transfers. The global wave power potential is 1-2 TW, which is the same order of magnitude of the world consumption of electrical energy. Europe is characterized by particularly high energy, the highest offshore power levels of 70 kW/m occur off Ireland and Scotland decreasing to about 30kW/m off Norway and off the southern archipelagos of Madeira and Canaries. The total (Atlantic and Mediterranean) European annual deep-water resource amounts to 320 GW (Pontes et al., 1998) from which 130-190 TWh/y may be produced.

## Technology

The complexity of waves and their irregularity has required new technology to an extent larger than for the other ocean renewable energy sources. Considerable research began only after 1973´s oil crisis, and took place in UK, Japan, Norway, Sweden and USA, Denmark, Ireland and

Portugal, in the 1980s started in India and China and in the 1990s in Mexico, Australia and Netherlands. Based on various energy-extracting methods a wide range of systems has been proposed and various continue to be developed indicating that a convergence to a best technology has not occurred yet such as happens with wind energy.

The first prototypes were of the OWC (oscillating water column) type. The OWC device comprises a partly submerged concrete or steel structure, open below the water surface, inside which air is trapped above the water free surface. The oscillation of the internal free surface produced by the incident waves makes the air to flow through a turbine that drives an electric generator. The self-rectifying axial-flow Wells turbine has been used in almost all the prototypes. Eight prototypes have been tested since 1985 in Norway, Japan, UK, India, China and Portugal, the rated power ranging between 20 and 500 kW. The Pico plant (400 kW, Azores, Portugal, 1999) and the LIMPET (500 kW, island of Islay, Scotland, 2000, www.wavegen.com) are connected to the grid. Their design and construction was partially funded by the EC JOULE Programme. These fixed devices are generally classified as *first generation* devices. These devices have been built on the shoreline where construction and maintenance are easier and submerged transmission cables are avoided. In two cases (India and Japan) bottom-fixed nearshore devices (*second generation)* have been located just outside or incorporated in a protecting breakwater (a way of building the plant at marginal costs). Two OWC plants are planned to be constructed. One is in Portugal (at the new breakwater in Porto) and the other in Australia (www.energetech.com.au). Another shoreline device is the Tapered Channel (TAPCHAN) that was built and operated in Norway from 1985 to mid 1990s. The TAPCHAN comprises a gradually narrowing channel with wall heights above mean water level. As the waves propagate down the channel, the wave height is amplified until the wave crests spill over the walls to a reservoir which provides a stable water supply to a conventional low-head turbine. This is considered a relatively mature technology but there was no follow-up of the first prototype. Limitations of shoreline devices are the requirement of special geomorphologic, environmental and economic conditions.

Offshore systems (*third generation*) are more appropriate for extensive exploitation of the wave energy resource. Their deployment is less constrained by geomorphologic and environmental aspects and they harness a higher resource because waves loose part of their energy in shallow waters due to breaking and (generally to a much less extent) to bottom friction.

Since the beginning of wave energy R&D thirty years ago a considerable variety of offshore devices has been proposed and developed but the construction of prototypes has started only very recently. The majority is floating devices but a bottom-mounted system (the AWS, www.waveswing.com) has also been developed. The devices can be large such as the Pelamis (an articulated *snake* about 130 m long, www.oceanpd.com) and the Wave Dragon (an overtopping device with large convex side walls 300m wide to concentrate incident waves, www.wavedragon.net), or relatively small buoys (5 - 15 m diameter) as the AquaBuOY (www.aquaenergygroup.com), Wavebob and others. While in the first generation and second generation systems the PTO (power take-off systems) are air and water turbines for third generation hydraulic, air and water turbines and linear generators were developed.

Prototypes of offshore systems started with the floating OWC *Mighty Whale* (rated 110 kW, not connected to grid, testing finished in 2002 in Japan by JAMSTEC), followed by the Dutch bottom-mounted 2 MW AWS (to be deployed of NW coast of Portugal in May 2004), the 1:4.5 scaled Wave Dragon being tested in a sheltered area in the Baltic Sea and the Pelamis (750 kW, that will be tested soon at the European Marine Energy Test Centre – wave test facility in Orkney, UK). Plans for constructing and testing soon other prototypes such as the AquaBuOY exist.

## Marine Currents

### Resource

The potential resource for marine currents is estimated as 5 TW but only a very small part of total energy concentrated near the periphery of oceans or through straits and narrow passages between islands and other landforms can be converted to electrical or other useful forms of energy. In Europe this resource is of special interest for UK, Ireland, Greece, France and Italy. In this area 106 suitable locations were identified and it was estimated that, using the available technology, these sites could supply 48 TWh/y to the European electrical grid network (CEC, 1996). The predictability of marine currents and the high load factor (20-60%) are important positive factors for its utilisation.

### Technology

The technique that has been mostly considered for the exploitation of marine currents is to use a turbine rotor, set normal to the flow direction, that is mounted on the seabed or suspended from a floating platform. An alternative concept, comprising a reciprocating wing design whose attitude to the water is controlled in such a way that the arms reciprocate against a power take-off restraint, such as a hydraulic ram, has been proposed. The greatest technical problems are likely to arise from the need for adequate operational life and low maintenance costs from machinery operating in a hard environment, although the offshore industry has solved similar problems.

In Italy, the Enermar 130 kW prototype has been tested in the Strait of Messina. This uses a cross-flow, 3-bladed Kobold turbine, mounted on a floating platform of cylindrical shape. In the UK, the 300 kW Seaflow system (www.marineturbines.com) uses a horizontal-axis rotor, and was installed on a mono-pile driven into the sea-bed in the Bristol Channel. Another system is the Stingray that uses a reciprocating wing design (www.tidal-eb.co.uk). A 150 kW demonstration plant has been under a series of tests near the Shetland Islands.

### Environmental Impacts

Wave energy and marine current energy generation are generally considered environmentally benign. For shoreline wave power plants, the main negative impacts are visual intrusion and noise from air turbines. Nearshore and offshore wave energy plants and marine currents plants may constitute obstacles to coastal marine traffic and, when deployed in large numbers, may promote modifications to coastal dynamics as a consequence of energy extraction. The main conflicts are expected to be with shipping, navigation and fishing. Other impacts, namely on the ecosystems, on fishing and on recreation and tourism may occur. Most of these burdens can be minimised and, in some cases, eliminated.

## CHALLENGES

The importance of the European wave energy and marine currents energy resources, the scientific and technical expertise and the existing industrial capacity should take Europe to the leadership of these two new industries which present significant exportation potential. This opportunity can be very welcome by industries with required skills such as the offshore and shipbuilding ones. This European capacity has been made possible through the support of the European Commission in addition to the national programmes. The EC effectively started to include these topics in the fourth Framework Programme in 1994 following successful completion of related studies and preparatory RTD work. In addition to direct financing of studies and prototypes, the series of five international conferences in wave energy starting in 1993 and the recent European Thematic Wave Energy Network also significantly contributed to the stimulation and coordination of the activities carried out throughout Europe within universities, national research centres and industry.

For these technologies to transform from pre-commercial to full maturity significant research and development has to continue. The priorities have been identified through reviews carried out by the WaveNet (CEC, 2003) and the International Energy Agency collaborative R&D Programme on ocean energy systems (www.iea-oes.org) which works in close relationship with the EC (FES, 2003).

## PRIORITIES

The following R&D priorities have been identified. For shoreline-fixed devices namely OWCs improving the efficiency and control of wave-to-air systems, refining the design of the main structures for survivability, energy capture enhancement and lower material cost are required.

The engineering challenges for floating devices include gaining a better understanding of different types of power take-off systems and how these can be tailored to wave energy, control, array configuration, moorings and flexible electrical connections.

Required generic research includes a wide range of topics such as tank-testing facilities improvement, computer modelling techniques, electrical conversion and storage, improved bearings and seals. Fabrication, transportation, operation and maintenance (O&M), monitoring, testing, proving and certification, power smoothing are other areas where improvement is relevant.

For marine current devices similar topics are important and also a better understanding of cavitation, corrosion, sealing and wakes.

Improving information sharing and technology transfer shall be instrumental for the development of the ERA regarding the exploitation of these two renewable energy sources.

## REFERENCES

Clément, A. et al. 2002. Wave energy in Europe: current status and perspectives, Renewable and Sustainable Energy Reviews*,* 6, 405–431.

Commission of the European Communities, DGXII (1996), Wave Energy Project Results: The Exploitation of Tidal Marine Currents. Report EUR16683EN.

Commission of the European Communities, 2003, Results from the work of the European Thematic Network on Wave Energy, Contract Nº ERK5-CT-1999-20001.

Future Energy Solutions, 2003, Wave and Marine Current Energy. Status and research and development priorities—a report for the International Energy Agency.

Pontes, M. T., Athanassoulis, GA, Barstow S, Bertotti L, Cavaleri L, Holmes B, Mollison, D. Pires, H O. 1998. The European wave energy resource. Proc. 3rd European Wave Energy Conference, Patras, Greece (Contract Nº JOU2-CP93-0390).

| | |
|---|---|
| **SESSION** | **THEME 4: EXPLORATION OF THE EUROPEAN OCEAN MARGIN, ITS DEEP SEA RESOURCES AND ECOSYSTEMS** |
| **TITLE** | **SESSIONS REPORT** |
| **RAPPORTEUR** | **LUIS FARIÑA BUSTO** |

University of Vigo
e-Mail: lfarina@uvigo.es

## SUMMARY

Session 4, focussing on the exploration of the European Ocean Margin and its deep-sea resources and ecosystems, included four keynote speakers: Bilal Haq (National Science Foundation, USA) addressed societal responsibilities and implications; two speakers - Gerold Wefer (DFG Research Centre Ocean Margins, University of Bremen, Germany) and Jean-Pierre Henriet (Renard Centre of Marine Geology, University of Gent, Belgium) - focussed on geological aspects, while the fourth speaker - Laura Giuliano (Instituto per l'Ambiente Marino Costiero (IAMC), Consiglio Nazionale delle Ricerche, Naples. Italy) - profiled marine microbes in the ocean margin.

## INTRODUCTION

European science in the domain of deep-sea and ocean margins research is entering a new phase, brought about by newly developed technology and recent discoveries. The domain has a strong potential for economic exploitation, including the involvement of industry and SMEs, a contribution to security of operations and protection of the environment, as well as a tradition and a future in international collaboration, both across the Atlantic and globally.

## DISCUSSION

Recent Developments in ocean margin and deep-sea research have opened up fields virtually unknown a decade ago. These include:

- Newly discovered ecosystems such as deep-water (cold-water) coral reefs, carbonate mounds, mud volcanoes, deep hydrothermal vents and seep communities. These ecosystems are only barely explored, although the cold-water corals in the Porcupine Seabight had already been recorded by the HMS Porcupine expedition in 1869;
- Deep-water coral reefs are a biodiversity hot-spot supporting a large diversity of life forms;
- Gas hydrates: their genesis, potential as a future fuel and their role in slope instability;
- Exploration of structures such as turbidites and slides, probably associated catastrophic instabilities and the generation of tsunamis;
- A variety of microorganisms adapted to extreme conditions, including sub-seafloor bacteria, which constitute an enormous pool of evolutionary diversity preserved in the oceans. Their potential applicability and their theoretical importance alone justify the study of the oceans.

Although still at an early stage of development, deep-sea / margins science has already shown its potential for applicability and commercial exploitation. For example, the global market for thermostable enzymes was estimated at US $250 million in 2000. Annual sales of only four antimicrobials derived from natural products are estimated to be worth over US $1 billion. While not all of these products are of marine origin, the wealth discovered in the preliminary exploration of extreme marine ecosystems suggests a very promising future.

A knowledge of gas hydrate deposits in the ocean margins (which are estimated to be of the same order of magnitude as the total reserves of hydrocarbons from other sources) may have an impact on the understanding of the role of the ocean in global climate change, and is essential for security of operations in the area. It should be noted in this context that at least one third of future (conventional) oil reserves is expected to be found at the ocean margin.

### Immediate applications of the results of deep-sea / margins research include:

- Improved safety of ocean margin operations and marine infrastructure;
- Extraction of new and traditional energy sources and non-living resources;
- Development and testing of new technologies in a demanding and extreme environment.

### Opportunities for Economic Exploitation in Related Fields Include:

- Applying or, when necessary developing of novel screening technologies (with emphasis on the newly, successfully applied metagenomic approaches for harvesting the genetic resources of unculturable organisms in marine environments) and ensuring sustainable sources of supply;
- Optimising production and recovery of bio-products;
- Design and optimisation of bioreactors for marine metabolite production;
- Opening up of new possibilities to address fundamental scientific questions through newly developed technology (such as 3D seismic profiling);
- High potential for industry (including SME) participation, which is already a reality, both through the technological aspects of the research itself and the industrial applicability of its results; New techniques and products useful in molecular biology, biotechnology, medicine, pharmacology.
- New techniques and products useful in molecular biology, biotechnology, medicine, pharmacology, etc.
- Cosmetics, detergents, paper bleaching, artificial snow;
- Baking and brewing, food additives, dietary supplements;
- Bioremediation.

## CONCLUSIONS

### Future Opportunities & Challenges

The potential contained in this domain can be realized and is open to progress in many directions:

- Exploration of newly discovered deep-sea structures and ecosystems (gas hydrates and related processes, cold-water corals, carbonate mounds, mud volcanoes, seep communities, etc.);
- New observational deployments (e.g. deep-sea medium to large scale networked instruments allowing remote real-time access);
- Development of targeted technology optimised for the exploration and sampling of extreme environments;
- Deep-water instrument recovery and tool standardisation is a challenge world-wide;
- Identification of new sources of bio-products;
- Important applications in the implementation of the provisions of the United Nations Convention for the Law of the Sea (UNCLOS), which covers in particular “exploitation issues” together with the related ones of delimitation and research.

## Relevance for the Objectives of the European Research Area

The initial exploratory stages of the European deep-sea and ocean margin domains have gone through an intense phase of Europe-wide integration and expansion under the EC Framework Programmes 4, 5 and 6, benefiting from an important initial impulse under MAST and arriving at a substantial level of integration in FP6.

The research community in this field has contributed very significantly to achieving the objectives of the Framework Programmes and bringing about the European Research Area: world-class science with substantial societal impact, involvement of industry (including SMEs), a high degree of European collaboration and integration and Europe-wide synergy of national activities even when Community funding was very limited or absent. OMARC and ECORD are good examples. HERMES will no doubt continue this trajectory.

A related and important element is the international dimension of research in ocean margins and deep-sea, in particular the design and implementation of research in harmonised way on both sides of the Atlantic. This is a marked feature of on-going ocean margin and deep-sea research and is in agreement with the objectives of the EC Framework Programme.

## Points of importance made during the discussion included that:

- An effort is required to promote public awareness in a field where the diversity of interests makes it necessary to be able to face and resolve conflicts. The exploitation of deep-sea living and non-living resources may easily lead to conflicts and a balanced approach must be found. Respect for nature and the preservation of pristine systems, with a systematic application of the precautionary principle, should be compatible with responsible research and sensible exploitation. It is worth bearing in mind that preservation of special ecosystems is a precondition of their use as a source of biotechnological products.
- Ocean margin research has progressed in Europe with initiatives and activities on a wide spectrum of scales, from individual entrepreneurs to large-scale integrated programmes.

## KEY POINTS THEMATIC SESSION 4
## OCEAN MARGINS

- Ocean margins and deep-sea ecosystems provide a promising territory for research, in terms of exploitable resources, and the insights to be gained in physiology, evolution and the origins of life itself;
- The complexity of the system, the challenging nature of the technology required for its exploration and its large exploitation potential points to the appropriateness and need to develop research through the complementary interaction of public and private actors on the one hand and a combination of EU and national funding on the other;
- Ocean margin research has a strong potential to support economic development, including the involvement of industry and SMEs, a contribution to security of operations and protection of the environment, as well as a tradition and a future of international collaboration;
- The exploitation of deep-sea living and non-living resources may easily lead to conflicts and a balanced approach must be found. Respect for nature and the preservation of pristine systems, with a systematic application of the precautionary principle, should be compatible with responsible research and responsible exploitation;
- Future challenges to support exploration of deep-sea structures and ecosystems (gas hydrates and related processes, cold-water corals, carbonate mounds, mudvolcanoes, seep communities, etc.) include:
    - New observational deployments (e.g. deep-sea medium to large scale networked instruments allowing remote real-time access);
    - Development of targeted technology optimised for the exploration and sampling of extreme environments;
    - Deep-water instrument recovery and tool standardisation;
    - Identification of new sources of bioproducts.
- A science domain with such high quality results, high potential for technological development and innovation and for economical exploitation, an established world-wide international dimension, with profound societal implications and such a real and committed contribution to the integration of European research must secure its place in the 7th Framework Programme.

**SESSION** **THEME 4: EXPLORATION OF THE EUROPEAN OCEAN MARGIN, ITS DEEP SEA RESOURCES AND ECOSYSTEMS**

**TITLE** **OCEAN MARGINS RESEARCH: SCIENCE, STAKEHOLDERS AND SOCIETAL RELEVANCE**

**AUTHOR(S)** ***BILAL U. HAQ***

National Science Foundation, Washington, USA

## SUMMARY

Ocean Margins are an area of great societal relevance with a vast number of stakeholders. This presentation will cover issues where academic research on ocean margins and resource exploration needs are convergent and contribute toward the understanding of how the Earth works, and issues where environmental concerns and research needs are at variance and hamper margins research. Ocean margins are where some of the fundamental questions about deep and superficial Earth processes remain to be answered and need to be addressed in several large experiments. In addition, UNCLOS-initiated activities to document marine scientific data for claims to shelfal limits by maritime nations also present a great opportunity for marine geoscientists to establish an inventory of the seabed resources and to create marine research infrastructures where they do not exist.

## INTRODUCTION

Ocean Margins include the vast real estate extending from the coastal plain to the shoreline and beyond to the edge of the continental margin that includes both the continental shelf and the slope. A recent estimate suggests that 40% of the world's population lives within 120 km of the shoreline, exerting environmental pressures on this area for their habitation and commercial and recreational needs. In the future the world will also look to the continental margins for more of its living and non-living resources, where potentially environment-altering activities of exploitation of non-living resources are in direct variance with management and harvesting of living resources. In addition, principal geological hazards such as, earthquakes, landslides and volcanic eruptions also converge at ocean margins and where the effects of future climate change, i.e. global warming and potential sea level rise, might be felt most readily. This makes it a societal imperative that we understand and predict the processes occurring at continental margins along with their repercussions!

In the last few years, and especially in the last decade, we have seen an exponential increase of interest in research on the ocean margins for several reasons. First and foremost, some of the most compelling scientific issues in marine geosciences remain to be resolved at the oceanic margins coupled with that fact that it is only recently that the technologies necessary for meaningful investigation of this area have become available. These include, deep-penetrating and 3D seismic profiling capable of detailed images of the seabed at multiple levels, remote unmanned vehicles (RUVs) and remotely operated vehicles (ROVs) capable of photographing, sampling and in-situ analysis on the seafloor, deep-towed high-resolution side scan sonars capable of high-resolution bathymetry, identification and development of environmental and climatic proxies through sophisticated isotopic and rare-element analytical techniques, in-situ Raman spectroscopy, and deployment of long-term seafloor observatories.

At least a part of the reason for increased surveying and mapping activities on the ocean margins are also a consequence of heightened interest in the seabed of the continental shelf in the wake of recent declarations of the United Nations Convention on the Law of the Sea which provides for the demarcation of the outer limits of the continental shelves by coastal states and affirms that such claims must be supported by sound marine scientific knowledge and evidence.

## DISCUSSION

### Science Issues

The deliberations of the geoscience community around the world have shown that some of the most significant questions concerning Earth processes remain to be addressed on the ocean margins. This amphibious zone also contains some of the thickest piles of sediments on the globe that are of obvious interest to the exploration industry as potential reservoirs for hydrocarbons.

Both academic and applied research argue for a better understanding of the complex interplay of processes that create and destroy continental margins over time, thereby concentrating resources as well as geohazards in this area. To understand these processes and their products several broad and basic questions about how the Earth works need to be addressed. These include:

1. How does lithosphere deform and how is strain partitioned within the crust and upper mantle?
2. How does heat and mass transfer associated with subduction lead to production of magma and what is the role of fluid flow in this system?
3. What are the relationships between small-scale spatial and temporal physical events and the formation of longer-term sedimentary record?
4. What is the role of fluid circulation through sediments and igneous rocks at active and passive margins?

These broad and fundamental questions are less likely to be answered by a business-as-usual approach. Instead we need to undertake several large, integrated experiments to resolve these issues. For example most earthquakes at the active margins (where the oceanic lithosphere is subducting underneath the continental crust) originate with a discrete depth range. Which begs a number of vexing questions about the *Seismogenic Zone*:

5. What is the nature of this tsunamigenic earthquake zone?
6. What controls the up- and down-dip limits of the Seismogenic Zone?
7. What is the nature of the strong, locked, parts of Seismogenic Zones?
8. What is the role of large thrust earthquakes in mass flux of material in the subduction system?

Similarly, if we consider the entire Subduction Factory at the subducting margins (of which seismogenic zone is a smaller part), several other crucial questions need answering:

9. How do forcing functions such as convergence rate and upper plate thickness regulate production of magma and fluid from the Subduction Factory?
10. How does the volatile cycle (H2O and CO2) impact chemical, physical and biological processes from trench to deep mantle?
11. What is the mass balance of chemical species and material across the Subduction Factory, and how does this balance affect continental growth and evolution?

Another of the large integrated experiments involves the understanding of how continental lithosphere ruptures to generate ocean crust? Some of the significant questions about the Rupture of the Continental Lithosphere include:

12. How does the strength of the lithosphere evolve during rupture and how is strain partitioned during rupturing?
13. What is the role of magmatism (and volatiles) during extension and in the transition from rupture to sea-floor spreading?
14. What is the stratigraphic response to lithospheric rupturing?
15. How are fluid fluxes modified or controlled by lithospheric rupturing?

Some of the fundamental questions concerning the sedimentary systems of the margins are focused on understanding the processes of weathering, transport, sequestration and further dispersal of the sediments to the ocean, also collectively known as the Source to Sink experiment. These include:

16. What processes control the rate of sediment and solute production in a dispersal system?
17. How does transport through the system alter the magnitude, grain size, and delivery rate to sediment sinks?
18. How is variability of sediment production, transport, and accumulation in a dispersal system preserved by the stratigraphic record?

## ENCUMBRANCES TO OCEAN MARGIN RESEARCH

There are a number of conflicting issues that are beginning to hamper research on continental margins and are likely to become even more challenging in the future if solutions cannot be found readily.

These issues include the obvious environmental concerns that might accompany an exploration or any exploitation activity for non-living resources on the margins. One issue that has come to a head in the last few years is the concern about the harmful effects of seismic research on marine mammals. Seismic profiling is carried out by releasing acoustic energy from air guns, either used singly or in multiple arrays. The acoustic energy bounces back from the seafloor and from sub-seafloor layers of contrasting density, providing us with the revealing cross-sectional images crucial for marine geophysical research. This acoustic energy or sound above a certain threshold is considered harmful to marine mammals that may use acoustics for their own radar directional systems. Thus, marine geophysical research cruises with seismic profiling as a part of their objectives have become targets of disruption by environmentally concerned groups. It is unthinkable that any scientific group or organization would intentionally harm marine mammals, but there also seems to be a lack of meaningful information on the actual effects of various levels of acoustic energy on marine mammals. The solution lies in a rigorous research program to study the effects of sound on marine mammals and establishing precise criteria and appropriate avoidance procedures during seismic work that are accepted and used internationally. In the meantime, a lot more permitting work and environmental impact studies, as well as on-board whale-watching and avoidance, are becoming a part of lead preparation for seismic cruises.

Here a word of caution about piracy, especially in coastal areas, may be appropriate, which has been disruptive to marine research cruises in recent years. Piracy is on the increase - in the year 2000 alone a total of 469 acts of piracy were reported worldwide by the Weekly Piracy Report. Oceanographic vessels are certainly not exempt from this activity. Margins research will often require cruises in areas where pirates are active and research vessels will have to prepare themselves for contingencies, requiring more expenditure of research euros and dollars on security related issues.

## Unclos-Related Issues

The United Nations Convention on the Law of the Sea is a remarkable declaration that provides a comprehensive framework not only for the dominion by the coastal states over a large part of the world ocean, but also for common heritage and usage of the deep sea by all mankind. It covers such vital subjects as, delimitation, environmental impact and management, scientific research as well as technology transfer to lesser developed nations, and economic and commercial issues. It also provides for peaceful settlement of disputes, and considering that over 150 maritime nations will exert their sovereign rights over 20% of the ocean area, disputes are all but unavoidable.

Article 76 of the UNCLOS is even more remarkable in that it provides for both the legal and the scientific basis for delimitation in resolving any claims and disputes that might occur. The framers recognized the importance of the scientific underpinning of such claims and provide that authorities charged with mediating, e.g., the International Seabed Authority and the Commission on the limits of Continental Shelf, must be supported by expert scientific knowledge in resolving any claims or disputes.

Thus, there have been heightened activities in the areas of marine geological and geophysical mapping of the offshore.

The kinds of data that might be useful in laying claims to the shelf areas beyond 200 nm could include: physiographic and geomorphologic data, detailed bathymetric data, accurate geodetic and navigational data, other geophysical data such as, seismic reflection and refraction profiles, gravity and magnetics data, as well as sedimentary data on the provenance or the source of the great piles of sediments that are deposited offshore, especially in deltaic regions.

These activities present a great opportunity for marine geoscientists in maritime countries for establishing a direct inventory of the seabed and its resources of their country and for ancillary research. In developing nations it is also an opportunity for creating the necessary infrastructures for future marine scientific research. In this area an important reference put together at the behest of UNESCO’s Intergovernmental Oceanographic Commission and International Hydrographic Organization is now available (Cook and Carleton, 2000). It brings together many of the issues and methodologies that may become relevant when a maritime nation gets ready to claim extra offshore territory on their continental shelf. A very useful set of examples and a useful reference indeed.

## Reference

Cook, P. and Carleton, C.M. (eds.) (2000). Continental Shelf Limits – The Scientific and Legal Interface. Oxford University Press, Oxford, UK, 363 p.

**SESSION** **THEME 4: EXPLORATION OF THE EUROPEAN OCEAN MARGIN, ITS DEEP SEA RESOURCES AND ECOSYSTEMS**

**TITLE** **OCEAN MARGIN SYSTEMS – SCIENTIFIC CHALLENGES AND NEW TECHNOLOGIES**

**AUTHOR(S)** ***GEROLD WEFER[1], GERHARD BOHRMANN[1], ACHIM KOPF[1], ANDRÉ FREIWALD[2]***

[1] DFG Research Center for Ocean Margins, Bremen University, PB 330440, D-28334 Bremen, Germany
Tel: +49 421 218 3389, Fax: +49 421 218 3116,
E-mail: gwefer@uni-bremen.de
[2] Institute for Paleontoloy, Erlangen-Nuremberg University,
Loewenichstr. 28, D-91054 Erlangen, Germany

## INTRODUCTION

Even today the deep ocean is still a vastly unexplored region of the earth. This can also be said of the ocean margins, and even of the shelf regions. In contrast to the remote satellite investigations of land surfaces, observations, measurements and recordings of the seafloor have to be carried out by vehicles that can descend directly to the ocean bottom. This requires special technology, including manned submersibles, remotely operated vehicles (ROV's), autonomous underwater vehicles (AUV's), towed cameras, and lander systems. Seismic, swath bathymetry, and side scan sonar systems are also a great help in mapping bottom topography and sub-bottom structures.

While the shelf and coastal regions have long been in the spotlight of social and economic attention because of the strong competition for their utilization (traffic corridors, energy and resource extraction, tourism, etc.), economic interest at greater depths (up to 3,000 m) has also intensified in recent years because of the expansion in oil and gas exploration there.

By using sophisticated technologies, new phenomena are constantly being discovered on the seafloor, for example, gas hydrate outcrops, cold seeps, slumps, and cold-water coral reefs. Learning more about these unknown regions is a great challenge for the marine science community. Because of its long and variable coastline, this is also an important European task.

## Gas hydrates

Keen attention has recently been given to gas hydrate, an ice-like solid substance composed of water and natural gas (mainly methane). Other gases like higher hydrocarbons, hydrogen sulphide and carbon dioxide may also be enclosed as minor constituents within the water cages. To date gas hydrates of three different crystal structures occur; structures SI and SII both crystallize to a cubic system, whereas the third structure (also denominated H) crystallizes to a hexagonal system, like ice. The structure of gas hydrate can be seen as a packing of polyhedral cages. All three structures occur naturally. Structure I is most frequent and can enclose gas molecules that are smaller in diameter than propane molecules, such as $CH_4$, $CO_2$ or $H_2S$. Therefore, the natural occurrence of this crystal structure mainly depends on the presence of biogenic gas, as commonly found in sediments of the ocean floor. Hence, structure II contains natural mixtures of gases with molecules bigger than ethane and smaller than pentane. It is usually confined to areas where a thermogenic formation of gas takes place in the sediment.

The stability of methane hydrate in a marine environment is defined predominantly by its physical conditions (temperature and pressure). Assuming a constant temperature of 0°C, e.g. in polar areas, methane hydrate cannot be stable at a water depth of 100 m. It may occur in a seafloor which is more than 400 m below sea level. The thickness of the hydrate zone will depend on the temperature gradient. However, with an increasing depth below the seafloor, temperatures get too high for a formation of gas hydrate, so that one can find free gas and water. Given an average temperature increase by 3°C per 100 m sediment depth, when drilling at a water depth of 300 m, we can expect to find a 300-m-thick hydrate layer. At 1000 m water depth, the layer will be 600 m thick. If, however, sediments are characterized by a stronger increase in temperature, which can be the case e.g. at active continental margins (4-6°C per 100 m depth), the hydrate zone will generally be thinner. Gas hydrate has been found in sediments up to 1100 m below the seafloor.

Apart from adequate temperature and pressure conditions, gas hydrate formation depends on how much gas, primarily $CH_4$, is available. Most of the methane found in the oceans is produced by fermentative decomposition of organic components or by bacterial reduction of $CO_2$ in sediments. Sometimes it may also be a product of thermo-catalytic alteration processes in deeper sediments. $CH_4$ production is highest at the continental margins. Along continental margins high plankton productivity and high sedimentation rates yield large amounts of organic matter, which becomes the basis for a production of gas in the sediment. Therefore, gas hydrate is found at almost all passive and active margins.

Gas hydrates form in the pore spaces of the sediments, but are also sometimes found in massive form directly at the seafloor and are responsible for a highly dynamic seafloor methane exchange. Innovative current research topics include the conditions of formation as well as the occurrence and amounts of methane stored in the gas hydrates. Interest in gas hydrate presence in marine sediments has a dual nature: as a possible energy source, and with respect to its capacity as a greenhouse gas. Although economic exploitation can't be realized at present, studies to estimate the depositional and stability conditions of the reservoirs are necessary. Global climate models have not, so far, considered the significance of methane from natural gas hydrate sources as a greenhouse gas, although proxy data from paleoclimate studies indicate that it has probably played a key role in climate development in the past. It is assumed that gas is released due to tectonic movement and ocean current changes, or as a result of temperature changes, and that this release can cause large-scale landslides in the continental slope regions.

## Stability of ocean margins

Exploitation of deposits to produce gas and oil from the continental slopes also brings up the question of the stability of ocean margins. Seismic, bathymetric and side-scan sonar mapping of the seafloor has shown that slides of different order of magnitude characterize all continental margins. When enclosed in sedimentary pore space, gas hydrate acts like cement, compacting and stabilizing the seafloor. However, if formed in deposits that are still unconsolidated, gas hydrate prevents the normal increase of compaction with increasing lithostatic pressure. If exposed to variations of pressure and/or temperature, interstitial gas hydrate decomposes. In this case, the compactness of the seafloor decreases, which may cause submarine land slides. There is hardly any immediate evidence for submarine slides triggered by gas hydrate dissociation. Still, the hypothesis seems to be corroborated by some observations. For instance, near slide scars one can often find traces of gas and fluid flux that move upward along seismically registered paths. The seafloor itself shows crater-like depressions, so-called pock marks, or bivalve and bacterial mats (cold vents) that indicate fluid venting. At the upper shelf edge there are slopes of more than 4°. Gravitational slides appear likely if such a slope becomes less stable due to gas hydrate dissociation. One important factor seems to be the expansion of the released gas, which increases with decreasing water depth. For example, at 650 m water depth, the volume of released gas and water is almost three times the original gas hydrate volume. Gas hydrate decomposition at the upper shelf edge thus results in an enormous pore pressure that leads to a massive loss of compactness while the large pore space makes the sediment highly deformable. Bottom simulating reflectors, with their slope-parallel trend, are another potential factor triggering submarine slides. When gas hydrate dissociates, they will be weak layers parallel to the slope. Gas hydrate dissociation at the upper shelf edge can be caused by reduced pressure due to a lower sea level. During the Last Glacial Maximum, the global sea level was approximately 120 m lower than at present. This should have led to gas hydrate dissociation and, subsequently, to destabilization of the upper shelf edge. Many slides indeed happened during this period or later. However, they may also have been caused by higher sedimentation rates at the continental slope.

Abundant examples of large-scale mass slumps, which can be triggered by earthquakes, the release of gas hydrates or other events, are found in the geologic record. These underwater landslides can trigger tsunamis or they can destroy technical infrastructures such as communication and production installations. Slumps occur around the world at active as well as passive continental margins, at oceanic islands and ridges as well as river deltas. There is a crucial need to carry out studies of the interrelationships of bottom mechanics and of seafloor instability and slumps, as well as investigations of the natural or anthropogenic mechanisms that trigger them.

## Deep-water coral reefs

Completely new and unknown biocoenoses are still being discovered in the deep ocean. An impressive example is the deep-water coral reef ecosystem. Deep-water coral reefs are distributed throughout the world and occur at a particular depth horizon along continental margins, oceanic banks, mid-ocean ridges and isolated seamounts, thus indicating a strong oceanographic control. Deepest reefs occur at 1.5 km water depth, whereas the shallowest reefs are known to exist in some Norwegian fjords in 60 - 40 m depth. Individual reef complexes are built of colonial, branching and non-symbiontic stone corals. During the past 9000 years, these corals have constructed some tens of kilometres large and up to 30 m thick reefs. These reefs form impressive topographic structures on the seabed and attract a highly diverse associated community. A first large-scale census on the diversity of the reef community conducted during the ACES-FP 5 Project along the north-western European continental margin yielded more than 2000 species – of which many are new to science. Deep-water coral reefs represent the most diverse benthic ecosystem in deep and permanently dark waters. The major difference to the well-known tropical coral reefs is the lack of light-dependant organisms in deep-water reefs. Therefore, the deep-water coral reefs are largely dependant from advected food resources of the productive and illuminated surface waters.

Deep-water coral reefs are known for centuries as rich grounds for local fisheries. Since the mid-80s, however, industrial fishery have started to exploit the deeper waters along the continental margins down to 1500 m water depth with robust mobile fishing gear of which bottom-trawls create the most devastating impact to any kind of benthic ecosystems. In many places, deep-water coral occurrences overlap with intense trawling areas. The demonstrated threats to the coral ecosystem are: habitat destruction, fragmentation, sediment siltation and alteration of the food-web through the removal of slow-growing and long living species. Unlimited continuation of this unsustainable fishing practise will contribute to the further global decline of fish population. The new and emerging field of deep-water coral reef research worldwide has reached the political agenda and is now discussed on major international conventions on the protection of biodiversity.

Deep-water coral reefs are not only an important biological and genetic resource. Due to the large fossilisation potential of the stone corals and associated fauna, these reefs must be regarded as a new environmental archive to reconstruct past and present changes of ocean circulation and/or climate. Deep-water corals contributed in the formation of the recently discovered carbonate mounds off Ireland, Gulf of Cadiz, off Morocco and Mauritania. These mounds are up to 250 m high and cover substantial parts of the continental slope. Although only the upper 15 m of these giant seabed structures were cored so far, corals were present during interglacial periods at least since the past 2 Million years off western Ireland.

## Technologies

Studies of the scientific topics discussed above require the application of both new and existing technology. For precisely aimed measurements and sampling of the seafloor, submersibles or remotely operated vehicles (ROV's) are necessary. To optimally deploy the deep-water ROV's that are presently available in the world, it is necessary to standardize the tools and connection ports as well as the navigation and data systems. For sampling the upper sediment and rock layers, drilling systems are being developed to fill the retrieval gap that presently exists between piston coring methods and the drilling technology employed by ships in the Integrated Ocean Drilling Program (IODP).

For large-scale seafloor mapping and investigations of the sediment structures, various seismic instruments are available that can be towed from research vessels. It will be important for future research efforts to install these instruments on autonomous underwater vehicles (AUV's). European institutes already possess highly sophisticated equipment for investigating ocean margin systems. The further development of this equipment and its deployment in the European realm is an important priority.

Continued development of tools that retrieve samples that remain under in situ temperature and pressure conditions are critical for the progress in gas and hydrate-bearing sediments. For drilling there are two complementary systems now available, the ODP Pressure Core Sampler (PCS) and the Hydrate Autoclave Coring Equipment (HYACE). Other autoclave sampling tools for deployments from conventional research vessels have been developed. Within the last 3 years a MultiAutoClave Sampler (MAC) and a Dynamic Autoclave Piston Corer (DAPC) were designed and build. The MAC takes 50 cm long cores and the DAPC can recover 2 m cores under in situ pressure.

**SESSION** **THEME 4: EXPLORATION OF THE EUROPEAN OCEAN MARGIN, ITS DEEP SEA RESOURCES AND ECOSYSTEMS**

**TITLE** **FRONTIERS IN DEEP-SEA BIOLOGICAL RESEARCH: TOWARDS UNDERSTANDING THE FUNCTIONAL AND STRUCTURAL ADAPTATION OF MARINE MICROBIAL COMMUNITIES TO THE DEEP-SEA OCEAN MARGINS**

**AUTHOR(S)** ***LAURA GIULIANO***

Istituto per l'Ambiente Marino Costiero (IAMC), Consiglio Nazionale delle Ricerche, Messina, Italy
giuliano@ist.me.cnr.it

## SUMMARY

The ocean remains as one of Earth's last unexplored frontiers. It has stirred our imaginations over the millennia and has lead to the discovery of new lands, immense deposits and reservoirs of resources, and startling scientific findings. The improvement of human ability to sample and to conduct experiments from the coastal regions to the deep ocean abyss has provided answers to questions on such critical issues as global change, waste disposal, mineral deposits, and the creation of life itself. The immense population numbers and overwhelming genomic diversity, typical of marine environments, gives evidence of the huge adaptive and evolutionary possibilities of bacteria in the oceans. Deep-sea bacteria are especially diversified in order to thrive in various kinds of typically "extreme" conditions so that the extreme deep-sea marine environments (hydrothermal vents, cold seeps, subterranean environments, hypersaline deep-sea basins) represent a virtually untapped resource for the discovery of novel bioproducts, cell components or metabolic pathways with potential industrial and biotechnological applications.

## INTRODUCTION

The oceans include the largest habitats on Earth (about two thirds of the Earth's surface) hosting biochemical processes that adapted, diversified and evolved over billions of years (Falkowski *et al*, 2004). Particularly, the deep-sea marine environments include a huge variety of still unexplored extreme environments where a multiplicity of selective processes is occurring simultaneously. Therefore, they represent a reservoir of untapped diversity with potential application. According to recent theories, the deep-sea extreme environments could harbour prototypes of ancient forms of life and make more plausible the search for life outside the Earth (Rothschild & Mancinelli, 2001; Marion *et al*., 2003). Among them, the deep hydrothermal vents show chemistry possibly compatible with prebiotic chemistry leading to the origin of life (Cody *et al*., 2000), and they are inhabited by bacteria exhibiting very unusual adaptive mechanisms. Volcanic heated areas of the ocean floor resemble those on the continents in their geological and chemical characteristics, but they are much richer biologically. More than three-quarters of the hyperthermophiles known today come from deep-sea (Huber and Stetter, 2001). Opposite than their continental counterpart, the extreme deep-sea environments are delimited by well detectable concentration gradients that are known to shape the microbial diversity generating patterns of spatial segregation and, usually, promoting microbial evolutionary branching (Dieckmann & Doebeli, 1999). Nevertheless, marine diversity studies have, to date, been mostly carried out on shallow-water samples. It is therefore crucial the implementation of research tools by the development of modern equipment for undersea bacterial exploration as well as for the cultivation of fastidious extremophilic deep-sea bacteria. Representatives of the dominant or abundant bacterial taxa from deep-sea extreme environments should be brought into genome programs, and the large application of genomics and proteomics on marine microbiota should be envisaged for biotechnological exploitation.

## DISCUSSION

### Bacterial life at deep-sea extremes: towards the bacterial molecular adaptation to multiple extreme forcing effects

Due to commercial pressures on the exploration of extreme environments, the ongoing research has greatly expanded our understanding of the limits to life on Earth. The newest frontiers for this search are extreme ocean environments. The ocean has been called a “high pressure refrigerator” with most of its volume below 100 meters at temperatures near 3°C, except in the vicinity of hydrothermal vents which are underwater geysers. In vents the temperature may be as high as 400 °C, but water remains liquid owing to the high hydrostatic pressure. Deep-sea prokaryotes are true extremophiles as they are usually adapted to several environmental constraints (multi-extreme conditions). In the ocean depths psychrophiles are commonly faced with extremely high pressures, and therefore must be piezo-psychrophiles (Yayanos, 1995). They usually encounter low organic carbon concentrations so that they must be oligotrophic as well. Piezo-halophilic bacteria are also expected to thrive in deep sea oceans as well as metalotolerant piezo-hyperthermophiles (Kashefi *et al.,* 2002). Progress in the molecular studies has indicated that bacterial cell membrane adapts to extremes of temperature by changing its composition in order to maintain the proper fluidity (Rothschild and Mancinelli, 2001). The modifications to protein structure for survival at extremes of temperature have been extensively reviewed (Fields, 2001) and they have underlined the involvement of weak interactions (rather than conformation changes at the level of the secondary or the three-dimensional structures) in ensuring stability and activity to the enzymes. Since the adaptation to halophily in the deep sea environments is always obtained by “compatible-solutes” rather than by “salt-in” strategy, the latter one being light-dependent the intracellular metabolic processes of deep sea prokaryotes seem to be never exposed to high salt conditions.

### Biotechnological prospects

Since the discovery of the *Taq*-polymerase (from *Thermus aquaticus*) that brought to the achievement of the PCR-based molecular analyses, extremophiles have endeared themselves to multibillion-dollar industries, including agricultural, chemical synthesis, laundry detergents and pharmaceuticals (Zeikus *et al*., 1998). The use of extremophiles includes the isolation of enzymes (extremozymes) with desirable properties, the use of whole organisms for specific purposes, and the search for natural products or active biometabolites. The newest frontiers for this search are the microorganisms from extreme ocean environments (Kelecom, 2002). Some foreseen applications of deep-sea “extremozymes” are in dealing with detoxification/bioremediation processes of hazardous compounds at the “near-critical” water conditions at which water can be a good solvent for both salts and non-polar organic compounds, including oils. Deep-sea symbioses of various types have been described that might easily result in the synthesis of natural products with potential industrial applications. Among them, culturable multiple-heavy-metal-resistant strains have been described as endosymbionts of Pacific vent worms. Several biotechnology research companies are in fierce competition to discover new applications from extremophiles, examples of which include: *(i)* the Marine Bioproducts, Engineering Center (MarBEC), California, USA; *(ii)* Diversa Corporation with its Recombinant Natural products Programme based on genomic screening strategies (California, USA), that has exclusive rights to all commercial applications from the novel extremophile *Nanoarcheum equitans* retrieved from the deep sea; *(iii)* Cubist Pharmaceuticals (Massachusetts, USA); Protéus (Nimes, France).

The European Commission has supported research, training and the commercialization of technology in this area since 1982. From 1996–1999 it funded the ‘Extremophiles as Cell Factories’ project (see http://www.tutech.de/ecf/ecf1_3.htm), which is now in a phase of industry-sponsored technology transfer to European companies. Among the more recent EU funded projects in this field, the “BIOtechnologies from the DEEP” (BIODEEP, EVK3-2000-00042) is aimed at the exploration of the Mediterranean deep hypersaline anoxic basins to discover novel compounds and biodiversity (http://www2.geo.unimib.it/BioDeep/Project.html). The main challenge of the project is to characterize the physiology and ecology of the isolated extremophiles and their cellular components or products and to identify how their features (novel compounds and activities) can translate into new biotechnologies.

## The new challenges for basic and applied research in the field of deep-sea microbiology

Extremophile research is entering an exciting phase. The commercial potential has been recognized, but is far from being realized. Our ignorance of microbial diversity coupled with improvements in exploration and analytical technology suggest that many more discoveries will be forthcoming.

The huge potential of deep-sea extremophilic bacteria relies first on access to sampling including the development of modern equipment specifically optimized for the different deep-sea extreme environments to be explored and sampled. Within this frame, novel international regulations should face up to the issues related to the conservation of marine extreme environments. Microbiologists should take a serious view on biogeographic distribution and to lobby for the protection of unusual, pristine, and threatened habitats. The choice of the environments to be protected needs the implementation of the databases. Genomics and proteomics will certainly contribute to make this an easier question to address[5].

None of the assays used in major pharmaceutical drug discovery programs takes into account the ecological role of marine-derived compounds in nature, i.e., the *in situ* biochemical functions of both primary and secondary metabolites (defence mechanisms, niche protection, signalling, feeding strategies). This gap, that might accelerate the industrial application, can be actually filled by the recent advances in culture-independent genomic analyses (metagenomics) as well as by the development of *in situ* biosensors for fast detection of expression of secondary metabolites in response to various stimuli.

Among the major problems confronting research in the exploitation of extremophiles, the concentration of the active compound is often extremely low. Perhaps the area in which marine biotechnology in general, and marine bioprocess engineering in particular, has the greatest potential is in the design and optimization of bioreactors for marine metabolite production. If the producer microorganisms can be isolated and cultured, optimization of production in marine microbial bioreactors may lead to an industrially feasible supply option. An understanding of the cellular and molecular processes that control production of these metabolites could be used to enhance upstream processing/culture optimization and to stimulate production of “unnatural” natural products—i.e., chemicals that the organism would not produce under normal conditions, but which may be more potent than the “natural” product.

Finally, an understanding of the adaptation of proteins to extreme environments will allow the design of specific proteins for more creative biotechnological application.

## What next?

While many space satellites have been launched, nothing comparable can be proclaimed for the ocean. Ocean exploration provides the experience necessary to undertake stewardship of the ocean and its resources. In any case, the International Space Station will enhance long-term biological studies in space, improving our understanding of the scope of that formerly inaccessible environment. Deep ocean basins are good analogues for the cold, high-pressure (putative) ocean of Europe (Marion *et al*., 2003). Colonization and terraforming of Mars will require a supporting biota, and where better to start than with extremophiles?

---

[5] Example of microbial diversity protection actions include the Yellowstone Thermophiles Conservation project, and the caution being exercised in penetrating and sampling Lake Vostok in East Antarctica in order to access organisms that have evolved novel metabolic activities and are usually recalcitrant to the cultivation efforts.

## ACKNOWLEDGMENT

Most of the ideas have been elaborated thanks to the constructive discussions with the BIODEEP partners. I thank Mikhail M. Yakimov for helpful assistance and for the critical supervision of this work. I am especially grateful to Dr. Gilles Ollier for having provided me with the possibility of contributing to the EUROCEAN2004 initiative.


## REFERENCES


Anthoni U, Nielsen PH, Perieira M, Christophersen C (1990) Bryozoan secondary metabolites: a chemotaxonomical challenge. *Comp Biochem Physiol* 96B: 431-437.

Cody GD, Boctor NZ, Filley TR, Hazen RM, Scott JH, Sharma A, Yoder HS Jr (2000) Primordial carbonylated iron-sulfur compounds and the synthesis of pyruvate. *Science* 289: 1337–1340.

Dieckmann U, Doebeli M (1999) On the origin of species by sympatric speciation. *Nature* 400: 354-357.

Falkowski PG, de Vargas C. (2004) Genomics and evolution. Shotgun sequencing in the sea: a blast from the past? Science. 304(5667): 58-60.

Feller G, Gerday C (2003) Psychrophilic enzymes: hot topics in cold adaptation. *Nat Rev Microbiol* 1(3): 200-208.

Fields PA (2001) Review: Protein function at thermal extremes: balancing stability and flexibility. *Comparative Biochemistry and Physiology* 129: 417-431.

Huber R, Stetter KO (2001) Discovery of hyperthermophilic microorganisms. *Methods Enzymol*. 330:11-24.

Kashefi K, Tor JM, Holmes DE, Gaw Van Praagh CV, Reysenbach AL, Lovley DR (2002) *Geoglobus ahangari* gen. nov., sp. nov., a novel hyperthermophilic archaeon capable of oxidizing organic acids and growing autotrophically on hydrogen with Fe(III) serving as the sole electron acceptor. *Int J Syst Evol Microbiol.* 52(3):719-28.

Kelecom A. (2002) Secondary metabolites from marine microorganisms. *Annals of the Brazilian Academy of Sciences*. 74 (1): 151-170.

Marion GM, Fritsen CH, Eicken H, Payne MC (2003) The Search for Life on Europa: limiting environmental factors, potential habitats, and earth analogues. *Astrobiology* 3(4): 785-811.

Price PB (2000) A habitat for psychrophiles in deep Antarctic ice. *Proc. Natl. Acad. Sci. USA* 97: 1247-1251.

Rothschild LJ, Mancinelli RL (2001) *Nature* 409: 1092-1101.

Zeikus, JG, Vielle C, Savchenko A (1998) Thermozymes: biotechnology and structure-function relationships. *Extremophiles* 2: 179–182.

Yayanos AA (1995) Microbiology to 10,500 meters in the deep sea. Annu. Rev. Microbiol. 49: 777-805.

**SESSION** **THEME 4: EXPLORATION OF THE EUROPEAN OCEAN MARGIN, ITS DEEP SEA RESOURCES AND ECOSYSTEMS**

**TITLE** **STEPS ON THE SLOPE: EUROPE'S EXPLORATORY TRACT IN OCEAN MARGIN RESEARCH**

**AUTHOR(S)** ***JEAN-PIERRE HENRIET***

Renard Centre of Marine Geology, Ghent University, Belgium
Jeanpierre.henriet@ugent.be

## SUMMARY

The development of Europe's exploration of ocean margins closely mirrors its cultural, socio-economic and political history. Great Scots, princes and inventors have paved the way for institutional research. Still, when ocean science went global, in the wake of the IGY, Europe played second, or was it third fiddle? North Sea oil would herald Europe's offshore economic momentum, and become the prime trigger of today's boosting margin research. Ocean science in Europe is nowadays, in an unprecedented way, driven and controlled by Europe's turbulent political development. The MAST epos, FP5 with its kaleidoscope of creativity have transfigured the European ocean research community, and raised grand expectations towards the European Ocean Margin Research Area and cross-Atlantic interaction.

## INTRODUCTION

It was American entrepreneurship that, in the mid-nineteenth century, prepared a first link between Europe and America: the first telegraph cable. But before Field came to success in 1858, tools had to be developed: the sounding tool and the dredge, the latter acquiring its patent of nobility within the Dredging Committee of the British Association for the Advancement of Science (1839). It was at a meeting of the BA in Cork in 1843 that one of the most eminent members of the Dredging Committee, the young professor Edward Forbes from King's College in London, coined the concept of "Life's zero level": below 300 fathoms (550 m), neither light nor animal could persist – the earliest bold statement about a Deep Biosphere, or its deficiency. This concept would soon be challenged. When on the American side Louis Agassiz obtained in 1866 funds for the first deep dredgings off the Antilles, a young UK teacher, Charles Wyville Thomson, travelled to Christiania (Oslo) to admire the best ranging "living fossils", collected by Michael Sars' son off the Lofoten: crinoids. While Agassiz saw herein proof of creationism, Charles Wyville Thomson and William Benjamin Carpenter cleverly exploited Darwin's ideas on evolution, to convince the Royal Society to invest in deep sea dredging (1868). The hybrid of professor, lobbyist, project writer, fund-raiser and chief scientist was born.

After first tests on board of the Lightning, it was on May 18$^{th}$, 1869, that HMS Porcupine set sail from Valentia, to dredge what is now known as Porcupine Bank and Porcupine Seabight. Between port calls for refuelling (coal) in Galway and Donegal, the first "*Lophohelia prolifera* (Pallas)" would be dredged. It is about 130 years after the first dredgings of *Lophelia* cold-water corals in Porcupine Seabight that scientists would discover - right on these sites - both in Porcupine Seabight and off the Lofoten, some of the ocean's most spectacular deep water coral reefs. And 130 years had to pass, before Man realized these incredible habitats on Europe's margins deserved due protection. The success of the Porcupine expedition, which would eventually translate and culminate into the historic cruise of HMS Challenger (1872-1876), paved the way to abyssal research. Sadly, the continental margin, the site where oceanography was born, would virtually turn into oblivion, for over 100 years.

## Inventors and artists

If the first technological drive for margin research – the transatlantic cable – had come from the New World, the second one, about one hundred years later, would come from the old one: the development of new tools, culminating in the manned exploration of the deep-sea. In 1948, Professor Auguste Piccard would test off Dakar the FNRS 2, the world's first manned deep-sea submarine. The "bathyscaphe" of this genial inventor features a score of key technological designs and security gadgets, still in use in the worldwide fleet of modern deep-sea submarines. The Piccard dynasty – father Auguste and son Jacques – would virtually close the era of the lonely riders in oceanography.

## Towards worldwide collective research: the drive of the International Geophysical Year 1957-1958

In those years when the deep-sea submarines became operational (the FNRS-3 and the Trieste, the latter taken over by the US), the scientific community involved in the study of our planet experienced the first real "globalization". A milestone was the International Geophysical Year, IGY 1957-58. By the closure of the golden sixties, the scientific stage was fully taken by America and Russia, European nations playing third fiddle. The verification of the plate tectonic paradigm (1968) would be the key rationale for the Deep Sea Drilling Programme. At least, the globalization in science was there to stay, with the UN, IOC-UNESCO and ICSU stepwise fostering worldwide, long-term science programmes, virtually none of them however addressing the ocean margins.

## From North Sea oil to environmentalism: Europe's first steps towards the slope

The discovery of the Ekofisk oil field in 1970 in the central North Sea refuelled Europe's already stagnating or declining early offshore exploration efforts. Steadily moving North, the new exploration wave reached the shelf edge by the early eighties. Europe's western frontier in hydrocarbon exploration – the continental slope – got within touch. In parallel, environmental awareness woke up. Not only in terms of limits of growth, as first expressed in 1972 by the Club of Rome, but also in terms of the fundamental significance of the Biosphere. The hydrocarbon industry and the environmental world initially started rather as foes than as friends. Environmental constraints, stringent in particular in the Norwegian sector, came as a harassment and cost-boosting factor. Few suspected that over the subsequent twenty years, it is the conjunction of both dynamics that would lay the base for one of the most challenging oceanic research fields. The systematic seismic exploration of Europe's continental slope would soon unveil the fundamental structure of this unique and varied continental margin. It is also the hydrocarbon exploration that would first reveal in the mid-nineties, in Porcupine Basin off Galway, the presence of large, enigmatic carbonate mounds, right where Wyville Thomson had dredged his first deep-water corals. Remarkably, it has indeed taken a long time to link science and industry into margin research. In the US, early attempts in the eighties to start a margins drilling programme with industrial support failed. It is only when NSF shifted focus towards academic interest, in the late eighties, that the US "Margins" programme would take off.

## The European Union sails off: MAST and the Grand Challenges

ESF, the European Science Foundation representing the national science agencies, had coordinated the participation of a number of smaller European countries in the Ocean Drilling Programme since 1985. In 1987, it hosted the Second Conference on Scientific Ocean Drilling (Cosod II) in Strasbourg. The influential report of this large-scale meeting identified the main challenges of ocean drilling. Remarkably, margins were not singled as such but they were covered by the Working Group on Fluid Circulation in the Crust and the Global Geochemical Budget. In the last pages of this report, nearly unnoticed, a veteran of DSDP, Yves Lancelot, promoted a new concept of a light, low-cost drilling vessel, not only for shallow drilling as an alternate platform, but also for the deployment of seafloor observatories. This visionary project would form the theme of the NEREIS Conference, organized under the auspices of the EC in Brussels, 1990. For complex reasons, NEREIS could never take off. We can only imagine what might have been margin research with this versatile vessel, tailored for stratigraphic drilling and the deployment of seafloor observatories, in particular in the present interregnum between ODP and IODP. In IODP, the concept of alternate platform has finally made its way, and has been entrusted to Europe, but too late for NEREIS.

The year 1990 was also the kick-off of the EC's first well-identified marine science and technology programme: MAST. MAST 1 and MAST 2 were embedded in the 3$^{rd}$ Framework Programme, between 1990 and 1995. In parallel with MAST 2, the ENVIRONMENT programme added additional resources. In MAST 1, margin research had a low profile. The main thrust was in coastal zone studies and general oceanographic research, as European contribution to global programmes like WOCE, TOGA etc. In MAST 2, the European North Atlantic Margin (ENAM) project set the stage for a well-identified margin research programme, in some Nordic areas in continuity with ESF's earlier PONAM project (Polar North Atlantic Margins).

In the same years 1993-1994, the EC and ESF teamed up in ECOPS, which had as major achievement the launching of a series of Euro conferences, culminating in the "Grand Challenges" meeting in Bremen, 1994. The margins topic was embedded in the San Feliu de Guixols meeting on "The Deep-Sea Floor as a Changing Environment", within the sub-programmes MASTER (Margin Stability and Environmental Records) and GEOFLOW (Geologically Induced Flow through the Seabed).

## The 4th and 5th Framework Programmes: the beat goes on, up to the 6th

The Grand Challenges faded out, but the offspring of this initiative made its way in MAST 3, under FP 4. Two major projects consolidated and developed margin research: ENAM 2 and STEAM, while the Concerted Action CORSAIRES contributed to develop the concept for margin drilling with alternate platforms and promoted training at sea and the development of new technologies (Logging-while-drilling) and research themes: the ENAM-CORSAIRES Workshop on Gas Hydrates (1996) and the IOC/UNESCO (TTR)-CORSAIRES Workshop on "Geosphere-Biosphere Coupling: Carbonate Mounds and Cold Water Reefs" (1998). Margin research would however gain momentum in a spectacular way under the 5$^{th}$ Framework Programme, at the turn of the century. Close to 20 scientific and technological projects were related to margin exploration and monitoring. A clustering of these projects under the OMARC consortium, which groups over a hundred European teams involved in margin research, increased interaction and visibility. In parallel, ESF's EUROCORES programme came in time to secure continuity of research between FP5 and FP6 and to give a chance to themes, less prominent in the priorities of the EU. The EUROCORES programme EUROMARGINS grew out into a dynamic cluster of projects, highly complementary to the EU initiatives. Such initiatives of large-scale clustering have naturally paved the way for larger-scale ventures, as components of the European Research Area under FP 6: networks of excellence and integrated projects.

### DISCUSSION AND CONCLUSION

Out of this short review and/or on top of it - and with due care – we might convey three messages.

(1) Ocean margin research has grown in Europe over a wide spectrum of initiatives and scales, from the entrepreneurship of individuals to large-scale institutional moves. It is important to preserve the energy contained in the full bandwidth. Within a European Research Area, the dynamics of *SME-scale projects* in particular are – just as in the industrial realm – as important for innovative research as those of large-scale projects such as IP's and NoE's. European margin research has proved flexibility, playing swiftly the ball when new challenges or insights emerged, even if not anticipated in the calls (cfr. the under FP4 emerging themes on gas hydrates and cold-water coral reefs). Care has to be taken at the level of IP's in particular to

preserve such flexibility. For instance when settling (contractually) in 2004 IP deliverables for 2006, care has to be taken not to lock the results of 2006 on scientific insights or technological constraints of 2004.

(2) We have a domain where, after decades in a retreat position, Europe moved back to the frontline, more by a critical mass of top-quality research than by a single tool. This is the time to intensify (though not in an exclusive way) cross-Atlantic cooperation and competition. The scientific logic of conjugated margins - familiar to most of us – can usefully be translated into a strategic logic of *conjugated research* on margins.

(3) We are however losing this strategic position – vital for European science and industry – if we neglect human resource management. Important pools of pre-doctoral and post-doctoral young researchers have been created. However, the top of the pyramid has still to be shaped, as a horizon for "the best of" our trainees and as a pool of senior expertise for recruitment by universities, governments and industry, at the pace of opportunities. Figures on the exodus towards America of highly qualified scientists, lacking a horizon in Europe, are worrying, if not alarming. *Europe is losing its stars*. One facet of the analysis is simple: beyond a period of mobility, scientists deserve some degree of stability, if only to shape and support a family, in a civilized way. The concern for the quality of Life for European citizens also applies to scientists. Disregarding this right, on top of other – professional – factors, will amplify the exodus of qualified scientists out of Europe and will move Europe back to the background. Historically, no country has been better able to turn such tide than Ireland: a challenge for the Irish Presidency?

## ACKNOWLEDGEMENT

The author is indebted to the officers of EC, ESF and NSF, to numerous colleagues from the academic or industrial realms and to students and young researchers for having contributed, directly or indirectly, to access information and to exchange ideas.

| | |
|---|---|
| **SESSION** | **PLENARY 2: THE CONTRIBUTION OF THE YOUNG GENERATIONS TO THE FUTURE OF THE EUROPEAN MARINE RESEARCH AREA: MARIE CURIE FELLOWSHIPS IN THE DOMAIN OF MARINE SCIENCES.** |
| **TITLE** | **SESSION REPORT** |
| **RAPPORTEUR** | ***ANU REINART*** |

e-Mail : anu.reinart@ebc.uu.se

## SUMMARY

The principal objectives of Plenary Session 2 were to highlight the contribution of young researchers to the European Marine Research Area, identify obstacles to their career development and pose solutions. After the opening of the Session by Evangelos Papathanassiou, Georges Bingen, Head of Unit of the Marie Curie Fellowship Programme, described the EC Marie Curie Programme. This was followed by presentations by three actual Marie Curie Fellows: Krishna Das (Belgium), Konrad Ocalewicz (Poland) and Irina Popescu (Romania) working in Germany, France and Belgium respectively. These young researchers described their work and what the Marie Curie Fellowship meant to them in terms of career and personal development. The final speaker, Kim Araujo Stobberup, of the Marie Curie Fellowship Association (MCFA), described the work of this Association in following up the careers of former Marie Curie Fellows.

## INTRODUCTION

**The Marie Curie Fellowship Programme**:

Georges Bingen introduced the EC's new €1.580 million Marie Curie Fellowship Programme promoting life-long training through mobility. The Marie Curie Programme follows a bottom-up approach and includes actions from early stage and advanced training, transfer of knowledge and possibilities for re-integration of young researchers to their country of origin. Under FP6, the Marie Curie Programme offers training and career opportunities to researchers from both academia and industry. .

## DISCUSSION

The Marie Curie Programme is clearly attractive to researchers, as evidenced by a high subscription rate. The downside of this level of interest is that, for instances, only 7% of early stage training proposals are financed; many excellent projects have to be rejected because of limitation of funds. In general, there is a notable South to North and East to West trend in mobility; the UK, followed by France and Germany, are the favourite destinations for young researchers. French, Spanish, German and Italian researchers, in that order, are the most mobile. New Member States are poorly represented both as applicants and, specially, as host institutes.

Planned activities to increase the effectiveness of the Marie Curie Programme in the training of scientists include:

- More focused calls for inter- and multidisciplinary projects;
- Promote more industry-academy collaboration through specific calls;
- Encourage greater participation of Accession and Candidate countries, especially through the modification of re-integration grants making these countries more attractive to researchers.

A new initiative, the European Researchers' Mobility Portal, aims to create a more favourable environment for career development by providing structured information on research fellowships and grants, as well as practical information on administrative and legal issues when moving from one country to another.

### CONTRIBUTION OF THE YOUNG GENERATION TO MARINE RESEARCH

Three Marie Curie Fellows presented their research projects in diversified marine fields and shared their experiences as Marie Curie Fellows.

Krishna Das described the effects of pollutants (heavy metal and endocrine disrupters) on the general health and immune system of the harbour porpoise. This work is also fundamental for the understanding of how the pollution of sea can impact on the endocrine and immune systems including the human ones.

Konrad Ocalewicz presented his work, on a multidisciplinary-based approach to fish biochemistry, evolution and molecular genetics, as a key for studying the complex metabolic pathways of vitamin C requirements in fish. When natural fish stocks are over fished, improvements of alternative source of fish (aquaculture) are very important.

Irina Popescu, described her work, on gas-hydrates in the Black Sea, a new potential energy resource.

Most appreciated by the fellows during their fellowships was the possibility of working in an attractive institution abroad with excellent research facilities, the international dimension given to their careers, the participation on scientific meetings, having scientific support, access to information and network, learning new languages and getting familiar with another culture.

## Current Status of Young Researchers

Kim Araujo Stobberup, a former Marie Curie Fellow, presented the results of a MCFA survey carried out in 2002 on the career prospects and mobility patterns of 2,790 researchers. Among the findings, the survey concluded that:

Kim Araujo Stobberup of the Marie Curie Fellowship Association (MCFA), and a former Marie Curie Fellow, presented the results of an MCFA survey carried out in 2002 on the career prospects and mobility patterns of 2,790 researchers. Among the findings, the survey concluded that:

- Marie Curie Fellows are highly employable; 85 % are employed within three months of the end of their fellowship, but most not in a permanent position;
- Many Marie Curie Fellows (52%) stayed in their host country or moved to another country; less than half (48%) returned to their home country.
- Most Marie Curie Fellows establish a career in academia or public research institutions, though many appeared flexible in their career direction; 55% of these indicated that they were open to a move from academia or public research institutions to industry at some point in their career.

**PROFILE OF A YOUNG MOBILE RESEARCHER**

No permanent home, no social security, no pension.

Highly motivated and independent; dedicated to his/her work.

Late 20s or early 30s; no children.

Long work hours, poorly paid.

Good at overcoming practical hurdles; flexible.

People with initiative and original ideas.

Highly employable (but not necessarily at home).

Short-term contracts/fellowships.

Long wait for permanent position and independence.

Non-linear-careers becoming more common.

Perceived as overskilled - too specialised for industry.

Lack of training in career essentials (e.g project management, proposal writing,

fundraising, communication).

K.A. Stobberup, EurOCEAN 2004

On the negative side, there is an

apparent rise in the number of "nomadic researchers". These are highly skilled and motivated researchers moving from project to project and country to country and missing out on the opportunities provided by stability (e.g. family life, community involvement, pensions, health insurance, social security, etc)..

## CONCLUSION

To maintain Europe's competitiveness, successive generations of scientists and researchers are clearly needed. Out of 1000 of its workforce the EU only employs five researchers compared with eight in the US and nine in Japan. Supporting young scientists and providing a satisfactory career structure is essential. Accordingly, it is important not only to provide research and training opportunities for young researchers, but also to treat them well and provide opportunities to continue with their research careers in universities and institutes (research and education), in applied science (industry and enterprises) and in the public sector (analysts, policymakers, managers).

To achieve these goals there is a need to:

- Develop mechanisms (e.g. the European Researchers' Mobility Portal), to better match skills acquired during a Marie Curie Fellowship period with the research needs of EU Member State and privately funded Research Programmes. This could enhance job possibilities by offering skills to the organisations that need them;
- Provide additional training in project drafting, management, communication skills, entrepreneurship, etc.
- Increase the responsibility of the host institutes towards young researchers in their stewardship.

Finally, but of no less importance, young researchers need to play a more active role in awareness raising for their own interests, take more responsibility for their own career, increase their visibility and communicate better with society.

PhD and Post-Doc Fellowships Opportunities:
In order to facilitate access to information related to PhD and Post-Doc Fellowships in the domain of marine science, the EurOcean website (http://ioc.unesco.org/eurocean/categories.php?category_no=38) currently hosts a list of available Marie-Curie Actions in marine science and technology.

For further information on the Marie Curie Programme see:
Marie Curie Programme: http://www.cordis.lu/improving/fellowships/home.htm.
The European Researchers' Mobility Portal: http://europa.eu.int/eracareers
The Marie Curie Fellowship Association: www.mariecurie.org

## KEY POINTS THEMATIC SESSION 4
## MARIE CURIE FELLOWSHIPS

- Maintaining Europe's competitiveness, and securing a knowledge-based economy will require investment in successive generations of scientists and researchers.
- There is a need to develop mechanisms (e.g. a brokerage mechanism – the European Researchers' Mobility Portal), to better match skills acquired during a Marie Curie Fellowship with the research needs of EU Member States.
- Marie Curie Fellows should be provided with additional training in project drafting, management, communication skills, entrepreneurship, etc.
- There is a need to increase the responsibility of the host institutes towards the young researchers in their stewardship.

**SESSION** **PLENARY 2: THE CONTRIBUTION OF THE YOUNG GENERATIONS TO THE FUTURE OF THE EUROPEAN MARINE RESEARCH AREA: MARIE CURIE FELLOWSHIPS IN THE DOMAIN OF MARINE SCIENCES.**

**TITLE** **THE MARIE CURIE FELLOWSHIP SUPPORT SCHEME**

**AUTHOR(S)** ***GEORGES BINGEN***

European Commission, Directorate General Research
Unit I1: Improving Human Potential Program (Policy unit)

## SUMMARY

The ability to carry out world-class research in Europe depends critically on the availability of skilled researchers and their capacity to produce, transfer and utilise knowledge. The promotion of the international mobility and training of researchers is therefore an essential element of the strategy proposed by the Commission for the creation of the European Research Area (ERA). Mobility helps to improve the quality and quantity of research training by offering the best available opportunities, regardless of where expertise is located. It also makes better use of the resources by providing a mechanism for exchange and dissemination of research results. In addition, it can help to relieve the tension in the research labour market and is fundamental to the achievement of 3% GDP investment in research in Europe.

All in all, improving the opportunities for mobility will open new paths for international collaboration and boost the attractiveness and competitiveness of European research.

## INTRODUCTION

The Human Resources and Mobility activity (or Marie Curie Actions) has a budget of 1.58 billion Euro and consists of a coherent set of actions that finance training and other career development opportunities for researchers. These are known as Marie Curie actions and aim at the development and transfer of research competencies, the consolidation and widening of researchers' career prospects, and the promotion of excellence in European research.

Each Marie Curie action will be open to all fields of research that contribute to the European Community's scientific and technological objectives. These will not be confined to the seven priority thematic areas that have been adopted for the main "Focusing and Integrating European Research" block of FP6. In this way, the activity is entirely "bottom up" and researchers are invited to submit proposals on any area of research (including social sciences, humanities etc). However, proposals that help to bring different subject areas together (multidisciplinarity) or to build relationships between academia and industry (intersectorial) will be particularly welcome.

## DISCUSSION:

Marie Curie actions can be divided into Host-driven actions, Individual–driven actions, Excellence Promotion and Recognition, and Return and Reintegration mechanisms.

Marie Curie actions cover all stages of the researcher careers. Initial training is aimed at researchers who are in the first four years of their career and typically undertaking doctoral studies. More advanced training, with greater emphasis on life-long training for career development, will be offered to researchers with more than four years of experience, or those who have a doctoral degree. There will also be the opportunity to participate in the transfer of knowledge schemes. Finally, world-class researchers will be eligible for the prestigious Marie Curie Excellence Grants, Chairs and Excellence Awards.

Host Driven Actions

In this category, organisations submit proposals to the Commission. Host-driven actions will provide structured training for researchers in the early stages of their career and will enable the development and transfer of competencies in research. The actions are:

- **Marie Curie Research Training Networks (RTN)** in which at least three institutions in three different countries offer scientific and complementary training and transfer of knowledge within the context of a collaborative international research project;
- **Marie Curie Host Fellowships for Early Stage Research Training (EST)** in which structured training (e.g. mainly through doctoral studies) is offered by one or more institutions for the acquisition of specific scientific and complementary skills;
- **Marie Curie Host Fellowships for the Transfer of Knowledge (ToK)** have two main objectives:
    - **Marie Curie Development Scheme** in which researchers transfer knowledge to develop the research potential of institutions. Entities in Less Favoured Regions of the EU and in the Candidate Countries will be given priority;
    - **Marie Curie Industry-Academia Strategic Partnership Scheme** supporting long-lasting collaborations between enterprises and universities via exchange of researchers;
- **Marie Curie Conferences and Training Courses comprising series of events (SCF) and large conferences (LCF)** to enable the organisation of conferences or training courses with support for the attendance of early-stage and more experienced researchers.

Under these schemes, the host institutions will be selected by the Commission and given the freedom (within certain guidelines that ensure the specific objectives of the various schemes) to select the researchers who will benefit from the training or participate in the transfer of knowledge.

Individual Driven Actions

In the case of the individual-driven actions, an individual researcher prepares and submits the proposal together with a hosting institution. The aim of these actions is to help experienced researchers to develop specialised or complementary knowledge and expertise to achieve independence. The actions include:

- **Marie Curie Intra-European Fellowships (EIF)** to enable the most promising researchers from EU and Associated States to undertake advanced/lifelong training within Europe;
- **Marie Curie Incoming International Fellowships (IIF)** to attract top-class researchers from outside the EU and Associated States whilst responding to their needs for individual training. A return phase may be contemplated for fellows coming from developing countries, emerging and transition economies;
- **Marie Curie Outgoing International Fellowships (OIF)** to enable researchers to broaden their international experience by carrying out a research training period in a Third Country with the security of a return phase in Europe;

Excellence Promotion and Recognition

These actions are concerned with increasing the visibility and attractiveness of European research. The aim is to highlight personal achievements of European researchers with a view to supporting their further development and international recognition, while also promoting the diffusion of their work for the benefit of the scientific community. Two actions involve individual researchers who apply to the Commission together with a hosting institution. These are:

- **Marie Curie Excellence Grants (EXT)** to provide support to a promising team-leader for the creation and development of European research teams;

- **Marie Curie Chairs (EXC)** to support world-class researchers for a period of research and lecturing, encouraging them to resume or further develop their careers in Europe.

In the case of the third action, which is a research prize, individual researchers may propose themselves or be proposed by others:

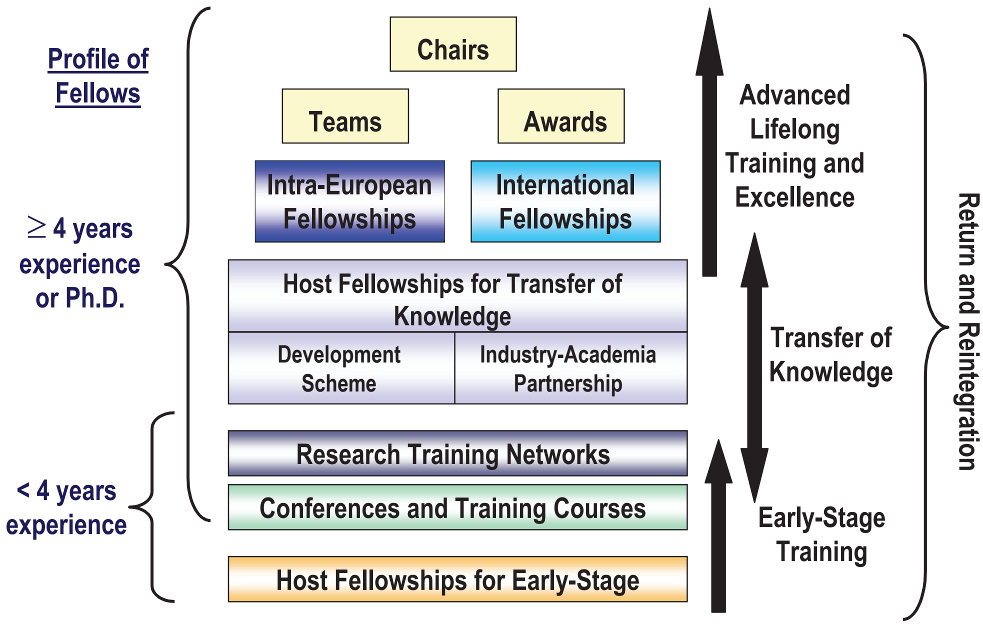
- **Marie Curie Excellence Awards (EXA)** are research prizes that aim to recognise the excellence achieved by researchers who have benefited from training and mobility support from the Community;

Return and Reintegration Mechanisms

There are two actions aimed at supporting researchers' integration in their careers in Europe after a period of mobility. In both cases, they enable researchers to resume or continue their careers in their home country or elsewhere within Europe and the Associated States.

To take part, an individual researcher prepares and submits a proposal together with a hosting institution on the basis of a career development plan.

- **Marie Curie European Reintegration Grants (RRG)**: This action is specific for researchers who have previously participated in a Marie Curie mobility action, to help them reintegrate in a stable research career at the end of a two-year fellowship;
- **Marie Curie International Reintegration Grants (IRG)**: This action will target European researchers who have been carrying out research outside Europe for more than five years and wish to return.




## CONCLUSION:

Maintaining Europe's competitiveness and securing a knowledge-based economy will require investment in successive generations of scientists and researchers. There is a need to develop mechanisms (e.g. brokerage mechanisms – the European Researchers Mobility Portal) to better match skills acquired during a Marie Curie fellowship with the research needs of EU Member States. Finally but of no less importance, young researchers need to play a more active role in awareness raising for their own interests, take more responsibility for their own career, increase their visibility and communicate better with society.

**SESSION** **PLENARY 2: THE CONTRIBUTION OF THE YOUNG GENERATIONS TO THE FUTURE OF THE EUROPEAN MARINE RESEARCH AREA: MARIE CURIE FELLOWSHIPS IN THE DOMAIN OF MARINE SCIENCES.**

# TITLE HEAVY METAL AND ENDOCRINE DISRUPTER IMPACT ON MARINE MAMMALS

**AUTHOR(S)** ***KRISHNA DAS[1,2] AND URSULA SIEBERT[1]***

[1]Forschung -und Technologiezentrum Westkueste (FTZ-Westkueste)
Christian-Albrechts-Universität Kiel, Werftstrasse 6, 25761 Buesum
[2]Laboratory for Oceanology, MARE Center, Liège University, B6c, B-4000 Liège-Sart-Tilman
Tel: +49 4834 E-mail: das@ftz-west.uni-kiel.de; krishna.das@ulg.ac.be

## SUMMARY

Due to their top position in the trophic network, their long life span and their low rate of pollutant elimination, marine mammals can accumulate high levels of chemicals, such as organic compounds and heavy metals. In the North Sea, high levels of mercury, PCBs, methyl sulfonyl PCBs, perfluorinated organochemicals, DDT and toxaphene have been found in the liver and blubber of the harbour porpoise *Phocoena phocoena* and the harbour seal *Phoca vitulina*. Such compounds may affect the immune and the endocrine systems of these species leading to e.g. an increase susceptibility to infectious diseases, cancers, reproductive and other endocrine dysfunctions.

## INTRODUCTION

During these lasts four decades, there has been increasing awareness that chemicals in the environment can exert profound and deleterious effects on wildlife populations and that human health is inextricably linked to the health of the environment. Marine mammals are at the end of the food chain and therefore accumulate high levels of toxic compounds. Several toxicological investigations revealed a high body burden of Zn, Hg and organochlorine compounds in harbour porpoises (Siebert et al. 1999; Jepson et al. 2002, Bennet et al. 2001; Covaci et al. 2002, Van de Vijver et al. 2004; Das et al. submitted); some of these compounds have endocrine disrupting effects on other species (Brouwer et al. 1999).

This Marie-Curie project integrates in the research framework of transport pathway and impact of pollutant studies in the marine ecosystem and aims to understand the effects of some pollutants on the general health status, the endocrine and immune systems of the harbour porpoise (*Phocoena phocoena*). Pollutants such as trace metals, or organochlorines which have been recognised to have endocrine or immune disrupting effects (Zn, Hg, Cd, PCBs, toxaphene and polybrominated-ethers) are currently analysed. These investigations will examine if some endocrine and immune functions are impaired by those pollutants to the extend that harbour porpoises are susceptible to infectious agents which may decrease the population size.

Specific objectives include:

1. Investigation on the pollutant levels (trace metals and organochlorine compounds) in the tissues of stranded and by caught harbour porpoises from the European coasts in collaboration with several research teams (Liège University, Belgium, GKSS, Germany, Giessen University, Germany).
2. Study of the expression of pro- (IL-1β, IL-2, Il-6 and tumor necrosis factor TNF-α) and anti inflammatory (Il-4, IL-10, transforming growth factor TGF- β) cytokines in the full blood

porpoises freshly stranded porpoises from the Belgium coasts using reverse transcription polymerase chain reaction (RT-PCR).

3. Investigation on the harbour porpoise thyroid gland for evidence of lesions such as fibrosis and semi-quantitative evaluation of the relative thyroid tissues (solid tissue, follicles and connective tissues). 91 thyroid glands of fresh porpoises stranded along the French and Belgian and UK coasts were stained with haematoxylin and eosin (HE) and by elastica van Gieson for the detection of collagen. A commercial anti-thyreoglobulin antibody is also tested on harbour porpoises is also used to check for cross reactivity and thyroid activity investigations using the avidin-biotin-peroxidase technique. Data obtained on porpoises from UK, French and Belgian coasts will be compared with previously acquired results on porpoises from the German, Danish, Norwegian and Icelandic coasts.

## RESULTS AND DISCUSSION

In some areas such as the Baltic sea, harbour porpoise population has decreased dramatically raising the need of a long term monitoring for this species. A more defined knowledge of the human pressure is primordial for protection and managements plans. The advisory committee and the parties of the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS 1998) as well as the International Whaling Commission (IWC 1997) and the International Council for the Exploration of the Sea (ICES 1998) have recommended strongly that systematic investigations should be conducted to provide information on the effects of pollutants on small cetaceans.

This project specifically addresses the study of effects of trace metals and organochlorines trophic pathways and potential impact on immune and endocrine systems. Only few European countries of the polluted North and Baltic Seas have performed systematic research to facilitate requirements for those investigations. The proposed project brings an European dimension to the study of the impact of contaminants on endocrine and immune systems of marine mammals as some of the samples will be provided by Belgium stranding network (Liège University), but also by others European countries such as Germany, Denmark, Norway and Iceland. (coordination by the host institution, *Forschungs-und Technologiezentrum Westküste*, FTZ).

The preliminary results are promising: the blood of by-caught and stranded harbour porpoises contained RNA of a quality high enough to amplify glyceraldeyde -3- phosphate dehydrogenase (GAPDH) mRNA, regardless it was collected from life or dead animals and independent of the post-mortem interval (by-caught or stranded). Cytokine detection by RT-PCR and Real-time RT-PCR are currently under progress but TGF-ß, IL-2 and IL-6 were often detected.

The rabbit polyclonal antibody designed to react against human thyreoglobulin cross-reacted positively in the thyroid of the harbour porpoises. Connective tissues were abundant in the thyroid of harbour porpoises stranded along the Belgian coasts reflecting interstitial fibroses.

The increase of connective tissues in the thyroid was previously correlated to the increase of PCBs concentrations in the blubber (Vossen et al. submitted). PCB-exposure was likely to be a causal agent for thyroid fibrosis in seals and porpoises from the German North Sea (Schumacher et al. 1993).

Porpoises from Iceland displayed striking differences in both their thyroid tissue proportion and their number of follicles < 62 µm. Icelandic porpoises displayed lower percentage (less than 3%) of connective tissues than porpoises from Norway, Germany and Belgium. These results clearly pointed out a relationship between toxaphene, PCBs, DDE and DDT compounds and histological characteristics of the harbour porpoises thyroids from Germany and Norway. The increase of connective tissues in this tissue was correlated to the increase of PCB concentrations in the blubber. Analyses of the thyroids of the Belgian porpoises and relationship with metals and organochlorines are still under investigation but first results indicated that the morphology of follicles of porpoises collected along the Belgian coasts are very similar to that of porpoises collected along the German coasts.

## CONCLUSIONS

Preliminary results indicate some thyroid dysfunction in harbour porpoises from the southern North Sea (Northern France, Belgian and German coasts) as well as in porpoises from the Norwegian coasts. These thyroid lesions were linked to the high level of organochlorine compounds present in their tissues. Trace metals impact on thyroid are still under investigation but high Zn and Hg levels were previously related to the body condition of the harbour porpoises. The actual toxic effects and cellular mechanisms of trace metals and organochlorine on marine mammal immune and endocrine systems remain poorly known. Are they responsible - even in part - for the decline of the harbour porpoises in the North and Baltic seas? As quoted above, that decline is obviously multifactorial: past and present overfishing, increasing human activities and accumulation of pollutants cannot be neglected. Further understanding on human impact on the marine environment will be one of the greatest challenge of the 21st century and therefore should remain a research priority as human health (and life) has always been linked to the health of is marine environment.

## AKNOWLEDGMENTS

The authors are grateful to K. Tolley (University of Stellenbosch, South Africa), G. Vikingsson (Marine Research Institute, Iceland), T. Jauniaux (Liège University, Belgium), the FTZ stranding network for sample collection from European coasts. Thanks to Dr S. Fonfara (GKSS) for useful advice and training about cytokines and PCR. Thanks to Dr A. Vossen for sharing previous results about harbour porpoise thyroids.

## REFERENCES

ASCOBANS (1998). Report of the Fifth Meeting of the Advisory Committee ASCOBANS, 22-24 April Hel, Poland.

Bennet P.M., Jepson P.D., Law R.J., Jones B.R., Kuiken T., Baker J.R., Rogan E., Kirkwood J.K. (2001) Exposure to heavy metals and infectious disease mortality in harbour porpoises from England and Wales. Environmental Pollution 112 : 33-40

Brouwer A., Longnecker M.P., Birnbaum L.S., Cogliano J., Kostyniak P., Moore J., Schantz S., Winneke G. (1999). Characterisation of potential endocrine-related health effects at loww dose levels of exposure to PCBs. Environmental Health Perspectives 107: 639-649

Covaci A., Van de Vijver K., Decoen W., Das K., Bouquegneau J.M., Blust R., Schepens P. (2002) Determination of organohalogenated contaminants in liver of harbour porpoises (*Phocoena phocoena*) stranded on the Belgian coast. Marine Pollution Bulletin 44 : 1152-1169

Das K., Siebert U., Fontaine M., Jauniaux T., Holsbeek L., Bouquegneau J.M. Ecological and pathological factors related to trace metal concentrations in harbour porpoises *Phocoena phocoena* from the North Sea and adjacent areas. Marine Ecology Progress Series under revision.

IWC (1997). Proposal to the IWC on furthering the recommendations of the Pollution Workshop. SC/49/Rep6.

Jepson P.D., Bennet P.M., Allchin C.R., Law R.J., Kuiken T., Baker J.R., Rogan E., Kirkwood J.K. (1999) Investigating potential associations between chronic exposure to polychlorinated biphenyls and infectious disease mortality in harbour porpoises from England and Wales. Science of the Total Environment 243/244: 339-348.

Vossen A., Das K., Tolley K., Vikingsson G., Thron K., Baumgärtner W., Siebert U. Interfollicular fibrosis as an endocrine disrupting effect on the thyroid glands of harbour porpoises (*Phocoena phocoena*). Submitted.

Schumacher Z., Zahler S., Horny H.P., Heidemann G., Skrinisson K., Welsch U. (1993). Histological investigation on the thyroid glands of marine mammals (*Phoca vitulina, Phocoena phocoena*) and the possible implications of marine pollution. Journal of Wildlife Disease 29: 103-108.

Siebert U., Joiris C., Holsbeek L., Benke H., Failing K., Frese K., Petzinger E. (1999) Potential Relation between mercury concentrations and necropsy findings in Cetaceans from German waters of the North and Baltic Seas. Marine Pollution Bulletin 38: 285-295

Van De Vijver K.I., Hoff P.T., Das K., Van Dongen W., Esmans E.L., Siebert U., Bouquegneau J.M., Blust R., De Coen W.M. (2004). Baseline study of perfluorochemicals in harbour porpoises (Phocoena phocoena) from Northern Europe. Marine Pollution Bulletin 48: 992-997

**SESSION** **PLENARY 2: THE CONTRIBUTION OF THE YOUNG GENERATIONS TO THE FUTURE OF THE EUROPEAN MARINE RESEARCH AREA: MARIE CURIE FELLOWSHIPS IN THE DOMAIN OF MARINE SCIENCES.**

**TITLE** **UNDERSTANDING VITAMIN C REQUIREMENTS IN FISH**

**AUTHOR(S)** ***OCALEWICZ KONRAD*[A, B], *MURIEL MAMBRINI*[B]**

[a]Laboratoire de Génétique des Poissons, INRA, 78352 Jouy-en-Josas, (France); [b]Department of Ichthyology, University of Warmia and Mazury in Olsztyn, ul. Oczapowskiego 5, 10-718 Olsztyn-Kortowo (Poland)

E-mail: con@uwm.edu.pl

**SUMMARY**

Vitamin C deficiency is one of the main factors explaining juvenile fish pathologies and mortality. However, the situation regarding vitamin C nourishment varies significantly amongst fish species. Contrary to scurvy prone Teleostei, chondrostean fish are able to synthesise vitamin C because L-gulono-lactone oxidase (GLO), the key enzyme from the vitamin C metabolic pathway, is still active in their cells. Our assumption was that a single mutation event during fish evolution might be responsible for the inactivation of the GLO gene in an ancestor of present-day Teleostei. Our objective was to investigate the fate of the GLO gene in scurvy prone fish, as well as fish able to synthesise vitamin C, by a multidisciplinary approach merging fish nutrition, genome evolution and molecular analysis. We have identified the gene in distant fish species with active GLO. Moreover, we characterized the remnants of the gene in rainbow trout, medaka and carp. Although the single mutation hypothesis remains valid, our results indicated a more complex evolution of the GLO gene.

**FISHERIES AND AQUACULTURE:**

## Sustainable marine resources, tragedy of the commons, development of inland and marine aquaculture

More and more fish species are close to extinction because of over-fishing, industrialization, urbanization and pollution. These factors can reduce natural habitations, affect the natural reproduction of fish, provoke their infertility, which finally decreases the number of individuals, which disturbs their genetic diversity (Holt and Pickard 1999). The over-fishing of natural fish stocks in oceans reported in recent decades shows that some fish species are endangered. The well-known story of the now almost extinct European sturgeon (*Acipenser sturio*) (Ludwig et al. 2002), or over-captured populations of tuna, swordfish and other species, should be a signal for undertaking some precautions against losing them (Myers and Warm 2003). One of the approaches to preserve natural fish populations from over-fishing is emphasising the role of aquaculture in providing fish on the market. The importance of both fresh and marine aquaculture is increasing and this tendency will remain, contrary to fish capture that will decline in the near future.

The choice of fish species, which can be reared under controlled conditions, depends on two aspects: fish requirements and consumers' demands. Climate, quality of water and fish biology (reproduction, food requirements) can be the natural factors limiting the choice of the species to be cultured. On the other hand, tradition, consumers' preferences and food availability affect the profile of the local aquaculture. The set up of a correct artificial diet and meeting the specific nutritional requirements is a key for developing the production of the given species. The accurate amount of energy, protein and indispensable elements like specific fatty acids, amino acids or vitamins must be evaluated for each fish species independently and precisely.

## VITAMIN C (ASCORBIC ACID, AA):

## structure and functions

Chemically, ascorbic acid is a simple carbohydrate material ($C_6H_8O_6$) of rather unique properties. The presence of the ene-diol group in the molecule confers electron liability, which makes it a member of an anti-oxidation-reduction system having electron donating and electron accepting properties. Vitamin C scavenges toxic free radicals and other reactive oxygen species (ROS) formed during cell metabolism. A free radical is capable of independent existence and has an unpaired electron in an orbital what makes it very reactive (unpaired electrons search a partner for stability). Interactions between ROS and protein thiol groups, DNA bases and polyunsaturated fatty acids (PUFA) has negative consequences and can lead to the enzymes inactivation, DNA mutations, membrane disruptions, mitochondrial dysfunction and cell death. Vitamin C protects collagen from the process of underhydroxylation, which seems to be the main reason for scurvy and Ehlers-Danlos syndrome (Prockop and Kivirikko 1984, Peterkofsky 1991). Moreover, vitamin C as a co-factor of several enzymes (AA-dependent digoxygenases) plays a specific role in the absorption of dietary iron (Arrigoni and Tullio, 2002).

### VITAMIN C IN FISH

Vitamin C seems to be essential for the different teleostean fish species studied so far. Lack of vitamin C in such species causes growth retardation, impairs bone formation and decreases the reproduction capacities (Dabrowski and Ciereszko 2001). The interest of the latter process is connected with the observation of the high level of AA in fish gonads (ovaries and sperm plasma) and gametes (oocytes) (Sandnes et al. 1984, Dabrowski and Blom 1994). The vitellogenesis process and the quality of sperm depend on ascorbic acid supply (Ciereszko and Dabrowski 1995, Ciereszko, Liu and Dabrowski 1996). Additionally, ascorbic acid supplementation can increase fecundity and egg-hatchability (Sandnes et al. 1984, Dabrowski and Blom 1994, Blom and Dabrowski 1995). The AA as an antioxidant protects DNA in gametes from the damage provoked by endogenous, as well as environmental, factors (Dabrowski and Ciereszko 2001). Thus, ascorbic acid is essential for the early stages of fish development and its supply has to be particularly controlled for larvae and broodstock nutrition.

## Metabolism of teleostei is “handicapped” because of disturbances in vitamin C synthesis pathway.

Vitamin C can be synthesized in some vertebrate species from glucose in the kidney or in the liver, the location depending on the species. The enzyme, L-gulonolactone oxidase (GLO), catalyses the last step of the pathway. In all species that are not able to synthesize vitamin C, and are thus dependant upon its dietary supply, no GLO activity has been detected. The ability to synthesize vitamin C has been lost in humans, some primates, bats, guinea pig and some birds. In human beings and guinea pigs, important parts of the gene have been lost, which explains the absence of the GLO protein. In fish, the situation varies significantly: in the evolutionary advanced *Teleostei* studied to date, no GLO activity has been detected, whilst *Chondrostei* exhibit active GLO (Moreau and Dabrowski 2001). The assumption is that a single mutation event during the evolution of fish may be responsible for the inactivation of the gene encoding GLO in the ancestors of present *Teleostei*. One of our aims is to understand the evolution of the GLO gene in fish and link this knowledge with the dependency status upon vitamin C nourishment by analyzing DNA sequences related to the GLO gene in fish with active and inactive enzymes.

## Multidisciplianry approach for studying the evolution of GLO activity and vitamin C requirements in fish

The evolution of vitamin C requirements in fish can be analysed at different levels, controlling the requirement for vitamin C in fish species by providing diets specifically deficient in this vitamin and analysing the response in terms of growth and bone deformation (1), measuring the activity of GLO in liver and kidney in studied species (2), and analysing the fate of the GLO gene in the fish (3). Merging fish nutrition, genome evolution studies and molecular approaches can provide a chance to find out why most of the fish are susceptible to vitamin C deficiency.

Our study is based on the current knowledge of vitamin C status in fish and the evolution of the fish genome. We have analyzed the gene in fish with active GLO [Lake sturgeon (*Acipenser flavescence*) and Syberian sturgeon (*Acipenser baeri*)] and bowfin (*Amia calva*), which is an exponent of the old Teleostei sister group. Among teleostei, rainbow trout (*Oncorhynchus mykis*) - a species for which nutrition and genetics have been extensively studied, medaka (*Oryzias latipes*) - a fish with highly developed genomic tools, and carp (*Cyprinus carpio*) have been studied.

For analyzing the fate of the GLO gene in the different fish species, we employed a Southern approach, using the shark GLO cDNA sequence as a probe (Nam et al. 2002). In every studied species, we observed a specific banding pattern of DNA fragments provided in the course of Southern hybridization. The length and number of the fragments were higher in species with inactive GLO and the most polymorphic in carp. This suggests the complicated fate of the GLO gene in fish species with inactive GLO, but does not invalidate the assumption of a single mutation event. In each of the analyzed species, DNA fragments provided in the course of PCR and degenerated fragments have been cloned and sequenced. The available sequence databases have been regularly screened for analyzing any new GLO related cDNA sequences, or identifying remnants of the gene in zebrafish, medaka (partially sequenced genomes), or fugu (fully sequenced genome).

### SCIENTIFIC AND ECONOMIC TARGETS OF THE PROJECT

Although, Teleostei are the most evolutionary advanced fish, their ancestors probably lost the ability to synthesise vitamin C. From this point of view, understanding the circumstances of that event can be used for subsequent studies concentrated on vitamin C requirements in vertebrates. Providing reliable proofs explaining our assumption that all Teleostei fish species are unable to synthesise vitamin C would let us infer the dietary vitamin C dependency status of newly reared fish species, by simply considering their position in the evolutionary tree.

### REFERENCES

Arrigoni, O. and De Tullio, M., C. 2002. Ascorbic acid: much more than just an oxidant. Biochimica and Biophysica Acta (Biochim et Biophis Acta) 1569: 1-9.

Blom, J., H . and Dabrowski, K. 1995. Reproductive success of female rainbow trout (Oncorhynchus mykiss) in response to graded dietary ascorbyl monophosphate levels. Biology of Reproduction 52: 1073-1080.

Ciereszko, A. and Dabrowski, K. (1995). Sperm quality and ascorbic acid concentration in rainbow trout semen are affected by dietary vitamin C: an across season study. Biology of Reproduction, 52: 982-988.

Ciereszko, A., Liu, L. and Dabrowski, K. (1996). Effects of season and dietary ascorbic acid on some biochemical characteristics if rainbow trout semen. Fish Physiology and Biochemistry, 15: 1-10.

Dabrowski, K. and Blom, J., H. 1994. Ascorbic acid deposition in rainbow trout (*Oncorhynchus mykiss*) eggs and survival of embryos. Comparative Biochemistry and Physiology 108A: 129-135.

Dabrowski, K. and Ciereszko, A. (2001). Ascorbic acid and reproduction in fish: endocrine regulation and gamete quality. Aquaculture Research 32: 623-638.

Holt, V., W. And Pickard, A., R. 1999. Role of reproductive technologies and genetic resource banks in animal conservation. Reviews of Reproduction 4: 143-150.

Ludwig, A., Debus, L., Lieckfeldt, D., Wirgin, I., Benecke, N., Jenneckens, I., Williot, P., Waldman, J., R., Pitra, C. 2002. When the American Sea sturgeon swam east. Nature, 419: 447-448.

Nam, Y., K., Cho, Y., S., Douglas, S., E., Gallant, J., W., Reith, M., E., Kim, D., S. 2002. Isolation and transient expression of a cDNA encoding L-gulono-γ-lactone oxidase, a key enzyme for L-ascorbic acid biosynthesis, from the tiger shark (*Scyliorhinus torazame*). Aquaculture 209: 271-284.

Myers, R., A. and Worm, B. 2003. Rapid worldwide depletion of predatory fish communities. Nature, 423: 280-283.

Moreau R. and K. Dabrowski. 2001. Gulonolactone oxidase presence in fishes, activity and significance. In: Ascorbic Acid in Aquatic Organisms. Boca Raton, CRC Press, 13-32.

Moreau, R. and Dabrowski, K. 2001. Gulonolactone oxidase presence in fishes: activity and significance. In Ascorbic acid in aquatic organisms. Status and Perspectives. CRC Press (13-32).

Peterkofsky, B. (1991). Ascorbate requirement for hydroxylation and secretion of procollagen: relationship to inhibition of collagen synthesis in scurvy. Am J Clin Nutr. 54: 1135S-1140S.

Prockop, D., J., and Kivirikko, K., L., (1984). Heritable diseases of collagen. N Engl J Med. 311(6): 376-86.

Sandnes, K., Ulgenes, Y., Braekkan, O., R., Utne, F. (1984). The effect of ascorbic acid suplementation in broodstock feed on reproduction of rainbow trout (*Salmo gaidneri*). Aquaculture 43: 167-177.

**SESSION** **PLENARY 2: THE CONTRIBUTION OF THE YOUNG GENERATIONS TO THE FUTURE OF THE EUROPEAN MARINE RESEARCH AREA: MARIE CURIE FELLOWSHIPS IN THE DOMAIN OF MARINE SCIENCES.**

**TITLE** **GAS AND HYDRATES IN THE BLACK-SEA**

**AUTHOR(S)** ***IRINA POPESCU***

Renard Centre of Marine Geology (RCMG), University of Gent (Belgium)
Tel: +32 9 264 4637, Fax: +32 9 264 4967
E-mail: irina.popescu@UGent.be

**SUMMARY**

This contribution tackles a topic that is currently focusing major interest worldwide: gas and gas hydrates occurrence in marine sediments. The discussion concentrates on the specific case of the gas and hydrate accumulations in the Black Sea, and outlines their main characteristics, as resulted from investigation through a Marie Curie supported project. Different aspects of the implementation of the project in this framework will be also discussed.

## INTRODUCTION

### Gas hydrates - What are they, and why do we care?

Gas hydrates are crystalline solid compounds, consisting of a gas molecule surrounded by a cage of water molecules. They are similar to ice, except that the crystalline structure is stabilized by the guest gas molecule. Many gases may form hydrates (including carbon dioxide, hydrogen sulfide, and several low-carbon-number hydrocarbons), but most natural gas hydrates analyzed so far are methane hydrates.

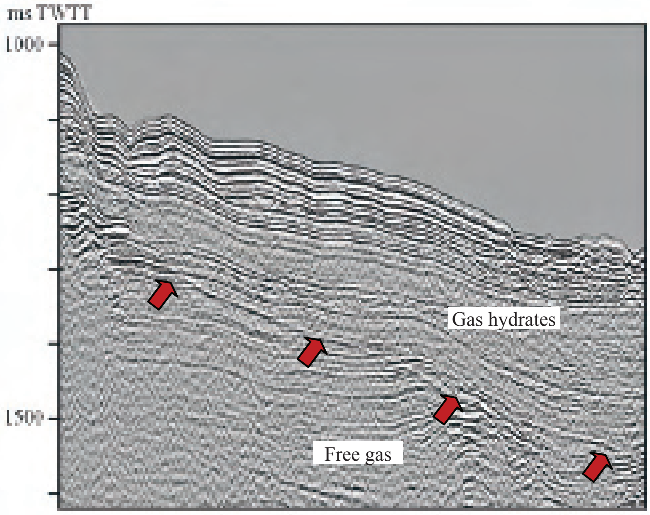
General interest is currently focusing on gas and gas hydrates contained in marine sediments.

This is mainly due to:

- the environmental consequences of gas releasing at the seafloor, as a contributor to the greenhouse effect,
- their impact on the seafloor stability, as a potential cause for submarine geohazards, and
- the fuel resource potential of the gas hydrates, as they contain a great volume of methane.Since the 1970's, naturally occurring gas hydrate has been recognized worldwide.

Hydrates form under specific conditions of high pressure and low temperature. Thus they are present either on land in polar settings, associated with permafrost, or in oceanic sediments along continental margins. Hydrates can occur within a layer of sediment up to 1000 m thick beneath the sea floor. The base of the layer is limited by increasing temperature, in relation to the local geotermal gradient.

Hydrates in marine sediments can be recovered directly, by sampling through sediment cores or drilling. They can be also recognized acoustically, by high-resolution reflection seismics. This is based on the fact that sediments containing gas hydrates are characterized by a high acoustic velocity. The contrast at the interface between high-velocity gas hydrate cemented sediments and the underlying low-velocity gas-bearing sediments creates a strong reflector: the "bottom simulating reflector" (BSR). A BSR is a high-amplitude, reversed polarity reflector that approximately parallels the sea floor and cross-cuts the acoustic bedding structure of the sediments (Figure 1). Thus, identifying BSRs on seismic profiles indicates the presence of gas hydrates, and notifies about the thickness of the hydrate accumulation in sediments.




IFREMER (Project BLASON)

Figure 1. Typical bottom simulating reflector (BSR) on a high-resolution reflection seismic profile in the NW Black Sea

## DISCUSSION

## Gas hydrates in the Black Sea — Description of the Marie Curie Project

The project “Assessment of the gas bearing sediments in the NW Black Sea” is financed by a Marie Curie Fellowship under contract HPMF-CT-2002-01835, from 1/01/03 to 31/12/04. The project is carried out at the Renard Centre of Marine Geology of the Ghent University in Belgium (supervisor Prof. Marc De Batist). Cooperation was established with IFREMER (France) and GeoEcoMar (Romania).

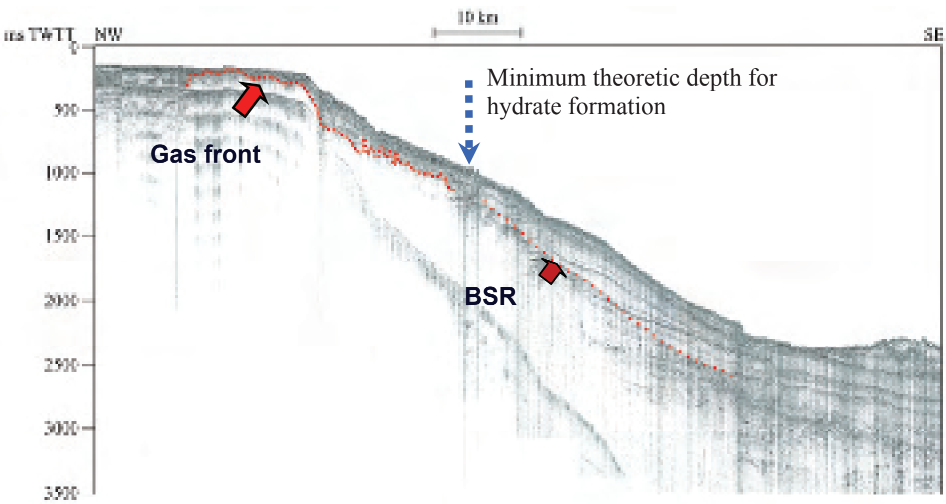
The project aims to define a general characterization of the gas accumulations in the recent sediments of the Black Sea. In this respect, potential occurrence of gas hydrates has been considered, as a topic of major interest. Investigation is based on high-resolution seismic reflection data and swath bathymetry acquired during the BlaSON and BlaSON 2 surveys by IFREMER. Seismic and bathymetric data from the CRIMEA EC Project have been also used, as well as sub-bottom profiles from GeoEcoMar surveys.

## RESULTS

The western Black Sea contains evidence of abundant subsurface gas accumulations. Gas appears in a complete suite of settings from the coastal zone to the deep basin, with features that vary significantly from one setting to another.

The shelf-edge zone (including the external shelf and the upper slope down to about 750 m water depth) shows a significant gas content in sediments (Figure 2). This is indicated by the association of gas-related seismic features: acoustic turbidity, repeated multiples, local complete wipeout, enhanced reflections, low frequency anomalies. Gas discharge through numerous gas seeps is commonly associated with areas where the gas front is close to the sea bottom. The spatial distribution of the gas seeps and gas facies follows the line of the shelfbreak all along the western Black Sea basin, still it shows sometimes a preferential location corresponding to deep regional faults, or to the major shelf-indenting Danube Canyon.

On the slope, at ca. 750 m depth, the gas front prolongs with bottom simulating reflectors - BSRs (Figure 2). As shown above, BSRs indicate the probable presence of gas hydrates, and mark the base of the hydrate layer. The depth of 750 m corresponds well to the minimum theoretic depth for the formation of gas hydrates in the Black Sea (Vassilev and Dimitrov, 2002). This depth also corresponds to the lower limit of intense gas seepage along the shelfbreak, which was confirmed by the preliminary results of the CRIMEA Project (Greinert et al., 2003). The depth of the BSR increases with increasing water depth (thus with increasing pressure) from 190 ms at 750 m water depth, to 460 ms at 1800 m water depth. Free gas occurs below the BSR, as indicated by acoustic facies. This suggests that gas hydrates may have sealing capacities, as they are able to trap free gas below them. It is worth noting that a remarkable and as yet unique pattern of multiple BSRs was reported in the Danube fan (Popescu et al., in prep.).




IFREMER (Project BLASON)

Figure 2. Seismic reflection profile across the NW Black Sea margin. The BSR occurs below the minimum theoretic depth for hydrate formation, and is situated in prolongation of the gas front. Amplitude blanking above the BSR typically indicates the presence of hydrates. Acoustic turbidity and patches of enhanced reflections appear below the BSR, and correspond to free gas.

## CONCLUSION

In the western Black Sea, the presence of gas hydrates bellow –750 m water depth is attested by BSRs. Intense gas seepage along the shelfbreak is limited above the area of gas hydrate occurrence, whereas free gas accumulations underlie the hydrate layer. We thus argue that gas hydrates may act as a seal for gas migration towards the seafloor.

## Implementation of the Project:

## Benefits from the Marie Curie Programme

Funding the project through a Marie Curie Fellowship created the opportunity to carry it out at the Renard Centre of Marine Geology (RCMG), as host institution. This has largely benefited from different points of view, as:

- transfer of knowledge : The assistance of a high-level scientific team, that gained considerable experience on the investigation of gassy sediments through numerous projects developed worldwide, proved to be a valuable basis for the development of this project;
- technical support : RCMG is an attractive environment, very well equipped for advanced processing and interpretation of seismic data. This provided the technical means to reach the objectives of the project;
- link to the ongoing CRIMEA FP5 project coordinated by RCMG : The CRIMEA project is dedicated to the study of the methane seeps in the Black Sea. As my project is strongly complementary to this topic, a close link was established, which benefited to both projects: data acquired through the CRIMEA project have been integrated in my study, whereas part of the results of my investigation contributed to define the general background of the CRIMEA zone; links to other projects : Cooperation with IFREMER and GeoEcoMar was essential to create the necessary framework for data exchange. Also, needs for further joint research were identified, as well as potential ways to valorise the results of this project. Thus, the results already obtained will be used as a basis for future investigation through the ongoing ASSEMBLAGE FP5 Project (WP7), coordinated by IFREMER.**ACKNOWLEDGEMENTS**

This project is financed by a Marie Curie Fellowship (HPMF-CT-2002-01835). IFREMER (BlaSON 1 and BlaSON 2 projects), GeoEcoMar, RCMG and GEOMAR (CRIMEA project) are acknowledged for supporting this project with high quality data.

## REFERENCES

Greinert J., Artemov Y., Van Rensbergen P., De Batist M., Bialas J., the CRIMEA 2003 Scientific Party (2003). Bathymetric, seismic, side scan sonar and hydroacoustic investigations of the water column in the Dnepr palaeo-delta area, Black Sea: Results from the CRIMEA cruise 2003. Ocean Margin Research Conference, Paris September 15-17: 25.

Vassilev A., Dimitrov, L. (2002). Spatial and quantity evaluation of the Black Sea gas hydrates. Russian Geology and Geophysics 43, 7: 672-684.

**SESSION** **PLENARY 2: THE CONTRIBUTION OF THE YOUNG GENERATIONS TO THE FUTURE OF THE EUROPEAN MARINE RESEARCH AREA: MARIE CURIE FELLOWSHIPS IN THE DOMAIN OF MARINE SCIENCES.**

**TITLE** **CAREER-PATHS AFTER A MARIE CURIE FELLOWSHIP**

**AUTHOR(S)** ***KIM A. STOBBERUP***

National Research Institute for Agriculture and Fisheries (INIAP-IPIMAR),
Av. Brasília, 1449-006 Lisbon, Portugal
Tel: +351 213027719, Fax: +351 213014859;
E-mail: karaujo@ipimar.pt

**SUMMARY**

Greater mobility of researchers has been promoted in successive framework programmes. This is considered important for a career in research and also, as essential in promoting a European dimension to research. In this context, the Marie Curie Fellowship Association (MCFA) was created in 1996 in order to increase public awareness about Marie Curie fellowships, including the reputation of fellows, and to help in the advance and communication of science. Results from surveys undertaken by the MCFA indicate that these fellowships have had a clearly positive impact on career perspectives. Some of the findings are given, including preliminary indicators, with emphasis on the field of marine sciences.

**INTRODUCTION**

One of the key issues of developing the European Research Area is promoting the training and mobility of young researchers. Recent developments in the 6$^{th}$ Framework Programme for R&D have introduced new initiatives in terms of support for the training and mobility of researchers. Mobility is a requirement in order to obtain support, but the impact of Marie Curie fellowships and effects of mobility in relation to career perspectives are difficult to measure, as there is a general lack of statistics on this issue. Member surveys undertaken by the MCFA can give some preliminary indicators in this respect

## The Marie Curie Fellowship Association (MCFA)

The Marie Curie Fellowship Association (MCFA) is the non-profit Association of scientists who, following a stringent selection procedure based on the strengths of the candidate, the project, and the site of work, were awarded a Marie Curie fellowship or other European Community research-training grant. There are presently more than 3000 members of the MCFA, most of which are past post-doctoral grant holders. Members are from a wide range of scientific disciplines, although life sciences, physics, chemistry, and engineering dominate. 28 European nationalities are represented, accounting for 95% of all members. This diversity in discipline and nationality represents the strength of the MCFA as a pan-European cross-cultural organisation, with global links.

The MCFA was created in 1996 under the auspices of the European Commission, but is now independent. One of the main objectives is to create a clear and visible identity for Marie Curie fellowships as well as to promote and increase the reputation of its members. The Association actively participates in science and science policy related discussions at meetings and in the form of publications. It organises meetings at international, national and local level like scientific workshops or science related conferences. It provides support for its members both in the host country and at home as well as facilitates the contact with industry (www.mariecurie.org).

## DISCUSSION

### Survey on the Impact and Benefits of a Marie Curie Fellowship

This survey was carried out between April and May 2000 among MCFA members and gave 207 answers. The questionnaires were rather extensive, but we concentrate on the impact of Marie Curie (MC) fellowships and effects on career progression. When asked why they had moved, the members generally answered that they sought an attractive institution abroad with excellent research facilities and wanted to add an international dimension to their careers. They did so by their own initiative (80%), taking advantage of the bottom-up approach inherent to the Marie Curie Individual Fellowships.

Regarding the scientific quality of the fellowships, the general picture that emerges is that these fellowships have a very positive impact, providing a chance to do "great science". When asked to rate aspects related to participation in conferences/meetings, scientific support, access to information, networking and training, most answered between good and excellent.

What happens after the fellowship? It appears that former MC fellows are highly employable as 85 % were employed within 3 months after the fellowship. In many cases they stayed on in the host country (35 %) while around half returned home (48 %). Almost nobody considered that the fellowship was an obstacle to finding another job (1 %). However, there are some hidden negative aspects related to employment and mobility, which will be dealt with in the following.

### Survey on Career Prospects and Mobility of Young Researchers

This survey was carried out in October 2002, with 2790 answers, involving three major European young scientists' associations: the Marie Curie Fellowship Association, Eurodoc and PI-net. A clear problem of inertia in mobility between academia and industry emerged once again from this survey. Most of the replies (76%) came from people who are currently working in the public research sector and who believe that they will stay there for some time to come. By contrast, 25 % of those in private research (about 7% of the total respondents) think that they will move to a public research institution within the next five years.

On the other hand, these young researchers appear to be flexible when asked whether they could imagine a change of professional direction, for example from academia to industry or from research to research management. Surprisingly, some 55% of those currently engaged in public research replied to this question with a strong "yes", while only 20% denied such a possibility. For researchers in the private sector the numbers were 62% and 17% respectively. So, in principle, they are flexible and prepared to try out something new, if the need arises. However, to most of them this need does not seem to be obvious.

### Internal Brain Drain?

Which countries in Europe appear to be attractive for young mobile researchers? This information was not readily available, but the MCFA member statistics on nationality and residence can be used as a preliminary indicator. A simple indicator was calculated as the difference between percentage of nationals and residents for each of the 30 European countries. If positive, this means that the country is attracting foreigners as well as nationals after a time abroad. Not surprisingly, the United Kingdom appears to be particularly attractive, while the southern countries of Spain, Italy and Greece appear to be least attractive.

Table 1: "Attractiveness"

| Country | % difference |
|---|---|
| United Kingdom | 11.4 |
| Netherlands | 2.6 |
| Switzerland | 1 |
| Sweden | 0.8 |
| Belgium | 0.8 |
| Ireland | -0.6 |
| Germany | -1.4 |
| Greece | -3.3 |
| Italy | -4.2 |
| Spain | -5.8 |

### Fellowships in Marine Science

Marie Curie fellows were asked to fill in a questionnaire in connection with their participation in the Eurocean 2004 conference, giving access to information regarding fellows working specifically in marine sciences. This was a sample of only 28 persons, but valuable and interesting to make comparisons with the other more general surveys.

Most hold post-doctoral (60%) or PhD (34%) grants to undertake research in environmental sciences (70%). It is interesting to see that females dominate (61%), which is in contrast with the results of more general surveys. Almost all worked in academia or the public research sector. And the vast majority (82%) indicated that they did not have any problems of integrating in the host country. This is good news as it indicates that the situation has improved in relation to administrative and other hurdles!

Again, there was no doubt that a MC fellowship has a positive impact on career perspectives, because of the associated scientific quality, reputation, and mobility. In spite of this, many (50%) expected to have problems with reintegration in their home country. This looks like the "one-way ticket" problem. Your CV may look better after a fellowship, but it will not help much in getting a job back home!

Another interesting result was that only around 50% had heard of the MCFA and a disappointing 11% were members. Clearly, the MCFA has to do more to communicate and attract members!

### "No permanent home, no social security, no pension"

Are we talking of a nomad or a researcher? The typical profile of a young mobile researcher is a highly motivated and independent person, late 20s or early 30s, married or not, no children, who is willing to work long hours for bad pay because he/she loves to do "great science". They find employment easily but not permanent positions, which are rare and you have to wait for them a long time! The irony is that these independent-minded persons have to wait a long time before they gain independence to do their work as principal investigators with access to funding.

Their weak points are that a university education has not adequately prepared them for professional life. Most think that there is a lack of training in career essentials such as project management, proposal writing, fund-raising, and communication skills. Usually there is a lack of guidance in career planning.

Unfortunately, mobile researchers still have to struggle with a lot of problems and disadvantages when moving to another country. Questions of social security such as eligibility for benefits and transferability of rights are important issues that even within the European Union (EU) have not been resolved in a satisfactory way. With regard to other administrative obstacles to mobility, such as the paperwork related to visas, work and residency permits, a clear majority demanded preferential treatment of researchers compared to other members of the mobile work force.

## CONCLUSION

Research in marine science has received progressively less emphasis over successive European Framework Programmes. Also, there has been a gradual shift towards more applied research, reflecting the increasing concerns on sustainability, environmental quality, and socio-economic considerations, with no specific programme for marine science. Yet, the abyss is still alien to us, further understanding of ocean currents is essential to determine our world's changing climate, and there are new frontiers in marine life and ocean margins that are challenges for the future.

Marine research is a particularly multidisciplinary science and discussions on the future of science and scientists show that the multidisciplinary approach to problem solving is essential as well as increased international cooperation. The MCFA network establishes bridges across frontiers, cultures, and disciplines to go one step further in the exchange of knowledge and a better integration of science and society, and it welcomes opportunities to share its ideas and initiatives with the rest of the scientific community.

New forms of scientific training and career structures for young scientists are necessary. A genuine and open labour market for researchers has to be created. But researchers need to play a more active role and lobby for their interests. And they also have to increase their visibility and learn to communicate with society. This is particularly important in view of the strategic goal to become the most competitive and dynamic knowledge-based economy in the world by 2010.

## ACKNOWLEDGEMENTS

I would like to thank Dagmar Meyer, Chair of the MCFA, Olga Lage, EC-Research Directorate-General, my colleagues of the young researchers session, and the organizers of the Eurocean 2004 conference for their help and feedback.


## BACKGROUND MATERIAL


European Science Foundation (2000). Towards a European Marine Research Area. (http://www.esf.org/publication/150/area.pdf).

European Commission (2003). Communication from the Commission to the Council and the European Parliament. Researchers in the European Research Area: One Profession, Multiple Careers. Brussels, 18.7.2003, COM(2003) 436 final.

Meyer, D. (2003). Young scientists' survey gets the dirt on life at the coal face. The ELSO gazette, February 2003, Issue Number 13 (http://www.the-elso-gazette.org)

# PART 2

# FP5 AND FP6 PROJECT ABSTRACTS

# BIODIVERSITY & ECOSYSTEM FUNCTIONING

# Atlantic Coral Ecosystem Study - (ACES)

*Freiwald, A.[1], Wolff, G.[2], Gage, J.[3], Grehan, A.J.[4]*

[1] Institute of Paleontology, Erlangen University, Germany; [2] Oceanography Laboratories, University of Liverpool, UK; [3] Scottish Association for Marine Science, Oban, UK; [4] National University of Galway, Ireland

e-mail: andre.freiwald@pal.uni-erlangen.de

| | |
|---|---|
| Contract No: EVK3-CT-1999-00008 | Project duration: 01/03/2000-28/02/2003 |
| Total project costs: € | EU contribution: € 2.024.667 |
| Website: http://www.pal.uni-erlangen.de/ | |

**Objectives**

Coral reefs are something usually associated with warm, tropical waters and exotic fish, but not with the cold, deep and dark waters of the North Atlantic where corals were regarded as oddities on the seafloor. It is now known that cold-water coral species also produce reefs which rival their tropical cousins in terms of species richness of associated marine life. Increasing commercial operations in deep waters, and the use of advanced offshore technology have slowly revealed the true extent of Europe's hidden coral ecosystems. The main deliverables of this project were therefore to focus on the following scientific objectives:

- Draft of the first deep-water coral ecosystem atlas
- ROV-based coral habitat definitions
- Reef-building potential and molecular genetics of Lophelia pertusa
- Analysis of physical forcing factors
- Biodiversity assessment and production of a species inventory atlas
- Fish community and fishing impact study
- Coral behaviour study
- Sensitivity coding of coral reefs
- Recommendations for sustainable use of cold-water coral ecosystems.

**Results and Conclusions**

Cold-water coral reefs are now identified as an essential ecosystem along Europe's deep-water ocean margin. They play a major role as biodiversity hotspots and attract economically valuable seafood. Unsustainable fishery, however, will lead to further destruction of this species-rich biological resource.

Within the lifetime of ACES the issue of cold-water reefs has been transferred from basic science to the political agenda. Cold-water coral reefs are recognised by the European Commission, the OSPAR-Convention and by UNEP as a prime target for immediate measures to prevent further loss of biodiversity.

Within the European Research Area, outstanding scientific institutions, universities and various groups of stakeholders are ready to further explore and understand the biological dynamics and biodiversity gradients of cold-water reefs within a globally changing environment.

# Algal introductions to European shores- (ALIENS)

*Rico, J. M.*

Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo, Spain

| | |
|---|---|
| Contract No : EVK3-CT-2001-00062 | Project duration : 02/2002 – 01/2005 |
| Project budget : € 1 257 658 | EC contribution : € 1 047 939 |
| Website: www.uniovi.es/bos/entrada.htm | |

**Objectives**

Objective 1.- To explain the underlying ecological causes of the introduction, establishment and development of seaweed invasions on European shores.

Objective 2.- To generate a baseline dataset on the present status of seaweed introductions to European shores, and of future susceptibility to further introductions/invasions.

Objective 3: To elucidate the genetic structure of various populations of selected invasive seaweeds in Atlantic and Mediterranean Europe, with a view to determining whether there have been multiple cryptic European introductions.

Objective 4.- To evaluate the economic impact of existing seaweed invasions on a European scale, comparing losses with costs associated with prevention and eradication.

Objective 5: To carry out risk assessment and propose a screening protocol for invasive macroalgae to be used in coastal zone management.

**Results**

Field surveys were completed by the 30$^{th}$ of September 2002. A common protocol agreed by all partners and released in May 2002 was used.

| Area | "Natural" Localities | "Impacted" localities |
|---|---|---|
| N. Ireland | 6, Intertidal | 6, Intertidal |
| S. England | 7, Intertidal | 5, Intertidal |
| The Netherlands* | - | 6, Mostly Intertidal |
| N. Spain | 6, Intertidal | 5, Subtidal |
| S. Portugal | 6, Subtidal | 2, Subtidal |
| Gulf of Lyon | 5, Subtidal | 5, Subtidal |
| Gulf of Naples | 6, Subtidal | 6, Subtidal |

*No natural rocky substrata

Three sites were randomly chosen in each locality and three 50x50 cm samples taken at each site. For each quadrat, all conspicuous species were listed and one 10x10 cm subsample was taken to the laboratory for complete identification of species.

Gulf of Naples. Preliminary results suggest that there is a larger number of invaders in recreational harbours than in open "natural". A complete and detailed analysis will be only possible when data for all localities are available.

Using present-day taxonomy, 52 introduced macroalgal taxa have been reported in the Mediterranean lagoons harbouring shellfish aquaculture activities. After the introduction in Europe, secondary dispersal probably occurs during the frequent transfers of spat, young and adult shellfish (oysters, mussels, clams) between the Atlantic and Mediterranean aquaculture regions. The most impacted lagoons are the Thau Lagoon and the Lagoon of Venice (Table 1). The majority (31 taxa) are Indo-Pacific species, 90.3 % (59.6% + 30.7%) of total may originate from the Indo-Pacific region (Tab. 2). 43 taxa (82.6% of total) grow in Japan and/or Korea, which are the two major oyster exporters in the world. The main primary way of introduction is the importation of *Crassostrea gigas* spat from Asia (Japan or Korea).

Table 1. Number of introduced macroalgae reported from Mediterranean lagoons harbouring shellfish aquaculture activities.

| | Thau France | Venice Italy | Salses-Leucate France | Mar piccolo Italy | Bizerte Tunisia | Mar Chica Morocco |
|---|---|---|---|---|---|---|
| N | 45 | 18 | 10 | 3 | 3 | 1 |
| % | 86.5 | 34.6 | 19.2 | 5.7 | 5.7 | 1.9 |

Table 2. Possible origin of the introduced macroalgae.

| | Indo-Pacific | Indo-Pacific or Atlantic | Atlantic | NE Atlantic or Black sea |
|---|---|---|---|---|
| N | 31 | 16 | 3 | 2 |
| % | 59.6 | 30.7 | 5.7 | 3.8 |

GENETIC ANALYSES

Seven plastid microsatellites were found in *Codium fragile* subsp*. tomentosoides*, and tested in a subset of samples. *Codium fragile* ssp*. tomentosoides* appears to have a very limited genepool worldwide There was limited polymorphism at only two loci: CFCPSSR 7 and CFCPSSR 4. Nevertheless variation at locus CFCPSSR7 provided good evidence that there have been two separate introductions of *Codium fragile* subsp*. tomentosoides* from the Pacific into the North Atlantic (the Oshoro Bay type) and the Mediterranean (Sagami Bay /Kochi type). More populations from Japan need to be studied to confirm this.

By comparison, intrapopulational variation was demonstrated with these microsatellite markers in fairly small sample of a native species, *Codium tomentosum*, from a very small area in Spain.

**Relevance to society**

Biological invasions are increasingly recognised as an economic and social problem worldwide. According to the recent IUCN Guidelines for the prevention of biodiversity loss caused by alien invasive species, approved by the 51st meeting of the IUCN Council on February 2000, the direct costs of biodiversity loss associated with alien invasives run into many billion dollars annually. They also have indirect costs, in the sense that biodiversity loss produces a loss in resilience, the ability of ecosystems to recover after impact. Biological invasions also have a cultural dimension, since cultural activities are very often linked to the available nature resources.

Recent Commission communications point to the social importance of preserving natural resources and biodiversity, and the EU has adhered to the Convention on Biological Diversity through Council Decision 93/626/EC. Undoubtedly introduction of alien species can be considered an important threat to biodiversity. Considering also the important economic return of activities included within the touristic sector, preserving the pristine nature of coastal communities and controlling nuisance species can contribute to improving employment in the touristic sector, enhancing the quality of coastal environments and, taking into account the potential effects of invaders on coastal communities, preserving the availability of natural resources.

# Centre of Excellence for Baltic Development, Education and Research – (BALTDER)

*Szaniawska A., Dmochowska B.*

Institute of Oceanography, University of Gdańsk, Poland, email: oceasz@univ.gda.pl

| | |
|---|---|
| Contract No : EVK3-CT-2002-80005 | Project duration : 01/12/2002 – 30/11/2005 |
| Project budget : € 1 600 000 | EC contribution : € 575 000 |
| Website : www.ocean.univ.gda.pl/baltder | |

**Objectives**

BALTDER reflects in detail the research profile of the Institute of Oceanography, University of Gdańsk, and the main emphasis of the project is put on the research into the actual state and biological, chemical and physical processes proceeding in the coastal ecosystem of the Baltic Sea. BALTDER intends to strengthen the links with national and international research centres and improve the acquisition and flow of data on the functioning of marine ecosystem and its sustainable development.

First 12 months of the activities had objectives consistent with the overall aim of the project: which is to confront the research and educational efforts of the Centre with the needs of the region. The objectives include:

- sustainable use of the Baltic resources and developing management strategies for the sea;
- dissemination of knowledge and data on the functioning of the Baltic ecosystem and opening of new opportunities for further cooperation – entering the European Research Area;
- development of BALTDER as a nationally and internationally recognized research and education centre;
- rise in the standards of research and education in the area of marine sciences;
- increase of intellectual potential and education of a new generation of scientists;
- transfer of scientific knowledge to management and help to react better to socio-economic needs of the region.

**Results**

2003 was an initial year for the project. However, BALTDER has already become a nationally and internationally recognised research and education centre in marine sciences. The cooperation has been strengthened through planned activities such as scientific visits, workshops, seminars, summer schools, conferences, lectures, and joint projects. Shared exchange of scientific knowledge, visits of young researchers to experienced European laboratories and lectures given by outstanding European scientists raised the standards of research and education in this area and improved compatibility between the Centre and different EU scientific institutes. What is more on the basis of this cooperation BLTDER participants have prepared scientific publications, posters, presentations, reports and have been involved in new EU 6FP initiatives.

The activities carried out and planned within the framework of BALTDER add knowledge of the natural and anthropogenic impacts on functioning of the Baltic ecosystem and its sustainable development. The Centre addresses the problem of the altering structure of marine organisms, including the occurrence of non-native and harmful species. Some activities refer to the influence of environmental factors on physiology and behaviour of marine organisms. Moreover, methods for coastal water quality assessment are being developed and use to solve environmental problems. Ecological education, leading to the increased public environmental awareness is also provided.

**Potential exploitation by end users**

Marine science, which is the focus of BALTDER, is closely related to the issue of the Baltic environment protection. Studies in the following areas have been carried out in the last 12 months of the project to reach the main objective of the Centre, which is to confront the research and educational efforts of the Centre with the needs of the region:

- water quality model, the pre-operational forecasting system for Polish coastal waters, which will be elaborated and offered to the local authorities;
- nutrient and pollutant load in different compartments of the sea and by the application of bioindicators;
- risk assessment associated with the bloom of toxic phytoplankton species (research into the causes of harmful phytoplankton blooms, which have a negative impact on the recreational and economic value of the region);
- creating a CCBA algal collection, where different algal strains will be available for educational, scientific and commercial purposes;
- adaptations and biomarkers, which will be used to determine a state of an ecosystem and a potential threat of stressors on functioning of ecosystem;
- socio-economic implications of the goods and services provided by the estuarine ecosystems. The degree and extent of changes in the benthic communities in these ecosystems may have a direct impact on fisheries, tourism, and may thus influence the economic development of European coasts;
- marine mammals belonging to the most endangered species in the Baltic Sea.

Promotional activities, ecological education, and dissemination of knowledge leading to the increased public environmental awareness on the functioning of the coastal ecosystem are provided through summer schools, workshops, seminars, and open lectures, web page and brochures. Some of the activities, such as seminars and meetings are aimed at environmental officers and other people interested in the sustainable development of the Baltic region. Activities of the Centre improve communication between researchers and managers at local, national and international levels. The co-operation is fruitful and resulted in a better management of the coastal region and improvement in its economic state.

# **Ba**cterial **si**ngle-**c**ell approaches to the relationship between diversity and function in the **S**ea (**BASICS**)

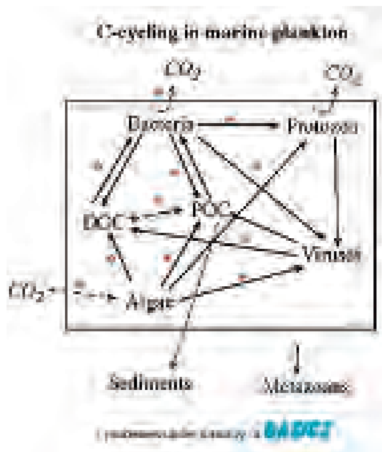
*Gasol, J.M.[1], Lebaron, P.[2], Herndl, G.J.[3], Hagström, Å.[4], Bordat, P.[5], Weinbauer, M.[6], Archer, S.D.[7], Pernthaler, J.[8], Fuchs, B. [8],Thingstad, T.F.[9], Heldal, M. [9], Burkill, P.H. [10], Zubkov, M.V. [10]*

[1]Institut de Ciències del Mar-CSIC, Barcelona, Catalunya, Spain; [2]Laboratoire d' Océanographie de Banyuls, France; [3]Netherlands Institute of Sea Research, The Netherlands; [4]Kalmar University, Sweden; [5]Pierre Fabre Dermo-Cosmétique, France; [6]Lab. d'Océanographie de Villefranche, France; [7]Plymouth Marine Lab, UK; [8]Max-Planck Institute für Marine Mikrobiologie, Germany, [9]University of Bergen, Norway; [10]Southampton Oceanographic Center, UK. Contact: pepgasol@icm.csic.es


| Contract No : EVK3-CT-2002-00078 | Project duration : 11/2002 – 10/2005 |
|---|---|
| Project budget : € 3 461 600 | EC contribution : € 1 914 960 |
| Website: www.icm.csic.es/bio/projects/basics | |


**Objectives**

By developing new methodologies, sampling different European seas and through laboratory and mesocosm experiments, project BASICS will address its main objective: *The identification of the most important prokaryotic organisms associated with the biogeochemical functioning (in the carbon and sulfur cycling) of the sea, through the development of single-cell analysis techniques applied to pelagic microbes*. BASICS will also study how resilient the link is between the diversity and the C and S biogeochemical cycling by bacterioplankton, in the face of the most important global environmental changes expected in European coastal waters.




The sea covers 72% of the Earth's surface and any biogeochemical process that occurs in it will have an effect on the whole of the Earth's life support systems. The functioning of ecosystems depends, to a large extent, on their biodiversity and knowledge of this diversity is a prerequisite for understanding how they work and predicting how the "function" will respond to global change. The most important processes in ocean functioning are driven by microbes, particularly bacterioplankton, which are the only significant transformers of DOC in the ocean, represent the largest living surface area, and participate in the reactivity of climatically active gases that are exchanged between the ocean and the atmosphere.

Bacteria lack, however, distinct morphological features and we need the recently developed molecular biology techniques which now allow us to gain insights into the dynamics and regulation mechanisms of the microbial food web

Our ultimate goal is to advance from a *description of microbial processes* to a *mechanistic understanding of the functioning of microbial communities*, which can only be performed if the key organisms responsible for each step in the biogeochemical cycling can be identified.

Project BASICS intends to fill this gap, by describing bacterial diversity and linking diversity to the biogeochemical role of bacteria in the cycle of oceanic and atmospheric carbon and sulfur. Our focus is also on the development of tools that will eventually be used for monitoring purposes

**Results**

Correspondence beween manual counting and fully automated evaluation of samples hybridized with various probes, one of the Single-cell analysis techniques developed in the framework of Basics. The lower signal-to-noise ratio for detection of probe-positive cells was 1.3 (130% of background gray value). Picture from[1].

Most of the scientific achievements of yr. 1 are still preliminary. For the moment, the most relevant one is the development of an improved FISH protocol (CARD-FISH) and the automatization of the microscopical counts of samples prepared with that protocol. Several partners have done work on the combination of CARD-FISH and autoradiography following different strategies, and some partners have also put together flow cytometric sorting of $^{32}$S-$^{14}$C-, and $^{3}$H-labelled organic precursors. A few of these methodological improvements have already been published. All 16S rDNA sequence data that might correspond to marine bacteria currently in the GenBank database were searched for and analyzed by bio-informatics techniques so that a coherent picture of the sequences obtained to date corresponding to cultured and uncultured bacteria has been constructed. This provides the tool to evaluate the bacteria isolated or sequenced in our sampling sites.

**Potential exploitation by end users**

BASICS will provide both, a thorough description of bacterial richness diversity in the coastal seas of Europe, and a series of tools and protocols to interrogate individual bacteria for their biogeochemical function *and* their genetic identity. Currently uncultured marine bacteria will be the focus of our research, but the SCA methods we will be developing, improving and fine-tuning will be applicable to other microorganisms, most notably pathogenic bacteria associated with organic loading. Thus, the knowledge gained from this project will be of direct importance to determine 1) health risks associated to animal or human pathogens, 2) the chemical quality of water in terms of nutrient and organic matter loads, since we will be determining some of the factors determining the ecosystem rates of absorption and recycling of dissolved and particulate organic matter and 3) the biological quality of water, through the study of the factors favoring the termination of algal bloom events.

An important aspect of our proposal concerns the isolation and maintenance of a very large collection of bacterial strains. Bacteria constitute an immense and yet untapped reservoir of novel species with a very wide potential for completely novel biosynthetic pathways. We view this strain collection as an invaluable resource that companies interested in bioproducts could screen for a variety of compounds.

We will also establish baseline values for bacterial biodiversity in the coastal seas of Europe, and try to understand the magnitude of genetic change that can occur through space and time, something necessary before we can make predictions about the role of anthropogenic input into marine ecosystems.

**References**

[1] Pernthaler, J., A. Pernthaler & R. Amann (2003) Appl. Environ. Microbiol. **69**, 2631-2637

# Bergen Advanced Training Site in Marine Ecology - (BATMARE)

*Booman, C.*[1]*, Giske, J.*[1]

[1] University of Bergen, Norway. Clelia.Booman@bio.uib.no

| | |
|---|---|
| Contract No : EVK3-CT-2000-57129 | Project duration : 15.02.2001 – 14.02.2005 |
| Project budget : not estimated | EC contribution : € 285 000 |
| Website : www.uib.no/batmare | |

**Objectives**

The Bergen Advanced Training Site in Marine Ecology – (BATMARE) is a Marie Curie Training Site [1], a fellowship scheme hosted by the University of Bergen funded by the European Commission through the Improving Human Research Potential Programme from FP5.

As a Marie Curie Training Site, BATMARE offers research training and graduate courses to EU citizens who are enrolled in PhD programmes at universities outside Norway. The research training and courses taken at BATMARE are thus integrated in the students' PhD programmes at their home universities. Applications are submitted directly to BATMARE, where also the evaluation procedure takes place, while the final approval relies on the European Commission.

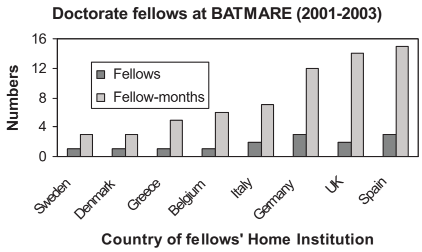
BATMARE consists of closely interrelated research units working together to offer interdisciplinary education and training in marine environmental and ecological science through research. BATMARE offers doctoral training in studies of marine processes, ecosystems and interactions, covering the range from microbial ecology to macroplankton and fish, and from physical and organismal processes to ecosystem dynamics. This wide perspective is needed to improve our understanding of the interactions of ecological processes in marine ecosystems.

The University of Bergen is situated ideally for marine sciences. The wealth of different marine biotopes, including areas with low anthropogenic influence, within exceptional short geographical distances, facilitates comparative studies and provides a high diversity of marine organisms for experimental studies. In addition, the rich choice of experimental environments from highly controlled lab conditions, medium controlled mesocosms, land locked and open fjords, to the open sea, makes Bergen a highly valuable site for marine environmental PhD studies.

The main objective of the project is to benefit European PhD students by offering them research training in Marine Ecology to complement their PhD studies at their home universities. As host, the University of Bergen benefits from expanding its European network.

## Results

There has been a widespread interest in the BATMARE activity and most of the proposals received have been of high quality. During 2001-2003, 14 fellows have been supported, accounting for 60 fellow-months. Seven of the fellows were women, and two of them have already obtained their PhDs. The fellows came from universities in 8 different EU countries. As Norway is an Associated Country, BATMARE has not been allowed to host students from other Associated Countries. As from May 2004, BATMARE will also welcome students from the new Member States.




Research training projects granted under BATMARE:

- Development of a life history model of the distribution of life stages of common copepods in Gullmarsfjorden, Sweden. Josefin Titelman, Göteborg University
- Ecological modelling of anoxic situations in estuarine zones without tidal forcing. Xavier de Pedro Puente, University of Barcelona
- Response of the CYP1A-like protein in mussels after exposure to organic pollutants. Henrik Jonsson, Rostock University
- Modelling size distribution in marine microbial food webs with A-life individual-based models using neural networks and genetic algorithms. Miguel Angel Rodríguez Arias, University of Barcelona
- Combining acoustic and trawl data for abundance estimates, expert systems – neural networks. Suzanna Neville, University of Leicester.
- Genetic structure and phylogeography of Pomatoschistus minutus, P. lozanoi and P. microps on the Belgian and European Continental Shelf and in the Mediterranean Sea. Els Gysels, Catholic University of Leuven.
- Phenotype-environment interactions and selective processes in the early life history of fish. Anders Bang, University of Aarhus.
- Morphometric, Meristic and genetic analyses of redfish from the Faroe Islands. Dolores Garabana, University of Vigo.
- Marine virology: live cycles of viruses that infect Emiliania huxleyi. Joaquín Martínez Martínez, University of Plymouth
- Assessing the interactions between populations of the endangered species of marine turtle Caretta caretta and the environment at the individual level with development of complementary modeling approaches (IBMs - Metapopulation models). Antonios Mazaris, University of the Aegean.
- Carbon biogeochemsitry on the continental shelves of the Nordic Seas. Nicoletta Ruggieri, University of Genoa
- Encounter rates between benthic organisms and particles at the shelves, the shelf edge and shelf slopes along Norway. Elisa Ravagnan, University of Venice
- Modelling the evolution of dispersal behaviour. Simone Heinz, UFZ-Centre for Environmental Research Leipzig
- The ecology of whiting (Merlangius merlangus L.) and poor cod (Trisopterus minutus L.) in the Celtic Sea. Oonagh Dwane, National University of Ireland, Galway (from 2004)

## References

[1]. http://www.cordis.lu/improving/fellowships/home.htm

# Bergen Marine Food Chain Research Infrastructure - (BERGEN MARINE)

*Booman, C.*[1], *Aksnes, D.*[1]

[1] University of Bergen, Norway. Clelia.Booman@bio.uib.no



| | |
|---|---|
| Contract No : HPRI-CT-1999-00056 and HPRI-2002-00181 | Project duration : 01.01.2000 – 31.12.2002 and 01.06.2002 – 28.02.2004 |
| Project budget : not estimated | EC contribution : € 900 000 and € 291 650 |
| Website : www.uib.no/bergenmarine | |



**Objectives**

The main objective of the project is to benefit European research teams by giving them access to a unique set of marine research installations at the University of Bergen and the Institute of Marine Research. BERGEN MARINE works as an umbrella for multiple short-term research projects conducted by guest scientists, and contributes to:

- Increase the mobility of European researchers
- Improve the use of existent research infrastructure
- Increase transeuropean cooperation

Activities oriented to facilitate the mobility of researchers and to optimise the use of existent infrastructure across Europe were introduced in 1989 with the Large Installations Plan under the 2nd Framework Programme (FP2). The concept has been present and evolving through all the subsequent framework programmes. BERGEN MARINE has been funded by the Access to Research Infrastructures activity in FP5, and previously by FP4 [1].

BERGEN MARINE is a set of complementary and closely integrated installations offering a rare combination of possibilities for laboratory-based and field research studies on marine ecosystems, their living resources and the production of marine organisms. The installations cover the range from experimental laboratories and mesocosms to observational platforms giving access to a series of unique habitats and model environments in the vicinity of Bergen.

Experimental systems

- Highly controlled systems
  - Culture rooms
  - Larval fish rearing unit
  - Quarantine units
  - Silo rearing tanks
  - Indoor fish tanks
- Meso-scale units
  - Fish pens and cages
  - Land-based and floating mesocosm (picture)
  - Seawater basins
  - Semi-enclosed lagoon

Natural systems

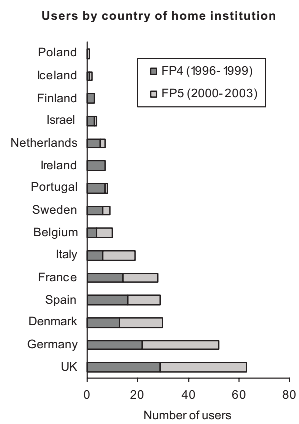
- Special habitats & model environments, accessible through:
  - Espeland Biological Station
  - Research vessels
  - Deep sea ROV

## Results

BERGEN MARINE offers access to 7 complementary installations, and it can be compared with a network of infrastructures from different operators with a highly integrated management. The contract offers high value for money in terms of capacity delivered, scientific results, contribution to career development of young scientists, as well as contribution to the European Research Area.

The previous and running contracts have resulted in more than 70 peer-reviewed scientific publications, several PhD theses and almost 100 presentations at international conferences (for list of scientific publications see: http://www.ifm.uib.no/lsf/articles.html), besides several publications still in preparation. BERGEN MARINE has had a positive impact on the University of Bergen and the Institute of Marine Research, contributing to visualise the university's marine profile and to strengthen or establish new cooperation with research groups from almost every European coastal country.

The BERGEN MARINE activity started under FP4 in 1996 as the "Large Scale Facility for Marine Pelagic Food Chain Research" and is still known among scientists as the "Bergen LSF". Since 1996, 272 scientists and PhD students have benefited from access to the Infrastructure (half of them under FP5) from 80 different universities and research institutes. These users have conducted 109 intensive, short-term research projects (39 of them under FP5), their activities at BERGEN MARINE accounting for approximately 40 working years.




According to an assessment carried out by an expert panel commissioned by the European Commission: *The facility proposes a large number of complementary installations and laboratories. It is unique for the study of the marine environment. It plays an important role in the research in Europe in this field. It allows many institutes to gather scientific information and data to develop a new activity. The support is good. The scientific impact is very large as shown by the rapidly increasing number of publications.* [2]. Regrettably, neither BERGEN MARINE nor any other marine research facilities have been selected for support under the Transnational Access to Research Infrastructures scheme of FP6, thus the activity has been discontinued in 2004 with the expiration of the FP5 contract.

## Potential exploitation by end users

European scientists may apply for access to the BERGEN MARINE research infrastructure, and get scientific, technical and logistical support, besides reimbursement of travel and subsistence expenses. Access is normally provided for a minimum of three weeks and a maximum of four months per user.

Bergen Marine has also fostered interdisciplinary work and has had a significant role in the training of European young researchers, including contribution to PhD dissertations. In particular some projects using experimental ecosystems (mesocosms) have brought together experienced scientists, postdoctoral researchers, students and technicians from different scientific fields and organisations in different countries.

## References

[1] Booman, C (1998). Ocean Challenge **8**, 6-7

[2] Anon. (2002) Assessment Report for Transnational Access Contract (FP5, ARI). European Commission. 3 pp

# Biotechnologies from the Deep - (BIODEEP)

*Corselli, C.[1], Bianchi, A.[2], Gerber, H.W.[3], Clauss G.[4], Bolhuis H.[5], McGenity T.[6], Timmis K.[7], Thomson J.[8], Varnavas S.P.[9], De Lange G.J.[10], Tselepides A.[11], Giuliano L.[12], Bloch J.-F.[13], Gasparoni F.[14] and BIODEEP Scientific Team**

cesare.corselli@unimib.it

[1] Consorzio Nazionale Interuniversitario per le Scienze del Mare – CoNISMa; [2] Laboratoire de Microbiologie Marine - Marseille ; [3] Technische Fachhochschule Berlin - University of Applied Sciences; [4] Technische Universitat Berlin - Technical University Berlin; [5] Laboratory for Microbial Ecology - University of Groningen; [6] Department of Biological Sciences - University of Essex; [7] Institut fur Mikrobiologie - Technical University Braunschweig; [8] Natural Environmental Research Council - Southampton Oceanography Centre; [9] Department of Geology - University of Patras; [10] Faculty of Earth Sciences - University of Utrecht; [11] Institute of Marine Biology of Crete; [12] Istituto Sperimentale Talassografico - CNR Messina; [13] PROTEUS Nimes; [14] TECNOMARE S.p.A. of Venezia


| | |
|---|---|
| Contract No : EVK3-2000-00042 | Project duration : 04/2001 – 03/2004 |
| Project budget : € 3 743 850 | EC contribution : € 2 733 437 |
| Website : www.geo.unimib.it/BioDeep/BD.htm | |


**Objectives**

BIODEEP Project proposes the exploration of unique habitats, namely the deep-sea hypersaline anoxic basins (DHABs) of the Eastern Mediterranean, and the isolation and culture of marine microorganisms, thereby offering new opportunities for discovery of novel chemicals with different potential application of European interest.

The principal objectives of the Project are:

- to develop and use new instruments and new techniques for geochemical and microbial exploration of the DHABs;

- to study, through chemical and physical analyses of samples (taken during the 2 planned specific cruises), the overlying water column, brines and sediments of four anoxic basins;

- to study, by microbiological sampling in the four basins (during the 2 specifically planned cruises), the diversity/phylogeny of naturally occurring communities,

- to isolate microorganisms and to characterise of the isolates, to assess microbial metabolic activities, genetic and enzymology of microbial isolates.

These objectives are addressed using different and modern techniques in 7 European laboratories to ensure a good quality control of the results. Molecular analysis, different isolation and culture techniques, screening of DNA and RNA sequences of strains, genes, enzymes, secondary metabolites and cellular components are some of the biological techniques that are being used during the project.

### Results

Within BIODEEP, an existing deep-sea Vehicle MODUS, capable to handle heavy payloads, designed and developed within previous EU projects, has been specifically adapted to fulfil the new purposes, also with the development of new scientific packages.

Geological and geochemical analyses on brines, suspended matter and sediments in the anoxic basins defined the main present-day and past fluxes and processes acting in the DHABs environment.

Analysis of species diversity, community structure and phylogeny of micro-organisms and meiofauna in the DHABs revealed that each basin has its own, unique microbial and meiofaunal community. Among the identified microorganisms, several novel species have been discovered of which only uncultured clones were known or no other relatives were ever identified before.

Isolation of microorganism from the DHABs resulted in a culture collection of over 400 strains representing many different, and new, genera. A wide diversity of organisms have been isolated and each basin seems to select for different types of microorganisms.

The study of the microbial activity of natural bacteria consortia and the physiological characterization and the metabolic activities among microbial isolates showed that microorganisms are able to develop in the extreme conditions of the DHABs.

Several strains were identified with metabolic activities that could be interesting for further biotechnological applications, such as strong hydrolithic activities (protease, lipase-esterase, glucosidase, phosphatase), polysaccarides and biosurfactants production, antimicrobial activity, growth on aromatic compounds as carbon source.

### Potential exploitation by end users

The peculiar environment of the DHABs was shown to host a large biodiversity, with the majority of microbial species still being uncultured or unidentified. Within BIODEEP the possibility to use DHABs organisms to develop new products for the benefit of human health and industry is assessed.

The results have a wide range of potential applications for the user community, that is identified in the following sectors: i) industries for food implementation and storage, ii) industries for mass production of interesting compounds (fermentors); iii) cleaning industries (detergents); iv) pharmaceutical industries (drugs and stabilising compounds); v) coal industries (desulfurication).

* BIODEEP Scientific Team (listed by alphabetic order): Borin S.[1], Calore D.[14], Daffonchio D.[1], D'Auria G.[12], Golyshin P.[7], Green D.[8], Hatziyanni E.[11], Hoog S.[4], Hubner A.[10], Lampadariou N.[11], Langner W.[3], Malinverno E.[1], Marty D.[2], Morel F.[2], Ravot G.[13], Sass A.[6], Scarfì S.[1], Tamburini C.[2], van der Wielen P.[5], Yakimov M.[12]

# Bonus for Baltic Sea Science- Network of Funding Agencies - (BONUS)

*Kononen, K. (co-ordinator)*

Academy of Finland, e-mail: kaisa.kononen@aka.fi

| | |
|---|---|
| Contract No: ERAC-CT-2003-510204 | Project duration: 2004-2007 |
| Project budget: 3 029 453 Euros | EC contribution: 100% |
| Website: www.balticsearesearch.net | |

**Objectives**

The Baltic Sea is receiving an increasing attention at national and international levels. Sustainable use of the living and non-living resources of seas has to be based on a strong scientific foundation. Networks of scientists and research institutes as well as international management agreements already exist in the Baltic Sea region, but further progress in creation of the Baltic Marine Research Area is blocked by the lack of co-operation on the level of funding organisations.

The main objective of BONUS is to form a network and partnership of key agencies funding aiming at deepening the understanding of conditions for science-based management of environmental issues in the Baltic Sea. Specific objectives include:

- Continuous and systematic collection and exchange of information and best practice at different stages of particular national or regional programmes
- Creation and maintenance of user-friendly Internet based communication and networking for the access of information about ongoing research, databases and marine research facilities operating in the Baltic Sea region
- Facilitating the synergistic use of marine research infrastructure in the Baltic Sea region
- Identification of knowledge gaps in order to define topics for future programmes.
- Systematic analysis and removal of administrative barriers hindering trans-national joint research programmes in the Baltic Sea region
- Durable integration of national marine research funding schemes in new EU Member States
- Integration of RTD funding agencies with other actors and networks in the Baltic sea research area.
- Identification of synergism that might be achieved by joint post-graduate training in marine sciences in the Baltic Sea region
- To serve as a pilot exercise for a broader European wide networking of research funding agencies operating in the field of marine research

**Expected results**

Expected results of the project are:

- BONUS portal will serve as a communication tool and a gateway to the information on the Baltic Sea science
- Mechanisms involved in national funding organisations will reach the status where a joint multinational Baltic Sea research programme is feasible
- A joint Baltic Sea research programme will be launched
- Mechanisms of shared use of marine research infrastructure will be defined and agreed
- Complementarity of postgraduate training in marine sciences will be improved

- Integration of the Baltic Sea research funding with marine environmental policies will be improved

**Potential exploitation by end users**

A large group of potential end users will benefit from BONUS findings and co-operation experiences. Marine research programme managers will benefit from the exchange of information about programme management and from the co-operation with other managers. Marine scientists will benefit from the creation and maintenance of the information portal which collects all relevant information about research funding opportunities. Environmental authorities will benefit from improved communication with scientists. The benefit for politicians arises from the bolstering up the Northern Dimension of the European Union and thus complementing the economic growth in the Baltic Sea region. Large public will benefit by gaining information about marine science and research funding. Experience is brought to the attention of the preparatory and implementing phases of other regional and pan-European ERA-NETs: BONUS will be presented in such forums (symposia, conferences, workshops etc.) where relevant actors convene.

# Integrating New Technologies for the Study of Benthic Ecosystem Response to Human Activity: Towards a Coastal Ocean Benthic Observatory - (COBO)

*Shimmield, G.B.**

Scottish Association for Marine Science, Scotland; Email: graham.shimmield@sams.ac.uk



| | |
|---|---|
| Contract No: To be confirmed | Project Duration: 02/2004 – 01/2007 |
| Project Budget: €3,340,000 | EC Contribution: €2,000,000 |
| Website: www.cobo.info | |



**Abstract:**

Coastal ecosystems are particularly vulnerable to anthropogenic perturbation, affecting biodiversity and ecosystem stability and resilience. Shallow water sediments and their associated biota represent a reservoir for biodiversity, hosting resting and reproductive stages of planktonic organisms, and regulating carbon and nutrient biogeochemical cycles. However, the relationship between tightly coupled biological and geochemical processes in this environment is poorly defined with respect to their temporal and spatial variability. The overall objective of COBO is to integrate emerging and innovative technologies from different disciplines (physics, chemistry, biology, imagery) to provide *in situ* monitoring of sediment habitats, a key component of coastal marine ecosystems, in order to understand complex interactions between the biota (function and diversity) and their chemical environment. Existing technologies have limited spatial and temporal sampling resolutions which has hampered progress in determining key parameters and, in explaining biogeochemical patterns / processes and in modelling ecosystem dynamics. Improved *in situ* technologies are required to provide rigorous scientific information on processes regulating this unique and fragile habitat and for assessing, controlling and minimising human impact on European coastal waters thus addressing societal need. Organism-sediment processes, with both enhancing and mediating effects, are still poorly understood in shallow water sediments that receive the bulk of anthropogenic disturbance. The combination of innovative instruments from different scientific disciplines will provide powerful tools to significantly advance our understanding of organism -sediment relations under dynamic coastal conditions and enhance predictive capability. COBO represents a major step towards the development of permanently operating benthic observatories for coastal management

**Objectives and Expected Results:**

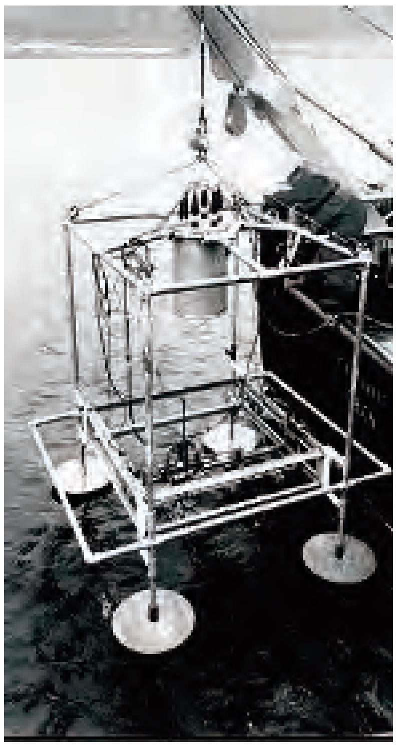
The primary objective of COBO is to integrate emerging and innovative technologies from different disciplines (physics, chemistry, biology, imagery) to provide for *in situ* monit oring of sediment ecosystems in order to understand the complex interactions between the biota (their functioning and diversity), the chemical environment and environmental perturbations / relaxations within the coastal environment. This is to be achieved through:

- Integration of sediment profile imagery (SPI) and Optodes will consist of coupling these systems to enable their simultaneous deployment. This will then allow for the measurement of bi-dimensional fields of oxygen with a visual link to macrofaunal movement.
- Development of a scale integrated sediment disturber that will be coupled to a frame allowing three-dimensional positioning. The control and disturbed zones will be monitored continuously using digital cameras and micro-profilers with oxygen microelectrodes and, at the start and end points, by examining sediment cores. This will allow the investigation

of biodiversity shifts in response to perturbation and the changing chemical condition of the sediment.

- Development of a chamber capable of regulating oxygen (oxystat) equipped with nitrate sensors that will allow the investigation of nitrogen recycling under a constant oxygen concentration. This will subsequently be optimised with the manipulated benthic chamber experiments.
- Integration of manipulated benthic chambers capable of particle addition and sediment resuspension. These chambers will allow particle or liquid addition (e.g. algae, oil) and sediment resuspension by changing stirring speed. An oxygen macro-sensor will follow the response of the ecosystem confined in the enclosure.
- Development of “smart” and adaptable systems integrating control electronics capable of reaction to external events with existing technology (chambers, micro-profilers and SPI-Optode systems). This will adapt frequency and resolution of sampling and environmental data recording to match the intensity and frequency of perturbation events. Adaptable systems will include a new generation of micro-sensor amplifier in lightweight housings for flexible and modular use in various *in situ* measuring systems.
- Development of numerical tools will consist of building 2D models of early diagenesis and sediment-organism relationship to exploit 2D images from the SPI-Optode systems and compare them to 1D models.

**Potential Exploitation and Dissemination:**



1. Enhance our understanding of ecosystem dynamics through chemical and biological cycling along with environmental forcing within the coastal zone.
2. Augment European capability in autonomous lander design and environmental monitoring for coastal seas over an extended observation period.
3. Contributing to national and EU policy development and directives (Marine Habitat, Water Framework, OSPAR, HELCOM).
4. Enable informed decision making with respect to Biodiversity, Sustainability and Conservation strategies.
5. Offer an unprecedented insight into the controlling factors associated with the dynamics and sensitivity of benthic and pelagic ecosystems under both natural and anthropogenically disturbed conditions.
6. Allow for the sustainable development of our natural resources and mitigation of anthropogenic perturbations.
7. Through the technical innovation associated with this project, new innovative products, which meet global environmental monitoring requirements, could be realised.

# Eupean Gelatinous Zooplankton: Mechanisms behind jellyfish blooms and their ecological and socio-economic effects - (EUROGEL)

*Båmstedt, U[1,2] et al.[3]*

[1]Department of Fisheries and Marine Biology, University of Bergen, Norway, and [2]Umeå Marine Sciences Centre, Sweden; [3]Nine other European partners involved in the project; Contact email: ulf.bamstedt@ifm.uib.no

| | |
|---|---|
| Contract N°: EVK3-CT-2002-00074 | Project duration: 11/2002 – 10/2005 |
| Project budget: € 3 355 034 | EC contribution: € 2 770 000 |
| Website: http://www.ifm.uib.no/eurogel/index.htm | |

**Objectives**

The overall objective of EUROGEL is to identify and quantify key factors regulating the abundance and succession of jellyplankton species in European waters and to quantitatively define problems related to aquaculture and fishery, coastal industry and recreational activities. This is done by a joint effort from 10 European partners, working in nine work packages with specific objectives, and especially studying five model environments with documented permanent or seasonal mass occurrence of gelatinous zooplankton.

**Scientific achievements**

New information on seasonal abundance, growth and feeding of target species from all “model environments” has been achieved. An estimation of the predation impact of the scyphomedusa *Aurelia aurita* in the Limfjord, Denmark, indicates that this single species might reduce the prey population to half in less than a day during spring and summer. Infestation of macroparasites seems to be very temporary in several of the species, and do not explain the cessation of jellyfish mass occurrence. Investigation on *Cyanea capillata* indicates that the sessile polyp stage might be a bottleneck in the population dynamics, with heavy mortality due to predation and space competition.

Field experiments and SCUBA-dive observations give evidences for an important role of decaying blooms of jellyfish as both substrate for a microbial community and food for benthic scavengers. Results of biochemical analyses of several jellyplankton species indicate a suitable organic composition with high content of valuable amino acids and fatty acids.

Seasonal surveys have been made in the “model environments” and the abundance and distribution of targeted species have been well described, and for some environments the whole community of gelatinous species have been quantified. A recent technique to detect a 42 kD protein with haemolytic activity has been successfully used on the nematocysts of *C. capillata*. This is the first evidence of this protein in any scyphozoan, and future work will focus on designing of primers for the detection of a gene sequence for this protein.

An extensive review of fisheries-related problems and jellyplankton occurrence has been compiled for the Black Sea, whereas data from other areas seem to be non-existent in the literature.

Two papers that include foraging mechanistic models for predation and competition between visual and tactile predators have been published by EUROGEL co-workers. The results are needed for the model formulations of the feeding process and competition between fish and gelatinous organisms. An example of the results is given below.

The particle tracking model has been developed to simulate all the relevant particle transport mechanisms: current advection, turbulent/random diffusion, wave action and wind action. The circulation model DIVAST has been coupled with the particle transport model and applied to the Irish study area. The coupled circulation-particle transport model has been developed using an existing calibrated model of Galway Bay with a grid spacing of 100 m.

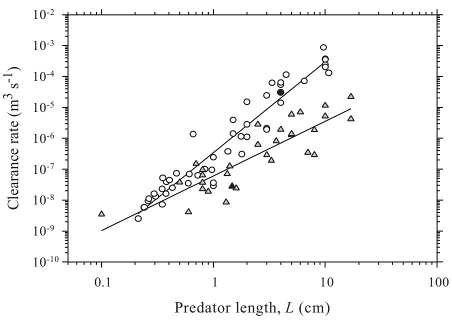



Fig. 1. Clearance rate versus length for visual (circles, *n*=48) and tactile (triangles, *n*=31) zooplanktivores obtained from reviewed literature [1].

**Socio-economic relevance and policy implications**

Jellyplankton blooms affect economic sectors such as aquaculture, fisheries and coastal zone tourism, while on the other hand, anthropogenic factors, such as overfishing and eutrophication seem to be aggravating the problem. Results hitherto achieved have quantitatively defined the importance of jellyplankton in different ecosystems and provided information that can be applied by the society and industry to reduce the negative impact of jellyplankton blooms.

EUROGEL will contribute to environmental management and indirectly to preserve and potentially increase employment in coastal areas. The project's results will be relevant in the context of the Sixth Environment Action Program of the European Community 2001-2010, the Council directive 92/43/EEC on Nature Protection , EC Water Policy (Directive 2000/60/EC) and the Common Fisheries Policy.

**Conclusions**

Recent increase in reported mass occurrence of jellyfishes, its proposed coupling to factors like overfishing and eutrophication, and the potentially negative impact on commercial interests in the society, are arguments for a broad research project on the mechanisms behind jellyfish "blooms". The first year of the program has been successful, with few delays in the schedule and a lot of achieved results. The experience from the first year of activities and the detailed plan for the future ensure a successful continuation of the program.

**References**

[1] Sørnes, T., Aksnes, D.L. (2004). Limnol. Oceanogr. 49:69-75.

# Towards DNA chip technology as a standard analytical tool for the identification of marine organisms - (FISH & CHIPS)

*Kochzius, M.[1], Meyerdierks, D.[1], Blohm, D.[1]*

[1] Centre for Applied Gensensorik (CAG), University of Bremen, Germany;
kochzius@uni-bremen.de



| | |
|---|---|
| Contract No : GOCE-CT-2003-505491-Fish&Chips | Project duration : 01/2004 – 12/2006 |
| Project budget : € 2 406 936 | EC contribution : € 1 599 995 |
| Website : www.fish-and-chips.uni-bremen.de | |



Sustainable development is a fundamental goal of the European Union and loss of biodiversity is emphasised as one of the main threats to it. However, biodiversity and ecosystems of European Seas are under human impact, such as pollution, eutrophication, and overfishing. Therefore it is necessary to monitor changes in biodiversity and ecosystem functioning.

The aim of the project is the development of DNA chips for the identification of marine organisms in European Seas as a cost effective, reliable and efficient technology in biodiversity and ecosystem science.

Many marine organisms, such as eggs and larvae of fishes, plankton, and benthic invertebrates, are difficult to identify by morphological characters. The classical methods are extremely time consuming and require a high degree of taxonomic expertise. Consequently, the basic step of identifying such organisms is a major bottleneck in biodiversity and ecosystem science.

Therefore, the project seeks to demonstrate that DNA chips can be a new powerful and innovative tool for the identification of marine organisms. Three DNA chips for the identification of fishes, phytoplankton, and invertebrates of European Seas will be developed. These chips will facilitate research on dispersal of ichthyoplankton, monitoring of phytoplankton, and identification of bioindicators as well as prey in gut contents analysis.

To achieve this goal a combined biological and technical approach has been initiated: The biological material will be sampled by marine biologists. The next step is the sequencing of suitable molecular markers for probe design. The technical part consists mainly in constructing gene probe libraries and determining their specificity. This will be done by biotech research centres in connection with SMEs engaged DNA chip technology. Therefore the project has the potential to bring Europe's marine biotechnology to the forefront of this field.

# Marine Biodiversity and Ecosystem Functioning - (MARBEF)

*Heip, Carlo*

Netherlands Institute of Ecology – Centre for Estuarine and Marine Ecology (General Coordinator, email: c.heip@nioo.knaw.nl)

| | |
|---|---|
| Contract no: GOCE-CT-2003-505446 | Project Duration: 02/2004 – 02/2009 |
| Estimated project budget: € 14 350 000 | EC Contribution: € 8 707 000 |
| Website: www.marbef.org | |

**Objectives**

The network of excellence MARBEF aims at initiating, integrating and using research efforts in marine biodiversity by:

- forming a dedicated group of top marine scientists and institutes in Europe
- initiating innovative and excellent interdisciplinary research
- creating a virtual European institute with a long-term research programme
- training, exchange and outreach
- supporting the EU and its member states in their international obligations.
- linking with industry and the public at large.

**Why?**

Marine Biodiversity is threatened and changing by overexploitation, habitat destruction, pollution, introduction of species and global climate change. The consequences of biodiversity loss for marine ecosystem functioning are unknown. Protection, sustainable use and restoration of living marine resources require interdisciplinary scientific understanding, spreading of knowledge and gaining support from society.

**How?**

In Europe we have world class marine scientists with outstanding skills and expertise in their own disciplines. MARBEF will bring this dispersed scientific excellence together and will create a virtual European centre of excellence in marine biodiversity and ecosystem functioning. MARBEF is science-driven. Top marine scientists are involved in MARBEF because they believe it will provide them with the right mix of expertise and resources that will enable them to effectively address the biggest and most topical science questions. Individual researchers or single institutions cannot address these questions alone.

**What?**

The scientific objectives of the MARBEF programme are:

- To understand how marine biodiversity varies across spatial and temporal scales, and between levels of biological organisation, in order to develop methods to detect significant change.
- To generate theory, models and tests of the relationship between marine biodiversity (at different levels of organization) and ecosystem function through the integration of theoretical and modeling exercises, comparative analyses and carefully-designed experimental tests.
- To understand the economic, social and cultural value of marine biodiversity and hence develop the research base required to support the sustainable management of marine biodiversity.

**The societal objectives of MARBEF are:**

- To stimulate exploration and new discoveries, to increase general awareness on life in the seas, its beauty and its ecological and economic importance to the general public.
- To create a forum for industry, and stakeholders, by using existing links between research and industry, by inviting SMEs to join the network in particular tasks
- To spread excellence by training young people to enter this new interdisciplinary field and by involving new countries also outside Europe.
- MARBEF will initiate and participate in public debate on sustainable use of marine ecosystems, marine products and marine biota, and ways of mitigating anthropogenic impact on these systems.

### Exploitation by end users

Sustainable exploitation of the marine environment requires informed and science based management. By the integration of multidisciplinary research and other stakeholders of marine biodiversity issues, MARBEF will be able to support the legal obligations of the EU and its member states and associated states for the Convention for Biological Diversity, the OSPAR and Barcelona conventions as well as several EU directives (Bird Directive, Habitat Directive, Water Framework Directive). The science must also be delivered to policy makers, managers and end-users, and also engage stakeholders and the public.

The network will also improve links with the large and growing number of industries depending on the sustainable use and exploitation of marine biodiversity. This includes tourism, fisheries and aquaculture but also new industries that explore and commercialise marine genetic and chemical products. MARBEF will create links with European industries, working with them to develop the right tools and products for their needs.

Outreach will be strongly supported and includes activities for building lasting contacts with end-users (governmental agencies, NGO's, the general public including school children).

### Partners

NIOO-CEME, Yerseke, The Netherlands[1] - NHM London, United Kingdom - PML, Plymouth, United Kingdom - UIB, Palma de Mallorca, Spain - USTAN-GML - USTAN- SMRU, St Andrews, United Kingdom - SZN, Naples, Italy - VLIZ, Oostende, Belgium - EcoServe, Dublin, Ireland - NERC – SOC, Swindon, United Kingdom - SNG, Frankfurt am Main, Germany - MPI-MM, Bremen, Germany - Uaç, Ponta Delgada, Portugal - IOPAS, Sopot, Poland - AWI, Bremerhaven, Germany - AAU, Turku, Finland - USOU, Southampton, United Kingdom - NIB, Ljubljana, Slovenia - DIFRES, Charlottenlund, Denmark - IOW, Rostock, Germany - CSIC, Madrid, Spain - UGent, Gent, Belgium - CoNISMa, Rome, Italy - SAHFOS, Plymouth, United Kingdom - UCD, Dublin, Ireland - IFM Kiel, Kiel, Germany - RUG, Groningen, The Netherlands - ICB-CNR, Napoli, Italy - UHULL, Hull, United Kingdom - CMRS, Esbjerg, Denmark - APN, Tromsø, Norway - RIVO, Ymuiden, The Netherlands - CIIMAR, Porto, Portugal - UO, Oslo, Norway - KU CORPI, Klaipeda, Lithuania - IFREMER, Issy les Moulineaux, France - UvA, Amsterdam, The Netherlands - CEFAS, Suffolk, United Kingdom - UG, Gdansk, Poland - ETI, Amsterdam, The Netherlands - RIKZ, The Hague, The Netherlands - IMBC, Crete, Greece - MBA, Plymouth, United Kingdom - CNRS-DIMAR, Marseille - CNRS-OOB, Banyuls - CNRS-SBR, Roscoff - CNRS-LOV, Villefranche - CNRS-MNHN, Paris, France - NATURALIS, Leiden, The Netherlands - UGOT, Goteborg, Sweden - UM/ICIS, Maastricht, The Netherlands - UWB Gwynedd, United Kingdom - WU, Wageningen, The Netherlands - UP, Pisa, Italy - NIOZ Den Burg, The Netherlands - IMR, Bergen, Norway

[1] General Coordinator

# Implementation of high-throughput genomic approaches to investigate the functioning of marine ecosystems and the biology of marine organisms - (MARINE GENOMICS)

*Boyen, C.*[1] *(scientific co-ordination)*

[1] Centre National de la Recherche Scientifique, France

| | |
|---|---|
| *Contract No:* | *Project duration: 03/2004 – 03/2008* |
| *Project budget: around € 40 000 000* | *EC contribution: € 10 000 000* |
| *Website:* http://www.seanomics.net | |

The overall aim of this project is to set up and develop a European Network of Excellence, referred to as "Marine Genomics", for the implementation of high-throughput genomic approaches in the biology of marine organisms. Marine Genomics will promote, develop, and spread throughout the European Union a broad range of genomic approaches, to investigate a wide range of questions related to the functioning of marine ecosystems and to the biology of marine organisms. With this aim in view, we propose to group and network experts in genomics, proteomics, and bioinformatics from several Centres of Excellence in genomics in Europe with marine biologists who can make use of high-throughput genomics data. This will involve the dedication and the development of common research infrastructures, both in genomics and in marine biology. Joining together these distinct scientific communities will establish Europe's lead in marine genomics.

The **Jointly Executed Research** of Marine Genomics is broken down into Comparative, Functional and Environmental Genomics, three sections which structure more traditional streamlines, leading to various microbial, algal, evolution development and diversity, and fish and shellfish nodes. This research can be applied to the management of marine ressources (prediction of global changes in marine populations, conservation of biodiversity, fisheries management and improvement of aquacultured species) and to gene mining for health and biotechnology.

The **Integration effort** of Marine Genomics is based on the following strategies: i) jointly develop enabling technologies; ii) sharing existing technical platforms iii) collectively gaining access to major Genomic centres; iv) regrouping under a common Bioinformatics Centre; and v), create and develop a Knowledge and Communication System, a permanent web-based interface for communications within and outside the network.

**Spreading activities** will include workshops and courses implemented by a Training & Education Council. Marine Genomics will also develop complementary dissemination strategies, targeting public, private and institutional communities with the purpose of enhancing the integration of marine biologists in the ERA.

# Lead Potential of Marine Micro-organisms from Coastal, Shelf and Deep Sea Sediments, A Comparative Assessment for Optimized Search Strategies - (MICROMAR)

*Amann, H.[1], Gromoll, L.[1], Maggiulli, M.[1], Erhard, M.[2], Halo, L.[3], Dieckmann, R.[4], v. Döhren, H.[4], Szewzyk, U.[4], Wenzel, W. [4], Heil, J.[5], Schüz, T.[5], Roussis, V.[6], Vagias, C.[6]*

[1]Fachgebiet Maritime Technik, MAT, Technische Universität Berlin, Germany; [2]Anagnostec GmbH, Luckenwalde, Germany; [3]Galilaeus Oy, Kaarina, Finland; [4]Fachgebiet Ökologie der Mikroorganismen, FÖM, TU Berlin, Germany; [5]Syngenta AG, Basel, Switzerland; [6]Dept. Pharmacognosy, University of Athens, Greece; (email contact: amann@vws.tu-berlin.de)


| | |
|---|---|
| Contract No: EVK3-CT-1999-00001 | Project duration: 03/2000 – 02/2003 |
| Project budget: € 1 705 100 | EC contribution: € 967 600 (excl. Swiss contrib.) |
| Website: http://www.tu-berlin.de/fb10/MAT/micromar | |


**Objectives**

The prospective potential for bio active lead structures from marine sedimentary micro-organisms, mainly aerobic bacteria, and their secondary metabolites was to be established. Ecological, technical, logistic and molecular similarities and differences between traditional research for natural products on land and the new search in the sea should be identified. Oceanographic and regional benthic ecosystem variations should be addressed: oxic sediments from the coast, the shelf, the continental slope and the deep sea of Europe and world wide in the open ocean and in one enclosed sea environment, the Mediterranean Sea.

**Methods and procedures**

Sediment samples were to be taken, about 200, well positioned, by different methods of grab, multicorer, piston and gravity coring, as well as scuba diving. Sea floor conditions, salinity, temperature, were maintained and controlled during sampling, retrieval, transport and storage. A large number of different research vessels (15) and cruises (49) had to be contracted for sampling of opportunity. Samples were subsequently prepared for cultivation and isolation of strains. Initial plans targeted 2000 strains. Established and novel cultivation methods and media were applied to improve traditionally low cultivation efficiencies of ~1%.

Characterisation of micro-organisms and metabolites was done by MALDI-TOF, sequencing, environmental characterisation (influences on growth from salinity, temperature) and by bio-assays. Micro-organisms showing activities were cultivated in small scale fermenters. Strains/extracts were selected for HTS, industrial high through-put screening. Secondary metabolites showing interesting responses were structurally elucidated. Their producers were retained as project strains, fermented and up-scaled for further technical and eventual application research. The project was co-ordinated and data documented with a relational database system, MicroMarDat, specifically developed for Project MicroMar.

**Results**

Prospecting and sample procurement, 336 samples were collected world wide, but mainly in the Greek Mediterranean waters and the southern North Sea, ~70% originated from coastal and shelf deposits, ~30% from slope and deep-sea sites in the Pacific, Atlantic and Indian Ocean. Reworked sandy and silty sediments near the continents and in tide influenced regions seem more prospective at present than pelagic clayey deposits. Instrumented sample logistics resulted in temperature controlled supplies.

Cultivation, isolation, storage. Altogether 2795 strains were cultivated by standard plating and in novel upflow reactors, isolated, transferred to partners and/or stored. They show a high phenotypic diversity, mostly Actinobacteria, low G+C-Gram Positive, Cytophaga, Alpha and Gamma Proteo Bacteria groups, no pathogens. High dilution of standard complex media (marine broth, peptones, others), emulating oligotrophic conditions, and use of selective media, gave optimum growth and enrichment.

Characterisation, MALDI-TOF mass spectrometry, micro-biological. 2416 strains and 16 samples were analysed and indicated high phenotypic diversity, phylogenetic confirmation (16S rDNA) was difficult. Biochemistry: indications for known polypeptides, in 30 % of all cases for potentially unknown molecules.

Characterisation, ecological, bio-assays, fermenting. Significant halotolerance (61%), and halophilic performance (34%) of strains show their marine adaptation. Media comparison and pre-selection of producers were established in 24 deep well plate fermenters and in small scale lab-bioassays for indicative insecticidal, fungicidal and herbicidal activities.

HTS, high through-put screening. Pre-identified producer strains were singled out by the extraction of solid fractions of cultures and put to HTS for selection of active strains. Comparison of UV/MS data with available data bases and identification of unknown compounds and their strains, re-fermentation, optimisation and up-scaling of fermentation followed for selective structure elucidation. Bio active metabolites are polypeptides, polyketides, macrolides (macrolactins), indol acetic acid, pyrrole carboxilic acid, *inter alia*, substances of known molecular activity and structure.

Prudent exploration and use of marine natural resources, Convention on Bio Diversity, CBD. Stipulations of the CBD, although not yet specified for marine natural product research, adequately regulate also bio-prospection in the sea, for both, scientific as well as industry oriented and EU motivated research and development.

**Potential exploitation by end users**

Eventual commercial uses for pharmaceutical, agrochemical and other industrial markets can well be imagined and are being further studied, esp. for agricultural applications.

Recommendations for optimised search. The oxic sedimentary ecology is more prolific where higher inputs of nutrients, oxygen and energy (by currents) prevail. This is the case in intertidal areas and along current-exposed deeper parts of continental slopes (e.g. channels). The deep sea contains many habitats for still unknown strains and their secondary metabolites. Novel methods and tools, esp. autoclave sampling and evaluation equipment, would be needed to prospect this vast region of the World Ocean.

Summary and outlook. Project MicroMar confirmed the bio prospectivity of aerobic sedimentary micro-organisms and their secondary metabolites in the oxygen influenced sea floor. Much more micro bio activity and eventual uses than so far discovered shall be and will be encountered in future years. Dedicated *in-situ* probing and again targeted autoclave sampling shall help. Anaerobic realms shall thereby be opened as well.

**References**


- Amann, H. and 13 authors (2003): MicroMar, Final Report, Section 2, Publishable Executive Summary, Berlin and Brussels, TU Berlin and EU Commission, May 2003
- Schüz, T. and 3 authors (2003): Natural Products from Marine Sediment Bacteria: Optimised Strategy for Fermentation and Extraction – First Results; International Symposium on Chemistry & Biology of Marine Organisms, Kolympari, Greece, Sept. 21-25, 2003 (poster presentation)

# Microbial Marine Communities Diversity: From Culture to Function - (MIRACLE)

*López-López, A., Zaballos, M., Galán, S., Alba, J.C., and Rodríguez-Valera, F.*

División de Microbiología, Universidad Miguel Hernández, Alicante, Spain. Mail: frvalera@umh.es



| | |
|---|---|
| Contract No : EVK3-CT-2002-00087 | Project duration : 3 years (Nov. 2002- Nov 2005) |
| Project budget : 2548746 euros | EC contribution : 1702,996 euros |
| Website : miracle.umh.es | |



**Objectives**

Pure culture is still the most powerful tool of Microbiology to study and exploit microbes. Although, marine micro-organisms have a very rich diversity, as detected by "the molecular approach", most of the relevant groups remain uncultured.
This project aims to improve the methods of culture of marine microbes by understanding the limitations and factors involved in the poor culturability of these groups.

Molecular tools and high through-put methodologies are being extensively used to provide a better picture of what organisms are there, what conditions favour or hamper their growth in axenic cultures and, eventually, how to develop adequate methodologies to obtain pure cultures of these microorganisms.
The project will result in the isolation and description by molecular markers of many microbial isolates.

A database of marine prokaryotes is being developed including organisms described only by their reporter sequences (typically 16S rDNA) and those of extant cultures which exist either in culture collections or in the project's own collection.
A screening of some biotechnological applications will be carried out with the organisms isolated during the project: pigment production, polymer production and emulsifying properties, capability to be used for heterologous expression of marine environmental DNA, and production of substances with anti-tumour activities.

This project involves a combination of innovative culture techniques and molecular ID, allowing a better and more complete description of microbes carrying essential functions in the sea.

**Results**

WP1 consists in the assesment of the prokaryotic biodiversity present in samples from European Seas. For this purpose we are studying the community structure of two different sites (one in the Mediterranean Sea and another in the Atlantic Ocean) at two different depths (50 and 3000 m) by amplifying 16S rDNA genes plus the Internal Transcribed Spacers (ITS) between 16S and 23S rDNA genes

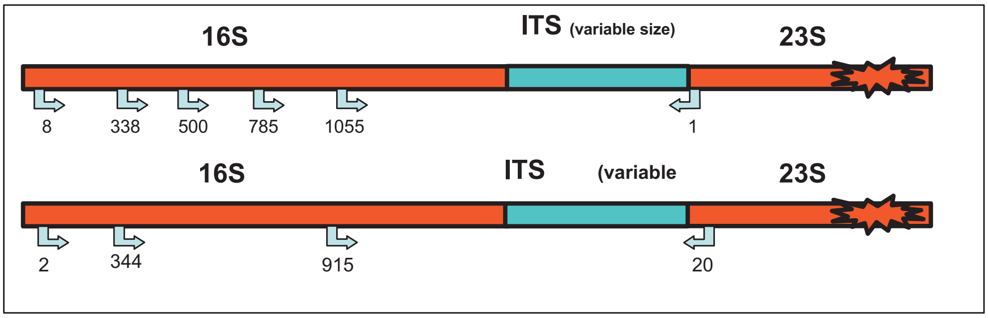



Figure 1. Prrimers used for amplification in *Bacteria* (A) and *Archaea* (B) Domains

The result of the amplification and cloning of these fragments is the construction of two 16S rDNA libraries of around 1000 clones for *Bacteria* and 200 clones for *Archaea*. These clones are being sequenced and analysed to asses and compare the prokaryotic biodiversity present at these two sampling sites. The first analysis of these clones allowed us to evaluate the culturability of the prokaryotes present in the both sites.

The first attemps to cultivate marine microorganisms have resulted in the isolation of different strains that are being analysed and identified by their 16S rDNA gene and ITS sequences. Each partner involved in the project is using high throughput techniques, different culture media and different seawater samples. These isolates

On the other hand, a data base has been created to collect DNA diversity data about marine prokaryotes in a way that makes it amenable to ecological and biogeographical analysis. Nowadays we have collected around 2500 sequences, coming from another data bases and from our own project. The data base is publicly accesible by internet: **http://miracle.umh.es/database**.

**Potential exploitation by end users**

It is expected that among the many novel marine prokaryotes that are being isolated and brought into culture, several new valuable compounds and processes will be discovered. These may include substances that posses anti-carcenogenic or anti-viral activities and new antibiotics, which may enhance the quality of life and health care. Furthermore, some of the isolated novel microorganisms may posses the capacity of degradation of xenobiotics and other pollutants and such microorganisms may be used for bioremediation purposes.

While MIRACLE aims at the discovery, isolation and cultivation of novel marine microorganisms, it emphasizes the importance of understanding their implication in the whole ecosystem functioning, with consequences at the level of better environmental quality control. Marine microorganisms themselves may be a renewable natural resource.

# Development of non-degrading, NOvel MArine TEChnologies for the sustainable exploitation and protection of Mediterranean marine resources - (NOMATEC)

*van Treeck P [1], Schröder HC [2], Gobert S [3], Aiello A [4], Lejeune, P [5], Wernerus F [6], Müller J [7], Schuhmacher H[1]*

[1] University of Duisburg-Essen, Germany; [2] University of Mainz, Germany; [3] University of Liege, Belgium; [4] University of Naples, Italy; [5] STARESO, France; [6]Corsecologie, France; [7]LIMARES, Germany



| | |
|---|---|
| Contract No : EVK3-2000-00033 | Project duration : 02/2001 – 01/2004 |
| Project budget : € 1 400 000 | EC contribution : € 1 205 000 |
| Website : www.nomatec.org | |



**Objectives**

The oceans are subject to an increased development and show marks of severe overexploitation and degradation with significant loss of productivity, biodiversity and aesthetics. For a sustainable development clean adapted technologies and concepts for the production of marine products without further degradation of the environment are required.

NOMATEC tackled the objectives from two sides:

- *A) The development of a key technology for the creation of submersed structures in an environmentally sound way (Electrochemical accretion technology =EAT).*
- *B) The identification of bioactive substances in extracts from marine sponges*

A novel clean technology to form hard structures in situ on the sea bed (A) and the identification of bioactive substances in sponges (B) are basic innovations.

They were further developed and combined on the application level in designing:

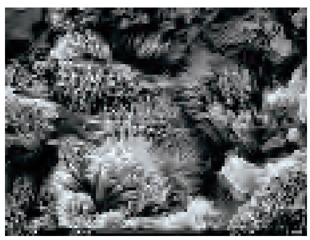
- *C) ecologically suitable mariculture units for pharmaceutical target species.*
- *D) methods applying EAT for the fixation and restoration of Posidonia* sea grass *beds.*

Market analyses connect basic research, application level and end users. Ecological surveys and impact assessments secured the non-degrading feature of all activities and processes.

**Results**

***A) Electrochemical accretion technology***

The electrochemical accretion technology was significantly improved by the development of an autonomous system to control all relevant electrical parameters during the formation of the mineral crusts. Having full control of the electrical features it was possible to direct the Ca/Mg ratio towards Ca thus the quality and mechanical strength of the precipitated material could be improved. As a market ready deliverable a prototype of a portable control unit is available which can work net independent with photovoltaic energy or in combination of regenerative power sources and net supply.

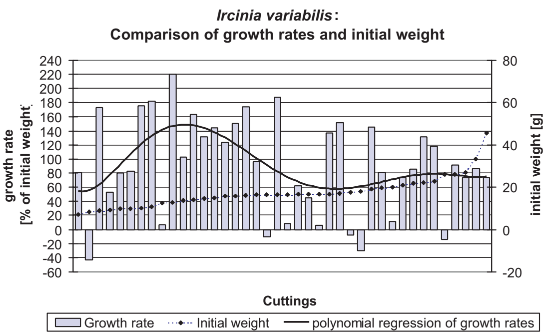


Aragonite cristals of an EAT structure

### *B) Bioactive compounds from marine sponges*

A series of bioactive compounds showing antibacterial, antifungal, anti-inflammatory, antitumor and neuroprotective activity were isolated from extracts of different Mediterranean sponges. Structural characterization was performed by application of chemical and spectroscopic analytical methods. The cDNA encoding a key enzyme for the biosynthesis of bioactive sponge etherlipids, the alkyldihydroxyacetonephosphate synthase was identified using differential display technology. In addition, a tachylectin-related antimicrobial sponge lectin was identified, cloned and characterized. Sponge skeletal proteins (collagen) were isolated, purified and/or cloned from different sponges.

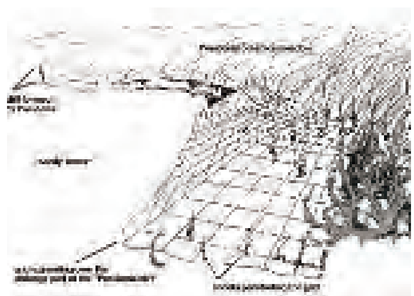
### *C) Mariculture of sponges*




Nine sponge species with bioactive metabolites were tested in different farming devices. For the first time *Ircinia variabilis* was successfully grown in mariculture [3]. The biomass required as stocking material was reduced by detailed analysis of growth rates and initial weight thus optimising the procedure. The growth of the sponge explants was monitored using a novel, non destructive video technique. The findings might be transferred beyond this species and was formulated into a patent application [1].

### *D) Rehabilitation of Posidonia oceanica meadows*

The EAT method was applied to protect an eroded part of a *Posidonia* cliff. The grid proofed to withstand even high hydraulic impacts, however the further sediment erosion had to be considered as a major threat and a mesh with smaller openings had to be added at endangered edges. In general it was shown that it is possible to slow down the erosion and accumulate sediment behind the mineral crusts. Seeding bare sand patches with *Posidonia* seedlings was tested comparing EAT fixation means against conventional bamboo grids. The EAT technique is successful if the mineral accretion process is carefully controlled and the accretion is stopped as soon as the required fixation has been achieved. The bamboo grids gave good results in the beginning but were ineffective to withstand higher hydraulic impacts. The principles of the restoration method were summarised in a manual for the application of EAT for *Posidonia* restoration The method is subject to patent preparation [2].



### Potential exploitation by end users

In the NOMATEC project sponge natural products and associated techniques have shown high potentials in various fields. Companies of the pharmaceutical and cosmetic division are mainly attracted by the new bioactive compounds with their curative potentials e.g. in the treatment of cancer. Also the high content of collagen offers a lot of cosmetic applications. The results significantly contribute to exploit products such as several metabolites from invertebrates which are known and described but unavailable for end users until aquaculture can be established [3] [5]. In connection with the development of sponge natural products The obtained results concerning culture techniques come into the focus of interest to the fishing and aquaculture enterprises. As the new marin products can be produced without additional feeding thus could supplement aquaculture in combination with conventional fish farming or could be established in places where such activities are prohibited due to ecological considerations. Beyond that manufactures for advanced marine technologies can make use of the results in a broad sense as EAT can be applied for various purposes of marine constructions [4] [2]. The autonomous control unit significantly facilitates the handling of the technology and its common establishment.

## References

[1] VAN TREECK P, PASTER M (2003) Deutsches Patent DE101 61 174 C1
[2] VAN TREECK P, PASTER M (2003) Offenlegungsschrift DE 101 49 356 A1
[3] van Treeck P, Eisinger M, Müller J, Paster M, Schuhmacher H (2003) Aquaculture
[4] Lepoint G, Vangeluwe D; Eisinger M, Paster M, van Treeck P, Bouquegneau JM, Gobert S (2003) Mar Poll Bull
[5] Aiello A, D'Esposito M, Fattorusso E, Menna M, Muller WEG, Perovic-Ottstadt S, Schröder HC (2004) J. Nat. Prod.in press
[6] Müller WEG, Klemt M, Thakur NL, Schröder HC, Aiello A, D'Esposito M, Menna M,Fattorusso E (2004). Mar. Biol. 144, 19-29

# OceAnic Seamounts: an Integrated Study – (OASIS)

*Christiansen, B.*

Universität Hamburg, Germany

| | |
|---|---|
| Contract No : EVK3-CT-2002-00073-OASIS | Project duration : 12/2002 – 11/2005 |
| Project budget : € 2 814 000 | EC contribution : € 2 443 000 |
| Website : www.rrz.uni-hamburg.de/OASIS | |

**Objectives**

OASIS aims at describing the functioning characteristics of seamount ecosystems. The project's holistic approach to investigate seamount ecosystems integrates hydrographic, biogeochemical and biological information. Based on two case studies, OASIS will yield an advanced mechanistic understanding of the processes characterizing seamount ecosystems, and their influence on the surrounding ocean. The scientific results, condensed in a conceptual ecosystem model, will be applied to outline a model management plan as well as site-specific management plans for the seamounts investigated.

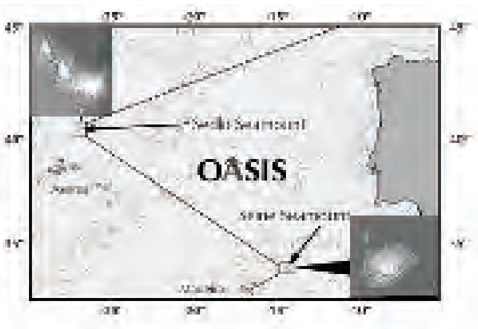
The primary goal of OASIS, to provide an holistic, integrated assessment of seamount ecology, will be achieved by addressing the following main objectives.

- *Objective 1: To identify and describe the physical forcing mechanisms effecting seamount systems*
- *Objective 2: To assess the origin, quality and dynamics of particulate organic material within the water column and surface sediment at seamounts.*
- *Objective 3: To describe aspects of the biodiversity and the ecology of seamount biota, to assess their dynamics and the maintenance of their production.*
- *Objective 4: Modelling the trophic ecology of seamount ecosystems.*
- *Objective 5: Application of scientific knowledge to practical conservation.*

**Expected results**

OASIS focusses on the study two seamounts in the NE Atlantic. Sampling of organic material, plankton, fish and benthos and the determination of metabolic activities and physical characteristics across target seamounts are conducted during the first 2 years. Reports, workshops and a Stakeholder Advisory Board will ensure efficient communication. The datasets and modelling will result in a full description of the biological and biogeochemical environment of the seamounts and lead to site-specific and model management plans for a sustainable exploitation.

First preliminary results show, e.g., clear differences between the distributions of particulate organic carbon, as well as between the plankton communities above the summit of a seamount and outside this region.




OASIS study sites

**Potential exploitation by end users**

OASIS will provide an holistic scientific description of a type of ecosystem that is currently under increasing pressure from fisheries and other forms of exploitation. Besides the benefit of an improved understanding of processes in important marine ecosystems and their interdependency, the project will produce a model for ecosystem dynamics that will advance the prediction of the risks associated with human activities that may disturb the equilibrium of European seamount ecosystems. In this respect, OASIS has direct relevance to applied issues like fisheries management and the conservation of biodiversity; these goals depend on a thorough understanding of ecosystem function. For example, although the inclusion of seamounts in a network of Marine Protected Areas was given a high priority in OSPAR's MPA programme, there is little or no reliable information on which to establish ecologically meaningful boundaries for such areas. In this respect, OASIS will serve to convert new, leading-edge science into a format appropriate to the needs of both political and public bodies. The science plan of the OASIS project provides a solid foundation from which to develop both rationale ‘management rules’ for northeast Atlantic seamount ecosystems to be protected in the European, OSPAR or global context, and an improved public understanding of these unique oceanic habitats.

# Monitoring the diversity of photosynthetic picoplankton in marine waters - (PICODIV)

*Vaulot D.*[1]*, Scanlan D.J.*[2]*, Medlin L.K.*[3]*, Pedrós-Alió C.* [4]*, Throndsen J.*[5] *and the PICODIV participants*

[1] Station Biologique de Roscoff, France (vaulot@sb-roscoff.fr); [2]University of Warwick, UK; [3]Alfred Wegener Institute for Polar Research, Bremerhaven, Germany; [4]Institut de Ciències del Mar, Barcelona, Spain; [5]University of Oslo, Norway.



| | |
|---|---|
| Contract No : EVK3-CT-1999-00021 | Project duration : 04/2000 – 03/2003 |
| Project budget : € 2 382 277 | EC contribution : € 1 324 979 |
| Website : www.sb-roscoff.fr/Phyto/PICODIV | |



**Objectives**

Picoplankton (defined operationally as cells that pass through a 3 micron filter) dominate the photosynthetic biomass in many marine ecosystems, not only in the very oligotrophic regions of the world oceans, such as the Eastern Mediterranean Sea, but also in mesotrophic areas. However, picophytoplankton are clearly not exclusively restricted to pelagic environments. In many coastal regions, they are present throughout the year and constitute a 'background' population, onto which episodic phenomena, such as the spring bloom develops. In some environments, such as coastal lagoons, picoplankton can be a major component of biomass and productivity for most of the year. In addition, some bloom-forming picoplankters, such as *Aureococcus* spp., are toxic. However, fewer than 50 species of picophytoplankton have been described. A clear proof of our poor knowledge of picophytoplankton diversity is revealed by the discovery of three novel algal classes in the last ten years described from picophytoplanktonic taxa.

Because so little is known about the taxonomy and systematics of picophytoplankton we have very little data to estimate the levels of its biodiversity under natural conditions and how picophytoplankton are affected by environmental variability linked to either anthropogenic influence or to larger scale phenomena, such as those linked to climate change or global warming.

The major objective of the PICODIV project was to develop, test and validate methods based on molecular biology techniques that allow for routine and extensive assessment of picophytoplankton diversity (species composition and relative contribution of taxa to total community) in the marine environment.

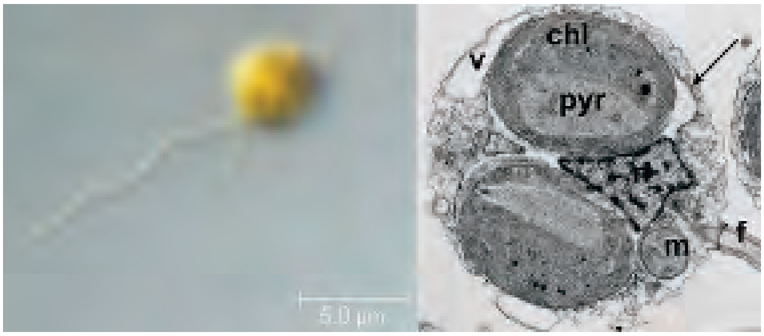
Our strategy to meet this objective was encapsulated in the following four steps:

(1) Obtain SSU rDNA sequences for as many as possible picophytoplankton taxa from both cultures and natural samples. Novel taxa will be assessed using a combination of methods including in particular pigment analysis and electron microscopy. (2) Using this sequence database, develop hierarchical probes recognizing each taxonomic group having picophytoplanktonic representatives (3) Develop fast and efficient techniques to quantify the fraction of the pico-phytoplankton recognized by the probes in natural samples. (4) Test and validate these probes on time series of picophytoplankton biodiversity in three coastal ecosystems.

**Results**

Cultures of picoplankton.

Obtaining cultures of novel picoplanktonic species is a key step to assess picoplankton diversity. More than 250 cultures were established from three coastal sites (Roscoff, Helgoland, Blanes) and from open ocean cruises. These cultures have been characterized by microscopy, pigment analysis and rDNA sequencing. We performed a detailed analysis of the phenotype (pigments, morphology) and genotype (18S rDNA phylogeny) of key groups of the picoplankton based on representative strains isolated during the project. This work led to the reorganization of the taxonomy of important groups such as the cyanobacteria and Prasinophyceae as well as to the description of novel species (e.g. *Florenciella parvula*) or the correct phylogenetic assignment of previously described species (e.g. *Telonema*).




*Florenciella parvula* RCC 446, a novel picoplankton species discovered during PICODIV: Light and electron microscopy

Clone libraries of marine picoplankton.

Construction of SSU rDNA clone libraries representative of the *in situ* picophytoplankton diversity, and subsequent sequencing of novel gene sequences, is critical for understanding and describing the total diversity present in contrasting marine aquatic environments. This is particularly so for identification of novel picophytoplankton groups for which cultured counterparts do not exist. The sequence data obtained provide the basis for the design of new phylogenetic probes, which can be used to retrieve their morphology..

In the course of the project we have obtained over 1,300 rDNA sequences from 46 clone libraries constructed both from coastal an open ocean samples. We analyzed the sequence data in order to both determine the spatial and seasonal variation of taxonomic groups at each coastal site and perform a detailed phylogenetic reconstruction for some of the groups, especially those for which no culture representatives are available (stramenopiles, alveolates). Two novel groups were discovered, one of which constitutes probably new algal class.

Molecular probes for marine picoplankton.

We have designed and tested the specificity of probes against some key taxonomic groups from the picoplankton. We then used probes to monitor the abundance in coastal waters of different groups among picoplankton (*Synechococcus*, Prasinophyceae, Prymnesiophyceae...) with detection techniques developed during the project, in particular fluorescent *in situ* hybridization coupled with the tyramide signal amplification (FISH-TSA) and DNA micro-arrays.

**Potential exploitation by end users**

The collection of cultures that have been isolated during the project should be a major resource both from a fundamental point of view because these strains are likely to represent key organisms in coastal waters and from the applied point of view because these strains could be screened in the future for interesting compounds. From the methodological point of view, the DGGE approach, that we have developed and applied, could prove very useful to assess and monitor the diversity of phytoplankton in oceanic waters. Finally the set of probes we have designed and tested as well the probing techniques (FISH-TSA, DNA micro-arrays) that have been developed should be very useful for routine monitoring of some key groups, such as the *Synechococcus* cyanobacteria and the Prasinophyceae, e.g. in the context of long term surveys to detect ecosystem response to global change or to pollution.

# Deep-Sea Hydrothermal Vents: A Natural Pollution Laboratory - (VENTOX)

*Dixon, D.R.[1], Dixon, L.R.J.[1], The VENTOX Consortium[2-9]*

[1]Southampton Oceanography Centre, United Kingdom (drd@soc.soton.ac.uk) ; [2]IFREMER, France; [3]Universidade do Algarve, Portugal; [4]Laboratòrio Maritimo da Guia, Portugal; [5]University of Wales-Bangor, Wales; [6]Observatoire Océanologique de Banyuls, France; [7]Université Pierre et Marie Curie, France; [8]Station Biologique de Roscoff, France; [9]Universidade do Azores, Portugal



| Contract No : EVK3 CT1999-00003 | Project duration : 03/2000 – 02/2003 |
|---|---|
| Project budget : €2 785 700 | EC contribution : €1 979 500 |
| Website : www.soc.soton.ac.uk/ventox/ | |



**Objectives**

Utilising deep-sea vents in European waters close to the Azores Archipelago, VENTOX set out to explore and identify those special adaptations: ecological, behavioural, physiological, cellular, biochemical and molecular, which enable vent organisms (mussels, shrimps and gastropods etc), to survive and thrive in what is arguably the most contaminated and stressful environment on the face of the planet. To achieve these aims required the development of new methods and approaches which on the one hand built on the findings of previous EU-funded programmes, and on the other represent important technical and conceptual breakthroughs at a series of biological levels and scales. Specific objectives included: the determination of the microscale distribution of organisms in relation to steep thermal and chemical gradients close to vents, the measurement of tissue toxicant burdens, a range of molecular, biochemical and physiological studies to provide insights into heavy metal, pH, thermal, $CO_2$ and sulphide tolerances, bacterial and megafaunal production rates, rates of DNA damage and repair, and the identification of bacterial-mediated detoxification processes that help to underpin survival in this extreme marine environment [1,2]. Given their close proximity to the Azores, and the importance of deep-sea fishing in the economy of the region, special attention was paid during VENTOX to possible linkages between the toxicity of the vent emissions and the risk to the human food chain represented by heavy metals and radionuclides.

**Results**

The great success of the retrievable cage concept was demonstrated by the high quality of the recovered animals and their extended availability throughout the winter period, something that could not be achieved with research cruises, due to severe weather limitations. The cages were both a scientific and economic success, which when coupled with LabHorta, a land-based research facility on Faial in the Azores, provide a unique research platform/facility for future vent research in European waters. The significance of this technological breakthrough was further highlighted by the discovery that the mussel *Bathymodiolus azoricus*, the dominant vent species close to the Azores, reproduces in the late winter, to take advantage of an early spring bloom in primary production, which provides food, as phytodetritus, for its dispersing larvae [3]. This unexpected dependence on photosynthesis, together with our recent discovery of significant levels of particulate feeding in this species, challenges previous vent theory which has tended to emphasise nutritional independence (viz. bacterial chemosynthesis) and other aspects of functional isolation. This important EU-funded discovery is forcing a paradigm shift in how we view vent organisms today and in an evolutionary context. Another important finding was the demonstration that vent crustaceans are capable of coping with high $CO_2$ levels, which may prove of value in future when considering the deep-ocean disposal of atmospheric carbon dioxide (relevance to global warming). Other significant findings included the discovery of new fish and invertebrate species (biodiversity) and the isolation of a new vent micro-organism with the capacity to degrade feather waste (biotechnology). Add to this the discoveries relating to thermal selection (adaptation genetics), toxicant and pressure sensitivities (DNA damage, metal resistance and hydrostatic pressure responses), the discovery of fine-scale structuring of vent communities in relation to chemical and physical gradients, and the success of maintaining deep-sea vent organisms for many months in laboratory aquaria, on a diet of hydrogen sulphide and methane (industrial waste products), and we have clear evidence of a highly successful research programme, with both fundamental and applied spin-offs.

### Potential exploitation by end users

Apart from the important significant scientific discoveries, VENTOX has achieved a number of instrumentational and technological advances in collaboration with several European SMEs. Plus has provided employment and training for a large number of staff and students, several of whom have already been successful in finding permanent employment or postgraduate positions in a range of European institutes and universities. Throughout its existence, VENTOX attracted considerable public and media attention through exhibitions (e.g. Science Museum, London), newspaper and magazine articles, including a major feature article in *National Geographic Magazine*, television and radio interviews, and in the conservation field through the creation of two, new Marine Protected Areas, the Menez Gwen and Lucky Strike vent fields, southwest of the Azores, which led to the award of the prestigious *Gift to the Earth* from the World Wildlife Fund for Nature. In addition, a number of VENTOX partners have contributed to a range of research proposals as part of Framework 6, including projects relating to the International *Census of Marine Life* and the Marine Genomics Network of Excellence.

### References

[1] Dixon, D.R., Dando, P.R., Santos, R.S., Gwynn, J.P. and the VENTOX Consortium, 2002. InterRidge News **10**, 21-23.

[2] Sarradin, P.M., Debruyères, D., Dixon, D.R., Almeida, A., Caprais, J.C. Colaço, A.. Company, R Cosson, R. Cueff, V. Dando, P.R.. Etoubleau, J., Fiala-Médioni, A.,. Gaill, F., Godfroy, A., Gwynn, J.P., Hourdez, S., Jollivet, D., Khripounoff, A., Lallier, F., Laulier, M., Le Bris, N., Martins, I., Mestre, N., Pruski, A.M., Rodier, P., Santos, R.S., Shillito, B., Zal, F. & Zbinden, M. (2001). InterRidge News **10**, 18-20.

[3] Dixon, D.R., Sarradin, P.M., Dixon, L.R.J., Khripounoff, A., Colaco, A., Serrao Santos, R. (2002). InterRidge News **11**, 14-17. An updated version of this article will shortly be submitted to the highly-rated journal Science.

# FISHERIES

# Association of Physical and Biological processes acting on Recruitment and Post-Recruitment stages of Anchovy - (ANREC)

*Kallianiotis, A, Tsamadias I., Milani Ch.*

National Agricultural Research Foundation – Fisheries Research Institute, Greece

| | |
|---|---|
| Contract No : Q5RS-2002-01216 | Project duration : 10/2002 – 09/2005 |
| Project budget : € 1 849 009 | EC Contribution : € 1 299 947 |
| Website : www.fishri.gr | |

**Objectives**

Environmental conditions, through climatic fluctuations, are closely linked to year-to-year abundance of fish populations. Small pelagic fish are notoriously prone to collapse under fishing pressure exacerbated by environmental stress. The main objectives of ANREC are to advance our understanding of the anchovy recruitment in North Aegean Sea, in relation to physical and biological forces and to develop the capability of predicting the effects of environmental and biological variability on anchovy recruitment. Specific objectives include:

I. analysis of archived meteorological and remote sensing data combined with fisheries landing data in order to identify correlation in time
II. collection and analysis of fleet dynamics information and calculation of cpue
III. identification of physical processes acting on recruitment coupled with biological factors such as food abundance and composition in all ontogenetic stages
IV. study of growth and genetic analysis of the stock
V. incorporation of all data into a model that leads to comprehension what drives anchovy recruitment and post recruitment stages in North Aegean Sea

**Results**

Retrospective analysis reports concerning all aspects of the project have been completed, and analyses of data are about to start. Fleet inventory, landings data and estimation of cpue, as well as a time series analysis using an ARIMA model, have finished in time. Moreover, analyses of historic chlorophyll-a data and a review of physicochemical and freshwater inflow data have been carried out. The establishment of protocol for genetic analysis was successful, while preliminary results concerning growth and population dynamics are available.

**Relevance for Society**

Modelling the population dynamics of anchovy in North Aegean Sea regarding its recruitment and post-recruitment stages will probably be a first step into sustainable and rational management of fisheries in Greece. Anchovy constitutes the most abundant species in Northern Aegean and fishing industry is heavily dependent on anchovy stock. Furthermore, fishing canning industry is also totally dependent on small pelagic catches. The fact that northern Aegean anchovy's catch is constituted mostly of 2+ aged-individuals should be taken into consideration. This fact turns the specific stock probably unique in terms of management and allows many scientific and administrative opportunities to be explored. Policy-makers after having integrated research findings may be able to manage the resource benefiting both people and environment and promoting sustainable yield of small pelagic fish. Therefore, modelling and subsequent prediction of the catch will enable all of them to rationally plan for the future. Finally, we should take into account that East Macedonia and Thrace are border regions of the EC and attention should be given to occupation and well-being of the local fishermen.

# Access to South European Finfish Aquaculture Facilities - (ASEFAF)

*Lacroix, D.*[1] *; Zambonino, J.L.*[2]

[1] Ifremer LRPM, Palavas-les-Flots, France ; [2] Ifremer ARN, Plouzané, France

| | |
|---|---|
| Contract No : HPRI-CT-2001-00146 | Project duration : 12/2001 – 6/2004 |
| Project budget : euros 1.100.000 | EC contribution : euros 816.667 |
| Website : www.ifremer.fr/asefaf | |

**Objectives**

The ASEFAF programme had been launched in December 2001 in the frame of the global programme "Improving the human research potential and the socio-economic knowledge base" under the umbrella of the Directorate General for Research. The goal was to offer facilities to European researchers for experiments they could not undertake in their own lab and to provide them all technical assistance to achieve useful and relevant trials and tests in the field of finfish aquaculture.

In its two main research aquaculture stations, IFREMER proposes 29 experiment units fitted with different tanks and sizes, supplied with sea water or fresh water including the possibility of recirculated systems and related scientific equipments for usual monitoring and analysis. The main fields are : controlled systems, nutrition, physiology, genetics and reproduction, immuno-pathology. Information is given through networking, meetings, advertisement in reviews and a website. A five members selection committee studies proposals twice a year.

**Results**

Although the end of the programme is in June 2004, a provisional synthesis can be done in few data :

- **19 projects** accepted from 26 proposals
- **26 visiting researchers from 11 countries** (4 from the North, 2 from the Eastern Europe, 5 from the Mediterranean)
- An average stay of 100 days (but 2/3 were below three months time) on a 90 m2 average surface unit
- About **20 scientific papers** ongoing or planned, including two from mixed teams
- Two phD thesis in preparation on topics related with ASEFAF experiment

The main topics were aquaculture in recirculated systems (40 %), fish nutrition (25 %) and reproduction & genetics (20 %).

**Potential exploitation by end users**

A network has been developing progressively, with the opportunity of several contacts and potential new cooperations, involving research labs and countries which had never been in touch before; for example a multilateral programme on recirculated systems in aquaculture had been started in Eastern Europe after two projects processed in parallel in ASEFAF.

The ASEFAF programme has demonstrated its capacity to achieve good scientific research work, stressing the networking of several research teams all over Europe; It has so contributed to the construction of the European Research Area. Its extended development as a European integrated infrastructure initiative is in preparation.

# Bioeconomic modelling of Mediterranean fisheries - (BEMMFISH)

**Contract number:** Q5RS-2001-01533
**Contract type:** Shared-cost project
**Starting date:** 1.11.2001
**Duration:** 36 months
**Scientific Officer:** Sigurdur Bogason
**Project web site**: www.bemmfish.net

**Coordinator**
Jordi Lleonart (1.11.2001–30.9.2002),
Francesc Maynou (from 1.10.2002)
Institut de Ciències del Mar
Passeig Maritim de la Barceloneta, 37–49
E-08003 Barcelona
Tel. (34) 932 30 95 59
Fax (34) 932 30 95 55
E-mail: maynouf@icm.csic.es

## PARTNERS

Pere Garcia, Institut d'Investigacio en Intelligencia Artifical, Campus de la Universitat Autonoma de Barcelona

Carl O'Brien Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory

Constantina Karlou-Riga, Fisheries Laboratory — Ministry of Agriculture

Vincenzo Placenti, Istituto di Ricerche Economiche per la Pesca e l'Acquacoltura

Ramon Franquesa, Universitat de Barcelona, Gabinete de Economia del Mar

Henri Farrugio, Institut Français de Recherche pour l'Exploitation de la Mer

Albert Prat, Universitat Politecnica de Catalunya, Departament d'Estadistica i Recerca Operational

Ragnar Arnason, University of Iceland, Institute of Economic Studies

Odile Pourtallier, Institut National de Recherche en Informatique et Automatique

### background

The purpose is to develop a bioeconomic model for Mediterranean fisheries and the realisation of simulation computer software allowing the testing of different management strategies. The work will be divided into the following areas: development of a theoretical background and building the conceptual model; development of the numerical model; elaboration of simulation computer software; validation of the model through case studies and dissemination. This project is expected to contribute both in practical and theoretical ways to the understanding of the functioning of Mediterranean fisheries and their management. The project integrates fisheries economists, fisheries biologists and computer scientists. A paramount aspect of this project is the exploration of new mathematical approaches, and their application to the modelling of Mediterranean fisheries. This will be ensured by bringing together specialists in different fields of applied mathematics.

### objectives

The objective of the research is to develop a theoretical bioeconomic model for Mediterranean and Mediterranean-type fisheries, and a practical computer simulation model addressed to the management of these fisheries. This model and software should be sufficiently general and flexible to accommodate easily the realities of most Mediterranean fisheries, and include multiple species and their interactions, multiple fleets and gear types, and all fisheries management tools currently used by Mediterranean fisheries managers. It should produce a wide range of fisheries performance measures, be dynamic, i.e. capable of simulating the fisheries over a long period of time, be stochastic to incorporate uncertainty in data and models, and run on the Windows platform.

**expected results and achievements**

The following practical and theoretical results are expected:

1. a ready-to-use software package for distribution among managers, fishermen and scientists;

2. a contribution to strengthening the scientific basis of the common fisheries policy and its application to the Mediterranean;

3. the establishment of a sound theoretical framework for the bioeconomic analysis of Mediterranean fisheries.

# Bridging genomes: an integrated genomic approach towards genetic improvement of aquacultured fish species - (BRIDGE-MAP)

**Contract number:** Q5RS-2001-01797
**Contract type:** Shared-cost project
**Starting date:** 1.11.2001
**Duration:** 48 months
**Scientiflc Officer:**
Mario Lopes dos Santos
**Project web site:**
http://www.bridgemap.tuc.gr

**Coördinator**
George Kotoulas
Institute of Marine Biology of Crete
Department of Genetics and Molecular Biotechnology
PO Box 2214
GR-71003 Iraklion, Crete
E-mail: kotoulas@imbc.gr

## PARTNERS

Tomaso Patarnello, Universita degli Studi di Padova, Dipartimento di Biologia

Robert Geisler, Max-Planck-Institut für Entwicklungsbiologie

Francis Galibert, Centre National de la Recherche Scientifique, UMR 6061 Génétique et Développement

Deborah M. Power, Universidade do Algarve, Centro de Ciências do Mar

Sergei Gorshkov, National Centre for Mariculture, Israël Oceanographic and Limnological Research

Costas Batargias, Nireus Chios Aquaculture SA, Department of Research and Development

Andreas Georgoudis, Aristotle University of Thessaloniki, Department of Animal Production

Manolis Koubarakis, Technical University of Crete, Department of Electronic and Computer Engineering

### background

The present project will use a combined approach of radiation hybrid, linkage and QTL mapping as well as creation of resources for genome research (BAG library, cDNA libraries, ESTs and database) to:

1. transfer genome information from model organisms to commercial species through the approach of comparative genomics;
2. bridge the gaps in maps by merging radiation hybrid maps and linkage maps;
3. bridge the distance between research and industry by accelerating the identification of DNA to phenotype relationships by a pilot application to a commercial selective breeding programme;
4. integrate evolutionary theory and modern technology to generate an applied endpoint;
5. integrate genome maps of various teleosts with data from higher vertebrates, thanks to the high potential of comparative mapping;
6. transfer technology and know-how from leading laboratories in genome analysis and mapping to more classical fish genetics laboratories.

### objectives

The project work plan is centreed around the application of modern biotechnological methods to aquaculture. It is subdivided into eight main work packages, each of which is coordinated by the partner with the relevant expertise, and the completion of which will contribute to the attainment of the project objectives.

The work packages articulate with each other and can be subdivided into three main groups according to the nature of the methods used:

1. Molecular biotechnology, which includes methodologies for generating mapping panels for the linkage map (WP1) and radiation hybrid mapping (RH) (WP2), a highly automatable new method for physical mapping, genotyping the linkage map (WPS) and RH map (WPS), by use of high-throughput automated methods, and isolating STS markers for RH mapping (WP4).

2. Conventional genetic: the tools generated in WPs 1 to 5 will be used to screen sea bream (Sparus aurata) generated in a breeding programme on an SME fish farm. This will result in the transfer of molecular biotechnological methodologies to conventional genetics and the implementation of technology transfer from science to industry;

3. The final work package which will run simultaneously with the other project tasks, is the analysis of the extensive data which will be generated by the various work packages of the project. Bioinformatics will be essential for the handling and interpretation of the data and for their successful dissemination in order that the project can have a maximum impact in the fields of aquaculture research, fish genetics, and comparative mapping.

**expected results and achievements**

Biotechnological and scientific expertise will be transferred from model organisms to commercial aquaculture species, for example the sea bream. An integrated map, merging physical and linkage maps, will be generated and applied to a selective breeding programme. This will be achieved by production of a radiation hybrid panel. Sea bream cDNA and BAG genomic libraries will be produced and coding genes with potentially commercial importance will be identified and mapped. A sea bream-zebra fish comparative map integrated with 'gene rich' vertebrate maps will shed light on the gene to phenotype relationship. This will be based on mapping of about 2000 genes and markers thanks to the creation of the radiation hybrid panel. Such a combined map of genes and polymorphic markers will directly link QTLs to chromosomal regions of known gene content through the comparative mapping approach. The project is expected to establish a reference genome information for marine percifomes species.

# Cephalopod Stocks in European Waters: Review, Analysis, Assessment and Sustainable Management - (CEPHSTOCK)

*Pierce, G.J., Wang, J., Santos Vázquez, M.B.*

Department of Zoology, the University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ, SCOTLAND. Email: g.j.pierce@abdn.ac.uk



| | |
|---|---|
| Contract No: Q5CA-2002-00962 | Project duration: 10/02 – 09/05 |
| Project budget: € 887 419 | EC contribution: € 887 419 |
| Website: www.abdn.ac.uk/eurosquid/cephstock.htm | |



**Objectives**

This project aims to review current knowledge and issues in cephalopod fisheries science, to assemble, organise, analyse and synthesise data from ongoing national projects, previous and new EC-funded R&D projects, and to recommend future actions for scientists and cephalopod fishery managers in European waters. This will be achieved through (a) co-ordinated reviews and (b) development of common databases and associated GIS analysis capability, leading to (c) a series of co-ordination meetings and workshops at which the status of fished European cephalopod stocks will be reviewed, stock assessments carried out and management recommendations proposed. Specific objectives:

1. To review the current state of knowledge on exploited cephalopods (biology, fisheries, environmental relationships, stock identity) in European waters, on a stock by stock basis, to identify gaps in knowledge and the best methods available to collect necessary data;
2. To review and document current data collection, stock assessment and management practices for cephalopod capture fisheries world-wide;
3. To review the current status of cephalopod culture and the prospects for commercial aquaculture;
4. To review socio-economic issues related to cephalopod fisheries: the economic and social value of cephalopod fishing, contribution to income and employment;
5. To review current knowledge of aspects of cephalopod biology and ecology related to their suitability as resource species for capture and culture fisheries, including life-history and ecological data and assessment of environmental factors which affect the immuno-competence and physiology of cephalopods;
6. To review management options for currently unregulated cephalopod fisheries, to meet ecological, economic, social and institutional goals for sustainable utilization, considering issues such as gear selectivity, minimum landing sizes, closed areas and seasons, stock enhancement;
7. To design appropriate data collection protocols for each stock to fill perceived gaps and ensure availability of the appropriate data to underpin management decisions (e.g. catch and effort data, stock identification studies, socio-economic data collection, gear trials etc);
8. To hold workshops on assessment and management, with invited experts, using existing data to make assessments of stock status, including explicit evaluation of associated uncertainties; to provide baseline precautionary management proposals and recommend future research directions;
9. To develop a common database and GIS of biological, fishery and bibliographic data on European cephalopod stocks;
10. To use the database and GIS to develop models of interactions between cephalopod fisheries, cephalopod stocks, and the environment;

11. To disseminate the information synthesised and results generated by the Concerted Action as peer-reviewed papers and conference presentations, in addition to reports to the CEC's DG Research.
12. To develop new research proposals to address perceived gaps in the information required for sustainable management of fished cephalopod stocks.

**Results**

The project will have access to published and unpublished results of previous CEC-funded research projects and data collection projects completed over the last decade, as well as access to results of nationally funded research and national fishery databases. As such, project personnel will be well positioned to use existing knowledge to produce measurable and verifiable outputs. The proposed outputs (by objective) are as follows:

1. An annual report, on a stock-by-stock basis, on current stock status for all exploited cephalopod species in European waters.
2. An annual report on fishery data collection and current cephalopod fishery management practice in all participating European countries..
3. A review paper on the socio-economic value of European cephalopod fisheries, in terms of income generated, employment, support for local communities, trade and food provision.
4. Review papers on aspects of cephalopod biology and ecology relevant to their sustainable exploitation.
5. A review paper on management options for currently unregulated cephalopod fisheries, explicitly addressing goals of social, economic and biological/ecological sustainability.
6. A review of cephalopod aquaculture.
7. An annual summary of recommendations for improving data collection on fished cephalopods.
8. Assessment workshops, leading to new assessments of stock status and recommendations for management.
9. A common database and GIS for cephalopod fisheries, building on those constructed under previous CEC-funded RTD projects.
10. A feasibility study of the commercial development of the GIS as a tool for managers and for provision of data products to fishermen.
11. New research papers based on analysis of data accumulated under objective 7.

**Potential exploitation by end users**

Results will be of direct interest to those partner institutes involved in the implementation of European, national and regional programmes of fishery assessment and regulation. Results will be communicated to the International Council for the Exploration of the Sea (ICES) through relevant Committees and Working Groups (notably WGCEPH). Some of the reviews and new modelling results produced will form the basis of publications in the mainstream (peer-reviewed) scientific literature. Certain other outputs, e.g. regressions for estimating cephalopod body weights, will be made available on CD-ROM.

The databases and GIS resulting from the project will be a useful resource for future research and/or stock assessment on cephalopod fisheries and a possible means of making this widely available for consultation would be to allow access through the internet. The web page will provide information to a wider audience, including the general public, the research and fishery management communities and fishermen's organisations. Targeted press releases will highlight new developments.

# Cod Spatial Dynamics and Vertical Movements in European Waters and Implications for Fishery Management - (CODYSSEY)

*Righton, D.[1], Heffernan, O.[1], Hinrichsen, H-H.[2], Huse, G.[3], Michalsen, K.[3], Neuenfeldt, S.[4], Steingrund, P.[5], Strand, E.[6], Thorsteinsson, V.[7], Wright, P.[8]*

[1] Centre for Environment, Aquaculture and Fisheries Science, UK; [2] Institut fur Meereskunde, Kiel University, Germany; [3] Institute of Marine Research, Norway; [4] Danish Institute for Fisheries Research; [5] Faroes Fisheries Laboratory, Faeroe Islands; [6] University of Bergen, Norway; [7] Marine Research Institute, Iceland; [8] Fisheries Research Services, UK ; E-mail: d.righton@cefas.co.uk

| | |
|---|---|
| Contract no: QLRT-2001-00813 | Project Duration: 01/10/2002-28/10/2006 |
| Project Budget: €4,196,448 | EU Contribution: €2,251,256 |
| Web site: www.codyssey.co.uk | |

**Objectives**

The state of NE Atlantic cod stocks has become increasingly alarming over the past decade, the severity of the situation being highlighted by the recent call from ICES for a complete fishing ban on several cod stocks in European waters. Current management measures focus on the urgent need to reduce fishing mortality to its lowest possible level. High-quality data on the population dynamics and behaviour of individual cod stocks are needed, however, to ensure the efficacy of long-term management strategies. The overall objective of CODYSSEY is to improve understanding of horizontal migrations and vertical movements of cod in relation to environmental and biological factors in different ecosystems of the NE Atlantic. The results will be used to advise fisheries managers on the horizontal availability, vertical accessibility and individual vulnerability of cod to fishing activities. Specifically, CODYSSEY aims to tag at least 1600 cod iwith electronic data storage tags (DSTs)in four ecosystems, namely Icelandic/Faroese waters, the Barents Sea, the Baltic Sea and the North Sea. High-resolution behavioural and environmental data from recaptured electronic tags will be used to identify and model the key environmental forcers of cod behaviour. Seasonal changes in activity and environment recorded from electronic tags will be related to otolith microstructures as a tool for reconstructing the behavioural histories of cod.

**Results**

To date, more than 1000 electronic tags have been deployed on cod in EU waters. Preliminary analyses indicate that the range of large-scale horizontal migrations varies widely between individuals, with some migrating on a seasonal basis between spawning and feeding grounds and others remaining relatively resident throughout the year. Analyses of tag records from various ecosystems in the NE Atlantic have shown that cod often exhibit rapid vertical movements, changing their buoyancy and orientation with depth. These results have implications for acoustic methods of fish biomass estimation and suggest that basic assumptions regarding cod physiology and behaviour require revision if the accuracy and precision of these methods are to be improved.

**Potential exploitation by end users**

The results from CODYSSEY will be of interest to a number of end users, including behavioural ecologists, fisheries managers, stock assessment scientists and the fishing industry at both a national and international level.

The output from the project will be increased understanding of cod behaviour at an individual-, population- and ecosystem-level in relation to key environmental factors. These data are expected to play a key role in the interpretation of stock assessments and the implementation of appropriate management and conservation measures for NE Atlantic cod stocks.

# Creation of Multi-annual Management Plans for Commitment - (COMMIT)

*Kell, L.*[1]

[1] The Centre for Environment, Fisheries and Aquaculture Science, United Kingdom (coordinator on behalf of all partners)



| | |
|---|---|
| Contract No : SSP8-CT-2003-502289 | Project duration : 04/2004 – 04/2007 |
| Project budget : € 2 421 185 | EC contribution : € 1 407 498 |
| Website : www.cefas.co.uk\commit | |



**Objectives**

To provide a sound scientific basis for the long-term planning of fisheries management consistent with sustainable development, while also identifying short-term biological and socio-economic consequences. This will be undertaken through the evaluation of multi-annual management plans that reduce annual fluctuations in exploitation strategy and ensure commitment of the stakeholders to the plan. Strategies will be based upon harvest rules, which will be developed explicitly recognising uncertainty due to process, measurement, estimation, model and implementation error. In particular a socio-economic analysis will identify mechanisms affecting the commitment of key stakeholders and hence the level of implementation error.

**Methods**

The project will be inter-disciplinary, combining experts from biological, economic and social disciplines. It will develop multi-annual management strategies for mixed fisheries considering the data collection protocols, assessment methods, choice of reference points and management options and the level of compliance needed to meet management targets. It will do this by evaluating candidate management strategies against simulated populations and fisheries for the various case studies. The simulated population and fishery models will be conditioned on real data and be able to explore a range of plausible hypothesis.

**Expected Results**

The expected results are improved management advice (in the form of simpler harvest control rules that are multi-annual management strategies); alternative plausible hypothesis, a tool for the analysis of case studies, methodology to explore alternative management scenarios and industry commitment to management strategies.

**Potential exploitation by end users**

Policy makers can benefit from the project results by incorporating aspects of expected results into policy initiatives. The identification of multi-annual management targets for European fisheries is critical if longer-term objectives of fisheries management are to be achieved. The new framework for the Common Fisheries Policy has identified three main objectives, which can be summarised as:

- Responsible and sustainable fisheries activities
- An economically viable and competitive fishing industry
- A fair standard of living for those who depend on fishing activities

This project will contribute to the achievement of all of these objectives.

# COSTing the IMPACT of demersal fishing on marine ecosystem processes and biodiversity: a holistic framework linking fisheries, environment and socio-economics - (COST IMPACT)

*Austen, M.*[1], *Emblow, C.S.*[2]

[1] Plymouth Marine Laboratory, UK (email: MCVA@pml.ac.uk); [2] Ecological Consultancy Services Limited (EcoServe), Ireland.

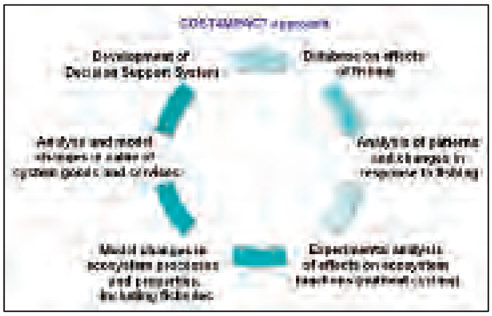


| Contract No : Q5RS-2001-00993 | Project duration : 12/2001 – 12/2004 |
|---|---|
| Project budget : € 2,245,853 | EC contribution : € 1,352,816 |
| Website : www.cost-impact.org | |



**Objectives**

COST-IMPACT is pioneering a framework to integrate fisheries and environmental management within a socio-economic context. Meta-analysis of existing data on fishing impacts on the benthos, as well as novel experimental and field data on the effects of fishing on functioning of benthic ecosystems, is being used to parameterise ecosystem models to determine the wider importance of these indicators to ecosystem functioning and sustainability. This includes effects of changes in benthic communities and their functioning on pelagic productivity.




Simultaneously, socio-economic analysis is determining the monetary and non-monetary value of ecosystem properties and functions, including the fisheries production. A bio-economic model is being developed to link ecosystem models with valuation models to determine how the values of environmental goods and services, including the fisheries value, will vary with changes in fishing effort. The bio-economic model will be used, in conjunction with stakeholder input, to develop a decision support tool for managing fisheries and the environment. This tool will be largely driven by socio-economic considerations (cost to society) supported by strong, underlying fisheries and ecology science.

The COST-IMPACT framework is a holistic 'ecosystem approach' to fisheries and marine environmental management.

**Results**

Field experiments

ROV, video and sidescan surveys were used to determine trawled and untrawled areas in Greece and Norway for further sampling to look at effects of trawling on nutrient flux and biota

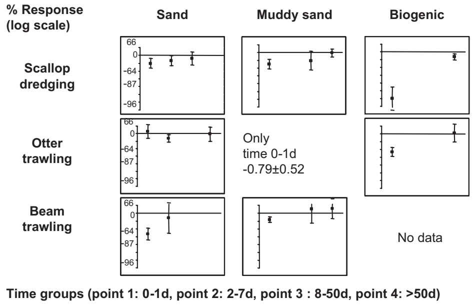
Mesocosm studies

Experimental evidence from COST-IMPACT mesocosm and field studies indicate that the bioturbating effects of large burrowing organisms (which are vulnerable to trawling) have significant influence on nutrient fluxes or associated biodiversity in the sediment.

Ecosystem modelling

The existing ERSEM GOTM model has been used in an exploratory model to examine the potential impact of demersal trawling upon the benthic ecosystem. The simulations have been made using a water column model of a seasonally stratified site in the central North Sea. The perturbation experiment is as follows, at day 100 trawling event occurs, the oxic layer removed (set close to zero), Aerobic bacteria suffer 75% mortality, meiofauna, deposit and suspension feeders all incur 50% mortality and all of the C, N and P generated is placed in benthic detrital pool.

The meiofauna recovers after 6 months, deposit feeders after 1 year and suspension feeders 2-3 years. These timescales are roughly in accordance with observations. The perturbation impacts on the simulated efflux of inorganic nutrients but not on the net primary production and biomass of pelagic biota. This is because primary production in seasonally stratified shelf seas is controlled by its physical environment (tidal mixing and light availability). Changes in benthic nutrient fluxes will be over-ridden by these effects.




**Statistical analysis Meta-analysis showing % change from control (log scale) of different aspects of benthic fauna (diversity, abundance, taxon abundance, for different combinations of habitat and treatment type.**

Changes in value of system goods and services

A searchable marine valuation database of over 500 studies has been developed to hold economic valuation data of fishery productivity and other ecosystem services.

Marine goods and services which will be influenced by fishing activity have been identified and preliminary investigations have been undertaken into how, and to what extent, they will be affected by demersal fishing.

A Multi Criteria Analysis is being developed as a decision support tool, with a methodology now nearing completion. Data has been input to the DEFINITE software for use in the Multi Criteria Analysis, and extensive analyses have been started. The analysis will be used at two facilitated stakeholder workshops in 2004.

**Potential exploitation by end users**

COST-IMPACT addresses the conflicting EU objectives of maintaining sustainable fisheries in European waters with all the economic benefits afforded to the community through the fishing industry, whilst at the same time maintaining biodiversity and avoiding negative effects on the environment. COST-IMPACT aims to put an economic valuation or costing on marine ecosystem resources or goods and services and indicate how this value is affected by fishing. This will provide fisheries and coastal zone managers with an effective tool to determine their policies.

With such knowledge strategies can be developed for management of fisheries effort. Such strategies would balance the environmental impact on marine benthic biodiversity and the services the benthos provides for marine ecosystem functioning against the socio-economic benefits of fishing.

# Towards the development of technologies for cryopreservation of fish oocytes - (CRYOCYTE)

**Contract number:** Q5RS-2002-00784

**Contract type:** Shared-cost project

**Starting date:** 11.9.2002

**Duration:** 36 months

**Scientific Officer:** Jacques Fuchs

**Project web site:** cryocyte@ocean.org.il — under construction

**Coordinator**

E. Lubzens

National Institute of Oceanography

Israel Oceanographic and Limnological Research

Department of Marine Biology and Biotechnology

PO Box 8030 Haifa 31080 Israel

Tel. (972-4) 856 52 60 (direct)

Fax (972-4) 851 19 11

E-mail: esther@ocean.org.il

## PARTNERS

Hanna Rosenfeld, Iris Meiri National Centre for Mariculture, Israel Oceanographic and Limnological Research, Department of Fish Reproduction

Per-Erik Olsson, Umea University, Department of Molecular Biology

Joan Cerda, Centre of Aquaculture — IRTA

Patrick J. Babin, Universite Bordeaux 1, Genomique et Physiologie des Poissons, USC INRA

Arie Admon, Technion — Israel Institute of Technology, Department of Biology

Oliana Carnevali, Universita di Ancona, Istituto Scienze del Mare

David M. Rawson, University of Luton, The Research Centre The Spires

Tiantian Zhang, University of Luton, The Research Centre, The Spires

Javier Sanchez-Molino, Carburos Metalicos SA, R & D Department

Glen Pagelson, Ardag Red Sea Mariculture

### background

The growth of intensive aquaculture requires efficient and effective methods to preserve gametes for higher flexibility in broodstock management, genetic improvement programmes and preservation of genetic diversity. While methods for cryopreservation of fish spermatozoa are well known, preserving maternally inherited important genetic factors has yet to be achieved. Methods for cryopreservation of yolk-laden fish embryos remain elusive so far, but immature or mature oocytes are a specific challenge. The objective is to develop technologies for cryopreservation of fish oocytes. Multidisciplinary studies will be performed on the oocyte envelope structure, on biological processes during oocyte maturation and hydration, on development of in vitro procedures for oocyte maturation, ovulation and fertilisation, and on molecular (nucleic acid and protein) markers for indicating oocyte viability prior to and after cryopreservation.

### objectives

The main objectives are to develop methods for cryopreservation of fish oocytes while ensuring their viability (e.g. maturation, fertilisation and embryonic development) after cryogenic storage and thawing. These aims will be achieved by innovative studies conducted on:

1. anticipated biological barriers for cryopreservation including the formation and structure of the vitelline envelope proteins and the process of oocyte hydration of pelagic eggs;

2. identification of specific biological markers to monitor oocyte viability after manipulation and/or cryopreservation;

3. development of oocyte in vitro incubation procedures to promote oocyte maturation, ovulation and fertilisation;

4. development of new cryopreservation technologies. Studies on two models (zebra fish and the gilthead sea bream) will highlight differences between marine and freshwater species and hydrating and non-hydrating oocytes. The results will improve fish production and increase its efficiency by genome banking of cultured and wild species.

**expected results and achievements**

1. The primary end-product will be the development of procedures for successful cryopreservation of fish oocytes maintaining their developmental capabilities.

2. New and powerful tools for evaluating oocyte and egg characteristics as important diagnostic products for farmed fish and eco-toxicological studies. These will include stage-specific molecular markers (in the form of DNA micro- or macroarrays) and protein markers for fish oocytes and egg envelopes, biochemical assays to test the correct enzymatic cleavage of the yolk proteins, and markers to evaluate the buoyancy of pelagic eggs.

3. Methods for obtaining oocyte maturation and ovulation in vitro that will be extremely helpful in promoting fertilisation of naturally non-ovulating oocytes from farmed and wild fish species.

4. The formation of cryobanks for storage of preserved oocytes for genetic improvement programmes, for storage of important maternal genetic traits and easier transfer of genetic material between culture locations at reduced costs and reduced danger of disease transmission. It will provide a unique methodology and greatly contribute to improving the competitiveness of the European aquaculture industry.

# European advice system evaluation -(EASE)

**Contract number:** Q5CA-2002-01693
**Contract type:** Concerted action
**Starting date:** 1.12.2002
**Duration:** 36 months
**Scientific Officer:** Mario Lopes dos Santos
**Project web site:** None

**Coordinator**
P. Sparre
Danish Institute for Fisheries Research
Jsgersborgvej 64-66
DK-2800 Lyngby
Tel. (45) 33 96 33 00
Fax (45) 33 96 33 33

## PARTNERS

Fredrik Arrhenius, National Board of Fisheries, Institute of Marine Research

Olav Rune Godø, Institute of Marine Research, Department of Marine Resources

Niels Daan, Netherlands Institute for Fisheries Research, Department of Biology and Ecology

Carl O'Brien, Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory

Ronald Stagg, The Scottish Ministers, acting through Fisheries Research Services

Peter B. Heffernan, Marine Institute

Benoit Mesnil, Ifremer — DRV/RH, Laboratoire Maerha

Alain Laurec, Ecole Nationale Superiere Agronomique de Rennes

Olga Moura, Institute de Investigafao das Pescas e do Mar, Departamento de Recursos Marinhos

Hans-Peter Cornus, Bundesfbrschungsanstalt fur Fischerei, Institut fur Seefischerei

Petri Suuronen, Finnish Game and Fisheries Research Institute

Bjorn Steinarsson, Marine Research Institute of Iceland

Rudolphe de Clerck, Ministerie van Middenstand en Landbouw, Departement voor Zeevisserij

### background

Routine work from data collection to the yearly updating of fish stock assessments absorbs a very significant amount of the available human and budgetary resources. Assessment methods used in most cases require a large amount of detailed data, collected in a standard way. The existing procedures imply an almost complete reassessment each year, especially for the more sensitive stocks. Nevertheless, the relationship between the amount of 'energy' devoted to each specific task or action (e.g. ageing fish or reassessing completely each year the status of a stock) and the quality of final scientific advice delivered to managers is rarely considered. The added value of the existing machinery compared with a less data and/or time-consuming procedure is not known.

It would be unwise to disrupt the present ongoing data collection and/or annual reassessment processes before the consequences of any changes are properly appreciated. However, the stress on the present processes and lack of clarity as to their cost-effectiveness indicate the need to improve procedures.

Until now, scientific research devoted to the methodology of 'classical' assessment (including data collection) methods has been limited. At present, even basic expertise in sampling techniques is lacking in many Member States. Due to insufficient communication between groups of scientists, some potentially useful techniques are ignored in some areas, while they are the only ones considered for other fisheries (e.g. length-based techniques or surplus production models). Existing methods are, however, far from being systematically used and combined. An overall framework would make it possible to establish links between scientific teams working on similar issues, to put within the proper context the 'partial' problems addressed until now, to promote awareness about existing methods, and to identify existing gaps not covered by any existing method and not addressed by any existing research programme.

**objectives**

The overall objective of the concerted action is to set up the basis for more appropriate data collection and analysis programmes in order to support existing and emerging fisheries management issues. The main objectives of the concerted action are as follows:

1. To understand the current balance between resources devoted to data collection and value of these data in the provision of advice. This requires the evaluation of the range of advice requested on fisheries management and the data needs to perform the science to support it. Of particular importance are the so-called basic data, i.e. routinely collected data to support existing fisheries management since these are used in almost all analyses. However, consideration will be given to other types of necessary data.

2. To quantify the quality of the scientific outputs derived from the data inputs. Since much advice is qualitative and relies on expert judgment, this objective will be limited to quantifying the reliability of routine annual stock assessments upon which advice is formulated.

3. To identify alternative uses of data and alternative analytical methods which could support present fisheries management needs as well as those which could address new and emerging issues.

4. To analyse ways of redeploying existing resources in order to support a modern fisheries management system.

**expected results and achievements**

The proposed concerted action will directly address problems related to competitiveness with direct implications for the sustainable production of renewable resources providing better objective information in support of fishing systems and of policy orientations of the common fisheries policy.

The action will not only take into account the existing procedures for delivering scientific advice as required by the implementation of the existing CFP, but it will also consider emerging requests for other management approaches, giving, among other things, more importance to environmental questions.

The concerted action is devoted to the issues of collection and interpretation of data resources and management, and more specifically to the efficiency and accuracy of such assessment. It will offer a strong basis for rationalising the collection of data essential for the common fisheries policy, and will suggest methods to improve the reliability and usefulness of the scientific advice concerning fisheries management. The results obtained will make it possible to improve the implementation of the existing regulations, and to facilitate the anticipated revision of these regulations.

# European fisheries ecosystem plan - (EFEP)

**Contract number:** Q5RS-2001-01685
**Contract type:** Shared-cost project
**Starting date:** 1.1.2001
**Duration:** 36 months
**Scientific Officer:** Jacques Fuchs
**Project web site:** www.efep.org

**Coordinator**
Christopher L. J. Frid
University of Newcastle
Dove Marine Laboratory
Cullercoats, North Shields
Tyne and Wear NE30 4PZ
United Kingdom
Tel. (44-191)2524850
Fax (44-191) 252 1054
E-mail: c.l.j.frid@newcastle.ac.uk

## PARTNERS

Maria-de-Fatima Borges, Institute de Investigafao das Pescas e do Mar
Knut Mikalsen, University of Tromsø Department of Political Sciences
Stefan Aki Ragnarsson, Marine Research Institute
Gerjan Piet, Netherlands Institute for Fisheries Research

### background

The US National Marine Fisheries Service developed the concept of fisheries ecosystem plans (FEPs). The plans are designed to incorporate the principles and policies of ecosystem conservation into fisheries management. Specifically, an PEP provides a description and understanding of the basic environmental and human context in which a fishery is managed, they direct the use of that information for fisheries management and define strategies by which management objectives can be developed and implemented.

The European fisheries ecosystem plan (EFEP) will be achieved through the involvement of marine scientists, social scientists, economists and stakeholders (fishermen, fisheries managers, non-governmental organisations, etc.). The North Sea will be used as a case study; however, consideration will be given to the additional issues/regional differences that would influence the development of such plans for the northern/subarctic and Atlantic margin fisheries.

### objectives

The specific objectives of the project incorporated into work packages are:

1. to consult and develop links with stakeholders that have an interest in the North Sea (WP1);

2. to characterise the biological and physico-chemical environment of the North Sea which supports the fishery and to develop a conceptual model of the North Sea's key processes and food-web (WP2);

3. to rationalise the North Sea web into a 'significant web' which includes, amongst other criteria, habitats/species (as defined in EC legislation). A review of the metrics that have been used to measure the state/health of ecosystems and, potentially, develop new and/or modify existing ones (WPS);

4. to calculate total removals of harvest by-catch and incidental mortality in the North Sea (WP4);

5. to assess the degree of uncertainty in WPS and WP4. A review of the input from stakeholders and develop a set of possible management regimes for later testing on the 'significant web model' (WPS);

6. to assess the evidence for ecosystem effects of fishing and match management responses that are acceptable to stakeholders and which are against them where they are significant (WP6);

7. to feed back results of management scenarios to stakeholders, elicit views and develop a draft FEP for the North Sea (WP7).

**expected results and achievements**

The EFEP project will lead to a greatly increased understanding of the effect of fisheries on major components of the ecosystem and food-web dynamics. In addition, a set of tested management responses will be produced giving indications as to how to control the effect where significant. Policy-makers and managers will be informed of the results through the adoption of a project web site, a strict publication plan, academic- and policy-based conferences via the members of the EFEP Steering Committee, ICES meetings, dissemination through workshops and regular briefing/press releases.

# Operational Evaluation Tools for Fisheries Management Options - (EFIMAS)

*Nielsen, J.R.[1], Sparre, P.J.[1], Kell, L.[2], Degnbol, P.[3], Pascoe, J.[4], Pastoors, M.[5], Motos, L.[6]*

*(Editors on behalf of the EFIMAS Consortium)*

[1] Danish Institute for Fisheries Research (DK), e-mail rn@dfu.min.dk; [2] The Secretary of State f. Environment, Food & Rural Affairs act. thr. Centre f. Environment, Fisheries and Aquaculture Science (UK), [3]Institute f. Fisheries Management and Coastal Community Development (DK), [4]University of Portsmouth Higher Education Corporation (UK), [5]Netherlands Institut for Fisheries Research (NL), [6]Fundación AZTI – AZTI Fundazioa (E).

| **Contract No : SSP8-CT-2003-50251** | Project duration : April 2004 – April 2008 |
|---|---|
| Project budget : € 7 523 725 | EC contribution : € 4 500 000 |
| Website : www.dfu.min.dk/efimas | |

**Objectives and expected results**

The objective of the EFIMAS project is to develop an operational management evaluation framework that allows evaluation of the trade-off between different management objectives when choosing between different management options. The evaluation framework will be developed to inform an exploratory, adaptive decision- making process. Evaluation tools will be developed to appraise the biological, social and economic effects of fisheries management measures in the EU, and these will be applied to important European fisheries. The tools will take account of the dynamics in the fisheries systems, as well as of uncertainties and will include risk assessments.

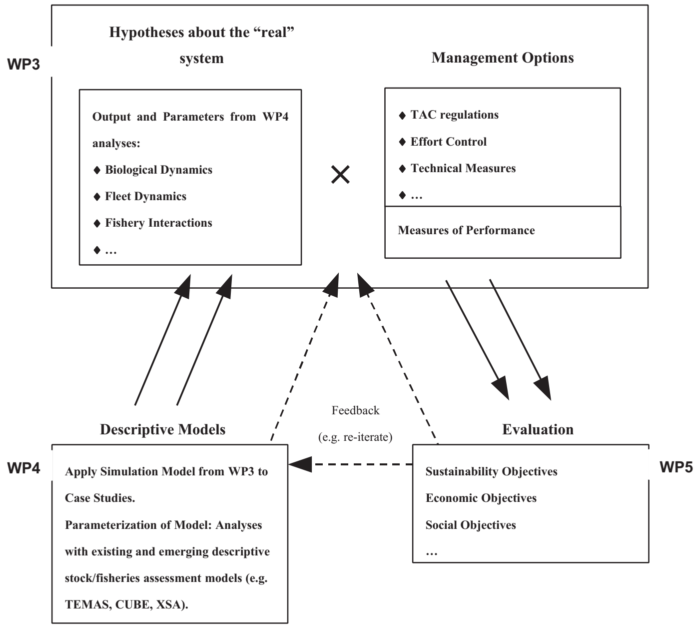
The overall approach uses stochastic simulation techniques. These cover the full scope of the fisheries system from the fish resources, through data collection, assessment and management, and the response of the system to management. The input data to the management system are generated by a descriptive model, which is assumed to represent the “true / real” system. The input data are then processed by a traditional assessment model, or by an alternative model, which is used to generate management advice. By simulating the effect that the resultant management actions would have on the ”true / real” system it is possible to generate a range of performance measures, covering the resource and the fishery. These measures can then be compared across different assessment models and management approaches.

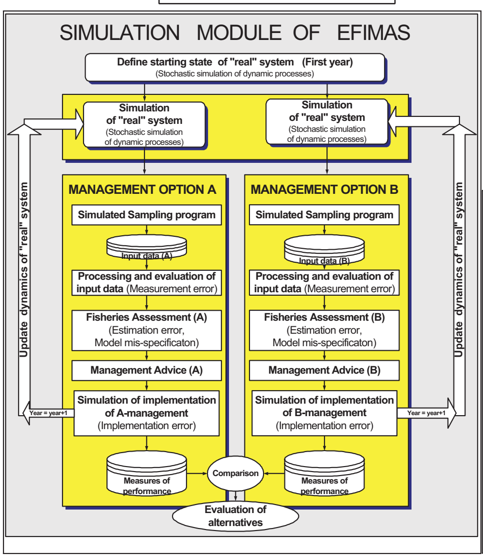
To give an example, a change from stock-based to fleet-based and fishery-based management would represent a change in paradigm of fisheries management. Such a change would allow advice to be given in the form of effort limits, and would account for technical interactions and might also involve economic and social parameters. In this case the evaluation tools would simulate both stock-structured input data and fleet-structured input data; it would perform the traditional assessment with stock-structured data and alternative assessment with fleet structured data. Replicate runs including stochastic variation would be used to estimate probability distributions of the performance measures of the two alternative management scenarios so that their performance could be compared.

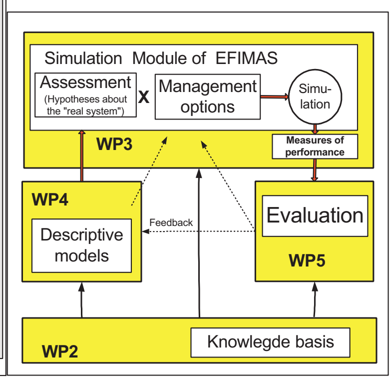
**Potential exploitation by end users, relevance, and expected implementation Results**

The operational evaluation tools will be developed in parallel with an evaluation of their utility in informing a decision making process and will be modified according to experiences from their use by stakeholders. The tools will be implemented in a range of case studies of important European fisheries and will be modified on the basis of experiences from case implementation. The intention is to only recommend for implementation of management options that have been evaluated through the management evaluation framework. The framework will be developed so that stakeholders can evaluate management options in relation to specific objectives and desired properties of the management procedures. This will enable participants in the decision-making process to explore different options by comparing the expected performance and expected outcomes of various options on the basis of an evaluation and simulation framework.

**Fisheries Management Evaluation Framework**



# The effect of turbidity and hypoxia on the behaviour of coastal Marine fishes - (ETHOFISH)

**Contract number** Q5RS-2002-00799
**Contract type:** Shared-cost project
**Starting date:** 1.10.2002
**Duration:** 36 months
**Scientific Officer:** Jacques Fuchs
**Project web site:**
www.ifremer.fr/crema/prog_europeens/Ethofish/ethofish.htm

**Coordinator**
Paolo Domenici
Organismal Biology Group
International Marine Centre
Localita Sa Mardini
I-09072 Torregrande, Or
Tel. (39) 078 32 20 27
Fax (39) 078 32 20 02
E-mail: p.domenici@imc-it.org

## PARTNERS

Roberts. Batty, Scottish Association for Marine Science, Dunstaffnage Marine Laboratory
John Fleng Steffensen, University of Copenhagen Marine Biological Laboratory
Guy Claireaux, Centre de Recherche en Ecologie Marine et Aquaculture, CNRS-Ifremer
Anne Christine Utne Palm, University of Bergen, Department of Fisheries and Marine Biology

### background

Current knowledge of the behavioural and physiological processes that regulate the interaction between environmental variations (both man-made and natural) and the ecology of animals (i.e. their abundance and distribution) is limited. This knowledge is fundamental for understanding and predicting the effect of environmental disturbances on ecosystems, while its limitation is an obstacle to the development of specific environmental regulations. Turbidity and oxygen availability are two important environmental factors that are greatly affected by human activities along coasts. We will examine the effect of turbidity and oxygen availability on ecologically relevant behaviours such as habitat selection, predator-prey interactions and aggregation. We will use modern methods integrating laboratory and field studies. As a result, we will determine experimentally the thresholds beyond which turbidity and oxygen saturation alter fish behavioural and/or physiological processes. Experimental results will be incorporated into a conceptual model, including situation-specific sub-models of fish behaviour in response to hypoxia and turbidity.

### objectives

1. To assemble and further develop an integrative laboratory and field methodology, linking physical measurement with behaviour and physiological monitoring, for in situ evaluation of the effects of turbidity and hypoxia on fish behaviour.

2. To determine experimentally the thresholds above which turbidity, and below which oxygen saturation, alter fish behavioural and/or physiological processes.

3. To understand how habitat selection behaviour, an important determinant of biodiversity, is modulated by variation in turbidity and oxygen levels.

4. To determine the extent to which predator-prey interactions (focusing both on predator and prey) and the schooling behaviour of fish are affected by turbidity and/or hypoxia.

5. To integrate the results obtained into a conceptual and predictive model.

**expected results and achievements**

1. Improved laboratory and field methodology for measuring physical variables and fish behaviour.

2. The effects of hypoxia and turbidity on metabolic scope and activity pattern.

3. Field observations on habitat selection and activity patterns in relation to oxygen and turbidity.

4. An understanding of the effects of variations in turbidity and oxygen on predator-prey interactions, aggregation behaviour and habitat selection.

5. Implementation of results into a conceptual model.

6. Dissemination through a web site, scientific articles in peer-reviewed journals, and conferences.

# Managing Fisheries to Conserve Groundfish and Benthic Invertebrate Species Diversity - (MAFCONS)

*Greenstreet, S.P.R., Robinson, L.A.*

Fisheries Research Services, The Marine Laboratory – Aberdeen, Scotland.

| Contract No : Q5RS-2002-00856 | Project duration : 01/2003 - 06/2006 |
|---|---|
| Project budget : € 3.172.459 | EC contribution : € 2.119.162 |
| Website: www.mafcons.org | |

**Objectives**

1. To provide the scientific advisors to fisheries managers with the mathematical models that would allow them to quantify the consequences to groundfish and benthic invertebrate species diversity of achieving particular fisheries objectives (eg. specific species Total Allowable Catches, TAC).

2. To develop the ecological theory, including rigorous hypothesis testing, necessary to underpin any mathematical model designed to predict the impact of varying fisheries activity on marine community diversity.

3. To collect the data required for hypothesis testing, including data on:

– variation in fishing effort to estimate variation in ecological disturbance;

– variation in benthic invertebrate productivity, species diversity and composition;

– variation in groundfish species diversity and composition.

4. To establish the relationships between fishing effort and landings in order to allow managers to pursue a policy of fisheries management by TAC. This will enable estimation of the effort required to take each TAC.

**Results**

This project started in January 2003 and the work undertaken during the first year has largely focused on the development of the theory behind Objectives 1 and 2 and the collection of the first years' samples, which are currently being analysed.

Two international workshops were held in the April and May 2003 to discuss issues related to: (1) the ecological theory underpinning the structuring of marine communities, and (2) the potential for developing indices of actual ecological disturbance from the available fishing effort statistics. One of the major achievements of MAFCONS will be to close the gap between our understanding of the processes that drive changes in marine communities and how fisheries disturbance affects these processes. Two important deliverables have been produced following these workshops. The first is a review of the literature on the ecological theory that underpins the structuring of communities, with reference to its' application in marine communities. The second is a review of the different sources of ecological disturbance to both demersal fish and benthic invertebrate communities that result from fishing in the North Sea. The data and information needed to map this actual ecological disturbance across the North Sea, using available statistics of the distribution and effort of the various fishing fleets, is discussed. Both of these reviews will be available on the MAFCONS website (www.mafcons.org) in Spring 2004 as downloadable files.

The other major achievements of the first year of MAFCONS have been, (1) the development of a robust methodology for undertaking sampling of both demersal fish and benthic invertebrate communities at a North Sea scale, and (2) the completion of the first year of benthic invertebrate sampling in collaboration with the ICES International Bottom Trawl surveys (IBTS) in Summer 2003. The development of viable benthic sampling in conjunction with the IBTS surveys, means that monitoring of both benthic invertebrate and demersal fish communities could be undertaken at a North Sea scale in the future as part of the routine ICES stock assessments. A number of project meetings have focused entirely on the development of the MAFCONS methods protocol, which is now detailed in the methods manual (also to be available at www.mafcons.org in Spring 2004).

**Potential exploitation by end users**

MAFCONS aims to provide both scientific advisors and management policy makers with the knowledge and tools required to predict the ecological consequences to fish and benthic invertebrate communities of fisheries management actions. In this way the best compromise between the need to maintain a healthy marine ecosystem in the North Sea and the requirement for a viable fishing industry might be realised.

As signatories to the Convention on Biological Diversity, Agenda 21, and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), the EC and most European governments, have a legal obligation to conserve the biological diversity of marine living resources and to restore biological diversity in situations where degradation can be demonstrated. To address these issues with respect to the North Sea, a series of ministerial conferences and meetings were held over the period 1984 to 2002. These culminated in the Fifth North Sea Ministerial Conference in Bergen 2002, where the final decision to implement an "ecosystem approach to management" was adopted.

Current scientific knowledge regarding the impact of fishing at a community level, within a variable environment, is largely descriptive. Consequently, scientists' ability to predict the consequences of future changes in fishing activity is limited. As a result, there is a real risk that, in attempting to achieve Ecological Quality Objectives (EcoQOs) set with respect to fish and benthic invertebrate species diversity (within the overarching Ecosystem Approach), management actions may be un-necessarily draconian and overly prohibitive with regard to the fishing industry. MAFCONS aims to establish the significance of the effects that fishing has on the processes that structure fish and benthic invertebrate communities in relation to the overall conservation of biological diversity in the North Sea.

# Mutualisation of fisheries and aquaculture European research institutes - (MUTFISHARE)

**Contract number:** Q5CA-2002-01353
**Contract type:** Concerted action
**Starting date:** 1.10.2002
**Duration:** 36 months
**Scientific Officer:** Jacques Fuchs
**Project web site:** None

**Coordinator**
Maurice Heral
Institut Franfais de Recherche pour
1'Exploitation de la Mer
155, rue Jean-Jacques Rousseau
F-92138 Issy-les-Moulineaux
Tel. (33) 146 48 22 81
Fax (33) 146 48 22 48
E-mail: Maurice.Heral@ifremer.fr

## PARTNERS

Rudy de Clerck, Sea Fisheries Department
Jørgen Løkkegaard, Danish Institute of Agricultural and Fisheries Economics
Niels Axel Nielsen, Danish Institute for Fisheries Research
Juhani Kettunen, Finnish Game and Fisheries Research Institute
Petri Suuronen, Finnish Game and Fisheries Research Institute
Philippe Gros, Institut Franfais de Recherche pour 1'Exploitation de la Mer
Hans-Stephan , Jenke Bundesforschungsanstalt fur Fischerei Institute for Fisheries Ecology
Gerd Hubold Bundesforschungsanstalt fur Fischerei Institut fur Seefischerei
Eleftherios Zouros, Institute of Marine Biology of Crete
Costas Papaconstantinou, Institute of Marine Biological Resources, National Centre for Marine Research
Olafur S. Astthorsson, Marine Research Institute
Johann Sigurjonsson, Marine Research Institute
Paul L. Connolly, The Marine Institute, Marine Fisheries Services Division, Abbotstown Laboratory
Otello Giovanardi, Central Institute for Applied Marine Research
Martin Sholten, Netherlands Institute for Fisheries Research
Luc van Hoof, Dutch Agricultural Economics Research Institute, Fisheries Research
Roald Vaage, Institute of Marine Research
Carlos Costa Monteiro, Institute de Investigafao das Pescas e do Mar
Eduardo Lopez-Jamar, Institute Espanol de Oceanografla
Fredrik Arrhenius, National Board of Fisheries, Institute of Marine Research
Magnus Appelberg, National Board of Fisheries, Institute of Coastal Research
Robin Cook, Fisheries Research Services Marine Laboratory
Mike Waldock, Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory
Tomacz Linkowski, Sea Fisheries Institute ul.

### background

The concerted action aims at contributing to a European research area on fisheries and aquaculture and supporting the common fisheries policy. The main objectives are to enable the coordination and integration of research in these fields in the Community. This action will allow the different directors of fisheries research organisations from the European Union to develop coordinated and joint effort on key biological issues and parameters for fisheries and aquaculture management.

### objectives

The common fisheries policy applies to the European fish populations and their fishermen for managing the European exclusive economic zone. This common framework, with the same objective to reach sustainability of fish populations and their ecosystems, could be strong enough to build the base of scientific research programmes which are well integrated and coordinated to give the best scientific advice. The analysis of the fourth and fifth programmes showed clearly that the way to answer European calls does not allow that objective to be achieved.

On some topics, there are duplications or redundancies, even if all the proposals are excellent on the basis of scientific criteria. On the other hand, on some other topics which are crucial for the future of the CFP, there are no answers. For example, on the marine protected areas in relation to the environmental impact of fisheries, there is no EU research effort, although the society demand needs to develop our scientific knowledge in relation to the evolution of the CFP which is described in the 'Green Paper on the future CFP'.

For these reasons, it is urgent to move 'towards a European research area' to establish 'a common system of scientific and technical reference' to build a common research programme. This strategic EU plan will be the foundation for cooperative research which will be based on national programmes of research institutes.

The directors of the main European institutes of research in fisheries and aquaculture propose this concerted action as a first step towards integrating and increasing cooperation between their institutes in order to achieve the sustainable development of fisheries and aquaculture in Europe.

During the last meeting of the directors of fisheries research organisations, it was decided to increase the cooperation between the main fisheries research organisations and to answer the fifth programme through a concerted action to focus on some research subjects:

1. to avoid duplication in research;
2. to create synergy between the different institutions;
3. to create critical masses of research for different institutions.

In order to contribute to building a European research area on fisheries and aquaculture to support the common fisheries policy and to develop coordinated and integrated research, it is proposed to develop some of the objectives of research detailed previously.

### expected results and achievements

Three types of outputs will be produced by this concerted action:

1. Technical exchanges of knowledge and standardisation of methods of research on the following subjects:

# Population structure, reproductive strategies and demography of redfish (genus *Sebastes)* in the Irminger Sea and adjacent waters (ICES V, XII and XIV; NAFO 1) -(REDFISH)

**Contract number:** QLK5-1999-01222
**Contract type:** Shared-cost project
**Starting date:** 1.1.2000
**Duration:** 48 months
**Scientific Officer:** Tore Jakobsen
**Project web site:** www.redfish.de

**Coordinator**
Hans-Joachim Ratz
Federal Research Centre for Fisheries
Palmaille 9
D-22767 Hamburg
Tel. (49-40) 38 90 51 69
Fax (49-40) 38 90 52 63
E-mail: raetz.ish@bfa-flsch.de

## PARTNERS

Juan Francisco Saborido Rey, Institute de Investigaciones Marinas
Thorsteinn Sigurdsson , Marine Research Institute
John Dalen, Institute of Marine Research
Gunnar Naevdal, University of Bergen, High Technology Centre

### background

The present project has been internationally developed to increase the fragmentary and preliminary biological knowledge about commercially exploited golden and deep-sea redflsh stocks (Sebastes marinus L. and S. mentella Travin) in the Irminger Sea and adjacent waters within the framework of an agreed four-year research programme. The multidisciplinary intentions are designed to jointly investigate unsolved problems in the field of stock delimitation, reproductive strategies and demography as three separate work packages, respectively. A total of 16 scientists and six technicians from the Federal Research Centre for Fisheries (EU-Germany coordination), the Institute of Marine Research (EU-Spain), the Marine Research Institute (Iceland), the Institute of Marine Research (Norway) and the University of Bergen (Norway) will collaborate and contribute to the various analyses.

### objectives

Two commercially exploited redfish species occur in the Irminger Sea and adjacent waters, golden redfish (Sebastes marinus, Linnaeus, 1758) and deep-sea redfish (Sebastes mentella, Travin, 1951) which are currently treated as three management units straddling over European, Faeroese, Icelandic and Greenlandic exclusive economic zones (EEZs) as well as international waters. They are defined as golden redfish and deep-sea redfish on the continental slopes and oceanic redfish distributed over the pelagic Irminger Sea waters. The pelagic occurrences of redfish below 500 m and the 'giants' of the Reykjanes Ridge remained unidentified. The first work package investigates the genetic relation across these redfish, while the second work package deals with the reproductive strategy of the viviparous redfish species in terms of fecundity and seasonal cycles by sex. The third work package focuses on the dynamic demography of the redfish stocks including scientific and commercial fleet data.

### expected results and achievements

The project will provide essential information on stock identification and genetic relations between the redfish occurrences, and improve the basis for assessing their biomass production. Thus, the results are expected to contribute significantly to international management regimes and achieve sustainable exploitation.

# Response of benthic communities and sediment to different regimens of fishing disturbance in European coastal waters - (RESPONSE)

**Contract number:** Q5RS-2002-00787
**Contract type:** Shared-cost project
**Starting date:** 1.10.2002
**Duration:** 36 months
**Scientific Officer:** Jacques Fuchs
**Project web site:**
www.icm.csic.es/rec/projectes/response

**Coordinator**
Montserrat Demestre
Consejo Superior de Investigaciones Cientiflcas
Institut de Ciencies del Mar
Department of Renewable Resources
Passeig Maritim de la Barceloneta, 37-49
E-08003 Barcelona
Tel. (34) 932 30 95 00
Fax (34) 932 30 95 55
E-mail: montse@icm.csic.es

## PARTNERS

Albert Palanques, Consejo Superior de Investigaciones Cientiflcas, Institut de Ciencies del Mar, Department of Marine Geology

Julio Mas, Institute Espanol de Oceanografia, Centre Oceanograflco de Murcia

Manuel Marhuenda, Mediterraneo Servicios Marines SL, Antigua Estacion Maritima

Rainer Knust, Alfred-Wegener-Institut fur Polar- und Meeresforschung, Sektion Vergleichende Okosystem-forschung

Michel Kaiser, University of Wales, Bangor, School of Ocean Sciences

Anna de Biasi, Consortio per il Centre Interuniversitario di Biologia Marina ed Ecologia Applicata, Centre Interuniversitario di Biologia Marina

### background

Response is an integrated strategy to determine the response of the biotic environment structure and the changes of the particulate matter dynamic caused by the disturbance of fishing activity. This research is focused to provide new perspectives and management options to the CFP in order to achieve sustainable fisheries and protection of biodiversity, a widely recognised problem in moving towards ecosystem-based management in fisheries. The main objective is to obtain more knowledge on medium- and long-term effects to different regimens of fishing trawl perturbation on the seabed, analysing cessation of fishing activity and different levels of fishing effort. The study will be performed in real fishing grounds of European coastal waters. The objectives will be achieved by means of six multidisciplinary work packages, by estimation of changes in the sedimentological process, benthic and fish community, and secondary production of the lower trophic levels.

### objectives

The main objective of Response is to analyse the physical and biological response of the benthic ecosystem to different regimens of fishing disturbance in real fishing grounds. Response will address the following specific objectives:

1. to identify an appropriate studied area in each study area of the North Sea, Irish Sea and Mediterranean Sea;
2. to estimate the seasonal fishery and fishing effort;

3. to analyse the responses (community structure variability, diversity and abundance) of the benthic communities (macroinfauna, epifauna, fish) and sediment (resuspension, water turbidity) by considering cessation of fishing activity and different levels of trawl fishing effort;

4. to estimate the secondary production of lower trophic levels to contribute to coupling and to integrate biological (benthic communities) and physical (sedimentological) data.

This is a case study for biological and physical geology interactions. Special attention will be devoted to synthesis of results from different work and recommendations to the CFP to achieve an ecosystem well-being. The comparison of the results of the different geographical areas can provide information on different responses of benthic communities and sediments to the same kind of disturbance. The dissemination of the results obtained to scientists, decision-makers, user groups and the public at large is an important objective of the project.

**expected results and achievements**

Response will provide additional information on the variability and resilience of marine ecosystems especially for marine communities relevant to fisheries. This information may help elucidate the potential effectiveness of using different time-limited closure periods on the impacts of fishing, providing unique data on organisms and sediments due to cessation of fishing activity and different levels of fishing effort, and on secondary production of different regimens of fishing disturbance. This investigation will be the mechanism that will permit us to minimise or to reduce fishing impact in order to allow recovery of the benthic ecosystems. Response will offer a valuable interface with stakeholders.

# Sharing responsibilities in fisheries management - (RESPONSIBLE)

**Contract number:** Q5RS-2001-01998
**Contract type:** Shared-cost project
**Starting date:** 1.1.2001
**Duration:** 36 months
**Scientific Officer:** Sigurdur Bogason
**Project web site:** Not available

**Coordinator**
Luc van Hoof
LEI, Dutch Agricultural Economics Research Institute
Fisheries Research
PO Box 29703
2502 LS The Hague
Netherlands
Tel. (31-70) 335 83 07/335 83 10
Fax (31-70) 361 5624
E-mail: l.j.w.vanhoof@lei.dlo.nl

## PARTNERS

Jesper Raakjsr Nielsen, Sten Sverdrup-Jensen, Institute for Fisheries Management and Coastal Community Development

Dominique Rommel, Pharos Fisheries Consultants Ltd

Steve Cunningham, Joseph Catanzano, Clotilde Bodiguel, Institut du Developpement Durable et des Ressources Aquatiques

Juan L. Suarez de Vivero, Universidad de Sevilla, Facultad de Geografla e Historia, Departamento de Geografla Humana

Svein Jentoft, Knut Mikalsen, Geir Runar Karlsen University of Tromsø, Faculty of Social Science, Institute of Planning and Community Studies

### background

The research provides different alternatives for division of responsibilities resulting from the CFP's conservation and structural policy and in the fisheries management of five EU countries and in Norway. These alternatives will be based upon an evaluation of the current division of responsibilities, whereby the perceptions of different stakeholders will be taken into account. The process towards more stakeholder involvement will be explored and external pressures upon responsibility chains will be assessed.

### objectives

The research aims to contribute to good governance in fisheries management by:

1. evaluating the division of responsibilities within the CFP and in the fisheries management of Denmark, France, the Netherlands, Spain, the United Kingdom and Norway;

2. investigating decentralisation and delegation of responsibilities.

The work will start with an elaboration of a framework for institutional analysis, based on the institutional framework that has been used in the OECD study 'Towards sustainable fisheries'. The completed common framework will then be used to describe the division of responsibilities within the CFP and in the fisheries management of Denmark, France, the Netherlands, Spain, the United Kingdom and Norway. Developments in these responsibility structures will also be described.

**expected results and achievements**

Comparison of these responsibility divisions between the countries mentioned above should give more insight into nation-specific (e.g. socio-cultural) circumstances and this will contribute to the evaluation of current divisions of responsibilities. Identifying the perceptions of stakeholders in the fisheries management in these countries about the responsibility chains will be another component of this evaluation.

If the outcome of this evaluation justifies changes, alternative divisions of responsibilities will be suggested. A process towards these alternatives will be explored and external pressures upon responsibility chains will be assessed. This includes external pressures arising from technological developments and from the markets.

The key results and outputs are:

1. completed common framework of analysis;
2. interim report containing division of responsibilities;
3. interim report containing comparison and evaluation of responsibility structures;
4. interim report containing conditions for devolved management and, if justified, alternatives for division of responsibilities.

# Promoting higher added value to a finfish species rejected to sea - (ROCKCOD)

*Portela, J.[1], Sacau, M.[1], Pierce, G[2], Wang, J[2], Ulloa, E[3], Otero, M[4], Tato,V[4]*

1 Instituto Español de Oceanografía (IEO), Spain; 2 University of Aberdeen, Scotland, UK; 3 Asociación Nacional de Armadores de Buques Congeladores de Pesca de Merluza, Spain; 4 MG Otero Consultores, Spain.



| | |
|---|---|
| Contract No : Q5CR-2002-71709 | Project duration : 01/2003 – 12/2004 |
| Project budget : € 880 199 | EC contribution : € 439 654 |
| Website : on-going | |



**Objectives**

This project aims to develop the research and the technology necessary to promote higher added value to fishing activity by taking profit from a finfish species (Rock cod, *Patagonotothen* spp.) not known to consumers and currently discarded by the EU fishing fleet operating in the South West Atlantic, in order to supply the EU seafood industry with a good quality raw material for human food manufacturing. Use of this species, caught as a by-catch in the existing fisheries targeting hakes and cephalopods, should also increase the profitability of the fleet, contribute to maintaining employment and help to counterbalance the negative effects of fishing activity and discards in the ecosystem.

Benefits from the seafood industry are directly dependent on the profitability of fishing operations, while good catches are also dependent on fish abundance. Searching for fish is an expensive activity (time and fuel consuming) inherent to fishing operations and critical to their profitability. In this sense, to take profit from a species that is already caught but is usually rejected (discarded) should increase the yield of fishing fleets and of the seafood processing industry.

The bottom trawl is one of the less selective fishing gears and, frequently, important amounts of non-desirable species are rejected to sea (discarded) with the subsequent loss of profitability to the fleets, damage to the ecosystems and wasted resources that could be used for food and increase food security.

Bottom trawl fisheries in the Patagonian Shelf targeting hakes and cephalopods are among the most important worldwide and have a great socio-economic value to the EU fishing fleet and to the EU seafood industry.

The main scientific-technological objectives are the following:

- Description of the fisheries
- Improved knowledge of the biology of the species
- Biomass assessment
- Estimation of catches and discards
- Analysis of the spatial and temporal distribution of the resource. Fishery forecasting and testing
- Sensorial, Microbiological, Nutritional and Biochemical Evaluation of Rockcod
- Development of the technical modifications on board commercial vessels
- Development of new processed products from frozen Rockcod

### Preliminary Results

During the first project year a preliminary description of the European fisheries on the Patagonian Shelf was made and observed catch per unit effort (CPUE) of the target species were obtained from data collected by scientific observers on board commercial vessels.

GIS analysis was an useful tool in order to study the seasonal geographical changes in the distribution of abundance, SST and densities calculated from CPUE corresponding to *Patagonotothen* spp. historical data. Moreover, preliminary analysis demonstrated that, within areas of occurrence, there are significant correlations between fish abundance and SST and depth in some months.

In relation with the characterization of the raw fish as food, the research has demonstrated that all individuals analysed showed good sensorial quality after frozen storage. The chemical and biochemical analyses performed proved that *P. ramsayi* could be very acceptable for consumption and posterior frozen storage and/or processing.

### Potential exploitation by end users

The obtained results of this project are of special interest because it provides a great opportunity to collect and integrate at an European level the necessary fishery and biological data for the improvement of the EU fishing fleet and industry from the point of view of increasing its profitability and suitability for exploitation of a discarded species.

# Sustainable management of interactions between aquaculture and wild salmonid fish -(SUMBAWS)

**Contract number:** Q5RS-2002-00730
**Contract type:** Shared-cost project
**Starting date:** 1.10.2002
**Duration:** 36 months
**Scientific Officer:** Jacques Fuchs
**Project web site:**
www.st-andrews.ac.uk/~sumbaws/

**Coordinators**
Neil Hazon, Chris Todd
University of St Andrews
School of Biology
Gatty Marine Laboratory
FifeKY168LB
United Kingdom
Tel. (44-1334) 46 34 51 (nh)/46 34 54 (cdt)
Fax (44-1334) 46 34 43
E-mail: nhl@st-andrews.ac.uk
cdt@st-and.ac.uk

## PARTNERS

John Curtis, Economic and Social Research Institute
Patrick Gargan, Central Fisheries Board
Bengt Finstad, Foundation for Nature Research and Cultural Heritage Research
Pal Arne Bjorn, Norwegian Institute of Fisheries and Aquaculture Ltd, NIFA University Campus
Sjoerd Wendelaar Bonga, Katholieke Universiteit Nijmegen, Department of Animal Physiology
Roar Kristofferson, University of Tromsø, Norwegian College of Fishery Science
Bernt Martinsen, Alpharma

### background

This multidisciplinary project addresses questions relating to:

1. the decline in wild salmonid populations in north-western Europe;
2. aspects of the migratory behaviour and physiological responses of juvenile salmonids, as they adapt to seawater and as they respond to the additional environmental challenge and stress of ectoparasitic sea lice infestation;
3. up-to-date appraisals and modelling of the socioeconomic importance, and interaction, of the aquaculture and game angling industries in peripheral rural regions of northwestern Europe.

The research is necessarily multidisciplinary in approach and will engage academic and applied scientists, an SME consultancy and an industrial pharmaceutical company in focusing the various components on the overall objectives of quantifying the infestation levels which elicit significant physiological stress on the host fish, and an assessment of the possibilities of conserving and enhancing small definable stocks of salmonids in a sustainable context, but with minimum management intervention.

### objectives

Using state-of-the-art cell biological and physiological techniques and socioeconomic modelling, recommendations on target lice burdens to allow the sustainable development of both industries will be achievable. For wild fishery managers, recommended levels will be those below which it can be assumed that sea lice are exerting no significant negative impact on local stocks. For the aquaculture industry, target infestation levels will be those below which significant impacts on the health of their stocks are minimal. Perhaps most importantly, however, by incorporating our data into mathematical models in a parallel programme, we will be able to recommend target levels for lice on farmed stocks which are sufficiently low as to minimise the possible impacts of farmed stocks on wild populations with regard to larval lice export and cross-infestation of wild fish. These latter farm levels are expected to be considerably lower than the minimal levels which elicit physiological stress effects on their own fish, and hence will have obvious economic consequences for the farming industry and social and economic implications for wild fishery interests.

**expected results and achievements**

1. Identification of early migratory routes of salmonid smolts.

2. Assessment of species' susceptibility to sea lice infestation and the levels eliciting lethal and significant non-lethal stress.

3. Assessment of a prophylactic treatment protecting smolts from initial infestation by sea lice.

4. Socioeconomic appraisals of the aquaculture and wild game fishery industries, and their interaction, in rural areas of the EU.

5. Recommendations of the minimal levels of ectoparasitic lice infestation which are mutually beneficial to both industries and allow their sustainable development.

# The Impact of UVR and Climate Conditions on Fish Stocks: A Case Study of the Northeast Arctic Cod - (UVAC)

*Hansen, G.*[1]*, Eilertsen, H.-C.*[2]*, Wyatt, T.*[3]*, Meerkötter, R.*[4]*, Verdebout, J.*[5]*, Borja, A.*[6]*, Skreslet, S.*[7]

[1] Norwegian Institute for Air Research, Norway; [2] Norwegian College of Fisheries Science, Norway; [3] CSIC – Institute of Marine Research, Spain; [4] DLR - Institute of Atmospheric Physics, Germany; [5] EC - Joint Research Centre, Italy; [6] AZTI, Spain; [7] Bodø College, Norway.

| Contract No : EVK3-CT-1999-00012 | Project duration : 03/2000 – 02/2003 |
|---|---|
| Project budget : € 1 478 000 | EC contribution : € 904 000 |
| Website : http://phaeocystis.nfh.uit.no/uvac | |

**Objectives**

The main objective of the UVAC project was to investigate the impact of solar ultra-violet radiation (UVR) on the Northeast Arctic cod stock. This relation was investigated as part of a more comprehensive impact system, including both other geophysical factors such as climate, and other (biological) components of the marine eco-system which are of importance for the cod stock (zooplankton: Calanus finmarchicus; phytoplankton). The UVR impact was studied both statistically using long-term biological and geophysical data records, and in-depth in dedicated field and laboratory experiments. A second major objective was to develop modelling tools which will be able to estimate cod stock size based on geophysical information available from remote-sensing and ground based monitoring, thus providing a more reliable basis for a sustainable management of marine resources.

**Results**

The UVAC project has yielded most of the deliverables envisaged, in some aspects beyond the expectations, in some other not fully to the expected scope:

- A set of fully homogenized time series of yields in tons for A-N cod from 1830 to 1999 (of which about 70% is from Lofoten fishery prior to introduction of trawling in 1920s); this is given as torrfisk and klippfisk separately. For Lofoten: weekly time series during the fishing season from 1871 to 1990, for landed fish (with the proviso highlighted), and, with a few insignificant gaps, yields of roe, liver, and tran oil (in hectolitres).
- Cod 0-year-class and 3-year class data back to 1967 and 1946, respectively
- Data on two Calanus sp. from Saltfjord and Mistfjord 1946 – 2000
- Sporadic data on phytoplankton since the 1940s
- Meteorological data from Skrova, Lofoten, (1934-2001), from Røst (1880-1969, 1979-1997) and from Skomvær (1970-1978)
- Daily total ozone data (March-May) and derived UVR (5 parameters) and PAR data (1936 – 2001)
- Two independent satellite–derived UVR climatologies (daily doses, weekly, and monthly means) for the periods 1984-2002 and 1990-2002, respectively for the research area and beyond; inter-comparison and validation with ground-based data of the UVR climatologies
- A large set of new radiation, oceanographic and marine-biological data from 10 field surveys during 2 spring seasons plus lab experiment data

- A comprehensive set of correlation studies (correlation coefficients, factor analysis) between geophysical and biological data sets
- A wavelet analysis of three of the biological (fish yield, roe, liver) and three of the geophysical time series (NAO, Kola meridian water temperatures), Røst/Skomvær air temperatures) in which multiannual signals are identified and their phases determined
- A conceptual model on climate impact on 0-year class cod and its food web
- Process model on UVR exposure of marine species, based on measured oceanographic and meteorological data, and derived UVR data

The most important deviation between expected and achieved deliverables results from the fact that the basic assumption of the proposal, namely that UVR is an important geophysical factor (with negative sign) for cod in its earliest life stage, was not confirmed by the multi-decadal correlation studies. This negative finding has been confirmed by process modelling of the exposure of cod eggs and larvae to UVR, using empirical oceanographic and meteorological data: only in few (1-2 out of 20 years), UVR in the uppermost layer of the water column reaches levels that may seriously damage cod eggs and larvae. This does, however, not explain the positive correlation found between cod recruitment and maximum daily UVR dose around 1 May. Hence, the envisaged year class size prediction tool based on UVR could not be realised in its planned form.

**Potential exploitation by end users**

Although the main goal, i.e., to develop a predictive tool based on radiation data, was not achieved, the results of the multi-linear correlation between climatic and biological data, and the wavelet analyses of the historical cod and climate data indicate predictive possibilities on annual and decadal time scales. In addition, the results of the project can be used for a wide spectre of related research:

- Climate studies on the UV trends in Europe in the recent 15 years, and in Northern Scandinavia over the last 60 years;
- Biological impact studies of UV effects on marine and terrestrial ecosystems as well as epidemiological studies of UV effects on human health;
- Assessment of the UV effects upon the offspring of cod and zooplankton in relation to the effects of other meteorological and oceanographic parameters ;
- Comprehensive biological and geophysical/oceanographic studies of the Lofoten/ Vestfjord marine eco-system;
- In-depth studies of the light/radiation regime in the North Atlantic and its interaction with marine species;
- Contribution to a better scientific foundation for the development of prognostic numerical models being applicable in fisheries management.

# HUMAN IMPACTS

# Structure and role of biological communities involved in the transport and transformation of persistent pollutants at the marine AIR-Water Interface - (AIRWIN)

*Lebaron, P.[1], Herndl, G.J.[2], Saliot, A.[3], Albaiges, J.[4], Bordat, P. C.[5]*

[1] Laboratoire d'Océanographie Biologique de Banyuls, France; lebaron@obs-banyuls.fr; [2] Netherlands Institute for Sea Research, Pays Bas; [3] Université Pierre et Marie Curie, France; [4] Institute of chemical and environmental studies, Barcelona, Spain; [5] Research center for Dermocosmetics and Dermatology, France



| | |
|---|---|
| Contract No: EVK3-2000-00577 | Project duration: 01/2001-01/2004 |
| Project budget:€ 2 490 151 | EC contribution:€ 1 200 000 |
| Website: airwin.obs-banyuls.fr | |



**Objectives**

The sea surface microlayer (SML) is one of the most important but also most poorly studied regions of the marine environment. During the project AIRWIN, a multidisciplinary approach was applied to characterize the processes occurring in the SML and their relevance to global change and the effect on the marine environment and its living resources.

The major objectives were

1) to investigate the structure of biological communities present in the SML
2) to identify natural and anthropogenic organic and inorganic compounds, including pollutants, in different biotic and abiotic compartments of the SML
3) to identify and characterize microorganisms present in the SML, with particular focus on their resistance to pollutants and ultraviolet (UV) radiation
4) to evaluate the role of microorganisms in the transport and cycling of natural organic matter and xenobiotics, including lipids, trace metals and persistent organic pollutants (POP's)
5) to investigate the biotechnological potentialities with special focus on pharmaceutical applications

**Results**

The wide range of chemical and biological parameters studied during the AIRWIIN project reveal that the SML represents a distinctly different micro-environment as compared to underlying waters (UW). The main study sites were in the NW Mediterranean Sea: the oligotrophic Bay of Banyuls-sur-Mer (France) and the industrialized coast off Barcelona (Spain). At both sites, the SML was consistently enriched in organic matter (e.g. particulate and dissolved organic carbon, lipids, organic pollutants) and the abundance and activity of a number of organisms (e.g. autotrophic and heterotrophic bacteria, photosynthetic pico- and nanoeukaryotes, heterotrophic flagellates).

Two specific results on the activity and structure of the biological community at the air-sea interface are presented here:

Community respiration provides an integrated measure of metabolic activity of the biological community. Respiration rates in the SML clearly exceeded those in underlying waters in all aquatic environments investigated (Fig. 1). This enhanced heterotrophic activity is likely sustained by a variety of sources of organic carbon that are concentrated in the SML.

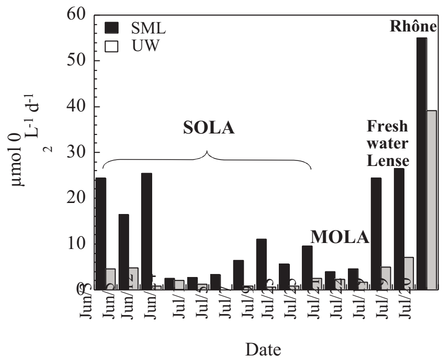



Fig. 1. Community respiration rates in the sea-surface microlayer (SML) and in underlying waters (UW) at an oligotrophic coastal (SOLA - Station d'Observation Laboratoire Arago) and offshore (MOLA – Microbial Observatory Laboratoire Arago) station in the Mediterranean Sea and in the river Rhône and its plume waters.

The biological community present at the SML therefore plays a crucial role in the transport and cycling of natural and anthropogenic organic matter at the air-water interface.

Bacterial community structure of culturable bacteria was determined for the SML and UW. Our results indicate that the major phylogenetic groups characteristic for the marine environment are also present in the SML (Fig. 2). However, Actinobacteria revealed a higher relative abundance in the SML as compared to UW. This bacterial group is known to degrade a number of complex molecules, such as hydrocarbons.

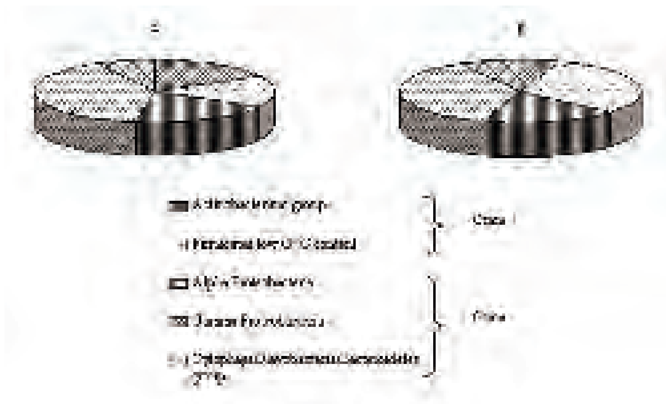


Fig. 2. Relative abundance (%) of major phylogenetic groups of culturable bacteria from (A) the surface microlayer and (B) underlying waters.

The higher abundance of Actinobacteria in the SML as compared to UW is likely related to higher concentrations of organic pollutants at the air-water interface. Collection, isolation and characterization of microorganisms from this particular environment, that is exposed to a variety of stress-factors, such as organic pollutants and high intensities of UV radiation, has important implications for their potential use for bioremediation purposes.

# Bioaccumulation of persistent organic pollutants in small cetaceans in European water: transport pathways and impact on reproduction - (BIOCET)

*Pierce, G.J., Santos Vázquez, M.B., Learmonth, J.A.*

Department of Zoology, the University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ, SCOTLAND. Email: g.j.pierce@abdn.ac.uk



| | |
|---|---|
| Contract No: **EVK3 - 2000 - 00556** | Project duration: 01/01 – 12/03 |
| Project budget: € 1 616 510 | EC contribution: € 1 183 996 |
| Website: www.abdn.ac.uk/biocet | |



**Objectives**

This project aims to quantify and model the transport pathways and impact on reproduction of bioaccumulation of persistent organic pollutants (POPs) in four species small cetaceans in European Atlantic waters. The species studied will be, primarily, harbour porpoises *Phocoena phocoena* and common dolphins *Delphinus delphis* and, secondarily, striped dolphins *Stenella coeruleoalba* and bottlenose dolphins *Tursiops truncatus.*

The project aims to:

- To quantify and model the effect of bioaccumulation of persistent organic pollutants (POPs) on the reproductive success of selected populations of porpoises and dolphins in relatively unpolluted and highly polluted areas within European Atlantic waters;
- To identify and model the pathways by which the selected pollutants bioaccumulate, identifying the trophic links which contribute most to bioaccumulation in the small cetaceans;
- To compare reproductive success between populations and thereby identify geographical areas in which porpoise and dolphins are particularly vulnerable to adverse effects of bioaccumulation;
- To compare reproductive success between individual females, relate these findings to age and diet choice, and quantify the effect of bioaccumulated pollutants on individual lifetime reproductive success;
- To quantify and model the time-course of bioaccumulation in female porpoises and dolphins;
- To take into account, in all the above, the role of potential confounding factors, in particular the bioaccumulation of toxic elements (e.g. mercury, cadmium) and health status as revealed by histopathological study;
- To provide a published synthesis of the findings of the project and recommendations relevant to the conservation of small cetaceans and the management of POP input into coastal zones and oceanic waters;
- To compile and publish results on basic biological parameters on all studied cetacean populations.

**Results**

The project involves studies of disease, age, reproduction, diet and contaminant burdens. The proposed research will lead to new results on the pathways and processes of bioaccumulation of organochlorines (and heavy metals) and on their effects on reproduction in female porpoises and dolphins.

Results will be synthesised to identify contaminants, geographic areas, cetacean populations, and prey species associated with negative impacts on reproduction and potential risks to cetacean population status. Recommendations will include identification of areas and issues of concern for the conservation of small cetaceans and management of pollution in coastal zone and open ocean waters. Quantitative results will be compared between areas, using appropriate statistical tests, and used to formulate simple empirical models. Several types and levels of model are needed, including quantitative descriptions of the effects of bioaccumulation for individuals and populations of each cetacean species. More detailed models should be possible for harbour porpoises and common dolphins, for which sample sizes are expected to be highest.

Deliverables will include reports on histopathological, viral & bacteriological findings, dietary studies, POP studies, toxic element studies, and models and synthesis, also CD-ROMs of tooth images and ovary images of value to other researchers.

The final report is due at the end of February 2004 and is not available at the time of writing this abstract.

**Potential exploitation by end users**

This proposal addresses an issue of Community-wide interest, one requiring the combination of complementary expertise and resources available Europe-wide in different organisations, and relevant to EU policy on marine pollution.

The particular importance of this project relates to its contribution to preserving and/or enhancing the environment and the minimum use/conservation of natural resources, with respect to providing knowledge, methods or models which assist in risk assessment and risk abatement.

An additional dimension is that porpoises and dolphins eat fish (e.g. whiting and herring) and invertebrates (e.g. squid and octopus) that are also eaten by man. Effects on reproduction, resulting from bioaccumulation of pollutants in food, seen in harbour porpoises and dolphins provide a model for effects that might be seen in human communities that have a substantial per-capita consumption of seafood.

# Community of Marine Microrganisms for Oil Degradation - (COMMODE)

*Yakimov,M.M.[1],Timmis,K.T.[2],Golyshin,P.[2],Giuliano,L.[1],Denaro,R.[1],Terren ceT. [3],Dalby,A. [4],Yanenko,A. [5],Ron,E. [6].*

[1] Istituto per l'Ambiente Marino Costiero (IAMC) CNR Messina, Italy; [2] Institute of Microbiology, Technical University of Braunschweig, Germany; [3] Department of Biological Sciences, University of Essex, Colchester, UK; [4] National Centre for Marine Research Hellinikon, Greece; [5] Institute of Genetics of Industrial Microorganisms, Moscow, Russia ; [6] Dean, Faculty of Life Sciences Tel Aviv University, Tel Aviv, Israel

| | |
|---|---|
| Contract No : EVK3-CT2002-00077 | Project duration : 10/2002 – 10/2005 |
| Project budget : € 1,943,000 | EC contribution : € 1,465,000 |
| Website : www.ist.me.cnr.it | |

## Objectives

The most rapid biological effect of oil pollution in marine environments is the shift in the structure of the authochtonous marine microbial communities with enhancement of the relative abundance of Marine Hydrocarbon Degrading Bacteria (MHDB), that seem to play a pivotal role in the recovery of the affected areas.

COMMODE aims at the study of MHDB with special attention to their biogeography, diversity, ecology, catabolic potential, ability to produce biosurfactants/bioemulsifiers, with the final objective to verify their suitability for bioremediation.Specific objectives included:

- The isolation and characterization of Marine Hydrocarbon Degrading Bacteria to study their biogeography,diversity,catabolic potential and biosurfactants/bioemulsifiers production.
- Determination of the composition and catabolic potential of culturable and unculturable oil-based microrganisms and development of taxonomic and functional probes for rapid analysisDiversity analysis of marine protozoan grazers feeding on oil-based communities.

## Relevance for society

COMMODE Project has focused on methodological development and the establishment of baseline datasets describing bacterial communities in oil impacted marine environments. This baseline data represents a crucial prerequisite in our effort to gain a thorough understanding of microbial degradation of oil in marine environment, which will subsequently enable the design of bioremediation strategies based on scientific understanding to limit the impact of both chronic oil pollution events and of smaller regular pollution events at coastal sites adjacent to oil industries (eg. oil refineries). An improved ability to deal with oil pollution will have positive impact on marine-based industries including tourism and fishing and on the overall ecological health of European and World waters and coastlines

## Results

Several areas around the world were tested for the study. In all sampled areas the presence of MHDB was detected by means of classical and/or molecular based approaches. Moreover, a collection of MHDB isolates was obtained that is being screened for the bacterial taxonomic, biochemical and eco-physiological main features. Briefly, the ubiquitous distribution of MHDB all over the oceans and their quite conservative metabolic features are the outputs. Table 1 reports preliminary results about the distribution of MHDB.

| Sampled areas | MHDB strains |
|---|---|
| Tirrenyan sea | *Alcanivorax*<br>*Cycloclasticus*<br>*Neptunomonas*<br>*Thalassolituus* |
| Eastern Mediterranean sea | *Acinetobacter*<br>*Alcanivorax* |
| Pacific Ocean | *Thalassolituus* |
| Barents sea | *Thalassolituus* |
| Antarctica | *Oleispira antarctica*<br>*Gelidicola* |

**Table 1**

Laboratory experiments carried out on samples from the Saronic Gulf (Greece), have pointed out that MHDB abundance may be controlled by petroleum-tolerant protozoan predators. In fact, an increase in the relative abundance of heterotrophic nanoflagellates (HNF) was immediately following the MHDB blooms and the ingestion rates were very high up to the moment when the bacterial concentration returned to natural background levels (4 to 7 days).

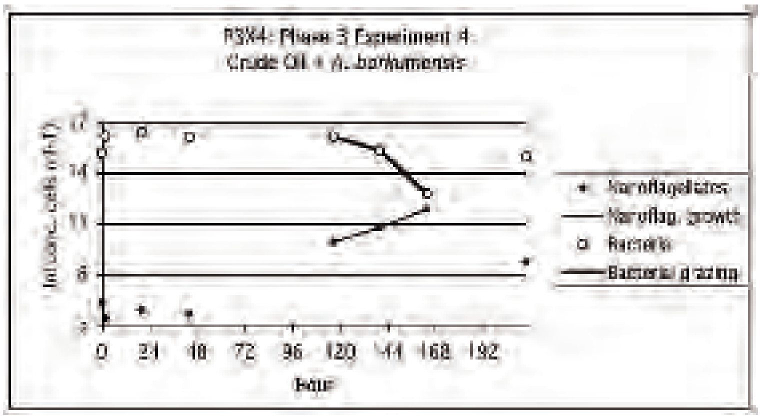


**Figure 1**

# Cycling of phosphorus in the Eastern Mediterranean (CYCLOPS)

M. Krom[1], P. Carbo[1],T. F. Thingstad[2], G. Fonnes[2], E. Skjoldal[2], N. Kress[3], T. Zohary[3], B. Herut[3], C. Law[4], M. Woodward[4], F. .Mantoura[4], M. Liddicoat[4], F. Rassoulzadegan[5], T. Tanaka[5], A. Tselepides[6], P. Pitta[6], S. Psara[6], T. .Polychronaki[6], P. Dragopoulos[6], P. Wassmann[7], C. Riser[7] & G. Zodiatis[8]

[1] Earth and Biosphere Institute, School of Earth Sciences, Leeds University, UK.
M.D.Krom@earth.leeds.ac.uk

| | | | |
|---|---|---|---|
| Contract n° | EVK3-1999-00009 | Project duration: | March 2000 to June 2003 |
| Project budget | € 2304958 | EC contribution: | € 1786700 |
| Website | www.earth.leeds.ac.uk/cyclops | | |

**Objectives**

To understand the processes which control primary productivity in the Eastern Mediterranean. This is particularly important because of the very low background productivity and high and changing inputs of anthropogenic pollutants to the system from both the atmosphere and from rivers and other point and non-point sources.

**Results**

The CYCLOPS team carried out a Lagrangian experiment involving an addition of the nutrient, phosphate. It was the first successful experiment of its kind, anywhere in the world, involving the addition of a nutrient other than iron. We added 18 tonnes of diluted and partially neutralised phosphoric acid, together with $SF_6$ as the inert tracer, to a 16 $km^2$ patch of water. This resulted in a mean initial phosphate concentration of 120 nmoles/litre. The patch, which was contained in the centre of a warm core eddy, was followed successfully for 9 days. We carried out detailed biological, chemical and physical measurements on the patch water, and also on a series of stations outside the patch. These data enabled us to monitor in detail the changes that occurred in the system in response to the phosphate addition.

In addition we carried out the most comprehensive set of co-ordinated and simultaneous modern measurements made in the Eastern Mediterranean. This included measurements of activity, biomass and species identification of bacteria, phytoplankton, micro and macro-grazers. We also measured community parameters such as photosynthesis rates, several different chlorophyll determinations and P uptake kinetics. During the project we developed, and carried out for the first time, measurements of nanomolar concentration nutrients (phosphate, nitrite and nitrate) as well as a new alkaline phosphatase method for estimating the amount of excess available nutrients present in a microbial sample. We also determined for the first time in this area the particulate C:N:P ratio and the dissolved organic C:N:P ratio. All these parameters were measured on water samples taken from both inside and outside the fertilised area.

We expected there to be an increase in phytoplankton biomass when we added P, the limiting nutrient to the system. In fact we observed a decrease in chlorophyll. Our results showed an unexpected complexity of response that we did not anticipate when we designed the project. The base of the food chain consists of heterotrophic bacteria, nano- and pico-phytoplankton. There are very few larger eukaryotic phytoplankton in these waters. When phosphate is added, it is taken up rapidly by the microbial community (as shown by the $^{33}P$ turnover rates combined with nanomolar phosphate measurements, and an increase in particulate phosphate). The bacteria show a significant increase in activity but not in biomass. The dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) that they are able to access from the water column sustain this increase. The DON, which was seen to decrease, provided them with the N source they need for growth. By contrast, the phytoplankton took up P but did not grow. However, when they were supplied with dissolved inorganic nitrogen, in the form of ammonia within the microcosm, rapid growth occurred. The induced changes caused an increase in grazers and in grazing rates, which caused the bacterial biomass to remain stable and caused a decrease in the phytoplankton chlorophyll. It is concluded that the bacteria are P limited and are able to access N from the DON pool. The phytoplankton are N&P co-limited. Microbial grazers are present within the system and seem to be 'hungry' and able to take advantage rapidly of short term changes in the food supply.

The system is ultra-oligotrophic with very low levels of chlorophyll and primary productivity. The primary producers are extremely small, dominantly in the nano- and picoplankton range. The levels of dissolved inorganic nutrients within the system are very low (generally below the detection limits even of the nanomolar technology). However the levels of DOC, DON and DOP are relatively high. We found that the system is P starved with no reservoirs of non-labile P present.

A total nutrient budget was carried out for the entire basin. This showed that there was a major imbalance in the nutrient input with an N:P ratio in the inputs of ~50:1. The largest input source was atmospheric input which represented 70% of the N and 30% of the Labile P. It was suggested that the reason why the basin was p limited was because more N was supplied than P. It retains this high N:P ratio because of the unique antiestuarine circulation which causes the system to be ultra-oligotrophic which results in very low accumulation of organic matter in the sediments and water column. The result is that the normal processes of biologically controlled buffering cannot occur in this system. There is no evidence or need for N fixation to occur.

**Potential importance and relevance to end users:**

Our work confirms the ultra-oligotrophic nature of the system. This is despite the major input of nutrients from the population in the catchment and the annual influx of tourists. This is because of the unique anti-estuarine circulation of the basin, which results in a large net export of nutrients through the straits of Sicily.

The major input of nutrients to the system is from the atmosphere. The flux is dominantly N, mainly anthropogenic from Europe (NOx from cars and $NH_3$ from agriculture). As a result, the regulations to control nutrient input from point sources have a limited effect on the nutrient status of the system as a whole. The input of atmospheric N is likely to be increasing as the general influx of atmospheric nitrogen increases. However, this has a relatively minor effect on the overall productivity of the system, since the system is P limited and most of the P is natural input via Saharan dust.

Previous attempts to calculate the fish biomass from primary productivity measurements using conventional food chain calculations resulted in a problem. There seemed to be too much fish biomass for the primary productivity measured. Our results may suggest a reason for this. It seems that relatively large micro-grazers, and even macro-grazers, are consuming bacteria and other primary producers. If this is true then the efficiency losses through the system will be much lower than expected, which would explain the relatively high fish yields for relatively low primary productivity.

# Transfer and fate of Harmful Algal Blooms (HAB) toxins in European marine waters – (FATE)

*Granéli E.[1], Legrand C.[1], Hagström J.[1], Wassmann P.[2], Svenssen C.[2], Wexels-Riser C.[2], Tamminen T.[3], Kuuppo P.[3], Guisande C.[4], Maneiro I.[4], Riveiro I.[4], Pagou K.[5], Giannakourou A.[5], Strogyloudi E.[5], Luckas B.[6], Dahlmann J.[6], Rhül A.[6], Anderson D.M.[7], Sengco M.[7], Sandberg-Kilpi E.[8], Olli K.[9]*

•

•[1] University of Kalmar, Sweden; [2] University of Tromsø, Norway; [3] Finnish Environment Institute, Finland; [4] University of Vigo, Spain; [5] National Centre for Marine Research, Inst. of Oceanography, Greece; [6] F. Schiller Univers; [7] Woods Hole Oceanographic Institution, USA; [8] University of Helsinki, Finland; [9] University of Tartu, Estonia.



| | |
|---|---|
| Contract No: EVK3-2002-00055 | Project duration: 01/2003-12/2004 |
| Project budget: € 1 712 000 | EC contribution: € 1 373 000 |
| Website: www.bom.hik.se/fate | |



**Objectives**

Harmful algal blooms (HAB) cause significant economical losses and ecological effects in European marine ecosystems every year. Due to potent toxins, some HAB have direct negative effects on cultured fish and shellfish and coastal fisheries. The occurrence of HAB also affects tourism negatively, because of the unwillingness to spend vacation in a contaminated area.

Although the direct effects of HAB toxins on cultured fish and on humans when consuming contaminated shellfish are known, it is virtually unknown what pathways HAB toxins take in the food web during and after a HAB event. The main objective of this project is to identify and quantify these pathways for different HAB toxins in European waters. To manage the occurrence of HAB and/or their toxicity by reducing eutrophication is a long-term process, and different ways to protect e.g. fish farms from the direct impact of HAB would be beneficial. In FATE, two innovative mitigation techniques preventing cultured fish to be killed by HAB will be tested and evaluated for the first time in Europe.

Specific objectives include:

- To examine how HAB toxins accumulate and degrade in pelagic and benthic marine food webs
- To identify and quantify HAB toxins in different compartments of the food webs
- To quantify degradation and transfer rates of HAB toxins in marine food webs
- To test mitigation techniques to reduce and mitigate HAB
- To provide management recommendations for fisheries and shellfish industry

**Results**

All generated information during year 1 of the project was used to create a descriptive scenario of the transfer of nodularin, a toxin produced by the cyanobacterium *Nodularia spumigena*, in the food web of the Baltic Sea (Fig. 1). This cyanobacterium forms large blooms during summer, which contain large amounts of nodularin. Although free nodularin is rapidly degraded by photo-oxidation and bacterial processes in the water, a large amount of toxin is transferred to the microbial loop and further on to mesozooplankton.

Nodularin also accumulates in shellfish, shellfish pseudofaeces and faeces and can be transferred to other benthic fish or shellfish. No accumulation was observed in benthic worms. The importance of sedimentation of the filamentous *N. spumigena* is under investigation.

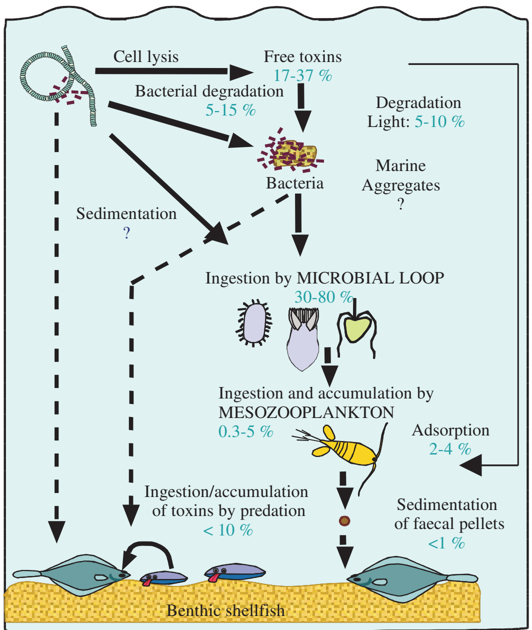



**Fig.1: Fate of the cyanobacterium *Nodularia spumigena* toxins in the Baltic Sea food web, during bloom decline**

The project also generated results on the FATE of

- Domoic Acid (*Pseudonitzschia* spp.),
- Okadaic Acid (*Dinophysis* spp.),
- Paralytic Shellfish Poisoning toxins (*Alexandrium* spp.),
- Ichthyotoxins (*Prymnesium parvum*).

The project allowed to describe the three most important types of pathways for HAB toxins in Europe:

1) Degradation in the water column,
2) Transfer through the food chain in the water column,
3) Sedimentation (with particulate material) to the bottom and accumulation in the benthic food chain.

Mitigation of HAB using clay flocculation showed that Swedish bentonite has a 50-70% removal efficiency of the fish-killing species *Prymnesium parvum*. Preliminary results revealed no toxic effects on benthic communities.

**Potential exploitation by end users**

FATE provides advanced knowledge to understand the importance and the impact of the different pathways of HAB toxins in marine food webs including benthic communities. The results are also a basis for risk assessment of HAB toxins in the marine ecosystem and provide a foundation for management recommendations concerning HAB toxins for fisheries, fish and shellfish aquaculture industry. The results impact tourism industry by increasing public awareness of HAB events. The evaluation of HAB mitigation techniques will, if successful, have a positive impact on the European fish farming industry.

# Laser fluorosensor for oil spot detection – (FLUOSENSE)

*Gatelis, V.[1], Gulbinas, V.[2], Reuter, R.[3], Westphal, R.[3]*

[1] Ekspla Ltd, Lithuania; [2] Institute of Physics, Lithuania; [3] University of Oldenburg, Germany

| | |
|---|---|
| Contract No : EVK3-CT-2002-300001 | Project duration : 01/2003 – 12/2004 |
| Project budget : € 1 152 355 | EC contribution : € 576 177 |
| Website : www.fluosense.com | |

**Objectives**

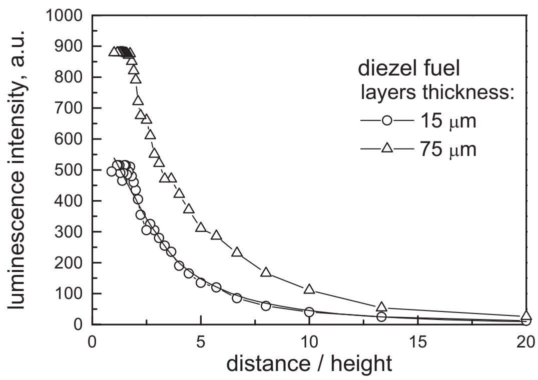
Rapid and reliable spill detection is an essential yet often overlooked part of oil spill prevention and response strategies. Early warning about pollution event is important for minimization of environmental and financial impacts.
The aim of this project is to develop a compact and cost-effective automated oil spill sensing technology – laser fluorosensor – to provide for early detection and alarm of petroleum hydrocarbon leaks and spills. It is projected to have the following advantages:

- Oil-on-water detection from up to hundred of meters distance and automatic scanning of specified areas
- Thin oil layer detection at day and night and oil classification capabilities
- Automatic long-term operation, oil detection and alarm
- Compactness, low energy consumption, easy installation and operation

Specific objectives also included:

- Development and leadership in the emerging oil spill/leak detection market
- Competitive price, about two-three times lower compared to existing laser fluorosensors
- Furthermore, reduction of oil pollution and economy of resources related to oil spill response actions

**Results**




The results of our investigation show that fluorescence signals from different sorts of oils and oil products can surely be registered and discriminated from background even in full sunshine. The maximum distance at which the target can still be registered depends on the fluorosensor's height from sea surface and on oil type and film thickness. Preliminary investigations show there is a definite possibility to detect even thin oil films on sea surface from 10 m high mast at distances of about 100 m and possibly even larger. Excitation laser emission necessary for the reliable detection may be provided by a low-cost, compact diode pumped solid state laser. Fluorescence signals in arbitrary units from different heights and for different distances are given in the figure above right. The graph shows that the inclination angle of laser beam excitation is the most limiting factor for scanning distance extension.

**Potential exploitation by end users**

The results obtained provide a solid background for successful project completion and further development of a commercial device. The laser fluorosensor to be developed within this project aims at two main application fields: spill/leak control and environment monitoring. Likely, cost considerations will compel us to market different fluorosensor systems designed for either “industrial” or “environmental” markets:

- The “industrial” fluorosensor will mostly be based on shore or stationary platform (installed on masts, lighthouses, etc.) It may require an extended operational range, unmanned 24 h operation and the capability of working for long periods without maintenance. But oil species recognition features may turn out not so important for these users.
- The “environmental” application will require a ship-based system, more complex mechanical structure to dampen wave action and oil species recognition feature. However, the scanning range (it may be 30-50 meters from the ship) and maintenance requirements are not so critical in this case.

The project, when successful, will contribute to the development of new advanced practices in spill prevention.

# Genomic tools for bio-monitoring of pollutant coastal impact (GENIPOL)

[1]*Tom, M., Auslander, M., Dyman, A., Yudkovski, Y., Funkenstein, B.*
[2]*Mose-Larsen, P., Fey, S., Roepstorff, P., Rogowska, A.*
[3]*George, S., Sabine, V., Diab, A.*
[4]*Chipman, K., Williams, T., Minchin, S.*

[1]Israel Oceanographic and Limnological Research, Israel (IOLR)
[2]University of Southern Denmark, Odense University, Denmark (CPA-SDU)
[3]University of Stirling, Scotland (UOS)
[4]University of Birmingham, England (UB)



| | |
|---|---|
| Contract No : EVK3- CT-2001-00057 | Project duration : 11/2002 – 10/2005 |
| Project budget : € 2 000 000 | EC contribution : € 2 000 000 |
| Website : : http://www.genipol.stir.ac.uk/ | |



**Objectives**

Establishing the evaluation of environmentally affected gene expression in fish liver as biomarkers of pollution effects, in European coastal environments.

The basic assumptions underlying this project are:

1) Fish inhabiting coastal waters, interacting with the sediment and water column of their habitat, and fed from local resources, can serve as indicators for environmental biological impact.

2) Gene products, transcripts and proteins, whose expression in the indicator fish is affected by environmental factors, are excellent environmental biomarkers. They underlie most biological events, therefore, a variety of environmental perturbations are assumed to affect their level. In addition, gene products can be measured using common methodologies, simplifying their application as biomarkers.

Two indicator fish species were selected, enabling the examination of the two major European water bodies: The flounder (*Platichthys flesus*), and the striped sea bream (*Lithognathus mormyrus*), covering the North-Eastern Atlantic and the Mediterranean coasts, respectively.

The project objectives are:

1) Evaluation of the hepatic levels of environmentally affected transcript and protein biomarkers using real time PCR and Enzyme Linked Immuno Sorbent Assay (ELISA), respectively. The methodology includes fully quantitative evaluation in absolute units, applying transcript and protein standards of known amounts, adequately normalized.

2) Identification of a variety of novel environment-affected fish genes, by screening suitable cDNA microarrays for affected transcripts and analyzing 2D electrophoretic gels coupled to mass spectrometry sequencing, revealing influenced proteins.

3) Semi-quantitative evaluation of environmental effects on multiple gene expression, using cDNA operational microarray.

**Results**

The GENIPOL project is in its second year, generally proceeding according to plan. Several bio-monitoring methods are ready for implementation.

1) The following real time PCR measurement methods were completed:

Flounder - cytochrome P4501A [1], Ah receptor and ARNT, all related to the P4501A expression system, and also for UDPGT, vitellogenin, EF1, alpha-tubulin, thioredoxin, and microsomal GST. 18S rRNA, evaluated also by real time PCR, is used as a normalizing agent.

Striped sea bream - cytochrome P4501A, metallothionein, vitellogenin, and also 18S rRNA, used as normalizing agent [2,3].

2) Competitive Enzyme Linked Immuno Sorbent Assay (ELISA) was developed for the measurement of the sea bream cytochrome P4501A [4] and vitellogenin protein levels.

3) Two cDNA plasmid libraries of several thousands clones, from flounder and striped sea bream RNA populations, were established, using the subtractive-suppression hybridization (SSH) methodology, followed by the construction of two cDNA microarrays on glass substrate.

4) Liver protein samples of both species were analysed by 2D gel electrophoresis, comparing proteins from induced and uninduced individual fish. Several up and down regulated protein spots were identified, on the 2D gels, one of them was identified as trypsin 1, using mass spectrometry.

**Exploitation**

Part of the developed methods in the framework of objective 1 above, are ready for implementation in natural habitats for the evaluation of pollution biological impacts. Actually, the IOLR partner and the Israeli ministry of the environment, are involved in the set up of a pilot bio monitoring system in the Eastern Mediterranean and the Adriatic, in cooperation with Croatian scientists and environmental authorities. The UOS partner cooperates with the British Centre for Environment, Fisheries and Aquaculture Science (CEFAS), and the methods developed during GENIPOL are used for assessing pollution along U.K. coasts.

**References**

[1] Dixon, T.J., Taggart, J.B., George, S.G. (2002) Mar. Environ. Res. 54, 267-270
[2] Tom, M., Chen, N., Segev, M., Herut, B., Rinkevich, B. (2004) Mar. Pollut. Bull. (in press).
[3] Funkenstein, B., Dyman, A., Berta Levavi-Sivan, B., Tom, M. (2004) Mar. Environ. Res. (in press).
[4] Tom, M., Myers, C.R., Waterman M.R. (2002) *Aquat. Toxicol.* 59: 101-114.

# Harmful Algal Blooms Expert System - (HABES)

*Blauw, A.N.[1], Peperzak, L.[2], Estrada, M.[3], Autio, R.[4], Laanemets, J.[5], Raine, R.[6], Purdie, D.[7], Lindahl, O.[8], Hansen, G.[9], Karlsson, B.[10]*

[1] Delft Hydraulics, Netherlands (anouk.blauw@wldelft.nl) [2] National Institute for Coastal and Marine Management, Netherlands; [3] Institut Ciencies del Mar, Spain; [4] Finnish Institute of Marine Research, Finland; [5] Talinn Technical University, Estonia; [6] Martin Ryan Marine Science Institute, Ireland; [7] University of Southampton, United Kingdom; [8] Kristineberg Marine Research Station, Sweden; [9] Botanical Institute, University of Copenhagen, Denmark; [10] Swedish Meteorological and Hydrological Institute, Sweden

| | |
|---|---|
| Contract No : EVK1-2000-22091 | Project duration : 03/2000 – 03/2004 |
| Project budget : € 2 375 500 | EC contribution : € 1 570 250 |
| Website : www.habes.net | |

**Objectives**

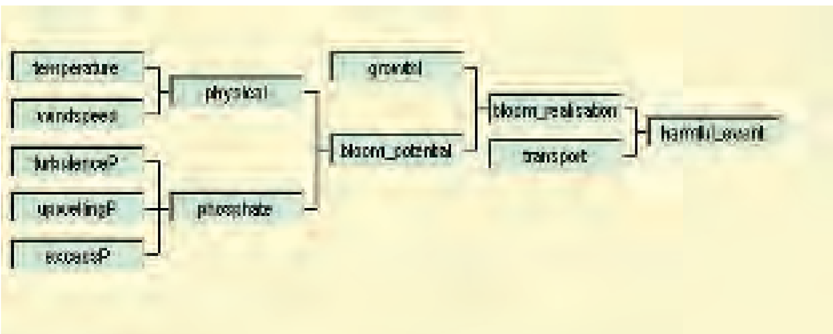
- to improve and extend our understanding of the interaction between physical and ecological factors determining the initiation and fate of harmful algal blooms;
- to provide an expert system and a knowledge base, publicly accessible through internet, based upon existing and newly-acquired knowledge on harmful algal blooms.

**Results**

Expert system models have been developed and tested with available data across Europe. The following (potentially) harmful algal species have been addressed:

- *Nodularia spumigena*
- *Phaeocystis globosa*
- *Dinophysis acuminata and D. acuta*
- *Alexandrium minutum*
- *Karenia mikimotoi*

The expert system models use simple knowledge rules to quantify cause-effect relations in the chain of processes involved in harmful algal bloom formation and their effects. Uncertainties in the knowledge rules are included in the model predictions by using fuzzy logic.




Example of a model set-up: the model for *Nodularia spumigena*

The biomass development and transport of *Nodularia spumigena* in the Baltic Sea and Gulf of Finland could be simulated accurately (see Figure below). Surface temperature, wind speed and phosphate concentration have been identified as the most critical factors for bloom development of *Nodularia spumigena.*

The timing of harmful algal events due to *Dinophysis acuminata* and *Karenia mikimotoi* along the Irish south-west coast could be predicted correctly in almost all 10 years where data were available. Only in one year it was (falsely) predicted that conditions were suitable, when in fact there was no harmful bloom.

For *Phaeocystis globosa* in Dutch and English coastal waters, the start of blooms was triggered by the underwater light climate. The maximum bloom intensity was related to fresh water input. The occurrence of foam on beaches was related to the presence of blooms, the wind speed and wind direction.

*Alexandrium minutum* blooms appeared related to nutrient rich enclosed areas, such as harbours in coastal waters near Barcelona. There was some evidence of strong winds and heavy rainfall reducing the probability of harmful events. Unfortunately there were only limited data available for model validation.

**Potential exploitation by end users**

Harmful algal blooms cause large economic losses every year in aquaculture throughout Europe, due to shellfish toxicity and mass fish mortality. Furthermore some harmful algal blooms lead to closure of beaches to tourists and have devastating effects on aquatic ecosystems. Prediction of blooms and insight in the impact of human activities on the frequency and intensity of blooms are needed to support water managers deciding on migitating measures.

Within the HABES project the knowledge available on the main harmful algal species in Europe is integrated and made more accessible to coastal managers and policy makers. With the knowledge base and expert systems publicly available through internet, they can estimate the relative importance of different natural and anthropogenic factors affecting harmful algal blooms. The project website: www.habes.net will be maintained at least until 2008.

The knowledge rules in the models and information from literature on the processes in the models are documented in a so-called ‘knowledge base’ publicly accessible through internet.

The expert system models that have been developed for each of the selected algal species have been made as much as possible generic. This means that the processes in the models have been analysed in different European areas and the controlling processes are similar for all European waters included in the project. On the project website model simulations can be performed online. This allows for sensitivity analyses, for example.

Furthermore the process of model development resulted in a better insight in what knowledge and data are required to allow for better predictability of harmful algal bloom events. One of the conclusions is that high frequency, long term monitoring is required for reducing the uncertainty about relations between anthropogenic forcings and harmful algal bloom events.

# The Cluster IMPACTS - (IMPACTS WORKSHOP 1)

*Caumette, P.*

University of Pau, Department of Biology, BP 1155, F-64013 Pau cedex

| | |
|---|---|
| Contract No: EVK3-CT-2001-60004 | Project duration: 1/11/2001 – 31/10/2002 |
| Project Budget: € 52200 | EC contribution: € 52200 |
| Website: http://www.univ-pau.fr/impacts | |

Energy, Environment and Sustainable Development (EESD) is one of the four thematic programmes of the V$^{th}$ Framework Programme (FP-V) of the European Union. Research into the development of Sustainable Marine Ecosystems forms Key Action 3 of EESD. Only integrated or multi-disciplinary approaches can lead to sustainability in the long term. Single projects can not adopt a sufficiently holistic approach towards sustainability. So as part of FP-V, projects sharing common environmental and socio-economic objectives have been grouped into clusters.

IMPACTS cluster operates by linking thematically complementary projects *via* (a) Project Web pages; (b) Cross representation; (c) Exchange of data; (d) Joint meetings of project leaders; (e) Workshops; and (f) Science-strategic inputs to European stakeholders.

The goal of research conducted within the IMPACTS cluster is to understand and quantify the effects of human activities on the contrasting marine ecosystems surrounding Europe. It focus on fate and impacts of pollutants, including endocrine disrupters, and nutrients in contrasting environments; on nutrient over-enrichment and eutrophication, and their relation to harmful algal blooms formation; impacts of episodic events and alien species introduction.

The projects SIGNAL, CYCLOPS, MEAD, MATBIOPOL, FAMIZ, BEEP, INTERPOL, ADIOS, AIRWIN, BIOCET and existing relevant MAST-III projects (ACE, MARA, BIOMARK) form the IMPACT cluster. Linked to the IMPACTS cluster are two data management projects MEDAR and MEDNET. Closely linked with the IMPACTS cluster is a group of projects, which focus on research on Harmful Algal Blooms in the frame of the EC EUROHAB Initiative. EUROHAB stands for European Initiative on Harmful Algal Blooms. The EUROHAB projects are: BIOHAB, NUTOX, Harmful Introductions by Ships.

The resulting RTD knowledge will (a) underpin Europe's emergent management models on the cost-benefits of pollution reduction, rehabilitation of degraded ecosystems and the sustainable development of the marine environment and (b) provide input to relevant conventions (e.g. OSPARCOM, HELCOM, Barcelona and Bucharest Conventions).

The IMPACTS CLUSTER has been structured into two themes which have broadly similar scientific aims and overlaps in methodologies. These themes are not intended to be mutually exclusive or permanently set. They will however make for more manageable discussions and exchange of information.

**THEME 1 : understanding the effects of natural and anthropogenic fluxes on marine microbial ecosystems**

Determine the relative importance of atmospheric versus other inputs of nutrients and contaminants in changing primary productivity. Determine how man has altered these fluxes and what the environmental effects of these changes are in terms of total plankton biomass and community structure, including particularly the issue of harmful algal blooms. The 7 projects which identified themselves as wishing to be included within this theme are:

ADIOS, CYCLOPS, INTERPOL, MEAD, MEDNET, MEDAR, and SIGNAL.

**THEME 2 : understanding how human activities affect the biodiversity and the functioning of marine ecosystems**

Determine how human activities and anthropogenic inputs (including contaminants and non-native species) affect the biodiversity and the functioning of marine ecosystems.

The 8 projects included within this theme are: ACE, AIRWIN, BEEP, FAMIZ, BIOMARK, BIOCET, INTERPOL, MATBIOPOL.

All participants to the CLUSTER IMPACTS presented their own project during the first workshop of the Cluster, held in the University of Pau, in February 2002.

The main objectives of the workshop were to allow exchanges of data and ideas between the complementary projects, to provide a space for discussions and creation of new links and cooperation between complementary projects, to produce scenarios for socio-economic benefits arising from the reduction of anthropogenic effects on the marine environment and finally to allow the reinforcement of the links between the projects and the end users.

A book of proceedings of the Workshop has been edited and published.

More informations concerning the CLUSTER IMPACTS are available on the Web site of the Workshop : http://www.univ-pau.fr/impacts

# Impact of Natural and Trawling Events on Resuspension, Dispersion and Fate of Pollutants – (INTERPOL)

*Lykousis, V.*

Hellenic Centre for Marine Research, Greece (vlikou@ncmr.gr)

| | |
|---|---|
| Contract No : EVK3-2000-00023 | Project duration : 01/2001 – 12/2003 |
| Project budget : € 1 960 384 | EC contribution : € 1 160 000 |
| Website : www.ncmr.gr/interpol | |

**Objectives**

The Mediterranean coastal zones experience intense trawling activity and severe storm surges including significant resuspension-release of nutrients, pollutants and toxic elements. Due to their oligotrophic character the resuspension processes play a key role in the carbon, nutrients and pollutants recycling in the Mediterranean coastal ecosystem. The INTERPOL project has brought together complementary expertise and know-how, in an unprecedented way and has provided new and unique data towards the understanding of the environmental impact of resuspension processes in the Mediterranean coastal ecosystem. Such data help to constrain and to identify the complex routes of pollutants transfer within the marine system. These are important steps towards a better assessment of the marine cycling of natural and anthropogenic substances, including toxic ones, and thus towards a better protection of the Mediterranean from pollution.

**Results**

Monitoring of oceanographic and atmospheric conditions was performed to assess the relative importance of natural (storms) versus anthropogenic (trawling) induced resuspension at near-shore and off shore sites. The main result is that naturally induced resuspension is limited to shallow areas, whereas trawling predominately affects the middle and the outer-shelf regions. Thus, trawling can be regarded as a mechanism extending resuspension to deeper waters, whereas in unaffected areas resuspension is limited to the near-shore zone (of less than 30 m depth).

Measurements of nutrients, key elements and organic micropollutants gave the following results: Elevated nutrient load was observed in the bottom boundary layer suggesting nutrient release from the seabed; relatively higher concentrations were observed in the storm season. The contribution of the benthic layer to the particulate organic matter of the water column greatly exceeded 20%, reaching 40% in some cases. Enrichment was observed for all the organic pollutants close to the sea floor. Anthropogenic (trawling) and natural (storms) resuspension caused elevated values of organic pollutants in the water column, whereas in sediments no differences were observed in the three sampling periods.

A net decrease in primary and bacterial production was observed during the trawling period. Increased primary production and chlorophyll in the deeper layers were found, whereas the bacterial production showed a surface and a near bottom maximum. Sediment resuspension favors the hatching of zooplankton eggs and build-up of inoculum cysts on the sea-bed. However, the resuspension-induced hatching appears to take place in non-suitable environmental conditions, as the timing of hatching induced by exogenous factors is crucial for benthic-pelagic coupling.

Regarding the impact of resuspension on the benthopelagic coupling, macrofaunal and biomass abundance did not appear affected, while no short term trawling impacts on meiofauna were observed. Significant effects on the community structure of nematodes were recorded. Trawling activities had a minor impact on organic matter biochemical composition and bioavailability compared to natural resuspension – benthic survivors compensate for the effects of trawling, while trophic conditions do not change markedly.

Human and natural resuspension cause changes of suspended organic loads of the comparable magnitudes. Prolonged storms had a major impact on the biochemical composition of suspended particulate organic matter (POM). The increase in POM concentrations occurs together with a general increase of bioavailable organic C, which could exert a major impact on POM early diagenesis. Dredging decreases bacterial and nanobenthos abundance, followed however by a rapid functional response after disturbance. Trawling and natural resuspension lead to a shift towards a smaller benthic cell size composition. Sediment resuspension increases rates of C mineralization.

Finally, resuspension events may exert influence on the chemical forms of the contaminants and thus on their bioavailabilty and their toxicity. Natural resuspension reduces the food value of both sedimenting and sedimented POM, which affects the absorption efficiency by the mussel *Mytilus galloprovincialis*.

**Potential exploitation by end users**

The potential exploitation of the project results may take place at two levels:

*1. Mediterranean/European level:*

The results of INTERPOL are of direct interest to multinational bodies, which share responsibilities for monitoring and managing European aquatic environments through international treaties such as the International Council for the Exploration of the Sea (ICES) and the Barcelona Convention on the Mediterranean Sea.

One of the major end users of the INTERPOL project is the United Nations Environmental Program – Mediterranean Action Plan (UNEP/MAP). INTERPOL could provide the lead in the specific sampling procedure for estimation of pollutants and nutrients due to resuspension.

Other important end users of the project will be integrated marine forecasting systems currently under development through a series of E.U.-funded projects (e.g. MFS, MFSTEP, ERSEM) in the framework of GOOS-related initiatives (MEDGOOS, BOOS, NOOS) aiming to provide tools for an efficient management of marine resources through monitoring and forecasting of hydrodynamic as well as ecological properties of the regions of interest.

European marine waters are subjects to transboundary conditions where EU has to meet certain international agreements and obligations. The EU environmental policy will directly benefit from the INTERPOL project, since it will provide increased understanding for the development of Harmful Algal Blooms (HABs), through the information for the existing cysts population.

*2. Regional/Local level:*

The results regarding the existence in the sediments of resting stages of phytoplankton cells that can be resuspended and initiate HABs will be useful to local decision makers and authorities such as the Ministry of Environment, Prefecture of Thessaloniki–Department of Fisheries, and Public Health Services, to protect public health and affected resources.

The final outcome of the INTERPOL project will enable local decision makers to implement the scientific results on the effects of anthropogenic and natural resuspension in modifying the current policy regarding coastal activities that could cause resuspension (like trawling) towards more efficient and less offensive policies.

# Role of microbial mats in the biodegradation of oil and hydrocarbons in the coastal zones - (MATBIOPOL)

*Caumette, P.*

University of Pau, Department of Biology, BP 1155, F-64013 PAU cedex

| | |
|---|---|
| Contract No: EVK3-CT-1999-00010 | Project duration: 02/2000 – 01/2003 |
| Project budget: € 2470 100 | EC contribution: € 2 100 900 |
| Website: http://www.univ-pau.fr/RECHERCHE/MATBIOPOL | |

**Objectives:**

The research programme "Role of microbial mats in bioremediation of hydrocarbon polluted coastal zones" (MATBIOPOL) is an interdisciplinary project as a consequence of its focus on the scientific interface between sedimentary chemistry, biogeochemistry, hydrocarbon chemistry, biochemistry, microbial ecology, microbial physiology and molecular biology. It will address the key question: How do hydrocarbons behave when crude oil is spilt in ecologically sensitive coastal areas and how can microbial mat systems be exploited for the bioremediation of such oil polluted coastal marine environments?

Recent studies showed that such mats played a significant role in the bioremediation of oil polluted coastal areas of the Arabian Gulf during the 1991 Gulf war as well as in coastal hypersaline areas – Sabkhas along the Red Sea and the Persian Gulf. Microbial mats rapidly covered entire areas of oil polluted sediment and hydrocarbon degradation was important. Both aerobic and anaerobic biodegradations were observed. A prerequisite is, however, a detailed knowledge of how hydrocarbons are metabolized and degraded in microbial mats, in order to assess the role and use of these microbial mats for bioremediation of oil polluted sediments.

**Results:**

The programme combines several specialist fields of research, including chemistry, biogeochemistry and microbiology. In particular, MATBIOPOL involves an intensive study of selected microbial mat systems and their response when subjected to varying levels of pollution by crude oil or selected hydrocarbon molecules. Three types of microbial mats are regularly investigated by the participants: Camargue Area mats (France), Delta del Ebro mats (Spain), Scapa Flow mats (Scotland). In addition, a parallel study is done in stabilized Solar Lake mats in mesocosms maintained at the marine research station in Eilat (Israel).

The research programme is organised into four workpackages:

Ecosystems level (Workpackage 1): Microbial mat ecosystems: fields studies and crude oil degradation: Analysis and comparison of different microbial mats (biogeochemistry with standard and microsensor techniques; microbial diversity with microscopy and molecular biology techniques) subjected to hydrocarbon pollution.

Community level (Workpackage 2): Mesocosm studies of the biodegradation of selected hydrocarbon molecules in a controlled microbial mat (aromatics or alkanes).

Organismic level (Workpackage 3): Microbial diversity and physiology of isolated bacteria from microbial mats subjected to oil pollution: Physiology of the isolated microorganisms of ecological importance in hydrocarbon degradation in the mats (cyanobacteria, anoxygenic phototrophic bacteria, sulfate-reducing bacteria, denitrifying bacteria, aerobic, microaerophilic and fermentative bacteria).

Sub-cellular level (Workpackage 4): Biodegradation of hydrocarbons by selected bacteria and analysis of metabolic pathways of hydrocarbon degradation in selected microorganisms (biochemistry of oxygenases in aerobic metabolism, anaerobic enzymes).

Two crude oils have been selected for degradation studies, Casablanca and Maya. The former has low viscosity and low sulphur content, its characteristics being similar to widely used oils such as Arabian light or Kuwait. The second is viscous and contains more than 2% of sulphur, constituting one representative example of the sulphur-rich oils which are more persistent in the environment upon eventual spillage. The aliphatic and aromatic composition of these two oils show that they are mature and non-biodegraded. The former was sourced from a carbonate rock and the latter likely originated from evaporitic source rocks.

Laboratory ecosystem experiments involving the spillage of these two crude oils on microbial mats have shown a transformation of the *n*-alkanes up to $C_{35}$. Isoprenoid, branched alkanes and cycloalkanes were not or only slightly degraded. In the aromatic fraction there were some changes in the naphthalene, fluorene and phenanthrene as well as in their methylated compounds.

**Potential exploitation by end users:**

Biological degradation of oil components under oxic conditions in mats is intense: when the microbial mats in coastal zones are fully covered by oil, they react by growing above the oil after few weeks of exposure. The filamentous gliding cyanobacteria grow through the layer of oil up to the surface and form a new bacterial layer above the oil. Thus the oil is trapped like "sandwich" between an oxic layer of bacteria above and an anoxic layer of bacteria below. This situation is favorable for a better biodegradation.

Mat systems from pristine environments change their community structure significantly upon contact with petroleum hydrocarbons and then form a matrix for a developing oil-degrading community: the cyanobacteria produces exopolysaccharides that form a matrix and act in bioemulsification of the oil. The aerobic bacteria degrading oil are more active in the matrix for the availability of oil components and due to high oxygen production by Cyanobacteria. In the mat, several bacterial types are selected mainly the aerobic genus *Marinobacter* and some sulfate-reducing bacteria.

Biological degradation of oil components under anoxic conditions in mat systems is slow and presumably highly selective, but influences the sulfur chemistry (sulfide formation, growth of sulfur oxidizing bacteria) of the mats: in the anoxic layers below the oil, sulfate-reducing bacteria are more efficient when they are cohabiting with purple sulfur bacteria, for a better but still low biodegradation.

The interactions between aerobic and anaerobic bacteria and processes at the microoxic/anoxic interface are more efficient for a good biodegradation but not yet fully understood: several molecules could by efficiently biodegraded including linear and ramified alcanes (hexadecane and pristane), polyaromatic compounds up to 3 aromatic cycles, sulfur compounds (dibenzothiophene). These molecules could be degraded even in aerobic conditions mainly by bacteria of the genus *Marinobact*er, and anaerobically with sulfate-reducing bacteria and denitrifying bacteria. This last process is very low however. The anaerobic biodegradation pathway is now better understood and some very important acting enzymes are now identified and the main process using the alkyl-succinate synthase is more distributed in several anaerobic bacterial groups than supposed.

Cyanobacteria are important structural elements in mats, even though their role in a direct biochemical attack of oil hydrocarbons is still unclear.

Thus, Microbial mats are very important for a good bioremediation of several coastal zones polluted chronically or accidentally by oil. These mats should be protected and maintained in such habitats.

The mesocosms utilized in this study are very efficient tools for assessing the impact of oil pollution in coastal microbial mats. They should be improved for their use in bioremediation processes

# Marine Effects of Atmospheric Deposition - (MEAD)

*[1]Jickells, T., [1]Spokes, L., [1] Weston, K., [1]Kelly, S., [2]Tjernström M., [2]Svensson, G., [2]Zagar, M., [3]Gustafsson, B., [3]Liljebladh, B., [3]Johnsson, M., [4]Sørenson, L.L., [4]Hasager, C., [4]Sempreviva, A.M., [4]Pryor, S., [4]Lund, S., [5]Conley, D., [5]Geernaert, G., [5]Pedersen, B., [5]Hertel, O., [5]Markager, S., [5]Carstensen, J. [5]Henriksen, P., [5]Lundsgaard, C., [5]Brandt, J., [5]Frohn, L., [5]Amberlas Skjødt, C., [5]Christiansen, T., [5]Jensen, B., [5]Sauerberg, K., [5]Martinsen, W., [5]Møller, B.*

[1] Environmental Sciences, University of East Anglia, Norwich UK; [2] Department of Meteorology, Stockholm University, Sweden; [3] Department of Oceanography, Gøteborg University, Sweden; [4] Risø National Laboratory, Roskilde, Denmark. [5] National Environmental Research Institute, Roskilde, Denmark.



| | |
|---|---|
| Contract Number: EVK3-CT-1999-00014 | Project Duration: Feb 2000 – Jan 2003 |
| Contact: t.jickells@uea.ac.uk | Web site: http://www.uea.ac.uk/env/mead |



**Objectives**

The overall objective of MEAD has been to describe the effects of atmospheric nitrogen deposition on surface water biogeochemistry.

**Results**

MEAD has documented that the phytoplankton community of the Kattegat responds to increased nitrogen inputs with increased biomass. We have documented that the atmosphere represents an important source of nitrogen to the Kattegat, particularly in summer. Oxidised (primarily nitrate and nitric acid) and reduced (primarily ammonia/ammonium) nitrogen are of approximately equal importance. This atmospheric input is regulated by a complex series of chemical and physical processes which can act to focus deposition into certain regions. These complex processes, coupled to the geography of the Kattegat, mean that atmospheric inputs are highly variable in space and time. Models developed and improved within MEAD can now describe reasonably well this complex deposition pattern.

In MEAD, the analysis of data sets from routine monitoring activities have been used to show for the first time the distribution and frequency of algal blooms in the Kattegat. Models developed in MEAD can simulate the pattern of algal activity seen in this area. The combination of MEAD field studies and modelling of the marine ecosystem, together with the retrospective studies of monitoring data, lead us to conclude that atmospheric deposition events are generally too small to trigger blooms in this region. Rather we conclude that mixing of nutrients from deep water is the primary mechanism responsible for bloom formation. However, atmospheric deposition does make an important contribution to the overall input of nitrogen to this region and hence contributes to the overall levels of phytoplankton activity and to eutrophication problems.

**Management Implications**

Globally nitrogen fixation has probably doubled as the result of human activities and nitrogen emissions have increased five fold. On a regional scale in Europe the increases have been greater than this, leading to real concern over eutrophication threats to coastal waters. It has been estimated that atmospheric inputs deliver 20->50% of the total input of reactive nitrogen from land to coastal waters and differ in many ways from riverine inputs. Effective management of coastal waters requires high quality scientific information on the magnitude and effect of atmospheric nitrogen inputs to coastal waters to inform policy makers.

In MEAD we have been able to evaluate the effects of various nitrogen emission control strategies on phytoplankton levels in the Kattegat. We show that regulation of local sources will primarily impact ammonia deposition, while Europe wide emission control will be required to reduce the input of oxidised nitrogen.

The methodologies and improved conceptual understanding developed within MEAD will provide a framework to evaluate the importance of atmospheric inputs in other European marine areas.

# An Integrated Approach to Assess the Mercury Cycling in the Mediterranean Basin - (MERCYMS)

*Pirrone, N.*[(*)]

CNR-Institute for Atmospheric Pollution, Division of Rende, 87036 Rende, Italy;
[(*)]Project Coordinator

| | |
|---|---|
| Contract No : EVK3-2002-00070 | Project duration : 10/2002 – 09/2005 |
| Project budget : € 2.527.331 | EC contribution : € 1.465.000 |
| Website : www.iia-cnr.unical.it/MERCYMS/project.htm | |

**Objectives**

The overall objective of MERCYMS is to investigate the major patterns affecting the cycle of mercury within and between the atmospheric and marine ecosystems of the Mediterranean basin by integrating modelling and experimental tasks. Specific objectives to be achieved are: (1) To improve our capability to model the fate of Hg in the marine environment and specifically its translocation from one compartment to the other; (2) To assess the qualitative and quantitative relationship between atmospheric input - direct discharges to the sea and cycle of Hg in the marine environment and its re-emission back to the atmosphere; (3) To develop an integrated modelling system to be used in the implementation of the EU Directives; (4) To apply this integrated modelling system for different environmental and socio-economic scenarios for the evaluation of optimal emission reduction strategies and control policies.

**Main Results**

The main expected results are:

1) A set of multiplayer databases reporting on (a) mercury emissions to the atmosphere from major anthropogenic and natural sources; (b) mercury releases to Mediterranean sea water from point and diffuse sources; (c) socio-economic database for major parameters needed in the scenario analysis.
2) Mercury speciation in the atmosphere and sea waters including sediments at off-shore and coastal sites for different seasons.
3) Integrated modelling tools (atmospheric-water-socio economic models) to evaluate different scenarios.
4) Socio-economic analysis

Results obtained up to now (first year) are:

1) Stand alone atmospheric model.
2) Stand alone water model.
3) Atmospheric and water measurements taken over the sea on board of the Research Vessel Urania for 28 days and at coastal sites during two intensive campaigns.
4) Databases for the atmospheric emissions and releases to Mediterranean waters.

**Potential exploitation by end users**

These methodologies and tools are clearly needed to support the implementation of the (a) EU Directive on Mercury, and of (b) EU Framework Water Directive and support their implementation plans. It will help achieve the targets and goals of several international conventions and programmes on the protection of marine ecosystems and environment (i.e., MEDPOL, HELCOM, OSPARCOM) and will represent the EU contribution to the on-going initiatives of the United Nation Environment Programme (UNEP) addressed to prepare the

"*Global Assessment of Mercury Pollution*". MERYCMS is part of the ELOISE cluster which represents the largest contribution of the EU to the IGBP programme, specifically to the core projects of IGBP-LOICZ and IGBP-IGAC.

# Multiparametric in-situ Spectroscopic Measuring Platform for Costal Monitoring - (MISPEC)

*Schmidt H.[1], Maiwald M.[1], Gallasch L.-H.[1],. Kronfeldt H.-D*[1], Konat-Stepowicz J.[1], Lehaître M.[2], LeNoac'h A.[2], Pfannkuche J.[3], Amann H.[3], Esteban-Martínez O.[4], Navarrete M.-C.[5], Díaz-Herrera N.[5], A. González-Cano A.[5], Bernabeu E.[5], Gibson C.[6], Mac Craith B. [6]*

[1]Optical Institute, Technical University Berlin, Germany; [2]Ifremer, Brest Centre, Plouzané, France; [3]Marine Technology, Technical University Berlin, Germany; [4]Department of Optics, Alcalá University, Madrid, Spain; [5]Department of Optics, University Complutense Madrid, Spain; [6]Optical Sensor Laboratory, Dublin City University, Ireland, * kf@physik.tu-berlin.de



| | |
|---|---|
| Contract No : EVK3-CT-2000-00045 | Project duration : 03/2001 – 02/2004 |
| Project budget : € 2.051.199 | EC contribution : € 1.703.748 |
| Website : www.physik.tu-berlin.de/mispec/ | |



**Objectives**

Pollution is a growing problem for marine costal zones mainly due to increase of the environmental impact of human activities in the catchment's areas. Therefore fast and efficient in-situ methods are required for monitoring of the marine environment. The main objective of this project was to provide a new type of multiparametric optical sensor system for in-situ marine water quality measurements. Central to this development is a platform for opical sensors sharing an underwater multichannel spectrometer and additional commercial probes.

**Results**

The MISPEC system is made up of an underwater core instrument (CI) which contained laser light sources and a multichannel spectrometer which is connected with three optical sensors (optodes) in a robust frame prepared to operate in-situ down to a depth of 300 m.

The system was tested successfully under real-world conditions during the field trials in the Baltic Sea on board of the vessel "Oceania" (owned by IO-PAS) and in the Atlantic Ocean on board of the vessel "Thalia" (owned by Ifremer). During cruises, the optodes: a surface-enhanced Raman scattering optode (SERS ) for detection of organic compounds (e.g PAHs) [1, 3, 4], a dissolved oxygen optode (DO) employing fluorescence quenching and a fibre-optic salinity sensor based on refractometry [2] worked according to a sequential protocol yielding multiple parameters on site and *in-situ*. Three measurement scenarios were successfully performed: stationary measurements (up to 6 h), depth profiles (down to 100 m), and towing experiments up to 4 knots on different areas. The results of DO and CTD optodes measurements obtained during the field trials shown good correlation with the data from the commercial probes. The "events" detected during stationary measurements proved that the SERS optode was suitable for observation of the rapid changes of organic compounds in the seawater.

### Potential exploitation by end users

The MISPEC system offers new possibilities for measuring the physical and chemical parameters, such as organic pollution in water *in-situ* with high spectral resolution. The fast response time of optical sensor would allow for monitoring of the rapid changes in water quality. This is relevant to understand the processes in the mixing zones of estuaries or coastal waters. In an emergency situation, when the rapid answer is necessary for example in ship accidents and spills, the system will allow to give early warning for endangered areas. Another usage of the device can be the routine monitoring of seawater quality parameters where the MISPEC system can act as an alarm system when background contamination levels exceed certain threshold. The core of MISPEC is a universal spectrometer. The light sources and the optodes are modular, can be replaced or arranged in various configurations and can operate under harsh conditions. It is therefore expected that future customers will also include groups interested in developing new sensing methods requiring such instrumentation. Expected customers are Environmental Pollution Agencies, Fishery Boards and coastal industries.

### References

[1] Schmidt H., Nguyen B. H., Kronfeldt H.-D (2002) Proc. 18$^{th}$ Int. Confer. Raman Spectroscopy, J. Mink, G. Jalsovszky, G. Keresztury, Wiley, p. 861-862

[2] Esteban O., Navarrete M.C., González-Cano A., Bernabeu E (1999) Applied Optics 38, 5267-71

[3] Lucht S., Murphy T., Schmidt H., Kronfeldt H.-D (2000) Journal of Raman Spectroscopy, 31, 1017-1022

[4] Schmidt H., Nguyen B.H., Pfannkuche J., Amann H., Kronfeldt H.-D., Kowalewska G (2003) Marine Pollution Bulletin (in print).

# Nitrate from Aquifers and influences on carbon cycling in Marine Ecosystems - (NAME)

*Postma, D, Andersen,M.S.*

Environment and Resources, Technical University of Denmark, Kgs Lyngby, Denmark

| | |
|---|---|
| Contract No : EVK3-CT-2001-00066 | Project duration : 12/2001 – 11/2004 |
| Project budget : € 2 000 000 | EC contribution : € 1 700 000 |
| Website : www.natur.ribeamt.dk/name | |

**Objectives**

Many of our near coastal waters experience periods of eutrophication, due to high amounts of nutrients leaching from the intense agriculture characterizing large parts of Europe. Eutrophication leads to algal blooms, deterioration of water quality, disappearance of biological niches and derived declines in species variety and sea-food production. Most of the nutrients presumably reach the sea via rivers and streams, but an unknown quantity possibly emerges directly into the sea through the sea bottom as nitrate-bearing groundwater. The overall objective of the NAME project is to resolve the importance of this nutrient input from nitrate bearing groundwater and into the marine environment by investigating the processes in detail at a suitable field site and then use the results as a benchmark for a broader evaluation of the problem at hand.

**Results**

Investigations are carried out at a common field site located near the village Hjerting, just north of the town Esbjerg at the Danish west coast and at the northern end of the Wadden Sea. At this location a sandy aquifer is situated adjacent to a tidal flat area. The fields on top of the aquifer are used for agriculture. The regional groundwater flow pattern is directed towards the sea and nitrate-bearing groundwater was expected to discharge into the marine environment.

The geological structure and the hydrogeological conditions in the aquifer adjacent to the shoreface were studied using hydrogeological and geophysical methods. The results are being used to determine groundwater flow paths and velocities and to establish a groundwater flow model. The pattern of freshwater discharge through the shoreface was mapped using underwater multi electrode profiling (UMEP). The results showed freshwater discharge to occur in a narrow and discontinuous belt along the shoreface.

The upper groundwater contains abundant nitrate with concentrations up to 1.5 mM. At the shoreface and through the intertidal zone nitrate-bearing groundwater discharges with a very high spatial variability. Denitrification, were nitrate is reduced by microorganisms to free nitrogen gas occurs both in the groundwater zone and in the intertidal marine sediments. This reduces the input of nitrate into the marine environment significantly.

There is a parallel effort to develop the modeling tools required to describe the processes going on at the interface between the groundwater and the marine environment. This comprises both physical transport processes of groundwater discharge in the marine environment considering the differences in salinity and density as well as the biogeochemical processes that affect nitrogen cycling. Modeling tools range in scale from detailed field site process models to regional groundwater flow and nutrient cycling models.

The scientific achievements obtained during year 2 can be summarized in the following points:

- Hydrogeological mapping has been completed and hydrogeological heterogeneity has a strong control on the freshwater discharge through the shoreface and intertidal zone.
- Mapping of the groundwater nitrate distribution has been completed. The nitrate content of the groundwater discharging through the shoreface and the intertidal zone shows considerable spatial variation.
- Denitrification appears to remove most nitrate from the groundwater before it enters the marine environment and mixes with seawater.
- Rates of denitrification show a high spatial variation but tend to be higher in the marine sediment as compared to the aquifer.
- A process model (MEDIA) to describe early diagenesis in the marine environment has been completed.

**Potential exploitation by end users**

There is hardly any doubt as to the position that a "clean" environment is a valuable resource in coastal areas for recreation, tourism as well as fishery. A "clean environment also significantly improves the quality of life for the residents. At the same time, a prosperous agriculture is a valuable asset in coastal areas as well. For a sustainable ICZM (Integrated Coastal Zone management) these different aspects should be viewed in a holistic way, firmly rooted in an understanding of the environmental systems involved. The NAME project aims at increasing the required understanding of the interrelationships between agricultural activities and the coastal marine environment with respect to nutrients. NAME is structured towards implementing the obtained results directly into local monitoring systems

Apart from ICZM, NAME has relevance for the EU Directive 91/676/EEC as it helps to identify the effect of nitrate bearing groundwater on coastal euthrophication. NAME has also significance for the Water Framework Directive which requires River Basin Management Plans that include adjacent coastal areas.

# Sand Transport and Morphology of Offshore Sand Mining Pits/Areas - (SANDPIT)

*Leo C. van Rijn[1], Richard Soulsby[2], Piet Hoekstra[3] and Alan Davies[4]*

[1]Delft Hydraulics, Netherlands; [2]HR Wallingford, UK; [3]University of Utrecht, Netherlands; [4] University of Bangor, UK



| | |
|---|---|
| Contract No : EVK3-2001-00056 | Project duration : 04/2002 – 04/2005 |
| Project budget : € 5.160 000 | EC contribution : € 3.377.000 |
| Website : //sandpit.wldelft.nl | |



## Introduction

Massive mining of sand from the middle and lower shoreface (depths of 10 to 30 m) in large-scale mining and borrow pits/areas will be required in future in many European countries to nourish beaches and coastal dunes in response to increased coastal erosion due to the expected sea level rise. Furthermore, the large-scale reclamation of land and the construction of large-scale artificial islands (for industrial purposes; ports and airports) in coastal seas which are presently being considered, will also require huge amounts of sand as building material. Given the scale of these undertakings, the volume of sand required in the near future (10 to 20 years) will be of the order of 100 to 1000 millions $m^3$ per country surrounding the Atlantic Ocean, North Sea and Mediterranean.

Large-scale mining pits by dredging in artificial sand pits or by removal (dredging) of existing sand banks/shoals will have a significant impact on the near-field and far-field (up to the coast) flow and wave patterns. The pit will act as a sink for sediments originating from the surrounding areas and depending on the local flow and wave patterns. Hence, erosion of the sea floor will take place in the (immediate) surrounding of the pit. Furthermore, the mining/dredging and dumping of sand will have various direct and indirect short and long term effects on marine and coastal benthic communities of plants and animals (ecology).

## Objectives, research topics and project organisation

The general objective of the SANDPIT project is to develop reliable prediction techniques and guidelines to better understand, simulate and predict the morphological behaviour of large-scale sand mining pits/areas and the associated sand transport processes at the middle and lower shoreface and the surrounding coastal zone. The basic research philosophy of the SAND PIT Poject is:

### Research on sand transport

- execution of field and laboratory experiments to fill missing gaps of existing databases (WP3),
- improvement of detailed research sand transport models (WP4),
- improvement of practical sand transport models using the results of field/laboratory experiments and of detailed process models (WP4),
- implementation of practical sand transport models in a community sand transport model (WP4),
- implementation of community sand transport model in morphodynamic models

### Research on morphology

- application of improved morphodynamic models to evaluate the morphological behaviour of sand banks at middle and lower shoreface, (WP4),

- application of improved morphodynamic models to evaluate the behaviour of sand mining pits at middle and lower shoreface (WP4),

**Practical guidelines**

Integration of all results into practical guidelines and tools for use by various types of end-user, such as coastal managers, consultants, contractors and modellers

**Organisation**

The scientific and practical work is being undertaken by the individual partners (17 participating institutes and universities from 7 European countries) within a workpackage structure. There are four main workpackages:

- ***Workpackage 1:*** Project management and dissemination of results;
- ***Workpackage 2:*** Practical guidelines and tools;
- ***Workpackage 3:*** Data sets on sand transport and morphology;
- ***Workpackage 4:*** Development, improvement and validation of predictive tools of sand transport and morphology.

**Results**

The study results sofar can be summarized, as follows:

***WP 2***

- management approach to problems of large scale sand mining,
- regulation tables and scenario testing procedures,

***WP 3***

- literature reviews on field and laboratory data sets for benchmarking,
- field experiments of Spring and Autumn 2003 campaign in the North Sea,
- experimental programmes of laboratory tests,

***WP 4***

- inventory of sand transport models and morphological models,
- inventory of ripple prediction methods,
- identification of benchmarking datasets on sand transport and morphology based on laboratory and field data collection in WP3,
- benchmarking computations on morphology of pits using existing models,
- improvement of sand transport and morphological models,
- first version of shell for community sand transport formulations.

**Potential exploitation by end users**

The results of the SANDPIT Project will represent a major technological advance with respect to the knowledge of mining-related morphological processes and associated sand transport processes at the middle and lower shoreface. This will be beneficial to the communities living and working in coastal regions. Enhanced morphological stability of these areas will enhance local investments and, hence, local employment. The results of the project will be shared by the organisations and their experts dealing with shoreface and coastal problems in seven European countries bordering the Atlantic Ocean, North Sea and the Mediterranean Sea. The following organisations and groups will be involved in the exploitation of results:

- National Authorities, Departments and Agencies in the participating countries,
- Consultants and Scientific community (research institutes, universities).

# Seafloor Imaging and Toxicity: Assessment of Risk caused by buried waste – (SITAR)

*Caiti, A.[1], Gelaziene, L.[2],Blondel, P.[3], Zakharia, M.[4], Karasalo, I.[5], Nilsson, A.[6], Dybedal, J.[7], Hovem, J.M.[8], Balk, L.[9], Jonsson, P.[10].*

[1] ISME – Interuniversity Ctr. Integrated Sys. Marine Env., Italy; [2] ECAT, Env. Ctr. Administration and Tech., Lithuania; [3] Dept. of Physics, Univ. of Bath, United Kingdom; [4] Naval Acad. res. ctr. , France; [5] FOI, Swedish Defense Research Agency, Sweden; [6] KTH, Royal Institute of Technology, Sweden; [7] KDA, Kongsberg Defense and Aerospace, Norway; [8] NTNU, University of Trondheim, Norway; [9] Stockholm University, Sweden; [10] Swedish Environmental Protection Agency, Sweden. Contact point: caiti@dsea.unipi.it (Andrea Caiti, ISME)

| | |
|---|---|
| Contract No : EVK3-2001-00047 | Project duration : 01/2002 – 12/2004 |
| Project budget : € 3 181 255 | EC contribution : € 2 112 723 |
| Website : www.isme.unige.it/sitar | |

**Objectives**

SITAR's goal is to investigate and develop innovative solutions to the technological and scientific problems that up to now have prevented the assessment of the environmental risk connected with toxic dumpsites in the seafloor, where a significant part of the toxic waste is buried within the bottom sediments. Currently, the major obstacle to risk evaluation at a given dumpsite is due to the fact that state-of-the-art technology has been proven ineffective at determining extension and location of buried dumped containers, and potential or already present toxic effects due to bioaccumulation and prolonged exposure to contaminants. Lack of a reliable mapping of a given dumpsite, and failure in assessing in situ bioaccumulated toxicity, may ultimately lead to erroneous decisions in monitoring and management of the dumpsite, with severe environmental and economic consequences for the marine life and human related activities. Specific objectives include:

- development of acoustic methods and instrumentation for imaging of waste containers of small dimension buried in unconsolidated sea sediments;
- development of biological testing methods to determine the relative in-situ bio-accumulated toxicity at a contaminated site;
- integration of the acoustical imaging data and of the biotoxicological information accordingly to end-users (decision makers) needs.

**Results**

At the moment of writing, SITAR has reached the beginning of the third project year. Though no final result has been reached yet, the main steps toward a positive project conclusion have been accomplished, including a major sea trial in the period Sep-Oct 2003. In the following, the scientific developments pursued within SITAR are reported in relation to the needs of dump-site survey and investigation; these include the stages of localization, inspection, bioassessment, data integration and evaluation.

*Localization:* SITAR is developing a bottom penetrating parametric side-scan sonar (SSS) instrument, that acoustically image the sub-bottom by using both high and low frequency signals. The instrument is complemented with innovative 3-D synthetic aperture sonar processing (SAS), to enhance data quality and facilitate image interpretation. A prototype has been tested in the field on Sep-Oct 2003, over an existing dump site in the Baltic Sea. SAS processing is currently on-going.

*Inspection:* once localized, a potential waste container has to be inspected to assess its true nature and hazard. Video inspection is ineffective on buried containers. SITAR is developing an acoustical imaging technique based on Multiple Aspect Scattering measurements (MAS) from the buried container. Scaled tank experiments to test the technique in controlled conditions have been completed. Field data have been collected in the Sep-Oct 2003 cruise.

*Bioassessment:* SITAR efforts are focused on bioaccumulated toxicity evaluation, in contrast with traditional acute toxicity analysis. The project is developing and testing the technique of nanoinjection into fertilized fish eggs of extracts from bottom samples. The observed percentage of growth disorders, when compared with the percent disorders resulting from extracts of a known reference site, gives a relative measure of accumulated toxicity. The technique mimics maternal exposure and food uptake. It is species and pollutant independent. Analysis of samples from the study site is on-going.

*Data integration and evaluation: a* GIS-based data presentation system is being developed, on end-users specifications. The GIS system includes a Decision Support System (DSS) for buried containers image analysis and inspection. The DSS works on 3-D images from the MAS data, with tools as 3-D acoustic image segmentation, feature extraction, rendering and virtual navigation. The overall GIS system includes at the moment the historical data at the survey site, plus the first processed data made available from the experiment.

**Potential exploitation by end users**

SITAR results can be exploited from two different perspectives:

- transfer of scientific results to technological implementation, and exploitation of technological results toward market possibilities;
- exploitation of overall project results for actions toward implementation of EU and international treaties requirements, to which the project intends firstly to respond.

In particular, the acoustic imaging methods developed are the basis for industrial development of equipment for ocean exploration at the moment not matched by any existing oceanographic instrument. They will allow for an efficient, non-invasive, safe and cost-effective oceanographic campaign not only as related to toxic dumpsite, but also for other relevant marine applications, as rescue operations, off-shore and geotechnical activities, marine archaeology. The bioaccumulated toxicity testing system is providing improved means for ecosystem monitoring, realistically reflecting environmental exposure to harmful substances; it may pave the way to long-term monitoring and standard testing procedures without need of previous knowledge on the nature of presumed pollutants. The integration of the acoustical imaging and of the biotoxicity data in a common presentation protocol may eventually lead to products and initiatives for the thematic mapping of seabed dumpsites and associated environmental risk in the European seas.

As for policy implementation, SITAR programme of work has been developed as a response to the Helsinki Commission recommendations: referring to post-WW II chemical munition dumpings in the Baltic Sea, it asked for determination of the amount of toxic waste buried within the sediment, and in situ investigation of the toxicity and bioaccumulation effects. SITAR results are making it possible to meet these requirements, identified as the more detailed specifications of actions to assess the threat posed by toxic dumpsites. Moreover, SITAR results will allow for the implementation of risk prevention and monitoring measures prescribed by the European regional seas conventions: toxic dumpsite in the seabed are encountered also in the North Sea and in shallow basins of the Mediterranean Sea.

**References**

[1] Ad Hoc Working Group on Dumped Chemical Munition (1994) *Report on chemical munitions dumped in the Baltic Sea*, report to the 16th meeting of the Helsinki Commission.

# Automatic Surface Pollution Detection: low cost automatic oil on water detection – (SPOT)

*Hlebarov, V [1], Chamberlain, D.[1], Gambao, E.[2]*

[1] City University - London, UK; [2] Universidad Politécnica de Madrid, Spain;

| | |
|---|---|
| Contract No : EVK3-2002-30003 | Project duration : 2/2003 – 2/2005 |
| Project budget : € 1 301 946 | EC contribution : € 650 922 |
| Website : http://www.disam.upm.es/spot/ contact: Vejen@mailexcite.com | |

**Objectives**

Economical and reliable detection of water borne pollutants is an important issue in industries such as petro-chemical, pharmaceutical, shipping, farming, water supply and recreation. The major pollution detection issues in the European Community are (i) economic loss caused by leakage of valuable products, (ii) waste water and groundwater pollution and (iii) large-scale explosion hazards.

The main objective is to design a new, low cost, automatic water borne pollution detector of a general-purpose nature. Whilst it is primarily aimed at oil-on-water detection, it will be applicable to a wide range of water pollution problems.

The primary technical objective of the project is to apply image-processing technology to the detection, recognition and quantification of separated pollution-on-water (or just below surface).

**Results**

Regarding oils, there are two types of oil-water condition, emulsified oil-in-water (<20 microns) and separated oil-on-water. Apart from a few cutting oils, which are stable emulsions, all oil, and numerous other pollutants predictably separate to the water surface.

Monitoring an area (10-50 sq. cm) from the water surface is much more reliable for early detection, and alarming system for pollution protection rather than monitoring just a single point. Also many new parameters have been extracted from the image. They can be used for prediction, continues measurement of the pollution level and approximate location of the pollution source (examinations of the oil spots features).

Applying different image segmentation techniques and manual observation, different new features has been extracted [1].

Despite the positive results several milestones prevented the industrial implementation of the system using visual light source as:

- requirement for perfect lighting conditions,
- needing of calm water surface,
- complicated mathematical algorithms,
- low visual noise requirement.

We proposed new physical approach for enhanced separating oil on water. It is based on fluorescence response [2] of the oil spots. This method reduces significantly the mathematical calculation for oil extraction by minimising the ratio signal/noise in the captured frame (Figure 2). The system (using UV source 1W light power) for monitoring area of 45 sq. cm has been developed and tested. It uses synchronous capturing method and can be powered from battery and operate remotely by transferring data via radio frequency.

The experiments have been provided in special water tank on similar to real conditions (water waves with turbulence). It has been experimented with different oil pollutants, different capturing regimes and light sources.

New mathematical algorithms have been developed and applied for continuous capturing and calculating of the water pollution. They allow extracting of different parameters and create possibilities for further experimenting. Some of these features extracted from the physical behaviour of the oils spots (shape of the oil spots, activity of the spots, intensity and size) can be used for further pollution assessment as time from the pollution occurs and type of the pollutant.

The implementation of our approach has been done in enclosed floating pod.

The floating pod presented on (Figure 1) reduces further the noise form external light sources, allows continuous (during day light), remote capturing of the oil pollution and can accommodate other detectors.

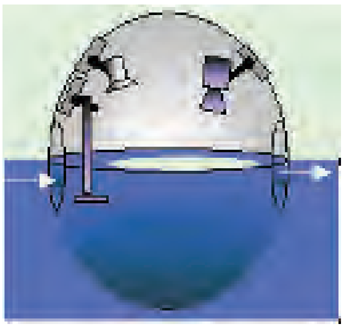


*Figure 1: Floating detection pod*

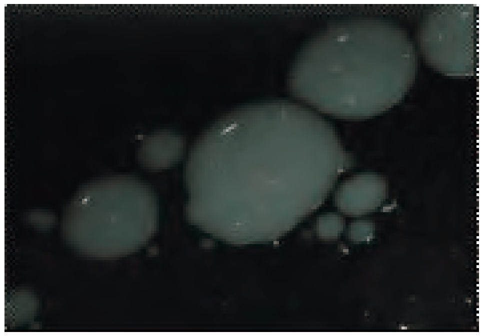


*Figure 2 Captured Oil pollutant (5cm sq.)*

Based on these new principles the detector is attractive for industry due to:

1. An affordable, portable/re-locatable and continuous monitoring system with high sensitivity [1-5 ppm].
2. Simultaneous recognition and quantification of individual products (e.g. type of oil, fat etc) rather than data on film thickness and the presence of specific molecules.
3. A general purpose solution in different formats for channels, open water, large pipes, hatchway access, etc.
4. High level sensor data interpretation with flexible access e.g. via secure Internet server.
5. Automatic prediction of critical levels and alarms based on trends in historic data.
6. Compatibility with production plant control systems.
7. Prediction and prevention of explosion hazards.

**Potential exploitation by end users**

Industrial needs for monitoring are found in oil-produced water, process water, non-contacting cooling water, ship ballast water, industrial wastewater, hydroelectric water, storm water, municipal wastewater, potable water and recreational water.

The system, suitable for continuous monitoring (several days), prediction and statistical measurement also creates possibilities for unique early detection alarm.

The possibilities to transfer real picture of the pollution area gives possibilities the pollutant to be assessed remotely by specialist.

The detector size (less than 70 $cm^3$ and less than 25kg), makes it easy for transport and relocation. It can be used as measurement device from laboratories, plants or environmental organisations.

**References**

[1] Hlebarov V.V.,(2000) A pilot investigation into image capture for moving oil-on-water, Research Report SRC-7/00, Structures Research Center, Department of Civil Engineering, City University.

[2] Aronstain, D. ,Bennink, R., Boyd, W., Stroud, C. (2002) Physical review A, Vol. **65**, 067401

# Transport, Reactions and Dynamics of Heavy Metals in Contaminated Marine Sediments - (TREAD)

*Finke N[1], Davison W[2], Geelhoed JS[4] Glud RN[3], Larsen O[1], Muyzer G[4], Sochaczewski L[2], Staahl H[3], Tankere-Muller SPC[2], Tengberg A[3], Toes ACM[4], Vamvakopoulos K[1], Zhang H[2]*

[1]Max-Planck Institute for marine Microbiology, Germany, [2]Environmental Science Department, Lancaster, UK, [3]Marine Biological Laboratory, Helsingør, Denmark, [4]Dept. of Biotechnology, Delft University of Technology, Delft, Netherlands

Contact: nfinke@mpi-bremen.de (N. Finke) or jwesnigk@mpi-bremen.de (J. Wesnigk)

| | |
|---|---|
| Contract No : EVK-CT-2002-00081 | Project duration : 11/2002 – 10/2005 |
| Project budget : € 1 670 000 | EC contribution : € 1 380 000 |
| Website : http://www.mpi-bremen.de/deutsch/euprojects/Tread/ | |

## Objectives

Heavy metals are a common pollutant in coastal marine sediments especially in harbour regions. Recent studies have shown that the concentrations of tin and copper, the two main components of anti fouling paints, are often highly enriched. To date, little is known about the small scale effect of high metal concentrations on biotic activity in the sediments. The processes that affect the speciation of heavy metals in sedimentary environments have so far not been investigated with a spatial resolution similar to the existing microenvironments. The main objectives of this project include:

- Detailed study in a marine system allowing to understand and numerically model heavy metal interactions and transport in three dimensions at the micro scale that controls the processes
- To enable environmental regulations and practise to be founded on true process understanding by establishing a network between decision makers, end-users and scientists

## Results

Within the TREAD project, the microbial activity regarding processes that effect the redox speciation of heavy metals are investigated in combination with measurements of the metal content and molecular biological and microbiological studies of the bacterial community. The main innovation here will be the combination of different high resolution measuring techniques. This will allow simultaneous measure of multiple parameters at the same spot with a high spatial resolution. Thus the effect of microniches on the geochemical parameters and the heavy metals in particular can be studied including the identification of the bacteria active in the microenvironment. The sediments investigated in the experiments accrue from two different environments.

One is a sandy intertidal sediment with low metal concentrations from the east coast of the German island Sylt, the second a fine silt from a basin of a northern metal contaminated German industrial harbour. The experiments are carried out in four flumes. Two contain “undisturbed” sediments from each of the two sites. The third contains homogenised harbour sediment to mimic dumping of dredged sediment. In the fourth flume harbour sediment was added to the sand to simulate dumping of polluted sediments in a region with higher bottom water currents and less polluted sediments.

Over the course of the experiment different parameters of the system will be changed to simulate different scenarios. The first step was the introduction of macrofauna (Nereis diversicolor) to the system to monitor the effect of bioturbation.

High resolution measurements of heavy metals and oxygen in the porewater shows not only a vertical but also a lateral heterogeneity, indicating the presence of microniches even in the homogenized sediments.

The microbial community of the sediments is investigated by DGGE (denaturing gradient gel electrophoreses), FISH (flourescence *in situ* hybridization) and with classical culturing techniques. The combination of these techniques will allow to identify the important microbes in the sediment, study their spatial resolution and their physiology including the response to metal stress.

The experimental results will be used as input data to a software model and to calibrate and verify it. This model will allow to predict distributions of metals in the sediments at a high resolution and changes of the speciation as a result of changes in the surrounding environment (e.g. temperature, dredging, bioturbation etc).

**Potential exploitation by end users**

There is hardly any doubt that a “clean” marine environment is a valuable resource. At the same time, prosperous harbour activities are valuable assets in coastal areas. For a sustainable ICZM (Integrated Coastal Zone Management) these different aspects should be viewed in a holistic way, firmly rooted in an understanding of the environmental systems involved. The TREAD project aims at increasing the required understanding of the interrelationships between harbour activities and the coastal marine environment with respect to heavy metals and organic matter turnover.

At present the rules governing polluted harbour sediments varies throughout Europe. This is particularly important for economically large harbours. Sediment with a given level of pollution may in one country be dumped in the marine environment whereas it in other countries must be treated as chemical waste. TREAD is structured towards implementing the obtained results directly into local monitoring systems and legislation.

# LAND OCEAN INTERACTIONS

# Centre for Environmental Engineering and Mechanics - (CEM)

*Sulisz, W.*[1]

[1] Institute of Hydro-engineering of the Polish Academy of Sciences, Poland

| | |
|---|---|
| Contract No : EVK3-CT-2002-80009 | Project duration : 12/2002-11/2005 |
| Project budget : € 1129048 | EC contribution : € 371918 |
| Website : www.ibwpan.gda.pl/cem/ | |

**Objectives**

Objectives of the Centre for Environmental Engineering and Mechanics (CEM) are realised within the following two thematic groups:

- sustainable management of inland and transitional waters;
- near-shore processes and sustainable coastal engineering.

The fundamental objective of the Centre is the contribution to the integration with the European Research Area (ERA) through networking, exchange and transfer of knowledge (by organising workshops, summer schools, study visits from both sides).

The other detailed objectives of the Centre are as follows: transfer of knowledge from research institutes to Polish organisations responsible for water resources' management; establish and re-establish co-operation with other Centres from NAS, Russia and the Ukraine; attract junior and senior researches; support applications for new projects in collaboration with ERA and participation in already existing projects; take advantage of existing research facilities in Poland (wave flume, CRS Lubiatowo) in the organisation of study visits, workshops, and summer schools; transfer new ideas in sustainable water management, flood protection and in particular upgrading of water quality based on the principles of the Water Framework Directive and other EU directives.

**Results**

All activities of the CEM are divided into seven groups. Below brief overview of the results achieved in the first year of the project is given.

1 – Promotion

The main objective is the promotion of CEM activities to establish or re-establish cooperation with institutes from ERA, NAS and administration responsible for water management on local, regional and national level. A web-page with information about most important events was established (http://www.ibwpan.gda.pl/cem/). A number of presentations during conferences, seminars and meetings has been done to spread the information on CEM, its plans and activities carried out.

2 - Networking with ERA

Co-operation with Germany (*Institute of Hydrology GSF* - Munich) was re-established, creating possibilities for future joint scientific activities. Some effort was put into creating new contacts with UK (*Cambridge University*, *Engineering Department*), France (*Ecole Superieure d'Ingenieurs de Marseille - Departament Hydrodynamique*), Portugal (*Instituto Superior Técnico* - Lisbon) and the Netherlands (*Dutch Ministry of Water Management and Public Works - RIKZ*).

3 - Twinning with wl|delft hydraulics

One of the main achievements of the first year was signing the Agreement for Co-operation that creates a good platform for co-operation with Dutch institutes for the next years. Extension of software and training session were important steps in capacity building in the domain of modelling sediment transport in inland and transitional waters. A background for study visits for the next years was settled.

4 - Networking with NAS, Russia and the Ukraine

The first year of CEM activities resulted in re-establishment co-operation with the *Institute of Hydrology Slovak Academy of Sciences* in Bratislava. Co-operation with two Russian institutes was re-newed (*Shirshov Institute of Oceanology, Atlantic Branch* – Kaliningrad, and *Shirshow Institute of Oceanology, Southern Branch* –Gelendzik). Contacts with *Institute of Oceanology of the Bulgarian Academy of Sciences* from Varna, and *University of Odessa* (Ukraine) were very much facilitated by the school *Coastal Zones '03* in which representatives from those institutes participated.

5 – Workshops

In the first year of CEM project one workshop *Water quality measurements in the Pomeranian region – recent status – year 2002* was organized, in the form of scientific session gathering representatives of administration on local and regional level, as well as scientists from a number of institutes from the region. This workshop gathered participants representing local administration of cities (Gdansk, Sopot, Gdynia) and Pomeranian Voivodeship responsible for environmental protection in the region, marine administration, Regional Water Board and scientists from University of Gdansk, Institute of Meteorology and Water Management, Institute of Marine and Tropical Medicine, Maritime Institute, Institute of Hydroengineering PAS.

6 - International summer schools

In the first year of the project summer school *Coastal Zones '03* was organized. It had two major goals: (1) to the present Coastal Research Station Lubiatowo and its research potential in order to integrate it with similar European facilities, to enable participation in the future EU research projects; (2) to discuss on current problems related to waves, near-shore current circulation, sediment transport, coastal morphology and shore protection. The school was attended by 44 researchers from various EU countries (France, Germany, Italy, the Netherlands, Spain, Sweden, UK) and from NAS joining EU soon (Poland) or within a few years (Bulgaria), as well as from Russia, Ukraine and Vietnam.

7 – Co-ordination

The co-ordination was carried out by Executive Committee (EC) formed by of seven staff members of the Institute (IBW PAN) who were responsible for the planning, promotion, and execution of all scientific, organization, administrative and financial tasks. Additionally an Advisory Board (AB) formed by six representatives of science and one from regional water management administration was established. Two meetings of Advisory Board were organized. The first meeting was organized in January 2003 to discuss the accepted plan for the three years' project CEM, and its details in the first year. The second meeting was organized in November 2003 to assess the execution of the achievements of the first year of project and to discuss plans for the second year.

To carry out administration of the project the CEM office was established.

**Exploitation of the results**

- scientific results for practical applications
- case studies and workshops for administration
- implementation of EU WFD in Poland
- support for administration in solving real engineering problems
- transfer of knowledge via cooperation and established network
- support in the management of coastal zone

# Crest Level Assessment of coastal Structures by full scale monitoring, neural network prediction and Hazard analysis on permissible wave overtopping – (CLASH)

*De Rouck, J.*[1]*, Van de Walle B.*[1]*, Geeraerts J.*[1]

[1] Ghent University, Belgium, julien.derouck@ugent.be



| Contract no: EVK3-CT-2001-00058 | Project duration: 01/2002 – 12/2004 |
|---|---|
| Project budget: € 2 792 115 | EC contribution: € 1 758 575 |
| Website: www.CLASH-eu.org | |



**Objectives and methodology**

Results from the EU-project OPTICREST (contract number MAS03-CT97-0116, 1998-2001) have shown that wave run-up on rubble mound slopes for full scale conditions is about 20% higher than in small scale model tests [1]. A similar trend is anticipated for wave overtopping and needs to be investigated in detail to overcome scaling problems in wave overtopping tests in small scale hydraulic models. In addition, there is a lack of a generic prediction method for crest level design of coastal structures. A lot of wave overtopping data on different types of coastal structures are available at various research institutes and universities. However, these overtopping data have not yet been combined. Within CLASH, all these data are collected in one database. Moreover, a neural network is used to create a generic wave overtopping prediction method based on this wave overtopping database.

The main scientific objectives of CLASH are (1) to solve the problem of suspected scale / model effects for wave overtopping and (2) to produce a generic prediction method for and guidelines on crest level design of coastal structures. To attain these objectives, the project uses two methods. The first method is based on full scale measurements, small scale modelling and numerical modelling of wave overtopping. Comparison of full scale measurements and model test results will lead to a conclusion on scale / model effects and how to deal with these. Linked to the full scale monitoring, a hazard analysis (including socio-economic impacts) will give an answer to the question of safety. The second method consists of collecting all existing overtopping data in one homogeneous database. This database is supplemented with new wave overtopping data obtained within CLASH. The generic prediction method is implemented by a neural network, which will be trained using the database and the conclusions on scale effects as input.

**Results**

A general methodology on how to achieve the overall objectives of CLASH has been established at the very beginning of the project. More than 6500 data on wave overtopping have been gathered around Europe's hydraulic engineering institutes and from outside Europe. All these data have been screened, harmonised and put into one database. Each test has been included in the database by means of 31 parameters of which 17 structural parameters, 11 hydraulic parameters and 3 general parameters. For the overtopping phenomenon, it is believed that a combination of only 11 structural parameters and 4 hydraulic parameters provide sufficient information to develop a good neural network prediction method. A first version of the prediction method is ready at this moment (January 2004).

Four field sites have been instrumented and are fully operational. In Zeebrugge (rubble mound breakwater, Belgium), a directional wave rider buoy, video cameras, wave detectors, a radar, dummy persons, an instrumented pipeline and window glasses have been added to the already existing measuring infrastructure. In Ostia (rubble mound breakwater, Italy), a totally new measuring site focussing on measurement for wave overtopping has been built. At Samphire Hoe (vertical wall, United Kingdom), flexible portable measuring devices to measure overtopping have been constructed. At Petten (dike, the Netherlands) detailed wave measurements have been carried out. Storm events have already been recorded at all these sites.

A review of previous work on model and scale effects has been carried out and some theoretical background is provided. Small scale model tests have been carried out to get a better insight in model and scale effects. Laboratory tests consist of three parts: (1) reproduction of measured full scale storm events, (2) parametric tests on wave overtopping for the selected structures and (3) so-called 'white spot' tests to fill up the gaps in the database as an example. As an example a preliminary comparison between the full scale measurements and the laboratory results for the Zeebrugge rubble mound breakwater is given in figure 1.

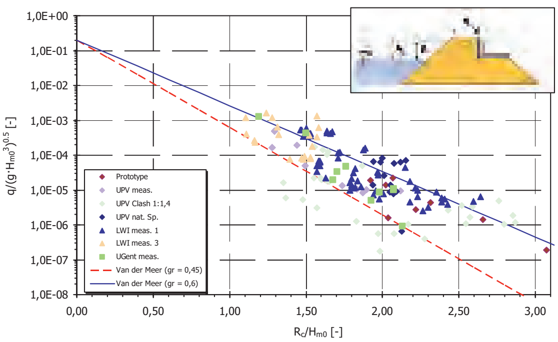



**Figure 1: Preliminary comparison of full scale measurement and laboratory results for the Zeebrugge rubble mound breakwater.**

Two volume of fluid (VOF) type codes are extended for the detailed simulation of wave overtopping at vertical and sloping structures. The codes will be validated using laboratory and prototype data. VOFbreak[2] uses a single fluid advection based on a volume fraction, AMAZON-VOF uses a multi-fluid formulation based on the advection of a partial density. The numerical codes will assist in examining suspected scale effects on overtopping.

Observations of hazards have been made at several selected places along the European coastline. Detailed analysis of these observations is ongoing at this moment (January 2004).

**Potential exploitation by end users**

The project will result in a generic prediction method and well validated guidelines on crest level design for various types of coastal structures. The guidelines will contain detailed information on permissible overtopping levels, resulting from the hazard analysis. The guidelines and the generic prediction method will be made available to all possible end users through the internet, for utilisation including design, safety and risk assessment, and applications in which crest level of coastal structures play an important role.

**References**

[1] De Rouck, J (2001) Coastline Structures and Breakwaters Conference, London.

# The CoastView Project - (COASTVIEW)

*Davidson, M. A.*

University of Plymouth, UK, PL4 8AA. e-mail: mdavidson@plymouth.ac.uk

| | |
|---|---|
| Contract No. : | Project Duration : 04/02 – 05/05 |
| Project budget : € 2, 425, 693 | EC contribution : € 2, 020, 000 |
| Website : www.TheCoastViewProject.org | |

This contribution gives an overview of the CoastView project which aims to develop coastal video monitoring systems in support of coastal zone management. The project utilises Argus video systems that are capable of remotely sensing waves, currents and beach elevation at high frequency over a scale of several kilometres. The CoastView project involves 12 partner institutions from six countries, including four national-scale coastal managers from Spain, Italy, Netherlands and the UK.

To date the development of coastal video systems has largely been motivated by scientific research into the evolution of the natural beaches due to the action of waves and tides. However, the potential for these systems to contribute greatly to the effective management of the coastal environment as well as science is becoming increasingly evident.

A primary focus of the CoastView project is to simplify the task of the coastal manager. The information currently available to the coastal manager about the physical state of the coastline from observations, models and scientific interpretation is often too complex and difficult to use directly. In order to assist in decision making, this complex information needs to be delivered promptly and in a simplified form. One way of achieving this is to reduce this complex information to a limited set of video-derived 'Coastal State Indicators' (CSIs) upon which management decisions and policy can be based. CSIs can be defined as, '*A reduced set of parameters that can simply, adequately and quantitatively describe the dynamic-state and evolutionary trends of a coastal system*'. Generally for each CSI there will be a benchmark range of values (or indicator standards) that will be tolerated without intervention, but a threshold above which intervention will be initiated.

The implementation of video-derived CSIs is expected to have an impact on several aspects of coastal zone management including coastal protection, recreation, navigation and ecosystem protection. For example, managers charged with ensuring navigational safety might need to track the location of a dynamic shipping channel and hazardous sandbars. In the area of coastal protection managers might be concerned with the stability of the coastline and the location of erosion hot-spots. Managers concerned with recreation may wish to know if it is safe to swim, or whether the width of the beach is adequate to sustain tourism. The CoastView project is currently deriving CSIs that will assist coastal managers in dealing with these and other issues.

The principle objectives of the project can be summarised as follows:

- To develop a set of issue-based CSIs in support of coastal zone managers
- To develop improved video systems for delivering CSIs promptly to the coastal manager at the appropriate temporal and spatial scales.
- To develop algorithms for the estimation of CSIs
- To ground-truth and evaluate confidence limits for video-derived CSIs
- To produce schemes for the interpretation of CSIs and prediction of coastal state

The CoastView consortium will occupy four morphologically dissimilar field sites that collectively typify the sort of management issues that are common to European coastlines, (Figure 1). These sites are located in El Puntal, N. Spain, Lido di Dante, Italy, Egmond, Netherlands and Teignmouth, UK. Each site has its own set of (generic) management problems and closely associated coastal manager who are directly engaged in the project.

This contribution will describe in detail the philosophy for defining coastal state indicators developed within the project. Detailed examples of CSIs developed to aid coastal managers in the fields of coastal protection; navigation and recreation will be described drawing on examples from each of the CoastView field sites.

**Figure 1.** Video images from the four CoastView field-sites. Top: Teignmouth, UK – A busy coastal inlet and tourist town. Upper-middle: Egmond, Netherlands – A long undefended coast subject to coastal erosion. Lower-middle: El Puntal, N. Spain – A busy commercial harbour and tourist resort. Bottom: Lido di Dante, Italy – A tourist location defended by groynes and offshore breakwaters.

# Coastal Sands as Biocatalytic Filters - (COSA)

*Cook, P[1],Huettel, M[1], Wenzhoefer, F[2], Glud, R[2].,Kotwicki, L[3], Weslawski, J[3] and COSA participants*

[1] Max Planck Institute, Bremen, Germany; [2] University of Copenhagen, Helsingoer, Denmark; [3] Institute of Oceanology, Polish Academy of Sciences.

Contact: jwesnigk@mpi-bremen.de (J. Wesnigk), mhuettel@ocean.fsu.edu (M. Huettel), pcook@mpi-bremen.de (P. Cook)

| | |
|---|---|
| Contract No : EVK3-CT2002-0076 | Project duration : 11/2002 – 11/2006 |
| Project budget : € 1 941 660 | EC contribution : € 1 739 978 |
| Website : www.eu-cosa.net | |

**Objectives**

Despite the fact that 70% of the continental shelf area is covered by sands, few representative studies have investigated ecosystem function and the role sandy ecosystems play in carbon budgets of the coastal zone. The project COSA combines institutions with expertise in process studies, trophic dynamics, sediment flora and fauna and biogeochemical modelling to gain a qualitative and quantitative understanding and ultimately a predictive capability for these sand ecosystems. The new knowledge gained from these institutions is being disseminated to the general public and integrated into management concepts by partner national park agencies.

The permeable nature of sandy sediments is of key importance to how they function. Percolation of water through the sandy sediments (a process called advection) means that nutrients don't usually build up in sands like in muddy sediments, creating the erroneous impression that sands are biologically inactive compared to more widely studied muddy systems. The process of advection also creates technological challenges for measuring processes in sands. Most existing measurement techniques prevent advection from occurring, thereby changing the measured rates. A major objective of this project was therefore to apply newly developed technologies and methods from the partner institutions to the study of organic matter cycling processes in sandy ecosystems. Here we present the first results from the COSA project specifically on the key process of oxygen dynamics in the sandy sediments studied.

**Results**

The in-situ measurements show that oxygen consumption increases with the filtration rate of the sediment (advection). Coastal currents and waves, thus, can efficiently increase microbial activity and decomposition in sandy sea beds. This also highlights the importance of measuring $O_2$ fluxes at realistic pressure gradients and is of direct relevance to managers wishing to optimize monitoring programs. High rates of primary production were also measured in these sandy ecosystems. Figure 2 shows light and dark profiles of oxygen measured in-situ at the sediment surface with micro-electrodes developed specifically for sand environments. It can be seen that in the light there is a production of oxygen at the sediment surface by diatoms. Estimated rates of production were up to 1g carbon per $m^2$ per day. Sandy sediments are therefore an important source of nutrition for commercially important fish species such as shrimps which inhabit near shore coastal environments.

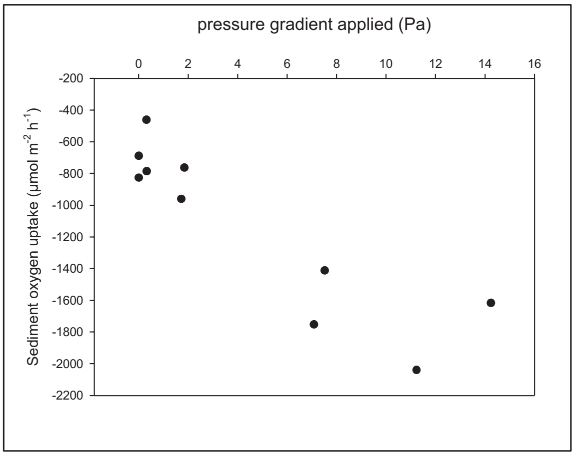



**Figure 1.**
measured rates of oxygen con-sumption in pressure calibrated benthic chambers. *$O_2$ consumption in sandy sediments increases with rates of advection (water flow) through the sediment.*

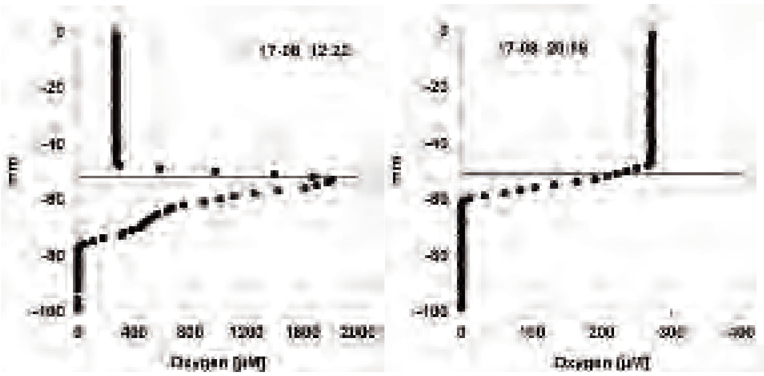


**Figure 2.**
*Profiles of oxygen at the sediment surface showing high rates of production in the day (left panel) and consumption at night (right panel).*

### Potential exploitation by end users

Permeable sandy coastal sediments in principle function like huge sand filters: they remove particulate and dissolved substances from the water column and thereby affect coastal water quality. This effect can decrease turbidity and remove bacteria from the water column. The filtered substances are decomposed in the sediment which leads to nutrient release fuelling benthic primary production. Observed high rates of primary production in these sandy sediments emphasize their role as source of nutrition for commercially important species such as shrimps and juvenile fish. This finding has much relevance for managing the sustainability of near shore fisheries. The filtration process also has the potential in removing contaminants from the water column since the majority of toxic materials is attached to particles. These important functions of advection highlight the need of revising management concepts and the techniques presently in use for monitoring coastal ecosystems. COSA results will provide a database that facilitates such a revision. The results of this project will also provide the general public and policy makers, who value sandy ecosystems for their recreational and economical value, with a new perspective on how these ecosystems function and their important role in maintaining the environmental health of coastal areas.

# Detection and Analysis of Nutrient Limitation -(DANLIM)

*Lignell, R.[1], Thingstad, F.[2], Geider, R.[3], Conley, D.[4], Tamminen, T.[5], Olli, K.[6], Jensen, M.Hj.[7], Andersen, T.[8]*

[1]Finnish Institute of Marine Research, Finland; [2]University of Bergen, Norway: [3]University of Essex, UK; [4]National Environmental Research Institute, Denmark; [5]Finnish Environment Institute, Finland; [6]University of Tartu, Estonia; [7]Fyns Amt, Denmark; [8]Norwegian Institute for Water Research, Norway



| | |
|---|---|
| Contract No : EVK3-2001-00049 | Project duration : 01/2002 – 12/2004 |
| Project budget : € 2 800 000 | EC contribution : € 1 700 000 |
| Website : http://www.fimr.fi//fi/tutkimus/tutkimusalueet/muu tutkimus/danlim.html | |



**Objectives**

DANLIM tests the applicability of new fundamental scientific knowledge in decision making and management of anthropogenic nutrient load in coastal systems. We use a variety of state-of-the-art methods and their advancements, ranging from fluorometric techniques on a single cell level to various aspects of community level nutrient responses in mesocosms. The physiological-systemic mechanisms controlling natural phytoplankton populations are analysed with a new theoretical model. All promising methodological and theoretical results (including empirical bioassay models) will be deployed in an annual monitoring program to test their suitability as tools for coastal zone management. Our main deliverable is *Guidelines for Monitoring Nutrient Limitation in Coastal Waters*, promoting evolution and unification of European monitoring programs.

**Results**

The potentials and limitations of novel photobiological methods for coastal processes monitoring were studied across a range of spatio-temporal scales (from bottles to large mesocosms) and levels of functional complexity (from laboratory cultures to whole plankton food webs). The reduction in quantum efficiency of nutrient deficient phytoplankton was demonstrated through changes in the ratio of variable to maximum fluorescence ($F_v/F_m$) of dark-adapted phytoplankton. However, contrary to expectations based on previous publications using laboratory cultures, the interspecific variability of $F_v/F_m$ for nutrient–replete cells and the delay between nutrient depletion and physiological response seems to limit the sensitivity of variable fluorescence as a tool for assessing nutrient limitation in field measurements. It was also shown that $F_v/F_m$ measurements can not be applied for diazotrophic ($N_2$ fixing) filamentous blue-green algae, typically predominating in late summer in the Baltic Sea.

In 2003, two natural coastal systems (Tvärminne archipelago and Odense Fjord in northern and southern Baltic coastal zones, respectively) were driven to varying degrees of extremity in nitrogen or phosphorus deficiency in mesocosms (5-50 $m^3$ enclosed bags) by different combinations of daily nutrient treatments ($NH_4$, $PO_4$, glucose). Judging from parallel 24-h nutrient treatment bioassays, photobiological methods ($F_v/F_m$ values) seemed promising in assessing physiological nutrient limitation for phytoplankton. Moreover, the phosphate ($^{33}PO_4$) turnover turned out to be a good indicator of P limitation, showing fast turnover rates under P deficient conditions.

In what we believe is the first use of a microscope imaging system to assess $F_v/F_m$ of natural phytoplankton, phytoplankton contained cells with a range of $F_v/F_m$ values, indicating both "healthy" and "moribund" cells within the same assemblage. Thus, bulk measurements of community-level variables may miss cell and species-specific variability that may be

# Nutrient Management in the Danube Basin and its Impact on the Black Sea (DANUBS)

Kroiss, H.[1], Lampert, C.[1], Zessner, M.[1]

[1] Institute for Water Quality and Waste Management, Vienna University of Technology, Austria. hkroiss@iwag.tuwien.ac.at



| | |
|---|---|
| Contract No : EVK1-CT-2000-00051 | Project duration : 02/2001 – 1/2005 |
| Project budget : € 3 213 902 | EC contribution : € 2 384 084 |
| Website : http://danubs.tuwien.ac.at/ | |



## Background

Mismanagement of nutrients in the Danube Basin has led to severe ecological problems, among them the deterioration of groundwater and the eutrophication of rivers, lakes and especially the Black Sea. These problems are directly related to social and economic issues (e.g. drinking water supply, tourism and fishery as suffering sectors; agriculture, nutrition, industry and waste water management as responsible sectors). If the economy will be recovered an increase of nutrient emissions can be expected. The interrelation between nutrient management in the catchment area, the transport in the Danube River system and the mixing zone of Danube river in Western Black Sea has to be investigated in order to recommend proper measures which combine economic development and low nutrient emissions into the hydrosphere. In order to recommend proper management for protection of the water system in the Danube Basin and the Black Sea, the interdisciplinary analysis of the Danube catchment, the Danube River system and the mixing zone of Danube river in Western Black Sea has to be further developed.

## General objectives of the daNUbs project are

- to improve the knowledge on the sources, pathways, stocks, losses and sinks of nutrients in a large river catchment,
- to improve the knowledge on the effects of nutrients (nitrogen, phosphorus and silica) on the receiving ecosystems with special emphasis on the coastal areas,
- to develop, improve and combine management tools for nutrients in the Danube Basins and
- to develop scenarios and prognoses for nutrient management and its effect on water quality and their consequences on the socio-economic development in the Danubian countries.

The Danube catchment offers the unique possibility to investigate the relationship between dramatic economic changes and water quality development in full scale and real time. It also offers a unique opportunity for the verification of the models developed.

## Expected impacts

Quality of human life and health are strongly related to a good ecological status of the environment. Improvement of water quality in the Danube Basin and in the Western Black

Sea is strongly influenced by the quality of nutrient management in the Danube Basin. Natural systems have to be managed anticipatory as the processes related sometimes react slowly and it might take decades until the effectiveness of measures taken becomes apparent. Therefore political decisions must be based on sound knowledge and have to be supported by effective management tools. This is extremely important in a heterogeneous area like the Danube Basin with its variety of neighbouring countries with different political and economical background.

**Results and conclusions up to now**

The modelling and understanding of the nutrient transport and of their effect on the Western Black Sea allows the following conclusions:

- The situation in the Western Black Sea coastal area has improved significantly in the last decade:
  - reduced eutrophication
  - the anaerobic conditions at the bottom of WBSC, indicators of eutrophication, have nearly completely disappeared in 2000-2002
  - regeneration of zoobenthos and
  - regeneration of phytoplankton.
  - the fish stock is out of balance still.
  - P-loads: minus 50 % since 1990.
  - P is the limiting nutrient now.
  - The recovery of the economic situation in the CEE countries might lead to increasing nutrient loads to the Black Sea (e.g. agriculture, fertiliser industry, sewer development, increasing use of detergents).
- measures to keep emissions of easily available dissolved P-compounds low:
  - P-free detergents,
  - P-removal at waste water treatment plants
  - avoidance of agricultural point sources
  - Erosion prevention is important to reduce the input of particulate phosphorus into the river system and the Black Sea which servers as a potential P-source for algae growth even if it is not immediately available.
- measures to decrease emissions of Nitrogen:
  - optimised agriculture based on best available techniques/practice; as the system reacts slowly effects will not be visible immediately.
  - N-removal at treatment plants can compensate for the increased nitrogen emissions from developing agriculture in the eastern Danubian countries.
  - The development of sewer systems will lead to an increase of nutrient discharges to the rivers if the waste water is treated without nutrient removal (if mechanical or biological treatment with C-removal only).
  - The Danube Delta has a minor function in respect to nutrient retention

The project aims to achieve the elaboration of a basis for political decision making that has to be based on a large consensus of countries involved. The potential users of the projects results will be both international organisations like the International Commission for Protection of the Danube River and relevant governmental institutions of the Danubian Countries in order to achieve an effective river basin management and to perform sound political decision making. The methodological approach will be applicable to other river basins and coastal systems.

important in understanding bloom dynamics. At that, we found that in osmoregulation marine bacteria substitute organic osmolytes with $Mg^{++}$ in C-deficient situations, suggesting a sensitive method for detecting ecological situations with C-limited bacteria. Convenient and reliable tools for identification of this ecologically and biogeochemically important feature have so far been missing.

Moreover, a sensitive and cost-efficient nutrient bioassay experimental protocol (48-h *in vitro* bottle incubations with replicated measures and factorial design or all combinations of nutrient treatments) was found suitable for identification of the nutrient that limits growth or biomass accumulation of the plankton community. Robust and flexible statistical procedures have been developed, enabling beautiful quality control, analysis and classification of these experiments to foster their use in routine coastal monitoring programs. A theoretical model was developed to plan the mesocosm experiments, and in 2004 it will be used to interpret the responses of the plankton food web (i.e. the cause-effects behind them) evoked by different nutrient treatments in the mesocosms. Finally, a state-of-the-art monitoring program is being conducted to uncover conditions relevant in governing nutrient limitation of phytoplankton in Odense Fjord. To sharpen the picture, promising nutrient bioassay and fluorescence methods are included along with basic monitoring variables.

**Relevance for society**

The control of nutrients from land to the sea has been a contentious issue in many countries, with scientific debates regarding nutrient limitation played out in national media outlets in several countries sharing coastline of the Baltic Sea and the North Sea, especially in Scandinavia. These debates concern directly targeting of considerable environmental investments to removal of anthropogenic nitrogen, phosphorus, or both, i.e. reliable identification of the limiting nutrient in the coastal areas.

Nutrient limitation is a cornerstone concept for sustainable management of all aquatic environments. However, at present no commonly accepted and routinely utilized methods to assess nutrient limitation are available for monitoring programs. Cost-efficient measures to reduce human impacts on receiving waters must be targeted at the limiting nutrient(s) for each locality. The adoption of several directives at the European level, dealing with effects of nutrients on aquatic environments, strongly emphasizes the need to formulate harmonized European strategies for sustainable use of especially the coastal ecosystems, which transcend national boundaries. Measures taken at the River Basin District level cannot be optimized without a thorough understanding of the mechanisms and effects of nutrient limitation at different scales.

**Potential exploitation by end users**

The deliverables will have a range of applications, fostering sustainable development and preserving the coastal environment:

*(i)* environmental discussions and increasing environmental awareness through the public media, based on the novel findings on causalities of coastal eutrophication

*(ii)* contributing to the evolution of monitoring programs executed by public authorities in the coastal zone, through delivering the *Guidelines for Monitoring Nutrient Limitation in Coastal Waters*

*(iii)* contributing to cost-efficient management policies (legislation for nutrient removal) by environmental authorities, through assessing preferences for targeting nutrient removal investments

*(iv)* providing increased skills and novel methodologies for research on aquatic ecosystems by the consortium partners due to the added value of the project

*(v)* advancing the state-of-the-art of aquatic ecosystem research through active communication of the results towards the international scientific community

# Environmental Design of Low-Crested Coastal Defence Structures - (DELOS)

*Lamberti, A., Zanuttigh, B.*[1]

[1] DISTART University of Bologna, Italy

| Contract No : EVK3-CT-2000-00041 | Project duration : 02/2001 – 02/2004 |
|---|---|
| Project budget : € 3 446 750 | EC contribution : € 2 718 170 |
| Website : www.delos.unibo.it | |

**Objectives**

DELOS aimed at promoting effective and environmentally compatible design of low crested structures (LCS) to defend European shores against erosion and to preserve the littoral environment and the coast economic development [1]. Specific objectives and methods were:

- to provide an inventory of existing LCS and a literature based description of their effects;
- to analyse LCS hydrodynamics, stability and effects on beach morphology by surveys on sites, laboratory experiments and numerical modelling;
- to investigate the impacts of LCS on biodiversity and functioning of coastal assemblages by observations and field experiments;
- to develop a general methodology to quantify benefits for "Integrated Coastal Zone Management" based on Contingent Valuation monetary values in different European countries;
- to provide local authorities with validated operational guidelines for the design of LCS based on the knowledge achieved within DELOS. **Results**

Ecological effects of LCS are site-specific reflecting the complexity and variability of natural systems [12]. LCS always produces an increase in biodiversity and generates inshore sedimentation that negatively affects the landward soft bottom habitat [11].

LCS design criteria must be addressed to [13]:

- avoid the development of insalubrious areas in the protected zone by increasing the water flow through the structures;
- promote the development of salubrious areas in the protected zone by increasing the water flow through the structures;
- reduce to the minimum LCSs length to avoid large-scale effects of habitat loss, fragmentation and community changes;
- increase structure stability, minimise maintenance works and manage human usage, to facilitate settlement/persistence of algae and marine invertebrates and reduce ephemeral green algae;
- avoid siltation and scouring that are felt as disturbances for abundance and composition of epibiotic assebmblages, for instance by increasing berm width;
- increase armour geometry complexity and heterogeneity that promote settlement of organisms and enhance diversity;
- assure structure submergence in low-tide to avoid consequent exsiccation of colonising organisms.The construction of LCSs for beach protection is 'justified' from an economic point of view by the CVM surveys carried out within DELOS. The value of enjoyment of a beach visit is in average 25 € per person per day. Beach erosion produces a loss of value of about 50%; moreover, the 20% of interviewed declared that would have

never visited the beach after the foreseen erosion in ten years. LCS design criteria shall account for the preferences that people expressed [2]:

- submerged structures for aesthetic reasons;
- groynes for water quality and recreational activities.

A Benefit Transfer Function was prepared with coefficients that should be calibrated on the site under analysis.

The engineering results can be summarised by methodology.

*Site-monitoring* [3] improved the knowledge of morpho-dynamic evolution [9] in presence of different intervention type. Currents at gaps appear to have a strong influence on local scour [9], LCS stability [10] and swimming safety.

*Laboratory experiments* allowed to cover the lack of information on waves and currents interaction with LCS both in 2D and 3D conditions. [4]. Stability [10], breaking [5], overtopping [7], filtration, transmission [6] were examined and parametrised after having identified the most relevant process parameters.

*Numerical modelling* produced new validated 2D and 3D tools and calibrated existent models [8]. Models are able to accurately predict most important processes as overtopping and transmission; the representation of morpho-dynamic effects at local scale [9] is still uncertain because of scale-effects.

The most significant Project global result consists of *Design Guidelines* for LCS construction covering economic, social, ecological and engineering aspects [1].

### Potential exploitation by end users

Project results were shared with end-users during Meetings and Workshops. The methodological and managerial knowledge achieved by DELOS was disseminated in the final workshop, which was entirely devoted to present and discuss the developed tools. In order to guarantee the up-take of information and facilitate the exploitation of the project outcomes, DELOS results are being formalised in a set of operational design guidelines for LCS, that will be generally applicable across European coastlines. Further information are provided by public informative booklets and by selected conclusive articles to be printed on a Special Issue of Coastal Engineering Journal. A web-site was regularly updated with project advances and will remain active to disseminate main Project results that will be open to the whole public.

### References (all in Coastal Engineering Special Issue for DELOS, to be printed end of 2004)

[1] Lamberti, A. Environmental design of LCSs: objectives and results.

[2] Polomè, Ph., Marzetti, S., van der Veen, A. Social effects of coastal defence: economics and societal demands.

[3] Lamberti, A., Archetti, R., Kramer, M., Paphitis, D., Mosso, C., Di Risio, M. Prototype experience regarding LCSs.

[4] Kramer, K., Zanuttigh, B., van der Meer, J. W., Vidal C., Gironella, X. 2D and 3D experiments on LCSs.

[5] Losada, I, Lara, J. L., Damgaard, E. Breaking process, velocities and turbulence intensity around LCSs.

[6] van der Meer, J., Wang, B. Briganti, R., Zanuttigh, B., Gironella, X. Wave transmission (and reflection) at LCSs: effects on the spectra and formulae for a conceptual design.

[7] Sanchez Arcilla, A., Caceres, I., Franco, L., Lamberti, A., Zanuttigh, B., Garcia, N., van der Meer, J. Wave overtopping and pumping effetcs around of LCSs.

[8] Johnson, H. K , Karambas, Th., Avgeris, J., Zanuttigh, B., Caceres, I., Bellotti, G., Brocchini, M. Modelling of wave and currents around submerged breakwaters.

[9] Sumer, B.M., Fredsøe, J., Dixen, M., Lamberti, A., Zysermann, J., Zanuttigh, B., Jimenes, J., Briganti,R. Local scour and erosion around LCSs.

[10] Burcharth H., Vidal, C., Lamberti, A., Franco, L., Noli, A., van der Meer, J. Structural stability, toe protection against scour and construction peculiarities of low crested breakwaters

[11] Martin, D., Bertasi, F., Colangelo, M., De Vries, M., Frost, M., Hawkins, S., Macpherson, E., Moschella, P., Satta, P., Thompson, R., Ceccherelli, V. Ecological impacts of LCSs on soft bottoms and mobile fauna: how to evaluate and predict the consequences of an unavoidable modification of the native habitats.

[12] Moschella, P., Abbiati, M., Aberg, P., Airoldi, L., Bacchiocchi, F., Bucchieri, F., Dinesen, G., Frost, M., Gacia, E., Granagh, L., Jonsson, P., Satta, P., Sundelof, A., Thompson, R., Hawkins, S. LCSs as artificial habitats for marine life: what lives where and why?
[13] Airoldi, L., Abbiati, M., Hawkins, S., Jonsson, P., Martin, D., Moschella, P., Sundelof, A., Thompson, R., Aberg, P. An ecological perspective on the deployment and design of LCS and other hard coastal defence structures.

# Dissolved organic matter (DOM) in coastal ecosystems: transport, dynamics and environmental impact – (DOMAINE)

*Søndergaard, M.*
Freshwater Biological Laboratory, University of Copenhagen, Denmark (MSondergaard@zi.ku.dk)



| | |
|---|---|
| Contract No: EVK3-CT-2000-00034 | Project duration: 01/2001 – 12/2003 |
| Project budget: € 2768453 | EC contribution: € 1499215 |
| Website: www.domaine.ku.dk | |



## Objectives

Through the history of eutrophication of aquatic ecosystems the effects of inorganic nutrients have been in primary focus –and for good reasons; however, the management and scientific communities have partly overlooked the huge amounts of nitrogen, phosphorous and oxygen demand embedded in terrestrial DOM transported to coastal waters. Furthermore, as DOM also controls to a large extent, the light climate of aquatic systems and functions as a ligand for metals and organic micro pollutants there are good reasons not to overlook the ecological effects of DOM. It is pertinent to learn more about DOM, both with respect to quantities in transport from land to sea and on which time scales it releases N, P and oxygen demand, how land use affects its export and the consequences of this. Finally, it deserves consideration from a management perspective, particularly within the context of the Water Framework Directive.
The overall aim of the project is to provide a better understanding of the terrestrial export of dissolved organic matter and its fate and impacts on coastal ecosystem functioning, i.e. the storage and cycling of carbon, nitrogen and phosphorous. More specifically it is the objectives

- to quantify the annual DOM export from four different European regions (Finland, Wales, France and Denmark)
- to relate the export to climate, land use and geographical location
- to develop DOM export models for managerial purposes

## Results

1) During this project we have developed cheap and easy optical methods (absorption and fluorescence spectrometry) to quantify and characterise coloured DOM components and can follow how terrestrial DOM in coastal waters is removed and transformed by microbial uptake and photochemical processes, and diluted by DOM produced within aquatic systems.

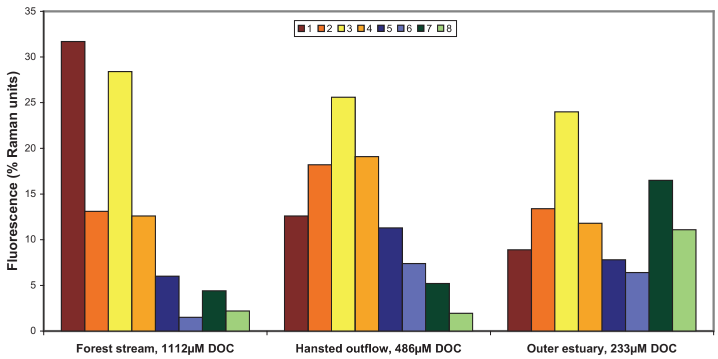



Fig. 1. Fluorometric analysis of DOM sampled in the upper reaches of Hansted Stream, at the outlet of a eutrophic lake and in the estuarine end-member Horsens Fjord. Eight compound groups were identified and it is shown how there is a shift in the relative distribution of the allochthonous compound groups 1, 2, 3 and 4 moving from the steam to the fjord dominated by the anthropogenic compound group 6, and autochthonous compound groups 7 and 8. The values are averages for 14 samples covering one year.

2) From intensive seasonal sampling campaigns we have constructed a database on DOM concentrations and export at a European climate and land use scale.

Table 1. Average values of selected land use cover variables in the DOMAINE study catchments.

| | Forest | Agricultural land % | Lakes | Wetlands |
|---|---|---|---|---|
| Finland (n=9) | 48 | 12 | 5 | 27 |
| Denmark (n=10) | 15 | 66 | 0.7 | 3 |
| UK (n=10) | 6 | 56 | 4 | 0.8 |
| France (n=5) | 43 | 14 | 0 | 0 |

Table 2. Average concentrations and annual export of DOC, DON and DOP in the DOMAINE catchments.

| | DOC | DON $\mu mol\ l^{-1}$ | DOP | DOC | DON $mmol\ m^{-2}\ yr^{-1}$ | DOP |
|---|---|---|---|---|---|---|
| Finland (n=9) | 1121 | 36 | 0.25 | 340 | 11 | 0.076 |
| Denmark (n=10) | 602 | 78 | 1.1 | 210 | 26 | 0.34 |
| UK (n=10) | 462 | 25 | 0.59 | | | |
| France (n=5) | 149 | 8.4 | 0.46 | 72 | 4.2 | 0.10 |

**Potential exploitation**

From GIS analyses of land use in specific catchments it is now possible to construct managerial scenarios and predict the effects of changes in land use on the coastal load of DOM. Fig. 2 shows the consequences of reducing the agricultural area in the Danish model catchment by 25% and to change these to forest and wetlands. While the export of dissolved organic carbon and nitrogen (DOC and DON) increase, the export of dissolved organic phosphorous (DOP) decreases. For the inorganic species the export of both N and P will decrease by the suggested change in land use.

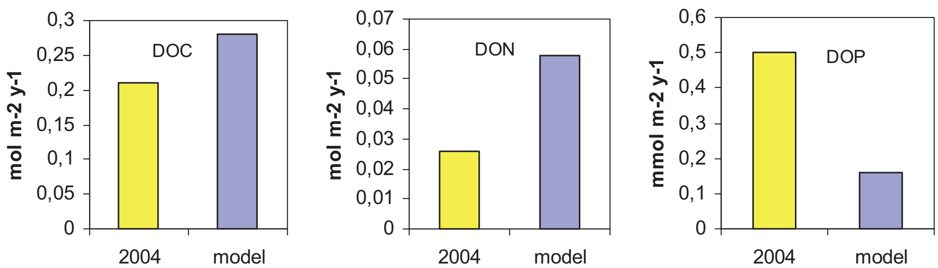



Fig. 2. A comparison of present and modelled changes in the export of DOM species from a Danish catchment. Hansted Stream, Vejle County.

# Past, Present and Future Catchments Changes and their Impact on the Coast (EUROCAT)

*Salomons, W.* [1],

[1] Institute for Environmental Studies, Free University Amsterdam, The Netherlands
*(wim.salomons@home.nl).*

| | |
|---|---|
| Contract No : EVK1--CT-2000-00044 | Project duration : 02/2001 – 02/2004 |
| Project budget : € 5 000 000 | EC contribution : € 3 000 000 |
| Website : http://www.iia-cnr.unical.it/EUROCAT/project.htm | |

**Objectives**

The coastal zone is under heavy pressure from land-based activities located in the catchment of rivers. Traditionally, both scientific research and the governance framework have treated catchments and coasts as separate entities. However, it is increasingly recognised that they should in fact be treated as an integrated whole, encompassing both environmental and socioeconomic and political systems.

The EuroCat project was established with an integrated perspective and analytical framework in mind. Across seven regional case studies, local teams of natural and social scientists used a common interdisciplinary strategy to:

- Identify the impacts on the coast
- Interface biophysical catchment and coastal models with socio-economic models
- Develop regional environmental change scenarios (2001-2020)
- Link scenarios with the modelling toolbox to evaluate plausible futures
- Evaluate the research outcomes with regional boards consisting of stakeholders and policy makers.

The seven systems cover all coastal types (with the exception of fjords) in Europe and different socio-economic settings. The approach is novel and not all teams had direct experience of working across geographical boundaries and disciplines, hence the project had a strong capacity building component.

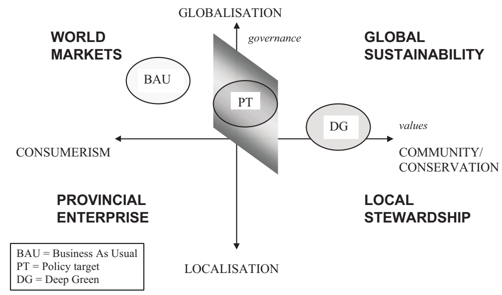
**Results**

The DPSIR framework was the basis for a scoping analysis of the regional catchment-coast cases (EuroCat, 2004). Eutrophication was considered to be important for the Vistula, Elbe, Rhine, Humber, Po, Axios and Provadijska Studies. Heavy metals were of prime concern in the Idrijca case study (mercury) and also identified in the Humber as a major issue. The relevant numerous treaties and policies in the various regional studies have been compiled (Lukewille (2003), analysed (Ledoux and Turner, 2003a) and put in an European perspective by Hisschemoller and van Tilburg, 2004). Existing mathematical models for the catchments and the coast were identified and linked. In this way providing a first linked model exercise for the catchment-coast continuum. Kannen et al (2004) summarizes the results within EuroCat on marine modelling. Catchment modelling is discussed in detail in Behrendt 2004. Scenarios are an integral part of the project. For each regional project scenarios adapted to local conditions were developed through story lines. In all studies a Business as Usual (BAU), Policy targets (PT) and Deep Green (DG) were considered. The scenarios were used to generate an array of inputs for the catchment- coastal zone modelling and the results were analysed in terms of their impacts on nutrients reductions. Results were analysed either as concentration of nitrogen and phosphorus, by using the TRIX indicator or by a newly developed indicator based on ecosystem integrity (Kannen et al. 2004). These results were subject to an economic and policy analysis (Turner 2004). Three reports put the pan-EuroCat project in an European context (Meybeck et al 2004a,b and c).

The combined results showed that even for the most stringent and plausible environmental protection scenarios, that eutrophication will remain a problem affecting the ecosystem and economic resources such as, for example, tourism and mussel farming. Strategies to combat eutrophication which included managed realignment and/or wetland creation schemes, together with improved water treatment programmes, or agricultural zoning and regime modifications were, however, much more effective, in the UK and The Netherlands scenarios.

**Potential exploitation by end users**

The EuroCat project was established with an integrated perspective and analytical framework in mind. In addition the regional teams interacted with their stakeholders for input and analysis of policy relevance of the results: Exploitation of the results already took place in the course of the project. Tools and frameworks have been developed which feed directly into the water framework directive (WFD). This refers in particular to the integrated catchments-coast approach and the linking (toolbox) of catchment, coast and socio-economic models.




*The Business as Usual (BUA), the Policy Targerts (PT) and the Deep Grain (DG) EuroCat standard scenarios in the concept of "Environmental Futures Scenarios (to 2080). OST/DTI, Environment Futures, Foresight, OST London."*

The European Integration (Meyback et al. 2004)) are relevant for supra-national bodies. Finally the regional results and the European Integration feed into the global network of LoiczBasins consisting of scientists and policy makers. Too date the information sharing with has been extensive: 21 peer reviewed have been published and another 22 are already submitted or forthcoming. During the lifetime of the project (2001-2004) 118 oral contributions were presented at national and international meetings (visit the webstite (http://www.iia-cnr.unical.it/EUROCAT/project.htm ) to download the documents and publications) **Key documents.**

Behrendt H (2004) Past, Present and future changes in catchment fluxes.230 pp

Colijn F., A. Kannen and W. Windhorst (2003) List of indicators and critical loads. 38 pp

EuroCat (2004) Scoping studies. 262 pp

Kannen A., W. Windhorst and F. Colijn (2004) Scenario based impact assessments for coastal waters. 354 pp.

Ledoux L., and K. Turner (2003a) Institutions, stakeholders and potential/actual conflicts of interest and values within a given catchment. 71 pp

Ledoux L., and K. Turner (2003b) Scenario Analysis. 121 pp.

Lukewille A. (2003) Inventory of national and international treaties and regulations relevant for the EuroCat catchment case studies. 155 pp

Meybeck M., J. Vogler, F. Moatar, H. Duerr, L. Laroche and L. Lachartre (2004B) Analysis of temporal variability in river systems. 90 pp

Meybeck M., J. Vogler, K. Turner, M. Hisschemoller and M van Tilburg (2004C) River-Coast Integration in European Regional Seas. Part 1: Improving basin-coast integration (Meybeck and Vogler) . Part II: Scenario Analysis (Turner). Part III: Institutional Analysis (Hisschemoller and van Tilburg).129 pp

Meybeck M.,, H. Duerr, J. Vogler, L. Lacharte and Y. Gueguen (2004A) Space analysis of catchment/coast relationships. 166 pp.

Turner K (2004). Assessment of scenarios, policy options and their effectiveness. 382 pp

# The impact of the Vistula river on the coastal waters of the Gulf of Gdansk, Scenarios analyses by ecohydrodynamic model - (EUROCAT - PL)

JEDRASIK J[1]., KOWALEWSKI M[1]., OLDAKOWSKI B[1]., NOWACKI J[2]., KOT-WASIK A[3]., NAMIESNIK J[3].

[1]University of Gdansk, [2]Medical University of Gdansk, [3]Gdansk University of Technology



| Contr. No. EVK1-CT-2000-00044 | Project duration: 01/2001-01/2004 |
|---|---|
| Project budget:: 81 035 e | EC contribution: 81 035 e |
| Website: http://www.iia-cnr.unical.it/EUROCAT/project.htm | |



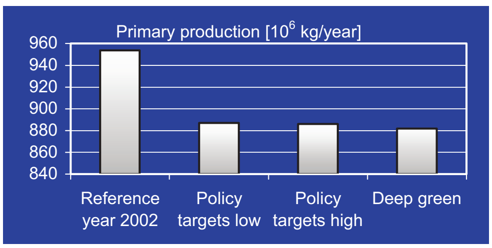
**Objectives:**

An impact of the Vistula River catchment on the biological state of the of Gulf of Gdansk due to three economic scenarios:

Policy targets - high scenario (5 - 6% growth in GDP in 2004-2020, this allows to realize the Program of Municipal Wastewater Treatment in aglomerations between 2 000 and 2010).

Policy targets – low scenario (2 - 4% growth in GDP in 2004-2020, the Program of Municipal Wastewater Treatment will be realized by the end of 2015).

Deep Green scenario (the Program of Municipal Wastewater Treatments until 2010; detergents without phosphates is reduced by 90 %, use of mineral fertilizers is decreasing). The projections for above scenarios determine the discharge of total N and P from the Vistula River into the Gulf of Gdansk.**Results:**




- Reductions of biological productivity for all scenarios are not very significant comparing to the reductions of phosphorus loads (from 40.9 % for the Policy target low scenario to 45.5 % for Deep green scenario).
- The lowest biological productivity has been obtained for Deep green scenario: the primary production is 7.5 % less than in the reference year 2002.The reduction in biological productivity for Policy targets low and high scenarios are 7.0 % and % 7.1 respectively less than in the reference year 2002.
- The costal waters are the most biologically productive areas of the Gulf of Gdansk including the recreational area along the beaches in Gdansk and along the Vistula Lagoon ( the reduction of primary production rate in these areas is rather low).
- Due to the fact that in the analyzed scenarios the reduction of phosphorus loads is much higher (more than 40 %) than nitrogen loads (less than 10 %) the phosphorus becomes a limiting nutrient in the Gulf of Gdansk. Further reduction of phosphorus load should lead to the reduction of biological productivity in the Gulf of Gdansk.

### Potential exploitation by end users

- The developed 3D modelling method as well as the obtained results are of special interest for decision makers responsible for coastal zone management at the national and the European level.Furthermore, the policy targeting on the reduction of nutrients should not limit to the single gulfs but has to cover the whole catchment of Baltic Sea.

### References:

[1] Kot-Wasik A., Bukowska B., Dabrowska D., Debska J., Pacyna J., Namiesnik J, Rev. Environ. Contam. Toxicol. 179, 2003, 1-36

[2] Buszewski B., Kowalska, J. Pacyna, J., Kot, A. and Namiesnik, J. (2001) Journal of Oceanology 31 (1-2), 1-9

# Euro-EcoGeoCentre Romania

*Panin N.*[1]

[1] National Institute of Marine Geology and Geo-ecology – GeoEcoMar, Romania, Bucharest 024053, Dimitrie Onciul Street No. 23-25; Tel/Fax: +40-21-252.25.94; E-mail: panin@geoecomar.ro

| | |
|---|---|
| Contract No : EVK3-CT-2002 - 80006 | Project duration : 02/2003 – 02/2006 |
| Project budget : € 579,204 | EC contribution : € 435,715 |
| Website : www.geoecomar.ro link: *Euro-EcoGeoCentre - Romania* | |

**Objectives**

The objectives of the project are structured in three main parts as follows:

- *Part I* - Continuous formation and training of young scientists for improving the scientific level of the Romanian R&D units;
- *Part II* - Enhanced scientific co-operation between Romanian R&D units and West-European research units by networking and improving mobility schemes;
- *Part III* - Enhanced long-term co-operative research and monitoring of the River Danube-its Delta-Black Sea system using jointly the local and international human and logistic resources. This co-operative research programme will act as a "matrix" and "catalyst" of the two previous objectives using jointly the local and international human and logistic resources; *this part will be supported mainly through the Romanian National Research Programmes.*

**The European Commission supports mainly the Part I dedicated to the formation of young scientists.**

**Results**

***Part I– Continuous formation and training of young scientists.*** This objective is addressed especially to the young scientists from GeoEcoMar and generally from Romania, but also from other European countries. The objective is accomplished through seven WP:

***WP.1 -*** *Specialised courses (duration two weeks yearly).*

For 2003, Course 1 "Hydrological, sedimentological, biogeochemical processes in fluvial, deltaic and coastal marine environments" was planned. The course was held in August 2003 for 12 days onboard of R/V "Halmyris" and R/V "Istros" in the Danube Delta. The research vessels were offered by the institute GeoEcoMar. The number of students who attended (23) was almost twice the number planned (12). 7 Professors from Romania and 2 from abroad participated.

***WP.2 -*** *Summer schools (10 days yearly).*

The first *summer school* covered a large range of topics: environmental complex studies, geo-ecology of the River Danube, its Delta and the coastal Black Sea; genesis and evolution of the Danube, of the Delta and of the Black Sea; structure and functioning of the characteristic ecosystems in the region; environmental changes impact on aquatic and sedimentary systems and many others. The school was organised in September 2003 for 12 days in the Danube Delta on the same vessels. A total number of 20 students and 11 professors (7 from Romania, 4 from abroad) participated.

***WP.3 -*** *Junior scientists visitors (two young scientists/one month each yearly).*

In 2003, four young scientists (instead of two) were successfully trained abroad (at IFREMER – Brest, TNO – the Netherlands, University Paris I) for 95 days (instead of 60 planned).

***WP.4 –*** *Two Ph.D. thesis with double supervision*

Two young researchers started their Ph.D. in Romania and the proceedings for signing agreements for double co-ordination (Aix-Marseille University, France. Delft University in the Netherlands).

***WP.5 –*** *Workshops*

Two “coupled” workshops were organised in January 2004 (at the end of the first year of Centre’s activity). The subjects were: " Present-day environmental problems of the Lower Danube River, including Danube Delta" and

"New ideas for an integrated observing and forecasting system in the Lower Danube River, Danube Delta and NW Black Sea“. Representatives of the most important players participated. Actually, these workshops prepared a larger international symposium that will be organised in April 2004 (see WP.6).

***WP.6 -*** *Symposia, conferences*

The symposium "Abnormal influxes into the European Seas, particularly BAB Seas (Baltic, Adriatic and Black Seas) – causes, consequences, correctives" was organised in April 2004 with the participation of different international bodies as European Commission, Danube Environmental Programme, European Danube Commission, WWF etc.

*P. 7 – A dedicated web site for a virtual school and dissemination of the Centre's results was established.*

*Parts II and III – “Enhanced scientific co-operation with West European research institutes by networking”* and *“Enhanced long-term co-operative research and monitoring of the River Danube-its Delta-Black Sea system using jointly the local and international human and logistic resources (a “matrix” and “catalyst” of the two previous objectives)”*.

This part of the project represents the support for bringing about the convergence of Centre’s and Western Partners’ activities in the field of theoretical and applied environmental and geo-ecological research of the European River Systems (focussed on studying and observing the River Danube – Danube Delta – Black Sea system). The networking includes Centre, other Romanian institutes and universities and West-European partners as the IFREMER – France, Université de Bretagne Occidentale at Brest, Université de Paris VI, VII and II, Université Aix-Marseilles, University of Hamburg – Germany, Institute of Marine Geology in Bologna – Italy a.o.

**Potential exploitation by end users**

Young scientists are the primary beneficiaries from the project. They are exclusively profiting from the facilities offered by improving mobility schemes and the educational and training process. Synergetic approach to continuous education, enhanced international East-West co-operation and wider long-term theoretical and applied scientific research on one of the largest European River - Sea Systems is offered through the Centre.

The Centre activities have strong relevance for the economy and for the environmental state of the River Danube-Delta-Black Sea System (improving the quality of Science, improving navigation and water use, enhancing commercial water-ways across Europe, rehabilitating ecosystems and bio-diversity, facilitating decisions for enhancing the economic strength of the region etc.).

The Euro-EcoGeoCentre - Romania represents a permanent European Union Commission point of contact and effective presence in the Danube - Black Sea Region of high geo-political importance.

# Nutrients Cycling and the Trophic Status of Coastal Ecosystems - (EUROTROPH)

*Frankignoulle, M.[1], Borges, A.V.[1], Gazeau, F.[1,2], Delille, B.[1], Schiettecatte, L.S.[1], Gattuso, J.-P.[2], Rochelle-Newall, E.J.[2], González-Benítez, N.[2], Bonilla-Findji, O.[2], Pizay, M.D.[2], Wollast, R.[3], Vanderborght, J.P.[3], Chou, L.[3], Loijens, M.[3], Folmer, I.[3], Middelburg, J.J.[4], Van-den-Meersche K.[4], Boschker, H.T.S.[4], Veuger, B.[4], Duarte, C.M.[5], Barron, C.[5], Navarro, N.[5], Iversen, N.[6], Elliot, M.[7], Hemingway, K.L.[7], Burdon, D.[7], Campuzano-Guillen, F.J.[7], Allen, J.[7]*

[1] Université de Liège, Belgium; [2] Observatoire Océanologique de Villefranche-sur-mer, France ; [3] Université Libre de Bruxelles, Belgium ; [4] Nederlands Instituut voor Oecologisch Onderzoek, The Netherlands ; [5] Instituto Mediterráneo de Estudios Avanzados, Spain ; [6] Aalborg Universitet, Denmark; [7] University of Hull, United Kingdom

| | |
|---|---|
| Contact No : EVK3-CT-2000-00040 | Project duration: 02/2001 – 02/2004 |
| Project budget : Euros 2 296 722 | EU contribution : Euros 1 828 731 |
| Websites : www.ulg.ac.be/oceanbio/eurotroph/ www.obs-vlfr.fr/eurotroph/index.php/ | |

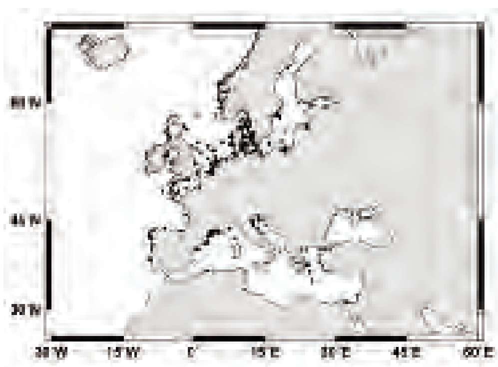
**Objectives**

An ecosystem is net autotrophic when production of organic carbon is higher than consumption. Conversely, it is net heterotrophic when consumption exceeds production. Despite its fundamental aspect in terms of carbon and nutrients cycling, the net metabolic state of the coastal ocean is still a matter of debate. Riverine fluxes of nutrients and organic carbon have been significantly affected by human activities and have probably modified the autotrophic versus heterotrophic balance in estuaries and, locally, in the coastal ocean. Any change or improvement in anthropogenic carbon and nutrients loadings will affect the trophic status of coastal ecosystems in ways that still have to be understood. Specific objectives included:

- Quantification of the trophic status of coastal ecosystems using different approaches at various time scales.
- A breakdown, unraveling and understanding of the nutrient cycles in autotrophic and heterotrophic systems.
- Integration and dissemination of results to all appropriate user communities.

**Results**

Two main approaches were applied to study ecosystem metabolism during EUROTROPH: 1) compilation of available data-sets at the European regional level [1,2] and, 2) the collection of detailed field measurements in the three study sites (Randers Fjord; Scheldt estuary; Bay of Palma). As an example of the large number of scientific outcomes of the project, the Figure below shows the map of the sites from the bibliographic database on metabolic performances of European



coastal waters (available at http://www.obs-vlfr.fr/eurotroph/index.php). The objectives of this part of the study were to compile published direct measurements on ecosystem function, essentially primary production and respiration and then to upscale these estimates, and to compare them with indirect estimates based on flux models in the coastal zone (Land-Ocean Interaction in the Coastal Zone).

By pinpointing several regions strongly impacted by human activities, this study should be useful for policy makers to decide where pollution reduction plans are strongly needed. Furthermore, this study pointed out a severe lack of knowledge in many European areas which precluded the satisfactory upscaling of estimates (for instance, Northern Baltic Sea and Eastern Mediterranean Sea). This paucity of results for certain regions can be used as a guideline for the selection of future scientific field work sites.

### Potential exploitation by end users

The EUROTROPH project aimed to use the produced data/information to improve communication between scientists and policy-makers. It allowed to set the regulatory framework for the project and to collate the gained scientific research information in an administrative, legislative and socio-economic framework. Five individual reports produced during the project are described below:

**(1) Ecological Impacts and Conceptual Models:** Background nutrient levels at each study site (including data from the sampling campaigns) are described and sources of inputs identified. Generic conceptual models have been derived, and the biological impacts of eutrophication and associated system effects discussed. Signs and symptoms of eutrophication observed at each site are highlighted and examined.

**(2) Ecological Modelling:** Numerous models were reviewed and the MOHID model chosen as the most suitable for all sites. The model serves as a management tool for testing different scenarios which produce eutrophic symptoms and for developing Decision Support Systems (DSS). Importantly, it provides data for cost-benefit analysis by testing different nutrient inputs, the repercussion of this in the environment, and the quantification of benefits to each study area.

**(3) Administration & Legislation:** Each study area is reviewed in relation to the regulatory framework at a national, European and international level. The administration and implementation of relevant water quality legislation at each study site is reviewed and compared, with the information produced allowing the assessment of differing administration and implementation strategies.

**(4) Socio-Economics:** The costs and benefits associated with reducing nutrient inputs as a result of implementing recent water quality legislation are addressed. The benefits of improved water quality in the Randers Fjord were assessed using a contingent valuation approach. The analysis provides information and advice to water quality managers in order to determine the efficacy of existing and future treatment strategies on a catchment-wide basis.

**(5) Monitoring and Management:** This report collates the management and monitoring issues raised within the project and summarises these issues for use by legislators and administrators in a way which allows dissemination of the results to a wider audience.

### References

[1] Gazeau, F, Gentili, B, Smith, SV, Frankignoulle, M, & Gattuso J-P (in press) Estuarine, Coastal and Shelf Science

[2] Middelburg, JJ, Duarte, CM, & J-P Gattuso (in press) In: Respiration in aquatic ecosystem

# A System of Hierarchical Monitoring Methods for assessing changes in the biological and physical state of intertidal areas – (HIMOM)

*Brockmann, C.[1], Consalvey, M.[2], Forster, R.[3], Jesus, B.[3], Casey, D.[3], Van Leeuwe, M.[3], van Bernem, C.[3]; Like, G.-J.[3]*

[1]Brockmann Consult, Germany; Carsten.brockmann@brockmann-consult.de; [2]University of St. Andrews, Scotland; [3]Netherlands Institute of Ecology, The Netherlands; [4]Instituto de Oceanografia, Portugal; [5]Environmental Research Institute, Ireland; [6]University Groningen, The Netherlands; [7]GKSS Reaearch Center, Germany; [8]National Institute for Coastal and Marine Management, The Netherlands



| | |
|---|---|
| Contract No : EVK3-CT2001-00052 | Project duration : 03/2002 – 2/2005 |
| Project budget : € 2,290,124 | EC contribution : € 1,821,924 |
| Website : http://www.brockmann-consult.de/himom | |



**Objectives**

The proper management of coastal environments requires appropriate and informed policy directives and the necessary combination of tools to carry out the requirements of these directives. Such a toolbox must include an accurate, efficient and cost effective system of monitoring methods. HIMOM provides a system of Hierarchical Monitoring Methods (HMM) to determine system change within tidal flat areas. By enabling the end users to interactively work online through the internet based application iMAP, they can also estimate the costs of implementing monitoring strategies of differing complexities. The main objectives or HIMOM are:

- European wide assessment of biological and physical dynamics of selected intertidal estuaries using remote sensing and ground measurement
- Providing coastal managers and end-users with a system of hierarchical monitoring methods (HMM)
- Demonstration of the application of the HMM concept in co-operation with concerned monitoring agencies in local experiments

**Results**

A practical handbook for carrying out monitoring of intertidal areas with recipes for sampling techniques and measurement methods as well as data analysis has been compiled. Links between the protocols shall be organised in a toolbox, ready to be used by the End Users. The HMM system, that is reflected in above mentioned toolbox, involves 34 validated and tested protocols for ground sampling, primary production, remote sensing and data management.

Field measurements are carried out every 2 – 3 months over 3 years in 4 different test sites spread over Europe. These seasonal measurements in each test site are performed in order to detect and compare changes throughout the years. In the scope of an intercalibration campaign different instruments and sampling as well as measurement methods were adjusted. During a simultaneous field campaign in all test sites, the vertical migration of microphytobenthos within a tidal cycle was analysed.

Spectral reflectances, which are measured regularly as standard parameter within the HMM, links the in-situ measurements with remote sensing data such as CASI or Landsat images. Methods like NDVI, linear spectral unmixing or supervised classification are used in order to retrieve sediment classifications and assessment of microphytobenthos in different scales. Landsat images of the estuaries of each test site have been classified and compiled to the HIMOM Estuary Atlas.

**Potential exploitation by end users**

The link to End Users is performed on the one hand through the HIMOM toolbox and on the other hand through the HIMOM iMap, which is designed as an interactive tool for making geoinformation available via the internet.

The HIMOM toolbox will include all protocols of sampling and measurement methods which contain to different levels. This provides the End User with a hierarchical suite of activities that are tailored to the specific needs of the End User. A socio-economic implication of change on management practise has been investigated and socio-economic benefits and related cost-benefit analysis will be presented to interest groups and decision makers.

The main purpose of the iMap is to allow end users to visualise and interpret this data immediately and together with other data sets including easy data up- and download. Visual interpretation and queries on all (spatial and non-spatial) data is possible, as well as presenting data in graphical form such as for example time series or reflectance spectra measured at different measurement points.

All preliminary results of HIMOM have been presented to a group of End Users and Stakeholders in order to discuss the scientific achievements with the practical experiments of the End Users and to develop a system that fits to their requirements.

# In-situ automated Monitoring of Trace metal speciation in Estuaries and Coastal zones in relation with the biogeochemical processes - (IMTEC)

*Graziottin, F.[1], Buffle, J.[2], Tercier-Waeber, M.-L.[2], Turner, D.[3], Achterberg, P.[4], Scarponi, G.[5], Koudelka-Hep, M.[6]*

[1] Idronaut s.r.l., Italy (idronaut@idronaut.it); [2] University of Geneva, Switzerland; [3] University of Göteborg, Sweden; [4] University of Plymouth, United Kingdom; [5] University of Ancona, Italy; [6] University of Neuchatel, Switzerland



| | |
|---|---|
| Contract No : EVK3-CT-2000-00036 | Project duration : 12/2000 – 11/2003 |
| Project budget : € 1 949 755 | EC contribution : € 930 000 |
| Website : www.idronaut.it/research_project/IMTEC/imtec.html | |



**Objectives**

Coastal ecosystems are threatened by anthropogenic activities and in particular by chemical pollution. Assessments of the impact of chemical pollutants are presently very difficult, because their speciation, i.e. the distribution of the various chemical forms of a given compound, cannot be determined accurately enough or at a sufficiently high time frequency. The specific objectives of the IMTEC project were: 1) to develop an ***automated real-time, in-situ monitoring buoy supported Multi Physical-Chemical Profiler (MPCP)*** for trace metal speciation measurements coupled to master variables in natural aquatic ecosystems; 2) to extensively deploy the novel MPCP and collect samples for laboratory complementary measurements in three complementary coastal ecosystems for i) field validation of the new developments, and ii) pollution monitoring and corresponding biogeochemical studies.

**Results**

The development of the buoy supported Multi Physical-Chemical Profiler (MPCP) has been successfully achieved. The MPCP allows simultaneous in situ, autonomous monitoring of three specific fractions of Cu(II), Pb(II), Cd(II), i.e.: free ions, dynamic and total extractable concentrations, which play important role in term of toxicity, transport properties and residence time, as well as master variables (pressure, temperature, pH, oxygen, conductivity, salinity, redox E and chlorophyll a) down to 150 meters. The MPCP probe is based on the VIP System developed recently (MAST-III VAMP project [1]). The heart of the VIP probe is a gel integrated microelectrode (GIME) which allows the specific measurement of the dynamic fraction of trace metals, defined as the sum of the free metal ions and the small labile complexes with size of few nanometres [1]. To improve the capability of the VIP, the following developments were performed: i) a complexing gel integrated microelectrode (CGIME) for voltammetric measurements of free metal ion concentrations; ii) a submersible FIA system for automatic, on-line sample pre-treatment and subsequent GIME measurements of total extractable metal concentrations; iii) an improved probe based on three independent voltammetric measuring channels integrating the GIME, the CGIME and the FIA-GIME devices as well as integrated standard physical, chemical and optical sensors, iv) hardware and firmware necessary to manage: simultaneous control of the fluidic systems as well as the measurements of trace metal speciation and master variables; data acquisition and transfer via telemetry; v) a user friendly Windows management software to control and set up the MPCP probe operating parameters and functions. Remote control of the MPCP has been achieved by coupling it to an improved Buoy Controller Module (BCM) which, via a stack of communication protocols and a remote management software, supervises the monitoring activities, collects/stores data from the MPCP measuring probe forwarding them, via a GSM network wireless connection, to a control land station. Systematic analytical tests and optimisation of the microsensors allowed to optimise the MPCP components and analytical procedures/conditions to insure simultaneous reliable measurements of the three metal fractions over typically a week (max. time tested) without maintenance of the system.

Intercalibration exercises, involving all IMTEC partners, undertaken during fieldworks in Sweden, Italy and UK have allowed co-ordination, integration and standardisation of sampling and common in situ and laboratory measurement methodologies resulting in accurate/precise measurements of specific metal fractions and biophysicochemical parameters by several European laboratories. They have also allowed evaluation of the suite of the MPCP speciation-sensitive measurement techniques, which showed a good agreement with our present knowledge of trace metal speciation, and field characterisation/ validation of the new analytical and technical developments.

The capability of the MPCP for reliable in situ monitoring of the temporal as well as spatial variations of trace metal speciation and master variables and its potentiality for i) more efficient environmental monitoring and rigorous interpretation of trace metal cycles and their ecotoxicological impact in aquatic system, and ii) pollution control were demonstrated by the results obtained during several field trials in various coastal ecosystems. The potentiality of the buoy supported MPCP with land station control as remote monitoring and early warning system was also demonstrated. Results of biogeochemical studies and pollution monitoring in the various aquatic ecosystems have lead to important findings. They demonstrated that physical and geochemical processes may readily influence the biologically available fraction of metal, for which total metal concentrations are poor indicator. A clear link between the concentrations of bioavailable metals and the production of chelating agents in phytoplankton has been demonstrated which provided an important first link between in situ measurements of specific metal fractions and their ecotoxicological effects. All these findings demonstrated the need and the usefulness of a system such as the buoy supported MPCP system developed for more efficient water quality evaluation, trace metal ecotoxicological assessment, legislation development which is essential for well-being and prosperity of society (see below).

**Potential exploitation by end users**

The MPCP is hoped to serve as a novel analytical tool of special interest for several end users, a long-term goal of IMTEC, e.g.:

- Water quality regulators because it will allow more efficient, cost effective: water quality evaluation, assessment of trace metal impact on biodiversity, real-time identification of trace pollutant inputs and fast remedial action (i.e. early warning strategies);

- Academic and water quality researchers, policy makers because it will provide large, reliable data banks allowing to develop/improve models and define scientific sound guidelines for assessing and forecasting the impact of trace metal pollutants which will allow enforcement and implementation of existing environmental legislation and water management. This will contribute to the protection of aquatic ecosystems, ensuring water quality for human consumption and maintenance of biodiversity by control over ecotoxicological risks, together with more rational socio-economic use of their resources, i.e. sustainable development to maintain the quality of life on the earth.

Moreover, international research programs, water quality regulator, consultancy firms and environmental agencies can benefit from the detailed Standard Operating Procedures and documentation provided by the IMTEC inter-comparison exercises and from the IMTEC data base on metal speciation and bioavailability, an information identified as lacking data on the environmental status of the estuaries and coastal zones studied.

**Reference**

[1] Tercier-Waeber, M.-L., Buffle, J., Koudelka-Hep, M., Graziottin, F. (2002) *Submersible voltammetric probes for in situ real-time trace element monitoring in natural aquatic systems,* Ch. 2 in :“Environmental Electrochemistry: Analysis of Trace Element Biogeochemistry“. Taillefert M., Rozan T..F. (Eds.), ACS Symposium Series No. 811, Washington DC.

# Monitoring and Managing of European Seagrass Beds (M&MS)

*Borum, J.*[1], *Krause-Jensen, D.*[2], *Kennedy, H.*[3], *Serrao, E.*[4], *Grade, N.*[5], *Duarte C.M.*[6], *Grau, A.*[7]

[1]University of Copenhagen, Denmark; [2]National Environmental Research Institute, Denmark; [3]University of Wales, United Kingdom; [4]University of Algarve, Portugal; [5]Instituto da Conservacão da Natureza, Portugal; [6]Consejo Superior de Investigaciones Científicas, Spain; [7]Direccio General de Pesca, Spain

| | |
|---|---|
| Contract No : EVK3-CT-2000-00044 | Project duration : 01/2000 - 06/2004 |
| Project budget : 2 353 912 | EC contribution : 1 829 290 |
| Website : www.seagrasses.org | |

**Objectives**

Seagrasses are rooted plants forming dense and highly productive stands in shallow coastal marine areas. They are important as primary producers providing food and shelter for commercially valuable invertebrates and juvenile fish, and they provide protection against coastal erosion. Therefore, seagrasses are key organisms of high interest to managers of coastal environments, and seagrasses are often important indicator organisms in monitoring programmes for European coastal waters. The main objectives of the M&MS project have been to define the habitat requirements of the European seagrass species, to identify the threats against them and to describe their resilience to disturbance in order to strengthen our forecast capacity and formulate cost-effective monitoring and management strategies. Specific objectives have been to compile and analyse data on relationships between water quality and seagrass performance, to determine interactions and relationships between plant performance and sediment composition, to determine if isotopic composition of carbon, nitrogen and sulphur reflects the degree of human disturbance, to determine the role of sexual reproduction and genetic diversity in resilience and recovery of seagrasses, and to examine the dynamics of spatial occupation of seagrasses, its importance for recovery and the role of seagrasses in coastal protection. The final objective is to integrate the knowledge into a handbook with recommendations for seagrass monitoring and management.

**Results**

Relationships between seagrass distribution and water quality have confirmed that light availability, determined by suspended sediments and phytoplankton biomass controlled by nutrient loading, is the most important factor regulating seagrass abundance and depth distribution. Physical exposure due to wave action and currents is also an important factor especially in more shallow areas. Short and long term changes in seagrass abundance are very often induced by changes in light conditions or exposure, but abrupt changes in seagrass distribution may also occur for other reasons. Nevertheless, seagrass abundance can be forecasted with reasonable precision as a stochastic phenomenon depending on physical exposure and water clarity which in turn is controlled by nutrient richness.

Sediment composition with differences in the contents of organic matter and reduced sulphur is of some importance to seagrass abundance and distribution. The three smaller and fast-growing European seagrass species, *Cymodocea nodosa*, *Zostera marina* and *Z. noltii*, have large air lacunae in rhizomes and roots supporting efficient supply of oxygen to below-ground tissues. This is likely the reason why these species can grow in muddy, organically rich sediments while the slow-growing *Posidonia oceanica* has small air lacunae and only grows in sandy or coarse-grained sediments with lower oxygen consumption. The latter species is thus more sensitive to organic loading. An efficient oxygen supply to seagrass below-ground tissues is necessary to prevent intrusion of toxic sulphide into seagrass roots and rhizomes with subsequent induction of tissue mortality. Longer periods with sulphide intrusion caused by poor water column oxygen conditions or high plant respiration due to high water temperature are likely responsible for sudden events of massive seagrass die-off. Hence, sediment quality is, in combination with water column conditions, a significant factor for seagrass growth and survival.

The isotopic composition of carbon, nitrogen and sulphur in seagrass tissues is a complex function of many environmental parameters and varies significantly over the season and with the degree of resource limitation. There are, however, systematic trends in elemental isotopic composition which can reflect anthropogenic disturbances and, therefore, can function as early warning indicators. The isotopic composition of nitrogen in seagrasses reflects the balance between inorganic nitrogen sources, and the influence of nitrogen runoff from land can be detected within the seagrass tissues. The isotopic composition of sulphur is not a direct function of anthropogenic runoff but seems to rely on environmental conditions. The isotopic sulphur composition separates conditions with sulphate as the main source from stress conditions where invading sulphide is reoxidized and subsequently incorporated within the plant tissues. Hence, isotopic sulphur composition may strongly indicate seagrass beds growing under critical environmental conditions.

The sexual reproductive effort varies considerably among the four seagrass species with annual seed production ranging from less than 0.1 seed $m^{-2}$ for *Posidonia* to more than 20,000 seeds $m^{-2}$ for *Zostera*. This difference results in very different recolonization potentials. The size of seeds and the means of their spreading vary similarly resulting in different genetic diversity among different seagrass stands. During the project, new microsatellites have been developed for *P. oceanica*, *C. nodosa* and *Z. noltii*, and the genetic diversity of all four seagrass species has been described from a large number of localities. In isolated geographic areas the genetic diversity varies from very high (*Z. noltii* in Portuguese estuaries) suggesting efficient genetic exchange probably by means of birds to no genetic diversity (*C. nodosa* in Ria Formosa). In Ria Formosa, a 25 $km^2$ *C. nodosa* population is formed from a single male plant reflecting colonization by an extremely rare event.

Vegetative propagation characteristics of the four seagrass species have been described under contrasting regimes of anthropogenic disturbance. Rhizome elongation rates, branching frequency and branching angles vary substantially among species and with different environmental conditions resulting in very different spatial and temporal scales of space occupation during seagrass recolonization. Models have been established to describe space occupation for all species, and combined with data for sexual reproduction effort, time scales of seagrass recovery ranges from years over decades to centuries for the slow-growing *P. oceanica*.

**Potential exploitation by end users**

Existing and acquired knowledge will be integrated into a handbook for, first of all, unexperienced environmental managers, who wish to establish operational and cost-effective monitoring and management strategies and programmes. Basic seagrass ecology will be described together with the information needed for quantifying seagrass beds, identifying threats to their sustainability, initiating protective actions and estimate spatial and temporal scales of seagrass recovery.

# Monitoring Long-term Trends in Eutrophication and Nutrients in the Coastal Zone - (MOLTEN)

*Conley, D.J.[1], Anderson, N.J.[2], Andrén, E.[3], Clarke, A.L.[1], de Jonge, V.[4], Ellegaard, M.[5], Juggins, S.[6], Kauppila, P.[7], Korhola, A.[8], Reuss, N.[1], Telford, R.J.[9], Vaalgamaa, S.[8], Weckström. K.[8]*

[1]National Environmental Research Institute, Denmark, dco@dmu.dk; [2]Loughborough University, U.K.; [3]Uppsala University, Sweden; [4]University of Groningen, The Netherlands; [5]University of Copenhagen, Denmark; [6]Newcastle University, UK; [7]Finnish Environmental Inststitute, Finland; [8]Helsinki University, Finland; [9]Bjerknes Center for Climate Research, Norway

| | |
|---|---|
| Contract No : EVK3-CT-2000-00031 | Project duration : 02/2001 – 01/2004 |
| Project budget : € 1.120.770 | EC contribution : € 860.000 |
| Website : http://Craticula.ncl.ac.uk:8000/Molten/jsp/index.jsp | |

### Objectives

Estuarine and coastal systems have experienced massive changes in nutrient loading from anthropogenic activities during the history of human occupation. In the EU funded MOLTEN project we have used high-resolution records of environmental change recorded in coastal sediments to reconstruct, or hindcast, long-term (ca. 100 years) changes in nutrient concentrations. The project involves novel approaches to reconstruct historical nutrient concentrations using the recently developed technique of diatom-based transfer functions and uses a multi-proxy approach to reconstruct different aspects of ecosystem response (phytoplankton, macrophytes, zoobenthos) to changes in nutrient loading.

### Results

Our construction of harmonized transfer functions for estuaries in northwest Europe, provides needed information on the distribution and optima of marine and estuarine diatom taxa. Reconstruction of total nitrogen (TN) from Roskilde Fjord, Denmark indicates an 85 % increase in TN concentration during the last century with the most rapid increase occurring after the 1950s, corresponding to the post-war increase in N fertilizer. In an urban embayment (Laajalahti) near Helsinki, Finland, transfer function application revealed impacts associated with growing wastewater inputs. These changes are small relative to the order of magnitude increases in nutrient loading that have occurred in northwestern Europe.

### Exploitation by end users

We have developed a novel palaeoecological methodology that provides environmental decision makers with a monitoring tool that can be used to assess the background, or reference conditions, and the degree of past and present departure from these conditions as required by the Water Framework Directive. In addition, this tool can be used to predict the likely recovery of these systems with reduced nutrient loads, such that appropriate policy and management measures can be taken both at the European and national scales. To ensure that our results are available to end-users, especially environmental decision-makers, we have prepared specific guidelines for the management authorities to be used in implementing the Water Framework Directive.

# Nutrient dynamics mediated through Turbulence And Plankton interactions – (NTAP)

*Marrasé, C.* [1], *Peters, F.* [1], *Dolan J.R.* [2], *Havskum, H.*[3], *Lorhman, A.*[4], *Pedley, T.J.*[5], *Thingstad, T.F.*[6]

[1] Institute of Marine Sciences (CSIC), Barcelona, Spain; [2] Station Zoologique (CNRS) Villefranche-Sur-Mer, France; [3] University of Copenhagen, Denmark; [4] Nortek AS, Norway; [5] University of Cambridge, United Kingdom; [6] University of Bergen, Norway.


| | |
|---|---|
| Contract No : EVK3-2000-00022 | Project duration : 04/2001 – 04/2004 |
| Project budget : EUR 2 257 339 | EC contribution : EUR 1 494 042 |
| Website : www.icm.csic.es/bio/projects/ntap | |


**Objectives**

The level of eutrophication and the number of harmful algal bloom events keep increasing in European coastal waters, affecting fisheries, tourism and aquaculture industries. Our inability to fully predict eutrophication or harmful algal bloom events derives from the present lack of an integral understanding of the influence of critical variables, such as small-scale turbulence, on the interaction between plankton and nutrient dynamics. The overall objective of NTAP was to provide a unified conceptual framework for nutrient dynamics as modulated by the interaction of turbulence and plankton. The specific objectives were four, each of them constituting a heading in the results section.

**Results**

**Objective 1) to build a database on turbulence effects from existing scattered data**

We constructed a database, in which we summarized the existing experimental data on the effects of turbulence upon plankton processes at organism and community level. The database is available in a searchable way for the general public at www.icm.csic.es/bio/projects/ntap.

***Objective 2) to produce experimental data on key organisms, interactions and mass transfer rates***

We performed a series of experiments at different scales of complexity (cultures of key species and natural plankton communities). Our results revealed a) Diatom affinity constants for phosphate are higher than estimated from theoretical approaches based on cell size. b) Effects of turbulence on clearance and growth of ciliates and dinoflagellates are species-specific and depend on indirect effects such as pH changes due to mixing and prey response to turbulence [1, 2]. c) The effect of turbulence on plankton yield and particulate organic matter stoichiometry depends on the concentration of available nutrient in the system and the initial environmental conditions. The maximum effect on plankton yield was found at intermediate nutrient values (Figure 1), while the effect on stoichiometry was more conspicuous at low nutrient levels [3, 4, 5, 6, 7]

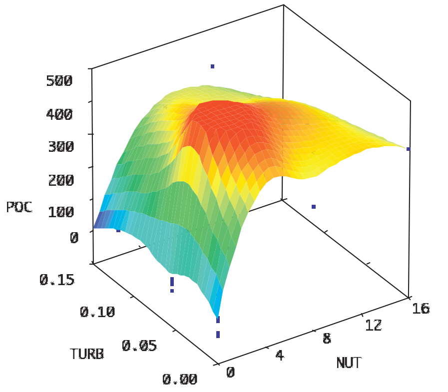



*Figure 1. Concentration of POC (μM) with respect to turbulence (cm2 s-3) and nutrient load (μM nitrate) in coastal waters.*

***Objective 3) to develop a sensor for laboratory measurement of small-scale of turbulence***

A prototype for a turbulence micro-sensor has been developed based on 3D acoustic Doppler technology, which is at present being testing. This new sensor will allow measurement of particle velocities in small recipients using acoustic methods.

***Objective 4) to produce a dynamical model at the community level with exploratory and predictive capabilities***

We have included theoretical predictions of the effect of turbulence on the different species in the system into a food web minimum model [8]. In this model nutrient uptake by osmotrophs and contact rates between predator-prey are dependent on turbulence. Different computational runs performed indicated an increase in the populations of diatoms and copepods with increasing turbulence, which is in agreement with experimental results [9]

## Potential exploitation by end users

The database constructed and the new experimental results obtained about the effects of turbulence on plankton activities revealed that turbulence induces changes in nutrient fluxes and nutrient thresholds for plankton yields. Our results show the need to create location specific legislation for nutrient loading and evidences the need for considering hydrodynamic characteristics when defining biogeochemical provinces. Predictions based in our experimental and modeling research will be useful for defining recommendations in the context of placement of waste outfall sites and aquaculture devices in coastal areas. Finally, the parameterizations of different biological rates under turbulence conditions will be available for scientists modeling biogeochemical fluxes in different contexts.

## References

[1] Dolan, JR, Sall, N, Metcalfe, A, Gasser, B (2003) Aquatic Microbial Ecology. 31: 183-192. ELOISE contribution Nr. 351/40.
[2] Havskum H. (in press). Ophelia.
[3] Alcaraz, M, Marrasé, C, Peters, F, Arin, L, Malits, A (2002) Marine Ecology Progress. Series 242: 63-71. ELOISE contribution Nr. 284/40.
[4] Arin, L, Marrasé, C, Maar, M, Peters, F, Sala, MM, Alcaraz, M (2002) Aquatic Microbial Ecology. 29: 51-61. ELOISE contribution Nr. 277/40.
[5] Maar, M, Arin, L, Simó, R, Sala, MM, Peters, F, Marrasé, C (2002) Aquatic Microbial Ecology. 26: 63-72. ELOISE contribution Nr. 278/40.
[6] Malits, A, Peters, F, Bayer, M, Marrasé, C, Zoppini, A, Guadayol, O, Alcaraz, M. (in press) Microbial Ecology. ELOISE contribution Nr. 443/40.
[7] Peters, F, Marrasé, C, Havskum, H, Rassoulzadegan, F, Dolan, J, Alcaraz, M, Gasol, JM (2002) Journal of Plankton Research. 24: 321-331. ELOISE contribution Nr. 254/40.
[8] Thingstad, TF , Havskum, H, Kass, H, Lefevre, D, Nielsen, TG, Rieman, B, Williams PJL (1999) Limnol. Oceanogr. 44:236-253.
[9] Metcalfe, A.M., Pedley, T.J., Thingstad, T.F. (in press) Journal of Marine Systems. ELOISE contribution Nr. 298/40.

# Operational Radar and Optical Mapping in monitoring hydrodynamic, morphodynamic and environmental parameters for coastal management - (OROMA)

*Ziemer, F.[1], Wensink, H.[2], Brockmann, C.[3], Kozakiewicz, A.[4], Krzyminski, W.[5], Hennings, I.[6], Vogelzang, J.[7], Hinnrichsen, A.[8], Vaughn, R. [9], and Verstraaten, J. [10]; Seemann, J.[11].*

[1] GKSS / ICR, G; [2] ARGOSS, NL, [3] BCABRC, G; [4] BMT, PL; [5] IMWM, PL; [6] Univ. of Kiel, G; [7] RWS.SD, NL; [8] ALR, G; [9] Univ. of Dundee, UK; [10] WWK, B; [11] V2T, G.



| | |
|---|---|
| Contract No EVK3-CT2001-00053 | Project duration : 02/2002 – 01/2005 |
| Project budget : € 3 333 539 | EC contribution : € 1 994 937 |
| Website : www.brockmann-consult.de/oroma/ | |



**Objectives**

Being of high natural variability near coastal morphodynamic as well as biological factors within the coastal area, require to be monitored by coastal managers in order to preserve the environment. To manage permanent human intervention such as dredging, beach nourishment, jetty construction or other coastal protection measures and to assess the status, the impact and the possible risks within the environment most actual thematic information is needed.

Therefore, the objective of OROMA is to present the necessary information on the most actual status of

- the coastal bathymetry and
- important parameter on water quality.

For this, OROMA develops radar and optic remote sensing tools for mapping and presenting the processes of interest over large areas in close to real time. The OROMA team, consisting of 6 developers and 4 end users (from coastal management), will pursue the problem of converting scientific-based knowledge into actual thematic information to be distributed via electronic network.

**Results**

Monitoring of the water quality by ships is time and cost consuming. Water constituent concentration derived from space borne sensors MERIS, SeaWiFS and MODIS provide complementary data, potentially leading to a reduction of in-situ measurements. OROMA has proven that the remote sensing data are comparable to the existing long-term in-situ archives by local calibration of the underlying biological algorithms.

The OROMA radar observations are mainly applied for the bathymetric survey. Two new techniques of information acquisition by ground based radar are used in OROMA: 1. Imaging the local ocean wave field refraction by a rotation antenna option and 2. scanning sea surface roughness by stop antenna with a moving ship/car method.

For the imaging method within a circular range of about 2 - 4 km around a fixed station the ocean wave field approaching the coast is observed by radar during about 10 minutes. Bathymetric maps with a 30 m grid resolution are deduced from these data by inverse modeling using the physics of wave refraction depending on the local water depth. Data acquired in 2001 and 2003 were used to study the bathymetric change due to sand transport. At the test site a significant loss of sand close to the shore could be observed, whereas a broad stripe between 200 m and 800 m distance showed a significant increase of sand. At the distance of around 1000 m another sand reduction zone was detected. These results have been verified by conventional observations.

The example chosen in this place (see figure 1.) shows an intermediate result for which the raw data have been acquired by scanning option.

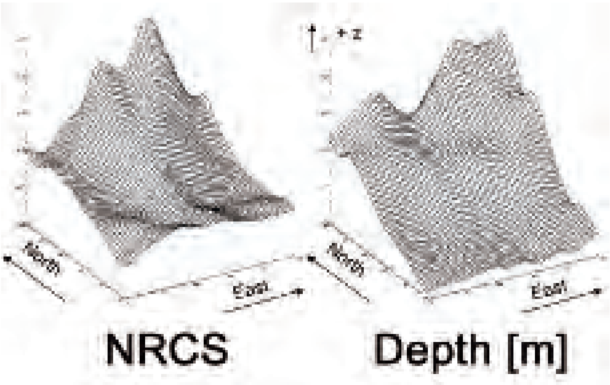



**Figure 1.** Grid map of he Normalised Radar Cross Section (NRCS) representing the small scaled sea surface roughness in comparison to the bathymetry of the test site "Lister deep".

The fine structure in the radar map and the bathymetry will be combined by a current model, which can be used for the survey of the bathymetric changes.

Under the use of a calibrated radar the geo coded field of the Normalised Radar Cross Section (NRCS) was composed to a map at the left in figure 1. The three-dimensional plane at the right gives the local water depth with the depth axes pointing upwards. The radar data were acquired during ebb tide, that means the current transports the water from the North east corner of the test site. It is evident that cross current high gradients in the bathymetry induce high radar cross sections. The next step during the still running OROMA project is to train a hydrodynamic model to reproduce the radar map from the actual bathymetry. At a later time only the radar map will be acquired and the model will be inverted to produce the new bathymetry.

**Potential exploitation by end users**

OROMA establishes radar observations taken from shore or from a vessel operating in the site can be used for near shore bathymetric survey, which is of importance for coastal areas with natural or men made high sand transport rates.

OROMA demonstrates the potential of optical observations from space borne sensors MERIS, SeaWiFS and MODIS to be used operationally for the survey of water quality parameter.

# Developing tools for the prediction of catastrophic coastal cliff collapse - (PROTECT)

*Busby, J. [1], Gourry, J. [2], Senfaute, G.[3], Pedersen, S.[4], Mortimore, R.[5]*

[1]British Geological Survey, UK; [2]Bureau de Recherche Géologiques et Minières, France; [3]Institut National de l'Environnement Industriel et des Risques, France; [4]Geological Survey of Denmark and Greenland, Denmark; [5]University of Brighton, UK. E-mail jpbu@bgs.ac.uk



| | |
|---|---|
| Contract No : EVK3-CT-2000-00029 | Project duration : 1/4/2001 – 30/6/2004 |
| Project budget : €1 553 372 | EC contribution : 852 721 |
| Website : www.brighton.ac.uk/environment/research/earth_systems/agru/projects.htm | |



**Objectives**

The erosion of coastal cliffs is inevitable. The cliff collapses are a hazard, a problem for coastal land use planners and limit the use of the coastline as an amenity. Techniques to monitor the rock mass adjacent to a cliff face have not been developed and hence alerts of impending catastrophic failure can only occur once movement of the cliff face has occurred. If rock mass parameters can be used to assess the state of a cliff then coastal managers will be better placed to manage the cliffed coastline, improve safety and make more informed land use planning decisions. The specific objectives of the project are:

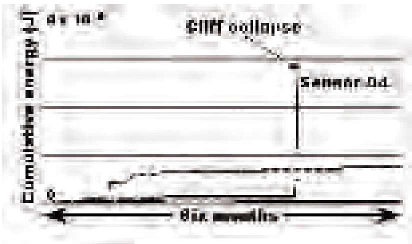
- To develop predictive tools, which will identify sections of cliffed coastline, that are approaching a state of imminent collapse.
- Attempt to determine if accurate predictions can be made of the timing of the collapse.
- To contribute to the wider goal of understanding the physical properties of the rock mass, which leads to unstable cliffs.

**Results**

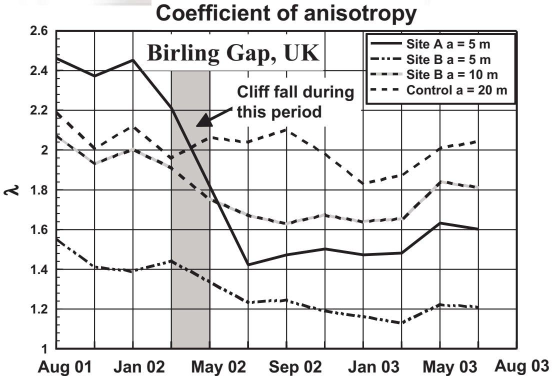
Two methodologies have been followed in order to identify any pre-cursors to a cliff collapse. For the first, it is assumed that in cliffs composed of a highly fractured rock such as chalk, any sub-vertical fractures will gradually dilate with time until a collapse is initiated. Since fractures often occur in sets with a preferred orientation they impose anisotropic physical properties to the rock mass. Hence, the apparent resistivity (a measure of electrical resistance) of the rock will vary with azimuth reflecting the dominant fracture orientation. A factor of anisotropy can be calculated from the measurements and this would be expected to vary with time if the fractures are dilating. Secondly, the rock mass will crack as a collapse approaches and the cracking will generate high frequency seismic signals, known as acoustic crack emissions. An increase in emitted seismic energy, recorded on accelerometers in boreholes within the cliff, would be expected as a collapse approaches.

A microseismic array was established in the chalk cliff at Mesnil-Val, on the Normandy coast of France. The purpose was to record cliff collapse precursor seismic signals near the cliff edge, a few minutes or hours before a rock collapse occurs. Each seismic station consisted of an accelerometer/geophone pair that measured vertical component seismic signals. Five stations were established, configured as follows;

- Two stations in vertical boreholes, drilled from the top of the cliff to a depth of 10 metres, 50 metres apart and located 10 metres from the cliff edge.
- Three stations in horizontal boreholes drilled into the cliff face to a depth of six metres.




A cliff fall occurred at Mesnil-Val on 23rd June 2002. Calculations from detailed topographic grid monitoring indicate that approximately 2700 $m^3$ of chalk dropped from a maximum height of around 50 m. The fall was preceded by a dramatic increase in released seismic energy up to 15 hours before the collapse.




Apparent resistivity measurements were taken at five, chalk, cliff top research sites in the UK, France and Denmark over a period of two years. Data were collected along 24 azimuths at 15° increments and plotted as polar diagrams. The coefficient of anisotropy, $\lambda$, defined as the ratio of the major to minor axis of the best fitting ellipse was calculated for each data set.This plot shows a dramatic change in $\lambda$ due to a cliff fall that occurred at Birling Gap, UK between March and May, 2002. The change is largest at the sites near the cliff edge, A and B, and is absent from the Control site, set back from the cliff. In addition, the research has demonstrated the existence of a cliff parallel fracture set near the cliff edge. It is likely that cracking within this fracture set is responsible for the seismicity and the variations in the coefficient of anisotropy.

**Potential exploitation by end users**

The results obtained to-date have demonstrated that changes within the rock mass adjacent to a cliff can be monitored prior to a cliff fall. The end users within the project are very supportive of the research and have identified the need for the technology developed to be practicable and usable and to be transferable to rock types other than chalk. It is anticipated that after proving the robustness of the techniques they could be installed by local authorities in high risk areas and that insurance companies may insist on their installation in such zones. These techniques will lead to improvements in the quality of life as follows:The use and availability of areas of high cliffs as an amenity will increase.

- Coastlines of high cliffs are associated with hazards from catastrophic collapses. The safety of those walking on the cliff tops or on the associated beaches (residents, tourists, etc.) will be improved with the ability to issue more informed hazard warnings.
- Communities that are threatened by encroaching cliffs can be closely monitored in order to assess the extent and time scale of the threat.

A considerable body of knowledge has also been accumulated on the geological, geomechanical and meteorological factors that influence the erosion of cliffs. These data will enable improved models of cliff erosion to be developed that will in turn lead to improved predictions of the effect of global warming and sea level rise on the coastal zone.

# Silicate and Baltic Sea Ecosystem Response - (SIBER)

*Humborg, C*[1]

[1] Department of Systems Ecology, Stockholm University, SE-10691 Stockholm, Sweden

| | |
|---|---|
| Contract No : EVK3-CT2002-00069 | Project duration : 11/2002 – 10/2005 |
| Project budget : € 1 800 000 | EC contribution : € 1 400 000 |
| Website : http://siber.ecology.su.se/ | |

**Objectives**

Regulation of rivers and eutrophication in river basins has largely reduced dissolved silicate (DSi) loads to the Baltic Sea, which is partly responsible for decreasing DSi stocks reported. Reductions in DSi stocks can also be influenced by enhanced deposition in Baltic sediments due to marine eutrophicaton. As a general consequence of the DSi reduction, phytoplankton species shifts have been reported world wide with far reaching effects for coastal ecosystems. This project aims to quantify the relative importance of reduced loads *vs.* marine eutrophicaton for decreasing DSi stocks and to investigate the possible ecological effects on phytoplankton assemblages. Specific objectives included:

- Estimation of changes in DSi loads and stocks
- Burial rate of opal and diatom stratigraphy
- Assessment of qualitative and quantitative changes in diatom populations in the early growth season

**Results**

A data set has been compiled on DSi loads to the Baltic based on 84 major rivers. It covers the period 1970-2000. Also a GIS database for 81 watersheds holding landscape variables critical for DSi land-sea fluxes has been established within WP1. DSi concentrations of the major rivers show the opposite patterns to what was expected and highest concentrations have been found in the subarctic unperturbed rivers running into the Bothnian Bay, whereas the regulated rivers in the North and eutrophied rivers of the Southeast drainage basins show the lowest concentrations. A first rough estimate suggests that the DSi load to the Baltic Sea was about double as high as before the onset of damming and eutrophication. Thus, SIBER will allow decision makers to evaluate how changes in land use (damming, eutrophication) will affect phytoplankton blooms in the Sea.


A DSi database for the entire Baltic Sea for the period 1970-2000 has been formed within WP2, including the corresponding hydrographic and hydrochemical data. Analyses of DSi trends in the Baltic waters were performed for the this time period. The calculations were carried out for nine monitoring stations. Significant decrease in DSi concentrations were revealed for all stations and most depth intervals (see Figure above). The analysis of long-term water column data contributes to biological reference values needed for establishing Ecological Quality Ratios as required by the Water Framework Directive.

WP3 has identified existing data, accessed existing sediment cores, collected new sediment cores, and analyzed sediments for biogenic silica (BSi) concentrations. In addition, the cores for historical diatom analysis have been identified and the work has started on those cores. From these studies it can be estimated how much of the DSi decrease in the Baltic Sea is due to marine eutrophication, i.e., deposition in marine sediments. The studies on diatom stratigraphy will allow us to see whether the diatom species composition has changed over time as a response to reduced DSi loads and stocks. Also, the sediment studies contribute to biological reference values needed for establishing Ecological Quality Ratios.

Within WP4 13 species of spring bloom diatoms and dinoflagellates from the Gulf of Finland have been isolated in cultures. Basic ecophysiological experiments have been successfully initiated with them, in order to prepare for the competition experiments planned in the next stage, and to provide hypotheses for their competitive success in mixed natural communities. These insights in physiological settings of diatoms are essential to give prognostic estimates on which diatom species may be preferred at various DSi concentrations and turbulence/light regimes.

In addition to these experiments 14 ecophysiological mesocosm experiments with natural phytoplankton communities collected during 5 cruises within the southern Baltic Sea have been conducted within WP5. These *in situ* observations will be complemented with historical hydrological and chemical data to follow up the long-term changes in phytoplankton composition in the Baltic Sea. Both WP's dealing with the assessment of qualitative and quantitative changes in diatom populations (4 and 5) contribute to biological reference values needed for establishing Ecological Quality Ratios as required by the Water Framework Directive.

**Potential exploitation by end users**

Results of the SIBER project might generate a new tool for the evaluation of the environment, especially for the assessment of eutrophication and hydrological alterations on a whole ecosystem, the Baltic Sea. Since the partners closely co-operate with the local and regional authorities monitoring this environment, the knowledge from the project is directly transferred to decision makers, and, thus, can facilitate decisions that address nutrient management of riverine inputs.

# OCEAN MARGIN

# Automatic evaluation of trawling impacts, sediment stability and coral carbonate mounds using UUVs - (AMASON)

*Capus, C.[1], Coiras, E.[1], Lane, D.[1], Lebart, K.[1], Petillot Y.[1], Tena Ruiz, I.[1], Banks, A.[2], Smith, C.[2], Grehan, A.[3], Canals, M.[4], Urgeles, R.[4], Cardew, M.[5], Jaffray, B.[6], Wallace, J.[7], Allais, A-G.[8], Rigaud, V.[8]*

[1]Heriot-Watt University, UK; [2] IMBC, Greece; [3] National University of Ireland, Galway, Ireland; [4] University of Barcelona, Spain; [5] System Technologies, UK; [6] Tritech International Ltd., UK; [7] Marine Informatics Ltd., Ireland; [8] IFREMER, France

| | |
|---|---|
| Contract No : EVK3-CT-2001-00059 | Project duration : 01/2002 – 12/2004 |
| Project budget : € 2 742 164 | EC contribution : € 1 795 011 |
| Website : www.ece.eps.hw.ac.uk/~amason | |

**Objectives:**

Offshore mapping and seafloor imaging is a major requirement for scientific evaluation of coral carbonate mounds, trawling impacts and hazard assessment related to sediment stability, as well as ecosystem monitoring. AMASON will provide this facility using small, commercial-off-the-shelf, sensors mounted on UUVs (Unmanned Underwater Vehicles) of opportunity.

The project will develop a modular system architecture, ensuring a scalable and re-configurable system. The Data Acquisition System (DAS) will interface with the sensors and store the raw data in a GIS (Geographical Information System) environment. The DAS will also interface with the Advanced Processing Algorithms (APA) module. The APA module will provide rapid object and region characterisation, classification, mapping and mosaicing for large concurrent data sets from the video, small sidescan, parametric sub-bottom and multibeam bathymetric sonars. Fusion of feature and symbolic data will be used to improve confidence in detected events of scientific interest.

The software suite will run on portable notebook computers and inexpensive network and computing components. The project will be tested using two UUVs of opportunity at relevant sites.

**Results:**

The AMASON project has recently carried out its mid-term trials in Crete, Greece. The trials proved the reliability of the AMASON DAS developed by Marine Informatics Ltd. The DAS was used to gather the data from the AMASON sensor suite developed by System Technologies. The sensors and DAS were mounted on IMBC's Max Rover ROV which was deployed from IMBC's research vessel Philia in Heraklion bay.

The data gathering trials took four days and a number of different missions were carried out. The multiple-sensor platform was carefully guided to best exploit the APA currently under development in Heriot-Watt University and in IFREMER. These algorithms help automate tasks normally carried out by scientists, such as assessment of trawling impact and monitoring of coral mounds and evidence of recent seafloor instability. In the final trials the post-processing will enter the mission planning loop, helping scientists take decisions based on the analysis of the most recently gathered data.

**Potential exploitation by end users:**

The research aims to:

Substantially reduce survey sensor capital/operational costs and labour in data analysis.

Provide the means to substantially increase the user community having regular access to the technology.

Improve decision making at the individual scientist level through better visualisation of historical and locally gathered data, before, during and after data gathering.

# Exploration and Evaluation of the Eastern Mediterranean Gas Hydrates and the the Associated Deep Biosphere - (ANAXIMANDER)

*Perissoratis, C.[1], Ioakim, Chr.[1], Zacharaki, P.[1], Lykousis, V.[2], Sakellariou, D.[2], Kormas, K.[2], Woodside, J.[3], Amann, H.[4], Maggiulli, M.[4], Daehlmann, A.[5], De Lange, G.[5], Casas, D.[6], Gemma, E.[6], Meyn, V.[7], Varotsis, N.[8], Marinakis, D.[8]*

[1] Institute of Geology and Mineral Exploration, Greece; [2] National Center for Marine Research, Greece; [3] Free University of Amsterdam, The Netherlands; [4] Technische Universitaet Berlin, Germany; [5] Utrecht University, The Netherlands; [6] Instituto de Ciencies del Mar, Spain; [7] Technische Universitaet Clausthal, Germany; [8] Technical University of Crete, Greece.



| Contract n$^{o}$ EVK3-CT-2002-00068 | Project duration: November 2002 – October 2005 |
|---|---|
| Project Budget: € 2 600 420 | EC CONTRIBUTION: € 2 002 389 |
| Website: www.igme.gr/anaximander | |



**Objectives**

The project ANAXIMANDER[1] has its target the Exploration and Evaluation of the Gas Hydrates (GH) and the associated deep biosphere in the Anaximander sea-mountains in the Eastern Mediterranean (av. water depth 2000m, bottom water temp. 12-14$^{o}$C). In this site the presence of GH has been confirmed during earlier research programs, their occurrence is near the sea bottom, and a characteristic methanophil and methanotrophic rich biota is present.

In the project appropriate and innovative coring and sampling instruments will be used in order to obtain undisturbed cores, to carry out subsampling with minimum distortion of the sediments containing GH, and to keep unaffected the associated biocommunities.

**Results**

During the first field work (May 2003) by the R/V AEGAEO, a detailed bathymetry of the area was obtained. Specific attention was given to three known MVs (Amsterdam, Kazan, and Kula) where high-resolution seismic (10 cu.in air gun) and bathymetric data (dense grid, low speed multibeam coverage) were obtained and selected box and gravity cores were retrieved. In addition CTD water samples were analyzed for $CH_4$ and other gases in order to identify active emissions.

The major results of the project up to now have been the following[2,3]:

The coring sites for the first and the second field work where defined.

The GH hosting sediments are mud flows interbedded with hemipelagic mud, with high content of clay and silt . The sand content is about 14% in the mud flows and less then 3% in the hemipelagic mud.

Micropaleontological analyses indicated a Late Cetaceous to Early-Middle Miocene age for the rock clasts present in the mud flows.

GH were sampled for the first time at Kazan MV, a third site in the Mediterranean with GH besides the known sites at Amsterdam and Kula MVs. They displayed “rice” – like appearance and a texture resembling compacted snow.

GH in layered form were sampled from Amsterdam MV at a subbottom depth of around 1m.

The last two successive mud flows identified in cores retrieved from Kula MV were estimated to have an episodicity of about 5-20 ka, based on the chronology of the sapropel and of the $Y_2$ tephra layer present (Cape Riva eruption).

A bottom simulating reflector (BSR) was inferred to occur at about 50-80 m below the seabed, throughout a mud flow south of Amsterdam MV.

New MVs were identified, one of which was sampled and documented as active and named “Athina”.

All cores bearing GH are characterized by temperatures much lower than the ambient water temperature. The largest anomaly (16.5$^{o}$ C) was found in a gravity core at Amsterdam MV.

The $CH_4$ total concentrations in sea floor sediments are up to 800 and 1400 μmol/1 wet sediment for Amsterdam and Kazan MVs. The GH bearing gravity cores shows concentrations, of up to 3300 μmol/1 wet sediment at the core top (<60cm) decreasing towards the bottom (130 cm). $CH_4$ and hydrogen sulfide concentrations of selected samples revealed that the depth of anoxic methane oxidation lies at about 10 to 15 cm below seafloor.

Low salinities found decreased to 25% and 10% at Amsterdam and Kazan MV. At Amsterdam MV, $CH_4$ concentrations in the seawater close to the seafloor are enhanced with respect to the average seawater values by a factor of 3 to 4. A small additional plume lies at about 100-150 m above sea bottom.

The GH dissociation temperatures may vary from 14$^{0}$ C to 24$^{0}$ C. Depth-dependent GH and liberated gas composition profiles may occur in the study area.

The maximum cell concentration (95%) has the same order of magnitude in all samples while both Bacteria and Archaea Domains were present in most of the sediment layers. Presence of methanogens, was noted in three sediment layers in a core from Kazan MV.

On the basis of the geological and geotechnical data collected, a Multi Autoclave Corer with four tubes of 0,7 m length, and an Autoclave Piston Corer with a 2,7 m long core barrel are currently being modified[4] to be used for the second field work (fall 2004) in order to obtain pristine cores.

### Potential exploitation by end users

The GH when decomposed can play an important role in the marine environment due to the methane that will be released, while at the same time it is a potential energy source. The results of the first year activities of the project strongly imply that the active mud volcanism and the presence of GH in the E. Mediterranean is much more extensive than previously thought. This has provoked the interest of both the decision makers and the greater public during the various presentations of the preliminary results of the Anaximander project. For this purpose the team has provided, in simplified form, these results to the responsible public agents, to decision makers and to daily newspapers where relative articles appeared.

Contact point for project: prs@igme .gr

### References

[1] Perissoratis, C., et. al, 2003, OMARC Conf. Abstr. p.89
[2] Lykousis, V., et. al, 2003, OMARC Conf. Abstr. p.36
[3] Daehlmann, A., et. al, 2003, OMARC Conf. Abstr. p.63
[4] Maggiulli, M., et. al, 2003, OMARC Conf. Abstr. p.78

# Array of Sensors for long term Seabed Monitoring of geohazards (ASSEM)

*Rolin, J.F.[1], Blandin, J.[1], Strout, J.M.[2], Briole, P.[3], Etiope, G.[4], Ferentinos, G.[5], Masson, M.[6], Smolders, S.[7], Lykousis, V.[8]*

[1]Ifremer, France ; [2]NGI, Norway ; [3]Institut de Physique du Globe de Paris, France ; [4]Istituto Nazionale di Geofisica e Vulcanologia, Italy ; [5]University of Patras, Greece ; [6]Capsum GmbH, Germany ; [7]THALES Geosolution, Belgium ; [8]NCMR, Greece

Contact : jblandin@ifremer.fr

| | |
|---|---|
| Contract No : EVK3 - CT2001- 00051 | Project duration : 01/2002 - 12/2004 |
| Project budget : 3 108 751 € | EC contribution : 1 916 500 € |
| Web site : www.ifremer.fr/assem | |

**Objectives**

The project consists in developing the means to measure and monitor a set of geotechnical, geodetic and chemical parameters distributed on a seabed area in order to better understand the slope instabilities phenomena or other geohazards, to assess and possibly anticipate the associated risks. The means are studied and realised to deploy a selection of adapted sensors on a seabed area (a few km$^2$) and transmit their data to shore for exploitation. The system is implemented during several months on two sites presenting risks with high socio-economic impacts. The technological developments of the array of sensors for monitoring addresses the necessity in many fields to have access to both spatial and temporal variability of seabed parameters.

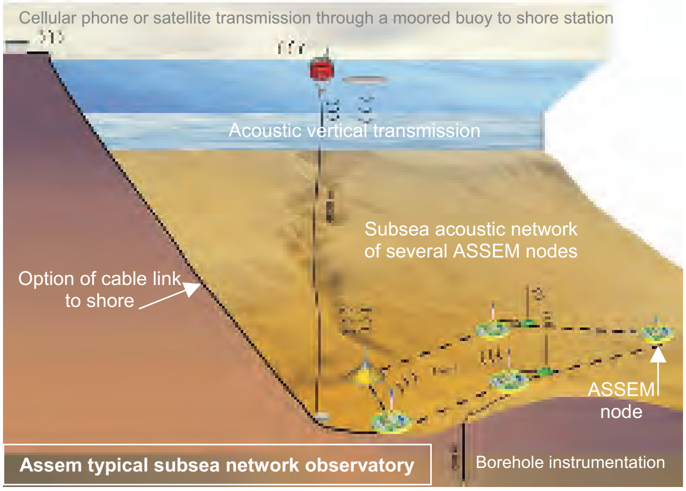
The study and realisation of the monitoring system organising the sensors into a network of monitoring nodes distributed on a seabed area is the first stage. Enhancement of sensors is performed by several partners. The enabling of the data flow throughout the system by acoustic networking and telecommunication link is designed and demonstrated during pilot experiments. Scientific assessment, technical and price related evaluation and market study will be performed in 2004.

**Results of the two first years**

The nodes are designed and built with the objectives of long term monitoring at lower costs. ASSEM brings several innovations and a modular design, with standard connecting and easy installation interfaces allowing to adapt the system to the site of interest, add new sensors and replace components for maintenance.

A two-way communication links the subsea network and the shore, it is built on either an acoustic network or wired links. A local storage of all raw data in each node with local analysis resources is able to generate alarm.

An array is composed of several nodes. Each node includes an electronic unit, providing a set of sensors with capabilities to communicate with the external world through an underwater network, and to locally store the collected data. The electronic architecture is organised around an internal CAN/CAN-open bus hosting sensors, communication and data storage resources on a common transmission backbone.




The same modularity concept is applied to the mechanical design. The usual deployment and maintenance procedures of the node imply the use of a submersible or a ROV, but free fall launching is possible. Among innovations : a low cost underwater connection system, a contact-less serial inductive link, an acoustic array mounted at the top of a flexible mast to have protection against trawlers.

Sensors have been enhanced to cope with long term deployment and geohazard monitoring.

Pore pressure is an important parameter for the modifications of the soil before and during geohazard event. It is possible to measure it at several freely chosen levels, in bore holes down to 200 m with innovative grouting and installation strategy.

A methane sensor from CAPSUM is being adapted for long term deployment and deeper operation (3500 m instead of 2000 m). Power consumption is divided by a factor of 2 to 3. A Gas Monitoring Module (GMM) including several sensors has been built for pockmark monitoring.

In tectonically active areas, ground deformation sensors are claimed but geodesy is still in its infancy in deep water. Different sensors are developed and installed : a long range taut wire distancemeter (NGI) for measurement of distances up to 100/200 m with accuracy of a few millimeters, an acoustic distancemeter (IPGP) and a tiltmeter. A benchmark, based on a suction anchor has been designed to build permanent references on the seafloor.

## Potential exploitation by end users

ASSEM contributes to the understanding of geohazards coming from the soil of the sea threatening population or belongings, their possible forecast and the specification of monitoring equipment.

Two complementary pilot experiments are underway. The first one takes place at a site with a risk of slope instability, in Finneidfjord, Norway, where a disaster occured a few years ago. The next step will be to deploy such a system in an area of interest for the oil industry such as Ormen Lange. ASSEM subsea networks may be used in other context of instable sediment or fluid seeps including Canyon of Var (Nice, France), mud volcanoes (Haakon Mosby), oil or gas production sites (Caspian sea, Gulf of Mexico, Indonesia).

The second experiment is taking place in the seismic area of the Gulf of Corinth in Greece. Pockmark fields of the shelf are instrumented with the GMM system to follow methane and water seeps. A faulted area is selected for the deployment of the ASSEM array of sensors. It is the most active extensional basin in Europe, with more than 1 cm/year of deformation across the Gulf and high rate of margin uplift. Several measurements are performed in land and in a borehole in the same area by the EU funded Corinth Rift Laboratory. The array of 4 nodes includes a satellite of the EU-ORION system, with a seismometer, demonstrating the compatibility between the two systems. Data collected in real time or after recovery of storage devices, will be available to end users over the internet. ASSEM subsea networks may be used in other context of seismic zone or rift such as Marmara sea or Azores.

# Holocene Black Sea sedimentary system - (ASSEMBLAGE)

*Lericolais, G.[1], Popescu, S.[2], Guichard, F.[3], Wong, H.K..[4], Panin, N.[5], Dinu, C.[6], Dimitrov, P.[7], Stanev, E.[8], Staneva, J.[9], Martinez-Ruiz, F.[10], Morigi, C.[11]*

[1] IFREMER, France; [2] University of Lyon, France; [3] LSCE, France; [4] University of Hamburg, Germany; [5] GEOECOMAR, Romania; [6] University of Bucarest, Romania; [7] IOBAS, Bulgaria; [8] ICBM, Germany; [9] University of Sofia, Bulgaria; [10] IACT, Spain; [11] University of Ancona, Italy

| | |
|---|---|
| Contract No : EVK3-2001-00142 | Project duration : 03/2003 – 03/2006 |
| Project budget : € 1 933 884 | EC contribution : € 1 400 251 |
| Website : www.ifremert.fr/assemblage | |

**Objectives**

The main objectives of the ASSEMBLAGE project is the assessment of the Black Sea sedimentary system since the Last Glacial Maximum, the quantification of the impacts of climate change and the sensitivity of the Black Sea system to external forcing, with respect to natural processes and human activity in facilitating access to and use of the seafloor and exploitation and exploration of the Black Sea resources. To resolve these major issues ASSEMBLAGE partners are and will be examining :

(1) the geomorphology and stratigraphy from the north-western shelf of the Black Sea to its deep-sea,

(2) a series of long cores retrieved from the Bosphorus outlet, the north-western shelf and the deep-sea fans (ASSEMBLAGE1 survey in May 2004))

(3) the determination of the consequences of a reduction of the river input

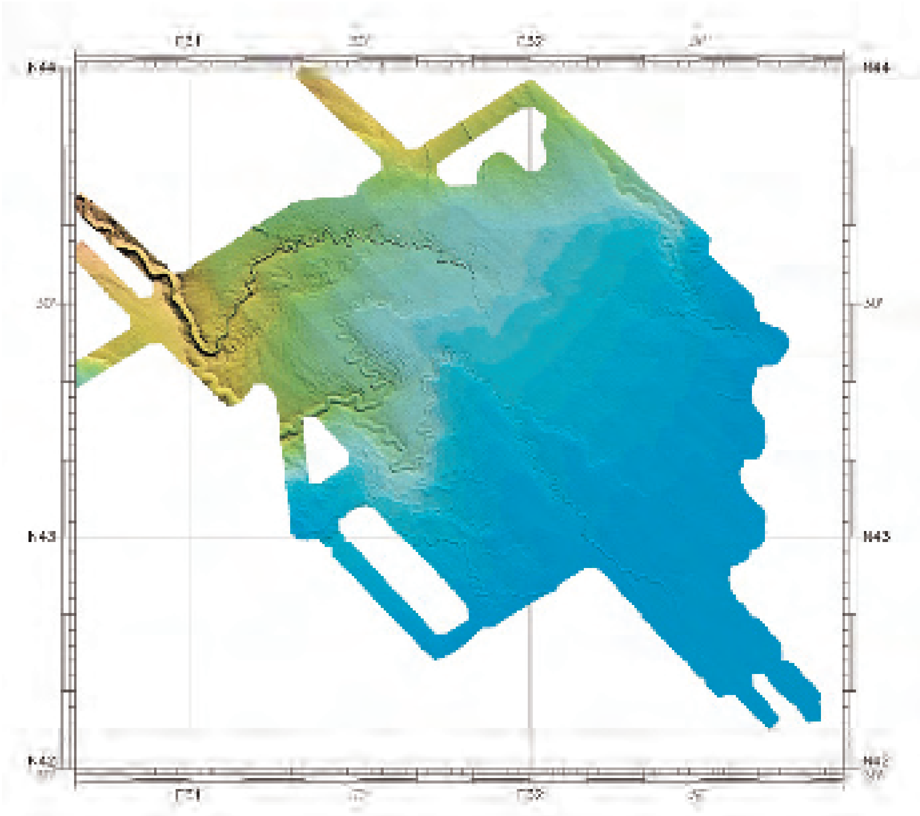
(4) the use of a computationally efficient ecological model (for 2006)

(5) the reconstruction of the depositional history of the sequences laid down during out-building of the Danube delta.

**Results**

Detailed images of the seafloor has already been provided by BlaSON 1 and BlaSON 2 cruises by swath mapping, side-scan sonar and very-high-resolution seismic profiling. These data increase the understanding of the timing of and the processes controlling Holocene sea-level rise on the shelf and to reconstruct the outbuilding of the Danube delta and deep-sea fan[1].

To characterise the last transgression (invasion of saltwater into a giant freshwater lake? [2,3]), sediments need to sampled from the coast to the deep basin to cover the Late Pleistocene lacustrine phase to the Holocene marine phase of the Black Sea. During this meeting the ASSEMBLAGE partners will be working at sea to collect long core samples on board the Marion Dufresne 2 (IPEV). These samples will allow detailed age determination. By studying the stable isotopes, pollen, molluscs, foraminifers, diatoms, and clay mineralogy of these cores and using proxies delivered by rivers that drain the interior of Asia and Europe, it will be possible to understand the history of climate change at a cm core-resolution.



*Danube deep Sea fan mapped from EM300 multibeam echosounder*

**Potential exploitation by end users**

The subaerial exposure of large parts of the Black Sea shelf during late glacial time may provide a potential source for the loess soils of eastern Europe and dust in the Greenland ice cap. Because the abrupt Holocene reconnection of the Black Sea to the Mediterranean is perhaps one of the most dramatic climatic events of the last 18,000 years in Europe, this knowledge can be used as a proxy for the future.

This project can be linked to previous and recent researches carried out in the Marmara sea in order to decipher the timing and processes of the re-connection. The data already processed for the purpose of the project have been used in the understanding of the gas processes and gas hydrate potential for this part of the Black Sea. The anoxia regime of this giant water body part of Europe needs also to be understood and a general mapping is still required.

**References**

1. Popescu, I., Lericolais, G., Panin, N., Wong, H. K. & Droz, L. Late Quaternary channel avulsions on the Danube deep-sea fan. *Marine Geology* **179**, 25-37 (2001).
2. Major, C. O., Ryan, W. B. F., Lericolais, G. & Hajdas, I. Constraints on Black Sea outflow to the Sea of Marmara during the last glacial-interglacial transition. *Marine Geology* **190**, 19-34 (2002).
3. Ryan, W. B. F., Major, C. O., Lericolais, G. & Goldstein, S. L. Catastrophic Flooding of the Black Sea. *Annu. Rev. Earth Planet. Sci.* **31**, 525-554 (2003).

# Greenland sea convection mechanisms and their climatic implications -(CONVECTION)

**Abstract**

The overall objective of the CONVECTION project was to understand the physics underlying open-ocean deep convection in the Greenland Sea and how this process links with climatic factors. This was achieved through a combination of field investigations, remote sensing and modelling. The benefits gained from such an understanding include a better assessment of our medium-term climatic prospects in Europe, and a better year-to-year prediction of the sea ice distribution, ocean structure and circulation of the Nordic Seas, all of which are of great importance for fisheries and commerce.

**Scientific breakthroughs**

Our understanding of Greenland Sea convection has been revolutionised by two major discoveries made during CONVECTION. The first was of a deep convective chimney near the centre of the Greenland Sea gyre at 75ºN 0ºW, extending to a depth of 2500 m and thus penetrating through to the deep waters. The chimney was discovered by CONVECTION in March 2001 and was subsequently revisited and remapped by successive CONVECTION cruises through the summer of 2001, winter and summer of 2002, and spring of 2003, with persuasive experimental evidence that the same chimney persisted, making this the longest-lived chimney yet observed in the world ocean. A second chimney was discovered during the comprehensive spring 2003 survey, and two chimneys are likely to be the total quantity of such features currently existing, in contrast to a larger number which may have existed in the late 1990s as suggested by the motion patterns of neutrally buoyant floats. The 75/0 chimney had a diameter of 10-20 km; was in anticyclonic rotation at a rate of f/2 out to a radius of 10 m then at a slower rate; became capped in summer by a fresh 50 m surface layer and an intrusion of Atlantic water down to a depth of 500 m leaving a deeper core untouched; and opened up again to the surface each winter. The chimney was also remarkably immobile, moving only a few km between measurements, although in spring 2003 it began a faster movement to the NW. These remarkable discoveries still remain to be embedded in a full synthesis of the convection process. We are not yet sure whether chimneys play an active role in the overall convection process, whether they provide a means for deep water formation, or indeed how they are created and maintain such longevity. They come in as a new and unexpected factor in the overall picture of the Greenland Sea convection process.

The second discovery is that the entire oceanographic structure of the region has changed during the last few years. The doming of isopycnals in the centre of the gyre has been superseded by a pronounced and persistent two-layer structure with a density-salinity step at a depth which has steadily increased to 1600-1800 m. The upper part is completely ventilated each winter, regardless of ice formation or its lack. The new field data shows that a mixed layer-like ventilation mechanism occurs in some years, which can actually lead to a warming of the ventilated layer by winter convection . This ventilation type, which is independent of ice formation, dominated from the late 1990s onward. It is not confined to shallow depth levels but also proceeds to the medium depth density step which permanently limits deeper convection. Consequently, there is not one single main driving mechanism for deep convection, and ice formation is not a necessary prerequisite for it.

The project has taken our understanding of Greenland Sea convection far beyond the level attained at the end of the previous EU-supported project in this field, ESOP-2. The discovery and mapping of long-lived chimneys, the investigation of how two modes of convection may prevail in different years, the innovative field research in acoustic mapping of plumes, in AUV mapping and tank studies of ice, and in large-scale and mesoscale modelling, have enriched our understanding of local and large scale processes. This is a critical region for the control of the Atlantic thermohaline circulation and hence the climate of NW Europe, and this project has revealed a new richness and complexity about the processes which go on here.

**Expolitation of results**

A serious problem identified by modelling centres is the likelihood that as convection slows or stops, on account of global warming, there will be an impact on the thermohaline circulation which will result in a reduction of oceanic heat transport in the northern Atlantic. The result will be the apparently paradoxical cooling of areas of NW Europe (Atlantic seaboard) in the midst of general global warming. The CONVECTION project has improved our understanding of what governs Greenland Sea convection so that we can assess this risk with greater confidence.

# Continental Slope Stability – (COSTA)

*Mienert, J.*[1]

[1] Department of Geology, University of Tromsø, Norway. E-mail: juergen.mienert@ig.uit.no

| | |
|---|---|
| Contract No : EVK3-CT-1999-00006 | Project duration : 04/2000 – 04/2003 |
| Project budget : € 2 200 000 | EC contribution : € 2 000 000 |
| Website : www.ig.uit.no/costa/main.htm | |

Understanding the frequency and causes of slope failures on European Continental Margins, their dynamic characteristics, their impact areas, and potential areas prone to sliding, e.g. due to "weak layers", to earthquakes or gas hydrate destabilisations is very important for the safety of the population living close to the sea and seafloor constructions. Given the variety of slope failures on Ocean Margins and the broad range of environments in which they occur, detailed information of one seafloor region will not yield what we need to learn about slope stability. Thus, through an international ocean margin co-operation the COSTA project EUROPE meets the COSTA project CANADA. We can now lay the foundations for systematic advancement in our understanding of continental slope stability on a trans-Atlantic scale. Our contribution addresses historical records of slope instability, seafloor-failure dynamics and sediment slide geometry including one of the largest known land slides, which occurs on the European Continental Margin. Climate or gas hydrate impacts on slope stability, modelling of forces and mechanics for sediment mass release mechanisms and flow dynamics, and finally risk-field assessment provide the key knowledge to predict risks inherent in continental slopes. Gas hydrates, storing large volumes of the green-house gas methane, in Norwegian margin sediments are disseminated in the pore space of the sediments in low concentrations of up to 5%, where fluids from deep-gas reservoirs may have contributed to their development.

The age radiocarbon dating methods of all known major submarine slides on the European Continental Margin shows that the surface mapped slides occur during the Holocene high level seastand or a sealevel rise and not as previously thought during a low-level sea stand. However, presently is not possible to conclude for all slides investigated if there is a causal relationship between the large-scale sliding and climate events, although some evidence exists. A submarine slide "event impact stratigraphy" contributes to this understanding of possible interactions between large scale ocean margin sea floor failure and climate. The international ocean margin co-operation between the COSTA project EUROPE and the COSTA project CANADA achieved a new book entitled "Submarine landslides and their consequences". Modelling of slope failure processes and gas hydrate melting scenarios predicts run out distances of slope failures and timing of melting gas hydrates in the subseabed during global ocean warming. A proposal to the international OCEAN DRILLING PROGRAM (IODP) for drilling and monitoring gas hydrates and slope stability achieved very positive evaluations.

**Socio-economic relevance and policy implications:**

The research has measurable socio-economic implications for countries along Ocean margins and in particular for Europe. Since increased exploitation of marine resources on continental slopes of Ocean Margins occur on a global scale but also on the European margin, an assessment of continental slope stability of various margin settings will put the European research community and industry at the forefront of stability studies. This has been proven through the cooperation between COSTA and the hydrocarbon industry, which have developed a trust and cooperation in deep-water gas field risk assessment studies. This is of economic relevance to Europe, where energy will be provided from deep-water gas fields for the next 20-30 years, and also for the employment of doctoral students by the industry.

# Development and Assessment of New Techniques and Approaches for Detecting Sub-Seafloor Bacteria and their Interaction with Geosphere Processes - (DEEPBUG)

*Parkes[1]*, R. J, Cragg[1]*, B A., Evershed[1], R , Mottram[1], H, Fry[2], J C., Weightman[2], A J., Newberry[2], C. J. Webster[2], G. Horsfield[3], B, Wilkes[3], H., Zink[3], K.G., Schenk[3], H., Jørgensen[4], B.B., Kallmeyer[4], J., Ferdelman[4], T.G., Prieur[5] D, Toffin[5] L,.*

[1]Department of Earth Sciences, University of Bristol, UK, [2]Cardiff School of Biosciences; Cardiff University, UK.; [3]GeoForschungsZentrum, Germany; [4]Max-Planck-Institute for Marine Microbiology, Germany; [5]Universite de Bretagne, France.
*New Address and contact details School of Earth, Ocean and Planetary Sciences, University of Cardiff, UK- J.Parkes@earth.cf.ac.uk



| **Contract N° : EVK3-CT-1999-00017** | **Project Duration:** 01/02/2000 to 31/7/2003 |
|---|---|
| **Total Project Cost:** €1,573,600 | **EU Contribution:** €1,436,000 |
| Website: http://www.chm.bris.ac.uk/deepbug | |



**Objectives**

- To develop new, and refine existing, techniques to quantify the presence and activity of prokaryotic microorganisms in sub-seafloor sediments.
- To explore the phylogenic diversity and physiological potential of the deep biota.
- To establish the fidelity of these new and improved techniques by integrated studies using different but complementary techniques and by comparison with geochemical data and the results from model thermal gradient and elevated pressure experiments simulating sediment burial.
- To develop sensitive indices for distinguishing thermogenic and biogenic processes and hence their interaction in deep sediments.
- To use these techniques and approaches on future ODP Legs of specific deep biosphere interest.

**Results**

A range of new sampling and subsampling systems have been designed and tested which enable consolidated sediments in excess of 1000 m deep to be processed effectively for microbiological analysis. These new systems were central to handling on ODP Leg 201, the first dedicated "deep biosphere" ODP Drilling Leg.

Detection limits for microscopic determination of sedimentary bacteria have been improved by a factor of 25, down to 2,400 cells/$cm^3$.

New approaches utilizing $^{13}C$-substrate incorporation to detect active bacteria (SIP) has identified the ability of a major division of uncultured bacteria, which are widespread in the subsurface (JS1), to utilize acetate under sulphate reducing conditions. This represents a major advance and may lead to the eventual isolation of members of this group[1,2 & Webster *et al.*, in preparation].

Intact PL (phosphatidylethanolamines, -cholines, and lysophospholipids) in all three sites of ODP Leg 190 up to 799 mbsf and ~80°C demonstrate viability of deep biosphere populations[3].

The sensitivity of radiotracer method for measuring rates of bacterial sulphate reduction has been greatly improved (<1 pmol $SO_4^{2-}/cm^3/d$) and used to demonstrate the presence of sulphate reduction in deep and ancient sediments, including the lowest rates ever measured in any marine environment[4].

A new high temperature, high pressure apparatus has been developed, which has shown that sulphate reduction rates can be highest up to 80-100°C and are stimulated by elevated pressure (220 and 450 bar). In contrast, initial investigation of methanogesis indicates that the processes is not influenced by pressure[5].

In the subsurface and to temperatures up to 50°C methane was shown to be a significant energy source for sulphate reduction, whereas, at higher temperatures other energy sources dominate.

Bicarbonate methanogenesis was confimed as the major methanogenic pathway in marine sediments.

Indications of deep bacterial methanogenesis to 1,100 mbsf and ca. 125°C provides evidence for the deepest and hottest deep biosphere so far.

New deep bacterial isolates obtained: *Marinolactobacillus piezotolerans*, *Acetobacterium submarines*, *Shewanella profundus*, this greatly extends our knowledge of the physiology of sub-seafloor bacteria.

Range of different approaches demonstrate overlap between biosphere and geosphere processes, including bacterial role in deep, high temperature alteration of organic matter and aspects of fossil fuel formation and geosphere processes providing deep bacterial energy sources[6 and Parkes *et al., submitted*].

Direct bacterial populations were enumerated from 15 new sites (27% increase in global data) representing a range of oceanographic, diagenetic and geological conditions, which further confirms that deep bacteria are globally present in marine sediments.

Detailed spatial sampling through deep geochemical and geological interfaces has demonstrated marked elevation of bacterial processes (especially methanogenesis and bacterial productivity) and populations. If this is widespread in sediments it may lead to an increase in the global estimate of the biomass of the subseafloor biosphere.

The range of different genetic approaches used (16S rRNA gene libaries, PCR DGGE profiling and functional gene libraries), combined with bacterial activity, total bacterial numbers, SIP, determination of viable populations and characterisation of deep sediment isolates) has enabled the most robust and comprehensive assessment of biodiversity (Bacterial and Archaea) and function in the sub-seafloor biosphere to date.

**Potential Expoitation**

These results are important to policies and issues related to global biogeochemical cycles, the amount of bacterial biomass on Earth, microbial biodiversity, depth of the biosphere in marine sediments, biopsphere:geosphere interactions and fossil fuel formation. The clear overlap between biosphere and geosphere processes and the bacterial role in high temperature alteration of organic matter (probably up to *ca.* 125°C) has wide significance for fossil fuel formation, oil reservoir exploitation and management and biotechnology. The presence of deep sediment bacterial processes is also important for deep geological disposal of radioactive waste and other pollutants.

**References**

1. Newberry, C. J., Webster, G., Cragg, B. A., Parkes, R. J., Weightman A. J. and Fry, J. C. , 2004, Environmental Microbiology*, In Press*
2.Webster G Fry JC Weightman AJ., 2004, .Applied and Environmental Microbiology, submitted
3. .Zink, K.-G., Wilkes, H., Disko, U., Elvert, M., Horsfield, B. , 2003, Organic Geochemistry*,* 34, 755-769
4. Kallmeyer, J., T.G. Ferdelman, A. Weber, H. Fossing, B.B. Jørgensen. 2004 *Biogeochemistry*, submitted.
5. Kallmeyer, J., T.G. Ferdelman, K.-H. Jansen, B.B. Jørgensen., 2003, , *J. Microbial. Methods*, 55, 165-172.
6. Horsfield B., Dieckmann V., Mangelsdorf K., di Primio R., Wilkes H., Schloemer S. and Schenk H. , 2002, Geochim et Cosmochim Acta, 66, S1, A342.

# Environmental Controls on Mound Formation along the European Margin - (ECOMOUND)

*Dullo, W.-Chr.[1], Rüggeberg, A., ECOMOUND Partners*

[1] ECOMOUND Project co-ordinator, IfM-GEOMAR, Leibniz-Institut für Meereswissenschaften, Kiel, Germany, email: cdullo@ifm-geomar.de



| | |
|---|---|
| Contract No : EVK3-1999-00013 | Project duration : 04/2000 – 03/2003 |
| Project budget : € 1 955 218 | EC contribution : € 1 500000 |
| Website : http://www.geomar.de/projekte/ecomound/ecomoundstart/ | |



## Objectives

Cold-water carbonate mounds along the European continental margin were object of detailed investigation. Main target areas were the Porcupine Seabight, along the Rockall Trough margins, and in the very north offshore Norway, where clusters of carbonate mounds have been reported, densely settled by cold-water coral *Lophelia pertusa*. The aim of ECOMOUND project was to investigate the external oceanographic control and forcing mechanisms on carbonate mound formation and build up formation.

Carbonate mounds, with cross sections between 100–1800m at their basis and rising up to 350 m above the seabed and surrounded by a 60–90 m deep circular moat, have been reported in the Porcupine Seabight in water depths of 650–1000m. More recently, carbonate mounds up to 350 m high were discovered on the continental slope north of the Porcupine Bank in water depths of 500–1100 m. In addition, carbonate mounds have been described in a zone up to 9 miles wide zone in water-depths of 500–1000 m in the south-western Rockall Trough. These mounds also rise up to 350 m above the seabed and appear associated with slumped or faulted margin sediments.

These biogenic accumulations are for the most part located within the depth range of the habitable zone of corals and apparently support a rich deep-water reef ecosystem. The acceptance of a simple model of mound formation is unsatisfactory owing to the observed variation in size, morphology (linear ridges, ring shapes etc.) and the prolific number of these mounds with their very localised clustering.

## Results

The mounds along the NW European margin occur within a distinct bathymetric range and are mostly confined to an uppermost seismic unit of Early Pleistocene (C10) age. High-resolution acoustic imaging and video documentation shows a prolific coral cover of many of the mounds. The oceanographic regime is governed by different water masses with a density gradient right in the vicinity of the mounds, where organic carbon from sea-surface prevails and serves as nutrients for the corals. The environmental setting of the mounds shows a strong influence of diurnal tides. The mounds consist of a high portion of biogenically derived carbonate material, where sandy and silty clays are baffled and then accumulated within the biogenic framework. The biosphere–geosphere interaction exhibits insight into the POM dynamics at the benthic boundary layer at this specific setting indicating enriched flow rates at the sediment surface. Detailed analyses on sediment cores reveal indications of coral growth occurring only during interglacial (and -stadial) times, as the glacial oceanography does not support the establishment of a density gradient right in the vicinity of the mounds and therefore not contributing enough nutrients for the deep-sea coral ecosystem. These observations finally lead to a model describing the growth and development of carbonate mounds controlled by environmental changes (Fig. 1).

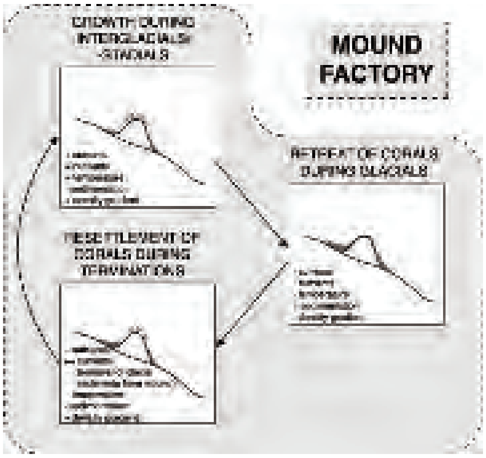



Figure 1: Model *Mound Factory* describing growth and development of carbonate mounds during the course of glacial–interglacial cycles controlled by environmental factors (current strength intensities, nutrient supply variability, intermediate water temperature, presence or absence of a density gradient in water depth of the mounds, sedimentation rate depending on current intensity).

**Potential exploitation by end users**

The ECOMOUND Project addresses the issues of the Environment and Sustainable Development Programme ‘Assessment of sedimentary systems for the sustainable management and use of the shelf, slope and deep sea floor’.

Carbonate mounds host the highest biodiverstity of marine benthic life along the European continental margin. Their visualisation is attractive to the public, important for their life (fisheries) and even plays an essential role in the global carbon cycle. It is of utmost importance to safe this exceptional ecosystems and to develop strategies for their sustainable use as these corals make an important contribution to the health of the seas by providing habitats for nursery grounds for several fish species, including some commercial fishes such as orange roughly and grenadiers. The results of ECOMOUND together with ACES and GEOMOUND provide the database for a European integrated Continental Margin Management.

Apart of trawling impacts, due to the exploration of fish, potential threats arise from expanding hydrocarbon exploration in deeper water setting. This potential conflict between industry and environment has already caused concern. The debate remains unresolved and could present a barrier to future economic development along Europe’s continental margin until sufficient independent research is carried out: 1) ascertain the potential sensitivity and vulnerability of the mounds, 2) identify the most significant conservation issues involved, and 3) meet the needs of environmental managers and regulatory authorities by recommending the measured necessary to permit sustainable resource development alongside effective conservation in the vicinity of these enigmatic ecosystems. Therefore, the results obtained through the ECOMOUND project will have a strong strategic importance to develop an integrated Continental Margin Management according to OSPAR convention as a new tool.

The increased threat of the hydrocarbon industry and the fisheries stresses the fact that there is urgent need for the development of a European integrated Continental Margin Management. However the underpinning scientific research must go on now to further preserve this unique ecosystem.

# The European Consortium for Ocean Research Drilling (ECORD-net)

*Ludden, J.*[1]*, Mevel, C.*[2]

[1] Co-ordinator of ECORD-net, Institut National des Sciences de l'Univers CNRS, France (John.Ludden@cnrs-dir.fr); [2] Director of ECORD Managing Agency, IPGP CNRS, France

| | |
|---|---|
| Contract N : ERAC-CT-2003- 510218 | Project duration : 12/2003 – 12/2007 |
| Project budget: € 2 324 966 | EC contribution : € 2 238 087 |
| Website : www.ecord.org | |

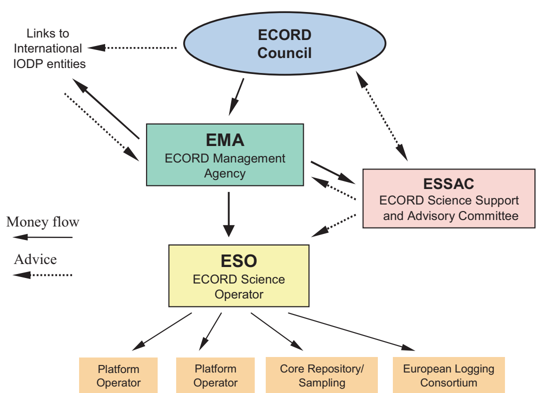
## Objectives

Research topics which are key concerns of the European Union, such as climate change, biodiverstity and natural resources, need a variety of tools to enable the science objectives to be achieved. A key tool used on a global scale is that of ocean drilling, which provides the ground truth for geophysical techniques, samples for analysis and a platform for new discoveries.

The 15 European research funding organisations that participated in the Ocean Drilling Project (ODP) have agreed to join its successor – the Integrated Ocean Drilling Programme (IODP). A single European umbrella, the European Consortium for Ocean Research Drilling (ECORD) has been formed to represent the interests of Europe in ocean drilling, particularly in the international Integrated Ocean Drilling Programme (IODP). As a coordinated unit, ECORD enables Europe to achieve critical mass and economies of scale in its progress towards equal partnership with the USA and Japan, which are currently considered the world leaders in marine geosciences.

Participation of Member organisations in ECORD will be assisted by the ECORD ERA-net, which is managed by the ECORD Management Agency (EMA), located in the Institut de Physique du Globe - INSU-CNRS, in Paris, and through which Member organisations will share information and best practice in order to produce high-quality research proposals at international level. By pooling their national funding of shore-based research, the national programmes involved will also encourage European laboratories to develop particular areas of geoscience expertise.

*Fig.1 ECORD Structure*




## First steps towards structuring the research area

ECORD signed a Memorandum of Understanding between its members in December 2003. In so doing the ECORD Science Support and Advisory Committee (ESSAC) Office was officially established in the Vrije Universiteit, Amsterdam and started the science coordination activities among the member countries, as well as formalizing the contracts with the Japanese and US partners.

The ECORD Science Operator (ESO), a group of Earth science institutes from across Europe, has been set up with the specific objective of undertaking scientific drilling operations using "fit to mission" platforms in parts of the ocean previously inaccessible to ODP.

The international Memorandum of Understanding was signed between ECORD, MEXT (Japan) and NSF (USA) on the 16$^{th}$ of March 2004 in Bremen. The first direct result of this MOU is that Europe, through the ECORD science operator will undertake the most ambitious project ever undertaken in scientific ocean drilling, namely drilling the Lomonosov Ridge in the central Arctic Ocean). The operation involves two ice-breakers and a specially equipped drilling vessel and the samples that will be recovered will provide invaluable information on the climatic and paleo-oceanographic evolution of the Arctic Ocean - the Earth's thermostat for past and current climate change.

### Relevance for society

A network of specialist facilities, all open for mutual access, in land based laboratories and in sea-floor technological platforms will enable European scientists to expand the scope and of marine geoscientific research. ECORD-net results in defining the offshore slopes may determine the shape of tomorrow's international treaties. Research results in climate change, when intercalibrated with continental and ice-core records will provide fundamental data on long term and short term (rapid) trends in the Earth's climate. Research on the bio-geochemistry of extreme environments may well provide new genetic materials for industry. Results related to the stability of hydrocarbons, in the shelf environment may provide new sea floor energy sources and important results for the sequestering of $CO_2$ and acid gases.

# European Co-ordination on Mediterranean and Black Sea Prodeltas - (EURODELTA)

*Trincardi, F.*

Istituto di Scienze Marine-CNR, Bologna. Contact: *fabio.trincardi@bo.ismar.cnr.it*

| | |
|---|---|
| Contract No: EVK3-CT-2001-20001 | Project duration: 12/2001 — 11/2004 |
| Project budget: 1,421,000 Euro | EC contribution: 1,421,000 Euro |
| Website: http://www.pangaea.de/Projects/EURODELTA /http://eurodelta.bo.ismar.cnr.it/ | |

**Objectives**

Prodeltas are large, shallow-marine features offshore river mouths that are characterised by significant mud accumulation below storm wave base. On Mediterranean and Black Sea shelves, prodelta deposits, up to 10's of m thick, are extensive, shore-parallel and mud-dominated. These deposits formed in the last ca. 5 kyr under the influence of fluvial supply and marine processes, and constitute shallow areas of rapid sediment accumulation and intense exploitation (trawling, mussle cultivation, cables, pipelines, platforms).

In view of the considerable economic and societal importance of European coasts, as well as the increasing need to manage and safely exploit the marine environment, it is vital to establish the long-term role and development of prodeltas. It is necessary to determine the future research urgently required to understand how modern prodeltas have evolved, how vital they are to the long-term stability of coastal regions, and how they could be managed to sustain economic activities and the natural environment.

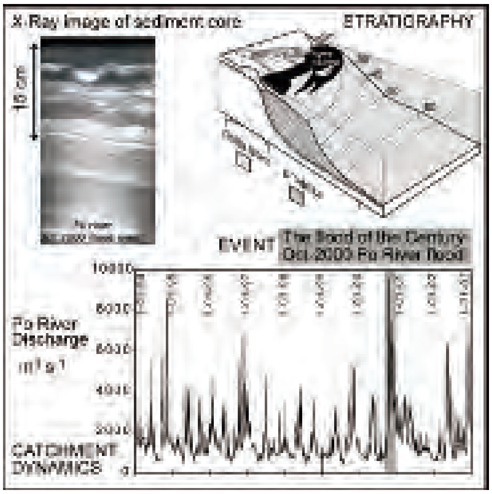
The overarching objective of EURODELTA is, therefore, to reconstruct the recent growth of such prodelta systems by integrating knowledge ranging from river-flood dynamics (magnitude, recurrence, offshore impact), to physical stratigraphy in shallow waters, revealed by high-resolution geophysical surveys. This data integration also includes key information from historical maps constraining the phases of delta construction in the last few centuries, and helping a better evaluation of climate and human forcing. Specific objectives include:

- -Understand architecture and growth patterns of Mediterranean and Black Sea prodeltas
- -Improve projections of prodelta modifications in the future
- -Define how (and how much) sediment escapes to deeper basins.

**Results**

Ongoing research in prodeltas is generating extensive databases for a variety of practical and scientific purposes. EURODELTA is contributing to understand modern prodelta systems through the integration of a large variety of data routinely produced by independent communities of scientists or by environmental agencies. Such data include observations on key transport events (such as a specific river flood or a peculiar historical event of sediment failure), time-series of river discharge and sediment load (extending back typically several decades to a century), estimates of sediment accumulation rates based on short-lived radionuclides and/or sedimentological analysis of sediment cores retrieved both in delta plain and prodelta environments. Seismic startigraphy and geophysical characterisation of sea floor help quantifying sediment distribution through complementary time scales ranging from events to millennia.

By harmonising the existing databases on Mediterranean and Black Sea prodeltas, we now understand better the factors that control changes in sediment supply to prodelta environments, the mechanisms of sediment dispersal, and the products, i.e. the extent, composition, internal architecture and stability of prodelta wedges. EURODELTA is leading to a better understanding of: 1. Prodelta PROCESSES (clarifying the relation between discrete depositional events and the long term construction of deltas); 2. Prodelta STRATIGRAPHY (unravelling the phase relationship of major human impacts and climatic events in different areas through improved geochronological analyses); Prodelta SEDIMENT BUDGET (quantifying long-term, time-averaged, distribution of prodelta deposits at pan-Mediterranean scale); 3. Prodelta GEOPHYSICS (Geophysical signatures of distinctive sedimentary processes and resulting sea-floor characters); 4. Prodelta TECHNOLOGIES (Defining geophysical developments needed in shallow-water surveys); 5. Prodelta RISKS (Evaluation of tools to improve risk assessment); 6. Prodelta MODELS (Improving existing Physical and Numerical Models). All data are quality checked and banked in a DATABASE.




EURODELTA documents:

- the impact of very short term supply fluctuations on the coastal environment;
- the asymmetric distribution of prodelta mud in response to oceanographic processes;
- the construction of subaqueus clinoforms through dominant shore-parallel transport;

the contrasting impact of two distinct kinds of sediment sources: large catchments with low sediment yield and small catchments with high yield;

- the applicability of new tools ($^{14}C$ dating, calibration, tephra, magnetic secular variations) to improve geochronology.

**Potential exploitation by end users**

Within Eurodelta, we integrated databases dealing with extremely diverse archives collected with highly complementary methods on variable temporal and spatial resolutions.

The integration of such observations allowed to place most of the key delta and prodelta systems of the Mediterranean and Black Sea in a source-to-sink perspective and, for the first time in Europe, quantitatively relate a specific depositional event to the construction of a sedimentary body (i.e.: the prodelta) in the near-shore environment (Figure). This is important scientifically, but also has important practical implications such as facilitating better predictions of where and how much river-borne pollutants tend to accumulate near-shore.

Environmental studies in the near-shore areas are intensive and time consuming. A better understanding of catchment dynamics, oceanographic processes and prodelta architecture will prove efficient also in directing rapid-response environmental studies to key areas.

**Selected References**

[1] Blockley, SPE, Lowe, JJ, Walker, M, Asioli, A, Trincardi F, Coope, GR, Donahue RE, Pollard, AM (2004) Journal of Quaternary Science 19, in press
[2] Cattaneo A., Correggiari A., Langone L., Trincardi F. 2003. Marine Geology vol. 193, pp. 61-91.
[3] Correggiari A, Cattaneo A, Trincardi F (2004) SEPM Special Publication on Deltas, In press
[4] Missiaen, T, Wardell, N, Dix J (2004) Special Issue on "Subsurface imaging and sediment characterisation in shallow water environments; Marine Geophysical Research, in prep.
[5] Oldfield F., A.Asioli, C.A.Accorsi, A.M.Mercuri, S.Juggins, L.Langone, T.Rolph, F. Trincardi, G.Wolff, Z.Gibbs, L.Vigliotti, M.Frignani, K.van der Post N.Branch 2003. Quaternary Sceince Review 22, 319-342.

# European Margin Strata Formation - (EUROSTRATAFORM)

*Prof. Philip Weaver[1] and the EUROSTRATAFORM consortium*

[1]Southampton Oceanography Centre, UK

| | |
|---|---|
| Contract No: EVK3-CT-2002-00079 | Project duration: 11/2002 – 11/2005 |
| Project budget: € 6 300 000 | EC contribution: €3 750 000 |

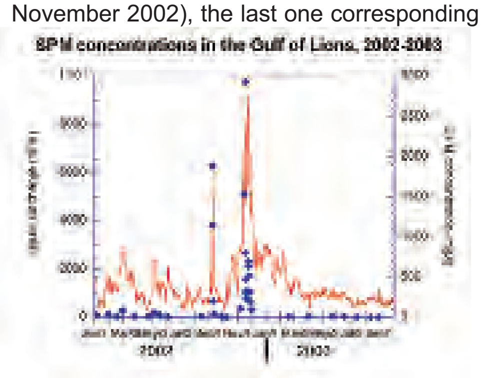
## Objectives

To study marine sediment dispersal from source to sink (river output to depositional on the shelf, slope or basin floor) on contrasted European margins, with the aim of understanding how geological strata are generated. This project will greatly improve our ability to forecast and hindcast the response of the marine system to natural and anthropogenic perturbations. This research is fundamental to understand matter and energy cycling, and to ensure the safe management of marine resources.

## Results

The start of the project coincided with a 100-year flood event of the Po River (October 2000) that resulted in a thick, (>15cm), sediment deposit on the delta. We were able to respond quickly and sample the deposits, which were located primarily adjacent to the river mouths. The majority of the Po sediment falls out of the water column as flocs inshore of the 6-m isobath, but there is still sediment carried offshore in the surface plume. This surface plume carries up to 5 times more than the benthic load but during storms, which occur about 10% of the time, the benthic sediment load can exceed the surface plume load. Historical data shows the very rapid outbuilding of the Modern-Age Po delta (up to 129 m/yr) since the onset of Little Ice Age (ca. 1450 - 1850 AD) under anthropogenic forcing on the river regime and increasing sediment supply driven by colder climatic conditions. In the deeper part of the Adriatic TOBI sidescan sonar images and very high resolution Chirp sonar profiles reveal widespread collapsing of the South Adriatic continental slope with extensive blocky landslides on the lower slope (blocks up to 200 x 500 m), and a basin-wide redeposited layer up to 40 m thick. This is overlain by late-Pleistocene-Holocene mud in water depths greater than 1000 m, suggesting the landsliding has ceased. The entire slope area is now swept by bottom currents generating furrowed areas up to several tens of km$^2$ in extent. There are two areas of upslope-migrating sediment waves in water depths of 400-600 and 1000 m. The former may reflect the activity of the Levantine Intermediate Waters, while the latter may be linked to the downslope flow of the Northern Adriatic Dense Waters.

Our work in the Gulf of Lions work also coincided with two major floods (September and November 2002), the last one corresponding to a centennial flood. In 2002 the annual flux of suspended particulate matter (SPM) from the Rhône River was 11.7 x10$^6$ tons, from which 2.2 x10$^6$ tons were transported in September and 7.15 in November (see figure). 80% of the suspended load was thus transported during the floods. In 2003 the liquid discharge was much more constant. SPM concentrations were less than 10 mg l$^{-1}$, giving a flux of 0.6 10$^6$ tons from January to September.




The difference between the two years probably represents the minimum and maximum SPM flux that can be delivered by the Rhône to the Gulf of Lions.

In the Gulf of Lions, sedimentation is strongly influenced by the strength of waves in the nearshore regions with sediment being transferred to the outer shelf. Under the effect of southern storms, circulation is cyclonic with strong currents in the western part of the shelf and advection of particles southwestward. Under prevailing northerly winds (Mistral to the north and Tramontane to the west of the gulf), the circulation induced by Mistral is clockwise in the northern part of the gulf while that linked to Tramontane is southward in the western part of the gulf. This causes currents to converge towards the very narrow southwest tip of the shelf inducing strong downwelling in the region of Cap Creus, which in turn produces particle export to depth. This export is reinforced in February by dense cascading water. This result indicates the major role of the southwest region of the Gulf of Lions for the export of matter and the importance of the Cap Creus Canyon. Sediment cores show sand deposition derived from turbidites extending from the deglacial into the Holocene. The sandy deposits seem to be related to the postglacial erosion of sand banks at the shelf break and canyon heads. These occur from 15.1 ky BP to 6.6 ky BP in the north, probably supplied from the Sete Canyon, and from 10.4 ky BP to 4.4 ky BP in the south, most likely derived through the La Fonera Canyon, offshore NE Spain.

The Nazare and Setúbal Canyons off Portugal show active sediment transport probably as episodic events. Hanging-walls indicate recent to sub-recent down-faulting of the canyon block whilst outcropping Cretaceous strata indicate sediment is not stored within the canyon. Turbid layers at the shelf edge were observed during surveys in the Setúbal and Nazaré Canyons suggesting that particulate matter is transported from the shelf into the canyon. Bottom water turbidity reaches maximum levels when surges of colder water replace the lower Mediterranean Water in the bottom of the canyon.

Observations from the Andøya Canyon off Norway suggest a combination of processes responsible for the canyon formation: an upper part indicative of erosion caused by downslope-flowing turbidity currents generated by mass wasting in the headwall area; piracy of winnowed shelf sediments or bottom currents and/or internal waves within the canyon; and retrogressive sidewall collapse due to sliding/slumping in the lower part of the canyon. Thus the Andøya Canyon may exemplify canyon formation both by downslope erosion by turbidity currents and upslope erosion from retrogressive sliding and slumping.

**Potential Exploitation by End Users**

Considerable progress has been made in understanding marine sediment dispersal systems. These are extremely complex and very variable. Ultimately we will gain a better understanding of how pollutants move through the marine environment. We will also be able to predict more accurately the likelihood of seabed structures being either buried or undermined by erosion due to currents and sediment transport. Our data on landslides and sedimentary archives (particularly the distribution of sand on the seabed) is of value to the hydrocarbon industry and their representatives have attended our scientific presentations. This work has benefited by close collaboration with a North American ONR funded project (also called EuroSTRATAFORM).

# EXtreme ecosystem studies in the deep OCEan : Technological Developments - (EXOCET/D)

Sarrazin[1], J.; Sarradin[1], P.-M.; Olu[1], K.; Sauter[2],E.; Serrão Santos[3],R.; Colaco[3], A.; Pascoal[4,]; A., Shillito[5],B.; Zal[6], F.; Schultz[7], A.; Lane[8], D.; du Buf[9], H.; Waldmann[10], C.; Cormack[11], A.; Sanfilippo[12], L.; Masson[13], M.

[1] Ifremer, France, [2] AWI, Germany, [3] University of the Azores, Portugal, [4] Instituto Superior Técnico Portugal, [5] Université Pierre et Marie Curie, France, [6] Station Biologique, Roscoff, France, [7] Cardiff University, UK, [8] Heriot-Watt University, UK, [9] University of Algarve, Portugal, [10] University of Bremen, Germany, [11] SeeByte Ltd, UK, [12] Systea srl, Italy, [13] CAPSUM technologie GmbH, Germany.

Contact e-mail : pierre.marie.sarradin@ifremer.fr



| | |
|---|---|
| Contract No : FP6-GOCE-CT-2003-505342 | Project duration : 01/2004 – 12/2007 |
| Project budget : € 3 454 000 | EC contribution : € 2 000 000 |
| Website : http://www.ifremer.fr/ exocetd | |



**Objective**

The aim of EXOCET/D is the technological development of a specific instrumentation allowing the study of natural or accidentally perturbed ecosystems found in the deep ocean. These ecosystems are related to the emission of reduced fluids (cold seeps, hydrothermal vents), peculiar topographic structures (seamounts, deep corals), massive organic inputs (sunken woods) or to unpredictable events (pollution, earthquakes). Beside their insularity in the abyssal plain, the targeted ecosystems are characterized by patchy faunal distributions, unusual biological productivity, steep chemical and/or physical gradients, high perturbation levels and strong organism/habitat interactions at infra-metric scales. Their reduced size and unique biological composition and functioning make them difficult to study with conventional instrumentation and require the use of submersibles able to work at small scales on the seafloor as well as the development of autonomous instruments for long-term monitoring (seafloor observatories e.g. EU projects ASSEM and ESONET). In addition, the increasing anthropic pressure on these poorly known deep-sea ecosystems emphasises the need for a rapid development of technologies dedicated to their investigation. Several European countries are now purchasing or developing deep-sea underwater vehicles but their acquisition alone is not sufficient to realise effective integrated deep-sea studies. There is an urgent need for fast but long term stable multi-sensor instrumentation that can be either connected to autonomous seafloor observatories or deployed on underwater vehicles.

The general objective of this project is to develop, implement and test specific technologies aimed at exploring, describing and quantifying biodiversity in deep-sea fragmented habitats as well as at identifying links between community structure and environmental dynamics. Onboard experimental devices will complement the approach, enabling experiments on species physiology.

**Scientific breakthroughs**

EXOCET/D deals with technological developments related to actual scientific questions. Collection of high resolution data is a crucial step forward to the understanding of factors influencing marine community structure and functioning at small spatial scales while time-series studies are essential to understand natural ecosystem dynamics. The achievement of

EXOCET/D technological and scientific objectives will be attained by a constant collaboration between the technological teams in charge of the development, and the scientists responsible of instrument specifications and final validation. Cost efficient and reliable solutions will be found to make these instruments suitable for long term deployments on stationary deep-sea observatories or used as payload systems on underwater vehicles. The themes that will be addressed in EXOCET/D include :

- 3D video imagery and small scale reconstruction, long term video module, potential of acoustic vs video imagery for ecosystem mapping
- in situ analysis of habitat chemical and physical components using in situ analyser and sensors (methane, flow) associated with water sampling,
- quantitative sampling of macro- and microorganisms, in vivo experiments in simulated in situ conditions;
- integration of multidisciplinary and multi-scale data on SIG software,
- instrument implementation on deep-submersibles
- sub-systems and scientific validation during demonstration actions, and final submersible cruise in 2006 (MoMARETO, hydrothermal vents, Mid Atlantic Ridge).

**Relevance for society**

Marine sciences require very specific technologies and instruments due to the particularities of their target fields. EXOCET/D will develop an integrated multidisciplinary instrumentation that can be used universally in a multitude of research fields all over European and international marine environments from shallow to deep waters, from natural structures to man-made risk objects located at the sea floor. The need to find technical solutions to cope with deep sea environmental constraints (high pressure, low temperatures, biofouling, corrosion) makes the dedicated instrumentation particularily specific and very expensive. On the other hand, the small number of users limits the commercial benefit of most small companies developing this dedicated instrumentation.

This co-operative project is of prime necessity to allow the European community to remain competitive in deep-sea operation field compared to other countries such as USA and Japan. The increasing number of underwater vehicles and the numerous upcoming multidisciplinary projects on long term seafloor observatories in Europe increase the requirements for such fitted and reliable instrumentation. EXOCET/D will have a significant impact on the effort of standardisation of electronic interfaces and data formats.

EXOCET/D will also increase the European capacity to operate on the deep seafloor to study biodiversity (including microbes with potential interests for biotechnological and pharmaceutical industries), to evaluate potential anthropogenic impacts on marine ecosystems (oil spills, sewage wastes, deep sea drilling, toxic and radioactive dumping) or to efficiently operate at oceanic depths. This intervention capacity is crucial to evaluate the impact of future catastrophic events on the biodiversity of the European Exclusive Economic Zone and also also takes into account the upcoming demand from the deep offshore industry for prospecting and environmental risk assessments.

**Exploitation of the results of the project by end users**

EXOCET/D project will lead to the development and/or improvement of prototype instruments dedicated to studying extreme marine environments. Some of these instruments will probably be industrialized in the near future. These new developments will greatly improve our capacity to study deep sea ecosystems at very small spatial scales and will serve several future projects on marine ecosystems, especially those upcoming European observatory projects such as MoMAR.

The final instrument testing and validation should be performed in 2006 during the MoMARETO cruise. The first leg of the cruise will be dedicated to the implementation and test of the instrumentation developed during EXOCET/D while the second leg will be entirely focused on realizing scientific objectives and deploying a first ecological long-term observatory in the Lucky Strike hydrothermal vent field (MoMAR area), using mobile and fixed platforms.

# The Internal Mound Factory - (GEOMOUND)

*Henriet, J.P.[1] and the GEOMOUND consortium*

[1] Renard Centre of Marine Geology, Belgium

| | |
|---|---|
| Contract No : EVK3-CT-1999-00016 | Project duration : 01/2004 – 12/2007 |
| Project budget : € 2 328 200 | EC contribution : € 1 474 300 |
| Website : http://geomound.ucd.ie./ | |

**Objectives**

The objectives of the GEOMOUND project were:

(a) to draft an inventory of recorded giant mound occurrences in Porcupine and Rockall basins, southwest of Ireland, documenting morphologies, structural associations, patterns and temporal relationships which might identify the underlying geological control point on the genesis of mounds and on their sustained or episodic growth,to critically evaluate relevant hypotheses and to test the diagnostic value of such mounds as potential indicators for hydrocarbons and for fluid expulsion events,

(c) to develop a model for the fluid migration paths and processes which might have fuelled surface vents in the mound provinces,

(d) to prepare and define the terms of reference for a conclusive Ocean drilling action.

**Results**

Achievements of the GEOMOUND project are as follows:

(a) a systematic inventory, geostatistical analysis and documentation of mound morphologies has been performed in the so-called Belgica, Hovland, Magellan and Rockall mound provinces, south-west of Ireland; where the subsurface control was accessible (fig. 1), a thorough analysis has been carried out of any plausible association with the underlying geology,

(b) various mound genesis hypotheses have been developed and critically evaluated,

(c) a preliminary diagnostic interpretation key was applied on a hitherto unexplored segment of the Moroccan margin, which indeed led to the discovery of a new mounds setting in the middle of giant mud volcanoes,

(d) for the first time, fluid migration models have been developed for the full transit from reservoir to the surface, for some major provinces in Porcupine basin: the Connemara field, the Magellan and the Belgica mound provinces (fig. 2), documenting both pace and pathways of fluid expulsion,

(e) an IODP proposal 573-Full has been drafted and support was given to a so-called PROD drilling proposal, for the use of an automated seabed drilling device.

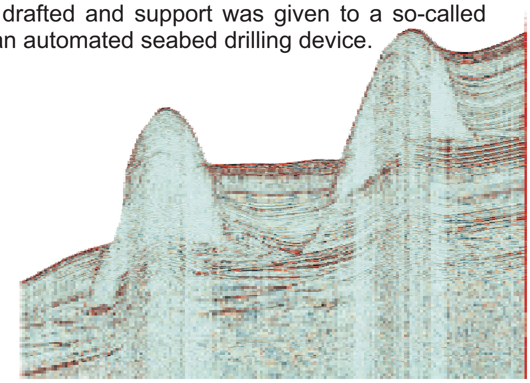


Fig.1 Very-high resolution seismic section through two “Belgica mounds”, southwest of Ireland, illustrating the subjacent setting and the burial history [1].

**Potential exploitation by end users**

The obtained results are of special interest to

(a) the oil industry, for three aspects: (1) the new insight in fluid migration pathways and modes (from focused to dispersed) from the reservoir to the slope, where fluids can interact with slope stability and Biosphere response, (2) the high-resolution imaging of carbonate mounds, known to be prime hydrocarbon reservoirs once buried, (3) the revelation of the dimension of cold-water coral ecosystems in hydrocarbon provinces, with outlook on preservation issues in areas of programmed deep oil exploitation;

(b) fundamental research, for (1) the new insights in the possible complex processes leading to the genesis of mounds, which form one of the most enigmatic features in the geological record, as ancient as the oceans: Geosphere-Biosphere coupling processes, seabed preparation and key actors, relays from internal to external control, etc., and (2) for a first step towards the quantification of carbonate mound provinces as carbon sink in the global carbon cycle.

Policy makers can benefit from the exploratory power of the GEOMOUND approach and strategy, in the service of conservation of valuable deep-water coral habitats.

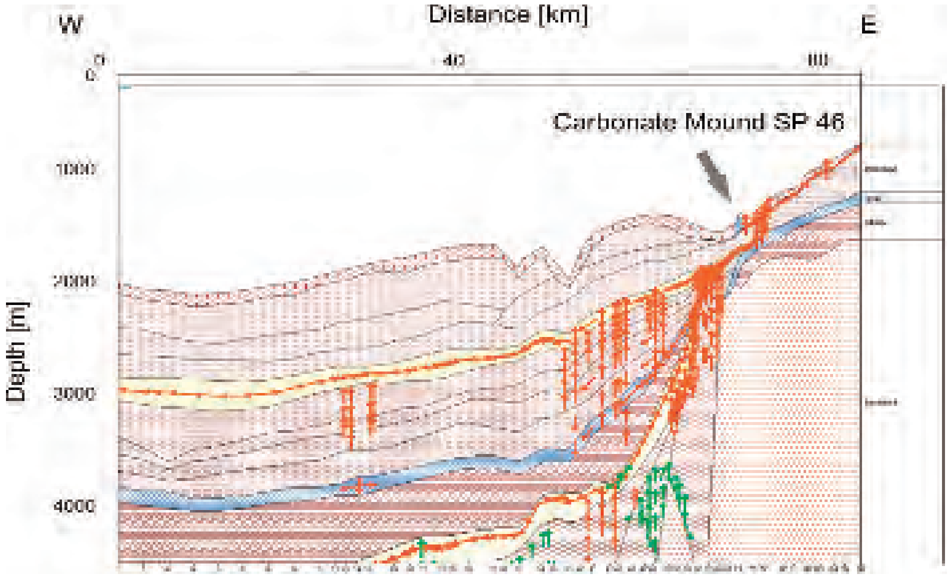



Fig. 2 Model of fluid migration pathways towards the Belgica carbonate mound province, Porcupine Basin, southwest of Ireland [2]

**References**

[1] Henriet, J.P. et al. (2002) in Ocean Margin Systems, Springer Verlag, 439-455
[2] Neath, J., PhD (2003)

# Deployment of HYACE tools In New Test on Hydrates (HYACINTH)

*Francis, T.[1], Thjunjoto [2], Martin, D.[3], Rothfuss, M.[4], Kouwenhoven, A.[5], Jackson, P.[6]*

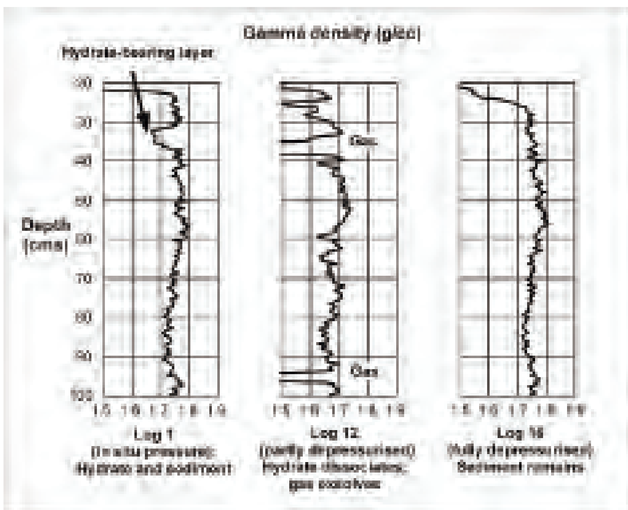
[1] Geotek Ltd, UK; [2] Technical University of Berlin, Germany; [3] University of Cardiff, UK; [4] Technical University of Clausthal, Germany; [5] Fugro Engineers BV, The Netherlands; [6] British Geological Survey, UK

| | |
|---|---|
| Contract No: EVK3-CT-2001-00060 | Project Duration: 12/2001 - 11/2004 |
| Project budget: € 2 574 773 | EC contribution: € 2 036 955 |
| Website: www.geotek.co.uk/hyacinth | |

**Objectives**

Gas hydrates are an important reservoir of methane in deep sea sediments whose role in the Earth's carbon cycle is still poorly understood. Their study has been hampered by the lack of suitable tools, both for their recovery and for their preservation and study in the laboratory. The primary aim of the HYACINTH project was to build on the earlier HYACE project, funded under the EC's MAST III programme, and to carry it forward to a fully operational stage [1]. Thus the first objective in the HYACINTH project was to recover good quality hydrate core with both the wireline pressure corers developed in the HYACE project - the HYACE Rotary Corer (HRC) and the Fugro Pressure Corer (FPC). The next objective was to transfer the pressure cores obtained into laboratory chambers without loss of pressure so that they could be geophysically logged. The means of geophysically logging pressurised cores would be extended. Further engineering development would be carried out in order to provide equipment for sub-sampling pressurised cores for chemical, microbiological and petrophysical study. The development of a system for carrying out microbiological experiments on pressurised sub-samples would also be pursued. Finally, microbiological analysis would be carried out on uncontaminated sediment cores acquired by either the HRC or the FPC.

**Results**




It was realised from the start that the success of the HYACINTH project would depend on close collaboration with the internationally funded Ocean Drilling Program and a formal agreement was signed between the HYACINTH partners and ODP in November 2001. As a result of this collaboration, five HYACINTH personnel and more than three tonnes of equipment were deployed in summer 2002 onto the scientific drillship *JOIDES Resolution* for ODP Leg 204, a two month operation devoted to the study of gas hydrates found on Hydrate Ridge, offshore Oregon [2]. During the course of this operation, cores at *in situ* pressures were recovered by both the HRC and the FPC, transferred into laboratory chambers without loss of pressure and geophysically logged in a vertical Multi-Sensor Core Logger [3,4]. This was the first time that laboratory measurements have been made of the physical properties of natural hydrates at sub-seafloor pressures without ever releasing the pressure. Some of the cores contained substantial quantities of methane hydrate. It was found that gamma density logs were the most useful and that they could be acquired from pressure cores contained in either the GRP-walled Logging Chamber or the steel-walled Storage Chamber. The geophysical logging of a hydrate-bearing pressure core is a time-consuming business because it has to be done repeatedly during pauses in the gradual degassing of the core. The figure shows three density profiles obtained during the degassing of Core 204-1244-8Y, acquired with the FPC. A total of 17 density logs were made of this core over a period of 12 hours. More examples of the geophysical logs of pressure cores can be found in the Initial Reports volume of Leg 204 [2].

Another operation to deploy the full HYACE-HYACINTH system at sea is scheduled to take place on the geotechnical drillship *Fugro Explorer* in spring 2004. Because this ship has a much smaller derrick than the JOIDES Resolution, the coring tools have had to be modified.

Development work in the HYACINTH project is proceeding in order to extend the range of studies which can be made on pressure cores. One work package is devoted to developing the means for measuring the electrical resistivity of the core, which requires the use of electrically conductive core liner. In another work package, progress is being made in the development of a system to obtain sub-samples from an HRC or FPC core, under contamination-controlled conditions and without depressurisation. The pressurised sub-samples can be transferred to a microbiological system of chambers, also under development, which will allow further sub-sampling, enrichment, isolation and experimentation to be performed on bacteria contained in the sediment. The whole process will be performed under anaerobic and aseptic conditions, and the bacteria will not be depressurised at any stage of the procedure.

**Potential exploitation by end users**

A fully operational HYACE-HYACINTH pressure coring system will be invaluable to government, industry and academic scientists working in the field of gas hydrate research, whose objectives range from establishing whether hydrates might be a future energy resource to understanding their role in the Earth's climate system. The pressure coring system will also allow barophilic organisms existing in the sub-seafloor biosphere to be sampled, isolated and studied; such research could allow potentially useful organisms for biotechnology to be identified. Finally, it will provide oil companies developing oil and gas resources in deep water on the world's continental margins, where gas hydrates are believed to exist in many places in the shallow sub-surface sediments, with the means to determine whether they pose a hazard to future seabed installations. In this latter application, the pressure coring tools are likely to be used in conjunction with more conventional site investigation techniques. One such operation, funded by an oil company, has already taken place.

**References**

[1] Francis, T (2003) Geophysical Research Abstracts **5**, 03922
[2] Tréhu, A.M, Bohrmann, G., Rack, F.R., Torres, M.E., et al. (2003) Proc. ODP, Init. Repts., 204 [CD-ROM]. Available from: Ocean Drilling Program, Texas A&M University, College Station TX 77845-9547, USA.
[3] Schultheiss, P, Holland, M. et al. (2003) Geophysical Research Abstracts **5**, 04375
[4] Francis, T & Schultheiss, P (2003) UKODP Newsletter **29**, 11-14

# Techniques for the Quantification of Methane Hydrate in European Continental Margins – (HYDRATECH)

*Westbrook, G.K.[1], Long, C.[1], Peacock S.[1], Haacke, R.[1], Reston, T.[2], Zillmer, M.[2], Flueh, E.[2], Foucher, J-P.[3], Nouzé, H.[3], Contrucci, I.[3], Marsset, B.[3], Klingelhoefer, F.[3], Best, A.I.[4], Priest, J.[4], Camerlenghi, A.[5], Carcione, J.[5], Rossi, G.[5], Madrussani, G.[5], Gei, D.[5], Mienert, J.[6], Vanneste, M.[6], Buenz, S.[6], Hetland, S.[7], Habetinova, E.[8], Minshull, T.A.[9], Chand, S.[9], Dean, S.[9], Clayton, C.[9]*

[1]Birmingham University, UK, email: G.K.Westbrook@bham.ac.uk; [2]IFM-GEOMAR, Germany; [3]IFREMER, France; [4]NERC SOC, UK; [5]OGS Trieste, Italy; [6]Tromsoe University, Norway; [7]RF, Norway; [8]SINTEF, Norway; [9]Southampton University, UK


| | |
|---|---|
| Contract No: EVK3-CT-2000-00043 | Project duration: 01/2001 – 06/2004 |
| Project budget: € 2,988,404 | EC contribution: € 2,180,711 |
| Website: http://www.hydratech.bham.ac.uk/ | |


**Objectives**

Methane hydrate, a solid, ice-like, clathrate of water and methane, is widespread in the top few hundred metres of sediment beneath continental margins in water depths greater than a few hundred metres. The base of the zone in which hydrate can exist is limited by the increase in temperature with depth beneath the seabed. The aim of the project is to evaluate and develop techniques that can be used on continental margins to quantify the amount of methane hydrate present in sediment, up to a depth of a few hundred metres below the seafloor in water depths of up to a few thousand metres. These techniques, utilising seismic measurements from seismic experiments with ocean-bottom seismographs with multi-component sensors and from 3D seismic reflection, should be viable in both the presence and absence of a bottom-simulating seismic reflector (BSR), formed at the boundary between hydrate-bearing sediment and sediment containing a small percentage of free gas held in pore spaces by surface tension. In the presence of a BSR, viable techniques should place bounds on the amount of gas present.

**Results**

Seismic data sets from arrays of four-component ocean-bottom seismic recorders and from high resolution seismic reflection surveys have been acquired at three sites, off NW and SW Svalbard, and off Storegga, Norway. These data have been inverted by ray-trace modelling and tomographic inversion to derive the spatial distribution of *P*- and *S*- wave velocities (Vp, Vs) and quality factor (Qp), with sufficiently high resolution to enable the prediction of the hydrate and free gas content of the sediments. Off NW Svalbard, positive Vp anomalies above the BSR at a depth of 200 m support the presence of gas hydrate, in low concentrations. A low-velocity zone about 65 m thick, containing free gas, is strongly developed beneath the BSR. The detail of the zone and the overlying hydrate-containing sediment has been clarified using waveform inversion. The concentration of free gas diminishes downward beneath this zone for a further 90 m.

The distribution of seismic properties has been related to the distribution of hydrate in the sediment, by employing theoretical and/or empirical relationships that predict the effect of hydrate on the seismic properties of sediment. Using information about sediment composition and porosity from the nearby ODP Site 986, a combination of self-consistent approximation (SCA) and differential effective medium theory (DEM), applied to the velocity models derived from ray-tracing inversion, predicts a hydrate saturation of less than 5%. Another approach, based on Biot theory, predicts hydrate saturations up to 20% and free gas saturations up to 0.2%. The results are preliminary, as *S*-wave velocity and attenuation (1/Qp) are not yet fully utilised by both methods.

These approaches to hydrate prediction are being tested by measuring the seismic properties of sediment containing hydrate grown experimentally in the laboratory in conditions simulating those found in nature. The work on hydrate grown in sediment in the laboratory has involved study of its mode of growth and the development of a resonant column to measure the seismic properties of the laboratory samples in the same frequency range as the seismic measurements made at the sites on the continental margin. Application of the SCA/DEM model to laboratory data from the resonant column system showed a good linear correlation between the predicted and actual amount hydrate present in the samples, with the predicted quantities of hydrate biased to higher values than the measured quantities. These are the first laboratory measurements of the seismic properties of sediment containing hydrate at seismic frequencies.

The data from NW Svalbard indicate the presence of seismic anisotropy, which modelling shows could be produced by the effect of micro-cracks aligned in a vertical plane that has a strike parallel to the contours the slope of the seabed. The strongest anisotropy is developed in the free-gas zone beneath the BSR, but is also present, more weakly, in the region above it. The cracks may be opened by down-slope gravitational stress and act as migration paths for fluid and gas. Overall, the anisotropy is not strong, and its systematic effect on the estimation of velocity and layer thickness is less than 2 %.

A major component of the research has been the development of the techniques for inverting the seismic data, ie. tomographic inversion for Qp, and tomographic and waveform inversion for Vs from mode-converted waves, and techniques for predicting hydrate concentration from seismic properties.

**Relevance to Society**

It is widely believed that hydrate in sediment acts as a bond between the sediment grains, increasing the sediment's shear strength. An increase in temperature or a decrease in pressure will cause hydrate to dissociate and release methane as a gas, weakening the sediment and making it prone to the formation of submarine slumps, which can be catastrophic in their consequences, such as the creation of tsunami. At a smaller scale, petroleum production platforms, by warming the region around the well, may destabilise hydrate, releasing methane gas and weakening the foundations of the platform. Problems have been encountered during petroleum exploration and production in areas of permafrost, and, arguably, offshore in areas such as the Gulf of Mexico. In European waters such as the North Sea, this has not been a problem to date, because the water depths have been too shallow for hydrate to be present, but as petroleum exploration and production moves into deeper water, hydrate becomes a potential hazard. Without knowledge of the distribution of hydrate in European continental margins, their exploration and exploitation could be hazardous and harmful to the environment.

# Marine Environment Test and Research Infrastructure - (METRI)

*Le Guen, Y.*

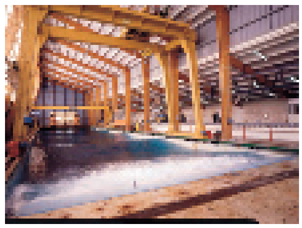
French Research Institute for Sea Exploitation (Ifremer) – France
Yvon.Le.Guen@ifremer.fr

| | |
|---|---|
| Contract No : HPRI-CT2001-00156 | Project duration : 11/2001 – 02/2004 |
| Project budget : € 466 667 | EC contribution : € 466 667 |
| Website : www.ifremer.fr/metri | |

**Objectives**

The main objective of the project is to give European research teams an access to an Infrastructure which is the only one in Europe which includes 5 installations allowing scientific and technical studies on the behaviour in marine environment of materials, equipment, sub-marine vehicle, instrumentation, physical and physico-chemical sensors… These installations are, for some of them, unique in Europe and located within multidisciplinary Ifremer Centres where more than one thousand researchers are working.

- The deep wave basin of Brest.
- The water circulation basin of Boulogne.
- The hyperbaric testing tanks.
- The marine material laboratory.
- The marine calibration laboratory.



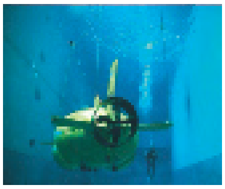
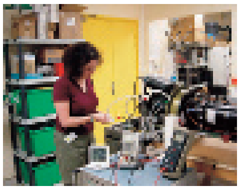
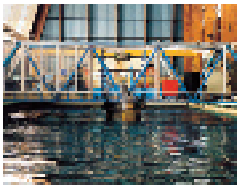
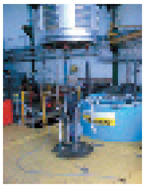
**Results**

12 research projects have been selected and 161 days of tests have been offered during the 28-month duration of the project. 32 researchers visited the Infrastructure. They came from United Kingdom, Norway, Greece, Ireland, Sweden, Italy, Germany, Spain and France.

- The University of Bremen in Germany tested a profiling, shallow, underwater instrument carrier system, called OKTOPUS, particularly designed to withstand heavy sea conditions and suited for arctic deployments.
- The University of Cranfield (UK) validated a model to predict the performance of a laser stripe imaging system for use on an Autonomous Underwater Vehicle (AUV).
- The University of Cranfield also studied the influence of pressure on the mechanical behaviour and fracture of composite and sandwich panels. The mechanical tests carried out into a pressure tank allowed concluding that a hydrostatic pressure of 300 bar does not affect the Mode I delamination toughness of the CFRP composite tested.
- The SUBEO Ltd Company (UK) tested a ¼ scale 3-person submarine and a 2-person craft called GEMINI. This submarine vehicle, designed for leisure and coastal scientific research, was successfully tested and will be proposed to customers very soon.
- The University of Goteborg (Sweden) evaluated in pressure, temperature and at different salinity rates, a conductivity cell newly developed to be not sensitive to marine conditions. AANDERAA Company could use the results of this study.
- The University of Cranfield studied the cathodic disbondment of protective coatings at high hydrostatic pressures. Steel panels coated with varied types of paint were tested in

natural seawater at a pressure of 250 bar. The results demonstrate that an increase of pressure and the application of cathodic overprotection both accelerate the natural degradation process that occurs in paint films.

- The University of Copenhagen (Denmark) tested 8 different current meters operating by 4 measurement principles on the same moorings in order to understand why, at sea, they do not deliver the same data in low current. The results show the influence of the vane and the suspended solid in water on the gap noticed.
- The SYSTEA Company (Italy) evaluated a newly developed deep-sea nutrient analyser. The test allowed noticing and solving some technical problems and adjusting parameters depending on the pressure. This new analyser can now be proposed to customers.
- The University of Plymouth (UK) validated an innovative system to recover wave energy. The results, according to the research team, could be crucial for the development of a commercially viable device for the generation of renewable electricity from wave energy.
- The National Institute of Geophysics and Vulcanology (Italy) tested a new bottom station network for deep-sea research. The tests allowed assessing the scientific instruments, simulating the operational sequences for the deployment and recovery of seafloor observatories and testing new acoustic communication systems.
- The National Centre for Sensor Research of the University of Dublin (Ireland) characterised the behaviour of a new radiometric fluorescence intensity-based dissolved oxygen sensor. The effect of temperature, generation of chorine (for fouling protection) and depth were investigated.
- The University of Madrid (Spain) characterised in temperature and pressure the behaviour of a new radiometric salinity sensor.

**Potential exploitation by end users**

These research projects allowed accelerating the development and the qualification of:

- sensors (salinity, dissolved oxygen sensors, nutrient analyser, current meters);
- instruments (profilers);
- measurement systems and techniques (bottom station network, laser stripe imaging system);
- underwater vehicles (manned submarine);
- materials for marine use (composite and sandwich);
- anticorrosion method;
- wave energy recovery method.

These developments will be used by the marine scientific community and by companies involved in sea research exploitation and seismic monitoring.

They also allowed “SMEs” to launch new products.

# Methane fluxes in ocean margin sediments: microbiological and geochemical control - (METROL)

*Borowski, C.[1], Boetius, A.[1], Cragg, B.[2], Dale, A.[3], Fossing, H.[4], Jensen, J.B.[5], Knab, N.J.[1], Pancost, R.D.[6], Jørgensen, B.B.[1], and METROL members*

[1] Max Planck Institute for Marine Microbiology, Germany, [2] Cardiff University, UK,[3] Utrecht University, The Netherlands, [4] National Environmental Research Institute, Denmark, [5] Geological Survey of Denmark and Greenland, Denmark, [6] University of Bristol, UK ; Contact: cborowsk@mpi-bremen.de



| | |
|---|---|
| Contract No: EVK3-CT-2002-00080 | Project duration: 11/2002 – 10/2005 |
| Project Budget: € 3 633 625 | EC Contribution: € 2 605 500 |
| Website: www.metrol.org | |



**Objectives**

Vast amounts of methane are formed in European margin sediments leading to the formation of free gas, to complex carbonate structures, and to enhanced methane emission. These processes are important for environmental quality, for offshore operations of the hydrocarbon industry, and for climate development. However, a high percentage of the entire methane flux is retained in the seafloor through anaerobic oxidation by microorganisms. While this process plays a critical role as a barrier against methane emission (accounting for estimated 90% of the total methane flux), its efficiency and environmental regulation are still poorly understood due to lack of relevant data and of understanding of the controlling factors. METROL aims to understand the controls and mechanisms of methane production and breakdown in ocean margin sediments. The special goals of METROL are to

- understand the microbial and geochemical processes involved in methanogenesis and anaerobic oxidation of methane in marine sediments,
- quantify the rates of turnover and fluxes of methane, sulfate and other intermediates at the sulphfate-methane transition zone in the sediment,
- explore these relationships by using a reaction-transport diagenetic model, and
- relate the depth of the methane-transition zone to broad-band geographical/geophysical surveying of distinct European coastal systems – the North Sea, Skagerrak, Kattegat, Baltic, and the Black Sea.

These objectives are achieved by interaction of nine international partners from science and industry with an interdisciplinary approach that integrates geophysics, geochemistry, microbiology, molecular biology, and numerical modeling.

**Results**

Hydroacoustic surveys of the occurrence of free gas in the sediment (Fig. 1) and pore water analyses (Fig. 2) indicate that free gas bubble formation is located considerably below the upper boundary of pore-water diluted $CH_4$. The sulphate-methane transition zone (SMTZ) is the narrow vertical horizon in the sediment in which $SO_4^{2-}$ and $CH_4$ coexist (Fig. 2). Based on our pore water analyses, we conclude that the rates of sulfate reduction (SRR) and anaerobic methane oxidation (AOM) increase the closer the SMTZ, and thus the $CH_4$ saturation zone, reach towards the sediment surface (see legend of Fig. 2).

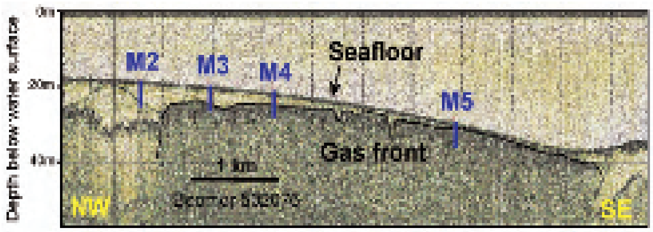



*Figure 1. Acoustic mapping of Aarhus Bay sediment along a 1.5 mile NW – SE transect. M2 - M5 = Stations for sediment sampling with a gravity corer. Sediment with free $CH_4$-gas appears dark with non-gaseous sediment on top. Sediment sampling locations are shown as blue vertical bars, which indicate 3-4 m penetration depth of the corer.*

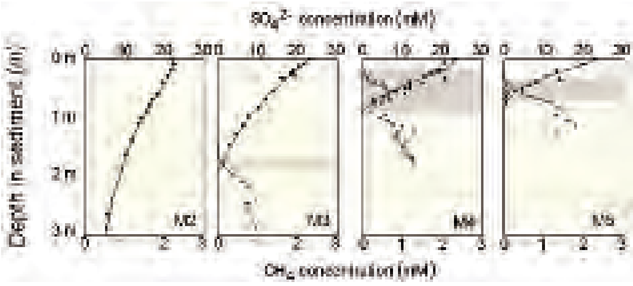



Figure 2. Pore-water profiles of $SO_4^{2-}$ (solid circles) and $CH_4$ (open circles) at Aarhus Bay stations M2 – M5. The sulphate-methane transition zone is shaded gray. The slopes of the profiles suggest that process rates (SRR, AOM) increase from M2 to M5.

Most of the sulphate is reduced in surface-near sediment layers, while rates for methanogenesis are highest in the $CH_4$ saturation zone below the SMTZ. However, significant activities for sulphate reduction and methanogenesis were measured within the SMTZ as well. As this zone is also related to high rates of AOM, this is indicative of substantial methane cycling in the SMTZ. This finding is strongly corroborated by (*i*) peaks of microbial biomarkers in the SMTZ which are indicative for the presence of archaea and sulphate reducing bacteria, and (*ii*) by the detection of anaerobic methanotrophs of the ANME-I group in the SMTZ of North Sea sediments. First experiments with these SMTZ sediments proved AOM activity even in vitro. The present structure of the generated SMTZ batch model allows the sensitivity of the most important parameters to be analysed, e.g., a doubling of the flux of organic matter to the SMTZ in the model results in a three-fold increase in AOM. This supports our conclusions on the relationship between the depth of the SMTZ and increasing process rates (see above).

**Potential exploitation by end users**

The narrow sulfate methane transition zone constitutes a very effective barrier against methane escape from deeper sediment strata. It is critical to know under which circumstances this barrier may become inefficient or even fail. The results will have significance for our understanding of the regulation of methane fluxes in ocean margin sediments and thus will considerable contribute to our ability to quantify and predict the release of the greenhouse gas methane from marine environments into the atmosphere. The results also contribute to our understanding of the processes which lead to the formation of subsurface carbonate structures and the processes of gas degradation in the sediment which may affect physical stability of the sea bed. Both are important factors for choosing suitable positions for off-shore installations.

# Ocean Bottom Seismic Instruments & advanced marine seismic reflection Data Imaging and Analysis - (OBSIDIAN)

*Flueh, Ernst R.*

[1] IFM-GEOMAR, Leibniz Institute for Marine Sciences, Kiel, Germany

| | |
|---|---|
| Contract No : HPRI – CT – 1999 – 00037 | Project duration : 3/2000 – 12/2003 |
| Project budget : € 690 000 | EC contribution : € 690 000 |
| Website : www.ifm-geomar.de | |

### Objectives

The aim of the project is to provide researchers from the community access to state-of-the-art facilities for advanced seismic processing, and to a modern fleet of ocean bottom seismic instrumentation. Training of young scientists is also an important aspect.

Among the academic community of the member states, IFM-GEOMAR offers the most advanced seismic processing facilities and operates the largest fleet of ocean bottom instruments for seismic surveys, currently consisting of 65 instruments [1].

### Results

Within the project, 37 scientists, representing 19 European research centres in eight different countries, benefited from the programme, which provided nearly 50 man-months of access to our computer centre. Ocean bottom instruments were operated during 10 cruises, with nearly 500 deployments. In total six completed PhD-theses profited from the programme, and currently fifteen PhD-Theses are in progress that incorporate results achieved by use of our large scale facility.

### Potential exploitation by end users

Research topics spanned a wide field, amongst which problems related to Natural Hazards (such as the Lisbon earthquake or the Storrega Slide) and Global Change (research into gas hydrates as a resource, as a factor influencing climate and as a control on slope stability) represent some of the highlights that achieved international recognition. More than 40 scientific papers have been written, and we expect more in the near future. Results obtained so far have also stimulated new programmes and proposals for additional field work and more qualified data analysis.

### References

[1] Flueh, E. R., Klaeschen, D., and Bialas, J., (2002) First Break, 20, 12, 764-769

# Ocean Margin Research Consortium – (OMARC)

*Mienert, J.*[1]

[1] Department of Geology, University of Tromsø, Norway.

E-mail: juergen.mienert@ig.uit.no

| | |
|---|---|
| Contract No : EVK3-2002-00513 | Project duration : 02/2003 – 03/2006 |
| Project budget : € 500 000 | EC contribution : € 400 000 |
| Website : www.ig.uit.no/omarc/index.htm | |

For modern natural science, the ocean is the very source of life on Earth, and it is crucial to bring ocean margin research issues more to the attention of decision makers and the public. Over 90 percent of our planet's living and non-living resources are found within a few hundred kilometres of the coasts, where two-thirds of the world's population is living. Even if we are improving our understanding of how the ocean margin system is functioning today, we are a very long way from being able to predict natural changes and man induced changes on the ocean margin that may be expected in the next century due to global impacts. Improved and more systematic observations of the ocean surrounding our continents are an obvious necessity to enable us to forecast imminent geohazards such as submarine slides or environmental impacts. The purpose of OMARC is to improve our knowledge about the functioning of ocean margin systems and to promote the wise use of the Earth's ocean margin system as a human habitat and as a target of natural marine resources. Ocean Margin research operates on global as well as regional related issues focusing on the needs of the society around the sea.

OMARC comprises 14 European margin projects that provide a critical mass of European resources with links to European industry. OMARC accompanying measure enhances cross fertilization of theses individual projects. Innovations both scientifically and technologically in the field of margin research can be anticipated. This concerted research development is developing further into an integrated effort covering all margin settings, for example around Europe, from active margins of the Mediterranean to passive margins of the northern north Atlantic and the Arctic.

OMARC reflects societal needs in for main areas: (1) increase our understanding of the natural factors that control the regional and global environment so that human living conditions may be improved along ocean margins, an area with the highest growing earth population; (2) develop more effective ways to find and assess potential future natural energy resources; (3) increase knowledge of geological processes and geological concepts through correlative studies of various locations around the ocean margin; (4) improve research methods and techniques for carrying out ocean margin research and ocean floor imaging in quality similar to satellite land images.

OMARC provides an excellent forum to enhance knowledge about our ocean margin systems, to create public awareness, and educational outreach. Bringing together leading scientists from Ocean Margin FP5 funded research projects inside and outside Europe provides a critical mass for planning future research, improving industry co-operation, and public awareness. This effort may allow developing ocean margin research as a continued activity leading to better understand the physical, chemical, biological and geological processes that control the functioning of the Ocean margin system as a whole.

# Profiles across Mediterranean sedimentary systems - (PROMESS 1)

*Berné, S. [1] Canals, M. [2], Skinner, A. [3], Trincardi, F. [4], and the Promess 1 group**

[1]IFREMER, France, [2]University of Barcelona, Spain , [3]BGS, United Kingdom, [4]IGM-CNR, Bologna, Italy

| | |
|---|---|
| Contract No : EV1-CT-2002-40024 | Project duration : 12/2002 – 6/2006 |
| Project budget : € 3 635 529 | EC contribution : € 2 717 984 |
| Website : www.pangea.de/Projects/PROMESS1/ | |

**Objectives**

"PROMESS" (PROfiles across MEditerranean Sedimentary Systems) is a group of complementary scientific proposals requiring three different coring and drilling platforms, each best suited for specific penetrations, recovery and water depths (ranging from 50 to 2500 m). Its general objective is to obtain comprehensive transects across two Mediterranean Deltaic Margins, in the Gulf of Lions and in the Adriatic, where seismic data base are very good and preservation of depositional sequences are exceptional. This will allow to better understand the effects of global and climate changes, sedimentary and oceanographic processes and tectonics on continental margins shaping.

Promess 1 is an integrated pan-European project (together with North American partners) that will use a geotechnical vessel from the industry for sampling long sections (50-300 m) and realise in situ measurements of shelf and upper slope sedimentary environments (50-300 m water depth). It will provide clues on sea-level changes, slope stability, canyon history and climate variability in physiographic settings where sedimentation rates in excess of 1m/kyr will allow high resolution studies. It is a companion project of "Eurostrataform" within the "Ocean Margin" cluster of European projects (OMARC). Sequences that deposited during glacial intervals are particularly well developed at the shelf edge. They will provide an expanded record for studying short period climatic oscillations. Clinoforms that deposited on the outer Gulf of Lions shelf will serve as a "dipstick" for past sea-levels during glacial periods of the last ca. 500 kyr, whereas the changes that occurred during the last deglacial period will better be investigated through the thick prodeltaic wedge of the Central Adriatic.

In order to process the ca. 700 m of coring and logging data, the project has been organized in work-packages and tasks that encompass a large number of techniques and research fields. To the great difference of ODP, most of the work will have to be done onshore, which implies a strong networking of European and North American laboratories.

**Results**

The project started in *December 2002*. Assessment of all geophysical data was carried out during the first year of the project, and drilling sites were selected. For each of the 4 sites, data bases were established using Geographic Information System, and a detailed report was prepared, gathering all information for each drilling site. In parallel, a call for tender, that specifies all requirements of the project, was published in the Official Journal of the EC in *April 2003*. In *June 2003*, the interim Pollution Prevention and Safety Panel of IODP (iPPSP) provided a courtesy review for the Promess drilling sites. Recommendations included the re-processing of some seismic lines, for better visualisation of amplitude anomalies. This was accomplished in July 2003. In *November 2003*, following the detailed evaluation of the proposals submitted to "Promess 1", FUGRO Engineers BV was proposed as the main sub-contractor for drilling and testing operations at sea. This was accepted by the EC on *December, 1st, 2003*. A technical meeting was held in Leidschendam (NL) on *December 16th, 2003*, together with a visit of the geotechnical vessel "BUCENTAUR", in order to arrange some of the contracting and technical aspects. The first Promess 1 annual meeting took place in Bologna (Italy) on Feb. 4 and 5, 2004. During this meeting, several technical aspects, dealing with safety, drilling procedures, organization of tasks onboard, downhole logging and sampling strategies, archiving and disseminating of data, were discussed. At the time of writing of this abstract, the expected time frame for drilling operations is comprised between *April and June, 2004*, using the SRV Bavenit of FUGRO.

**Acknowledgements:** Thanks are due to JEODI (Joint European Ocean Drilling Initiative) and IODP for providing technical and advisory support.

*IFREMER Brest: S. Berné, B. Dennielou and N. Sultan ; IGM Bologna : A. Asioli, A. Cattaneao and F. Trincardi ; BGS : A. Skinner and M. Stoker ; GGA Hannover : R. Gelfort and Th. Wonik ; Un. Barcelona : I. Cacho, M. Canals, R. Urgeles and R. Zahn ; Un. Salamanca : J.A. Flores and F. Sierro ; IUEM Brest : L. Droz and M. Rabineau ; Un. Bremen : R. Schneider and H.J. Wallrabe-Adams ; Un. Lyon : C. Beaudouin and J.P. Suc ;*

*CSIC Granada and Barcelona : F. Martinez-Ruiz and J.O. Grimalt ; Instaar, Boulder : J. Syvitski ; Lamont DEO : G. Mountain.*

# Stratigraphical Development of the Glaciated European Margin - (STRATAGEM)

*Evans, D.*[1]*, STRATAGEM partners*

[1] British Geological Survey, UK, devans@bgs.ac.uk



| Contract No: EVK3-CT-1999-00011 | Project Duration: 03/2000 – 02/2003 |
|---|---|
| Project Budget: 2,506,409 Euros | EC contribution: 1,507,000Euros |
| Website: www.stratagem-europe.org | |



## Objectives

The project was a regional study of the Neogene stratigraphic development of the glaciated European margin from Lofoten to Porcupine. In order to generate a Neogene stratigraphic framework for this part of the margin. The second objective was to use these data and interpretations to generate a model for the evolution of the margin.

## Results

The stratigraphic atlas presents a unified stratigraphic framework for the margin by establishing two unconformity-bounded megasequences, of Miocene to lower Pliocene and lower Pliocene to Holocene age respectively, that are informally termed the 'lower' and 'upper' Neogene successions. The main characteristics of these units are defined and described, with seismic data examples, distribution maps, and a compilation of core and sample data from the region. There is also a section on higher-resolution stratigraphy that provides more-detailed information on some of the younger units at a range of scales.

In the margin evolution model, a six-stage event stratigraphy is proposed that documents the Neogene development of the margin. The glaciated European margin is classed tectonically as passive, but the post-rift history of the margin, including the Neogene, has been anything but passive, for a physically dynamic Neogene evolution is demonstrated.

The model includes the results of post-rift backstripping modelling that has been carried out on selected transects along the margin. Another section makes comparisons with other glaciated margins, thus placing our study in a global perspective.

## Potential exploitation by end users

The main deliverables generated by STRATAGEM have been distributed to all 29 oil companies that supported the project. In addition, as a result of further industry sponsorship, CDRoms of the reports have been sent to 50 relevant academic institutes throughout Europe. Furthermore several papers, including a thematic volume will or have been produced, and a number of presentations made at conferences.

## References

STRATAGEM Partners. Stoker, M.S. (Compiler) 2002. The Neogene stratigraphy of the glaciated European margin from Lofoten to Porcupine. A product of the EC-supported STRATAGEM Project. World Wide Web Address: http://www.stratagem-europe.org

STRATAGEM Partners. Stoker, M.S. (Compiler) 2003. Neogene evolution of the glaciated European margin. A product of the EC-supported STRATAGEM Project. World Wide Web Address: http://www.stratagem-europe.org

Stoker, M.S., Praeg, D., Shannon, P.M., Hjelstuen, B.O., Laberg, J.S., Nielsen, T., van Weering, T.C.E., Sejrup, H.P. & Evans, D. In press. Neogene evolution of the Atlantic continental margin of NW Europe (Lofoten Islands to SW Ireland): anything but passive. In: Doré, A.G. (ed), Petroleum Geology of Northwest Europe: Proceedings of the 6th Conference, Geological Society, London.

# Tracer and Circulation in the Nordic Seas - (TRACTOR)

*Johannessen, T.[1], Olsson, A. [1], Messias, M-J. [2], Watson, A. J. [2], Gascard, J-C [3], Drange, H. [4], Eldevik, T. [4] Anderson, L.[5], Ólafssón, J.[6], Nøst, O.A.[7]*

[1] Geophysical Institute, University of Bergen and the Bjerknes Centre for Climate Research, Norway; [2] School of Environmental Sciences, University of East Anglia, UK; [3] Laboratoire D'Océanographie Dynamique et de Climatogie, Paris, France; [4] Nansen Environmental and Remote Sensing Center, [5]Goeteborg University, Sweden, [6]The Marine Research Institute, Iceland, [7]Norwegian Polar Institute, Norway



| | |
|---|---|
| Contract No : EVK2-2000-00080 | Project duration : 02/2001 – 01/2004 |
| Project budget : € 2 342 632 | EC contribution : € 1 887 530 |
| Website: http://www.bjerknes.uib.no/research/TRACTOR/index.html | |



**Objectives**

- Describe and quantify the present strength and variability of the circulation and oceanic processes of the Nordic Seas regions using primarily observations of the long term spread of a tracer purposefully released into the Greenland Sea Gyre in 1996
- Improve our understanding of ocean processes critical to the thermohaline circulation in the Nordic Seas regions so as to be able to predict how this region may respond to climate change.
- Assess the role of mixing and ageing of water masses on the carbon transport and the role of the thermohaline circulation in carbon storage using water transports and mixing coefficients derived from the tracer distribution.

**Results**

The Greenland Sea (GS) is believed to be one of the most important regions to ventilate the world oceans, and convective processes there is regarded to be an important contributor to drive the general thermohaline circulation of the oceans. For this reason, in August 1996, a tracer release experiment was begun in the intermediate-depth waters of the central Greenland Sea, to study water mass transformations associated with dense water production and contributing to the thermohaline overturn. In this poster we briefly summarize the outcome of this study. The data and model results presented give an overview of the mode of convective activity, and the general spread of the tracer in the vertical and horizontal direction during the 7 years of EU. The start of the experiment was conducted during the EU contract MAS3-CT95-0015, ESOP-project. We focus on three main observations:

(1) The deepening of the tracer patch in the GS gyre, from the injection depth of 300m in August 1996, to 800m in September 1998

The deepening of the tracer patch (isopycknal) seems to generally being caused by a lightening of the complete water column within the Greenland Sea. The main cause seems to be heating and depict the more sloppy convection that has been observed in the region since 1990's. No real bottom water formation has been observed in the region since 1991.

(2) The redistribution of the tracer over the water column from 300 to 1200-1500 dbars respectively in May 1997 and June 2002 as the result of winter convection.

Two styles of ventilation have been observed. The eddy formation and rejection as that modifies the water column down to 2500m published in Nature (Gascard et al., 2002), and the more classic style for deepwater formation in 2002. The general picture for both these styles of ventilation is that they do not produce bottom water, but ventilate the critical zone in the upper layer (approx. 1500 m) of the Greenland Sea that communicate into the North Atlantic Ocean.

(3) The advective routes, internally in the Nordic Seas and over the choke point into the adjacent oceans

New information about the timing of when the tracer-influenced waters reach the choke point and enters into the North Atlantic Ocean is obtained. The earliest observation of tracer water just north of the Denmark Strait were approx. 2,5 years and in the Faeroe-Shetland channel approx. 3,5 years after the release respectively.

### Potential exploitation by end users

This unique dataset will be used to perform a model exercise, where data to model intercomperison and model-to-model intercomparison is central. A suit of General Circulation Models (GCM's) will be tested. These styles of models are often used to predict future climate change, but at the present stage of development clear short comes in the way the present the real ocean. Based upon data and modelling this ambitious and work intensive project we are now much more The advantage using a one point tracer field, where we know when and where the tracer was released are that we get much more robust calculations on advection and vertical mixing in the ocean. In sum the results from the TRACTOR-project can be used to improve the present day modelling tool in such a direction that more reliable scenarios can be made for future global and climate change. This will make the science within our field more valuable for future guidance in policymaking and for this reason for society.

### References

Eldevik, T., F. Straneo, A.B. Sandø, and T. Furevik. 2003: Ventilation and spreading of Greenland Sea Water. Submitted to *Climate Variability in the Nordic Seas*, Geophysical Monograph Series, AGU.

ESOP2 Group, 1999: *The thermohaline circulation in the Greenland Sea*, ESOP2/MAST3 Final scientific report, E. Jansen and V. Opheim, Eds. University of Bergen.

Gascard, J.-C., A.J. Watson, M.-J. Messias, K A. Olsson, T. Johannessen, and K. Simonsen, 2002: Long-lived vortices as a mode of deep ventilation in the Greenland Sea. *Nature*, **416**, 525-527.

Messias, M.-J. and co-authors, 2004: The Greenland Sea tracer experiment. Unpublished manuscript.

Olsson, K.A., E. Jeansson, L.G. Anderson, B. Hansen, T. Eldevik, R. Kristiansen, M.-J. Messias, T. Johannessen, and A.J. Watson, 2004: Intermediate water from the Greenland Sea in the Faroe Bank Channel: spreading of released sulphur hexafluoride. Submitted to *Deep Sea Res.*

Watson, A.J., Messias, M.-J., Fogelqvist, E. , Van Scoy, K.A., Johannessen, T. , Oliver K.I.C., Stevens, D.P. Rey, F., Tanhua, T., Carse, F. , Simonsen, K., Ledwell, J., Jansen, E., Cooper, D.,J. Kruepke, J.A. and Guilyardi, E.. Mixing and convection in the Greenland Sea from a tracer-release experiment, *Nature, 40*, 902-904, 1999.

# OCEAN ENERGY

# Optimising the Performance (Electrical and Economic) of Tidal Current Turbines - (OPTCURRENT)

*Bryden, I.G.[1], Deluré, Y.[2], De Nat, L.[3], Gravili, D.[4], Holmes, B.[2], Lewis, A.[2], Melville, G.T.[1] and Thake, J.[5]*

[1] The Robert Gordon University, UK; [2] University College Cork, Ireland; [3] Thetis SpA, Italy, [4]CEOM SCpA, Italy, [5]IT Power Ltd, UK

| | |
|---|---|
| Contract No : JOR3CT980205 | Project duration : 08/1998 – 07/2001 |
| Project budget : € 531 246 | EC contribution : € 531 246 |

**Objectives**

The principal aim of this project was the development of a methodology for the optimal matching of tidal current driven turbines to local flow conditions, taking account of environmental, social and economic constraints. The methodologies were presented in the form of a "tool-box", which consisted primarily of software required for the identification of optimal solutions with guidelines on establishing the necessary input databases. The project was split in to six distinct tasks.

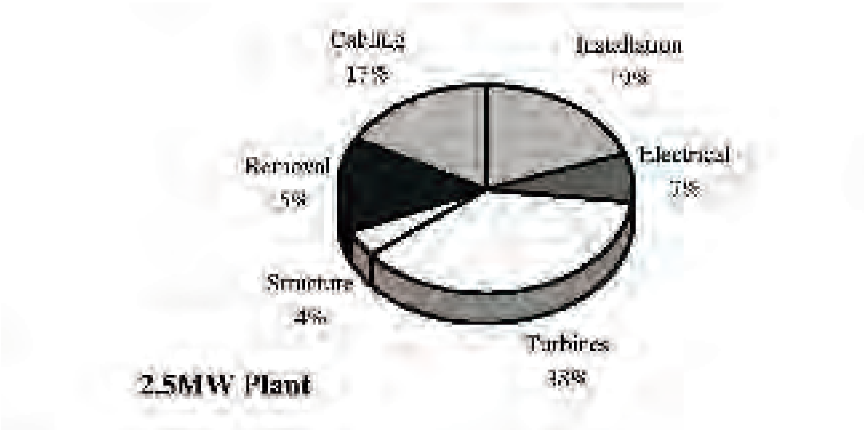
- Methodology development
- Identification of suitable test sites
- Hydrographic surveys of two sites
- Development of hydrodynamic computational models for each site
- Development of the optimisation software
- Development of the 'Toolbox' containing software and documentation on the process

**Results**

The optimisation software contains within it, the cost functions developed during the second task and the tidal parameters output by the hydrodynamic model. Within a particular tidal area, it first filters the available locations based on topology, tide, shipping and other environmental exclusions. The annual energy production is estimated for a list of 'off the shelf' tidal turbines. Given a capacity power production, the package calculates the size and cost (capital and operating) of the plant using these turbines and produces an ordered list of power plant giving the turbine, location, number, costs and cost efficiency.

The optimisation package was applied to the two surveyed areas. Assumptions were made on seabed conditions, environmental constraints and electricity network connectivity. These demonstrated the cost effectiveness of medium scale tidal power developments and the necessity of the optimisation process for choosing plant location and the turbine design.

The 'toolbox' was designed to facilitate the use of the tidal modelling and optimisation packages and provide documentation on the parameterisation, site selection, data preparation and instructions on model operation. The GUI interface access to the results for plotting and printing. Information is accessed through a geographical information system (GIS) which will allow for further expansion of the data available to the operator.




The OPT-Current partnership have successfully developed and tested a ‘toolbox’ which can be used on any tidal area. It can predict the most suitable location s within the area and assess its economic potential for tidal current power generation. In doing so, the partnership have met all the project’s deliverable targets.

**Potential exploitation by end users**

Establishment of economic tidal power options will stimulate substantial opportunities for development in some of Europe's most peripheral regions with key opportunities for local industry and, therefore, on employment in many areas which are currently suffering from de-population. As a new technology there will be requirement for training as well as for manufacturing. The social benefit would, therefore, extend beyond manufacturing industry.

Most of the skills required to develop tidal current power are already present in Europe’s energy industry. There will, however, be substantial requirements for continual professional education for employees and entrepreneurs whose background is in more traditional industries. It is, however, considered that the attractiveness of the resource in cost term will stimulate development and the associated educational initiatives. Both of the Universities in the OptCurrent project have indicated that they will be well placed to participate in these activities.

The size of the resource suggests that the potential for CO2 reduction from development is considerable. All studies to date have suggested that the technology would be environmentally benign with few if any substantial disadvantages. All forms of electricity generation have an effect upon the environment. Renewable technology is no exception. The very nature of renewable energy schemes means that it is not always possible to hide the engineering from view and it is a matter for debate whether wind turbines, for example, are aesthetically pleasing or not. Tidal turbines will benefit from the fact that being submerged they will be almost invisible. The total environmental impact from tidal turbines will be minimal.

# Renewable energy from the osmotic power potential in European estuaries – (SALINITY POWER)

*Aaberg, R.J.[1*], Bordado, J.[2], Thorsen T.[3], Lampinen M.[4], Peinemann K.[5]*

[1] Statkraft SF, Norway; [2] ICTPOL, Portugal; [3] SINTEF, Norway; [4] Helsinki University of Technology, Finland; [5] Forschungszentrum GKSS, Germany

*Co-ordinator e-mail address: Rolf.Jarle.Aaberg@statkraft.com



| | |
|---|---|
| Contract No : ENK6-CT-2001-00504 | Project duration : 11/2001 – 10/2004 |
| Project budget : € 3 371 000 | EC contribution : 1 809 000 |
| Website : www.statkraft.com (no official project website) | |



**Objectives**

Large amounts of renewable energy can be extracted wherever freshwater from rivers and lakes meets with the saltwater in the ocean. If freshwater and saltwater is separated by a membrane the freshwater will spontaneously migrate through the membrane and dilute the saltwater due to the chemical potential difference. The flux of water through the membrane generates a hydrostatic pressure corresponding to a water head of 100 m or more which can be used to generate power in a hydropower turbine. This technology is called pressure retarded osmosis (PRO) and has an enormous unexploited power production potential world-wide.

The PRO process is similar to a reverse osmosis desalination plant running backwards. Most of the components are thus well known and proven technology. The major challenge is to develop an efficient and cheap forward osmosis membrane that is capable of transferring large amounts of freshwater towards a significant pressure gradient.

Specific objectives include: Increase the membrane performance to 4 W/m$^2$ at a mass production cost of 4 €/m$^2$. A feasibility study to establish the potential for salinity power in a European renewable energy production scenario will also be concluded.

**Results**

A wide range of membrane types have been developed and tested during the first 24 months of the project and the characteristic parameters such as permeability of water and salt, and osmotic pressure have been studied. In process simulation experiments a membrane performance of more than 1.5 W/m$^2$ has been verified. This is about half the power density objective at this time in the project. However, reverse osmosis measurements of the same membranes showed a potential power density of about 5 W/m$^2$, which shows that indicate the future capability of present membrane types. Present membrane performance is more than twice the values measured one year ago and the progress is steady. Until now the scientists have not observed any fundamental obstacles in membrane development suggesting that membrane performance of 4 W W/m$^2$ or more can be achieved by clever membrane design and engineering.

The various tasks of the feasibility study are in progress and preliminary results are encouraging. Concept development and process simulations show that osmotic power can become competitive on the European renewable energy market. Although technology development will continue after the completion of the present project it is evident that significant progress has been made towards establishing a new environmentally friendly power source.

### Potential exploitation by end users

The present project is the only major research activity into salinity power exploitation world-wide. The consortium partners are world leaders in the development of a vast unexploited power source which has a technical generating potential estimated at 250 TWh per year only in Europe. The efforts of this consortium are expected to establish the necessary theoretical and practical know-how (pre-engineering level) for the future construction of a salinity power plant. The project is further expected to bring about a breakthrough in membrane development by achieving a power density equivalent to 4 W/m2 of membrane. Even if membrane development is expected to continue beyond the duration of this project a membrane power density in this range would verify the market feasibility of the concept.

The feasibility study will establish the competitiveness and environmental performance of a salinity power plant in operation. Although firm conclusions are premature recent results suggest that salinity power plant can be constructed with a very gentle environmental impact and so that the local environment and biodiversity is well conserved. Taking this into account and assuming realistic membrane performance and cost data it is expected that salinity power will be competitive with other emerging renewable energy sources such as off-shore wind power and biomass power generation.

Provided the successful development of salinity power the demand for membrane will increase substantially compared to present global production capacity and the construction of power plants will sustain a massive expansion of the membrane industry over a period of many years.

Statkraft SF is the second largest producer of renewable energy in Europe with a strong position in hydro power generation. The company has a strategic vision to become a European leader in environmentally friendly energy. Participation in the SALINITY POWER project is part of the long term strategic perspectives in Statkraft SF and offers a great potential for future renewable energy generation.

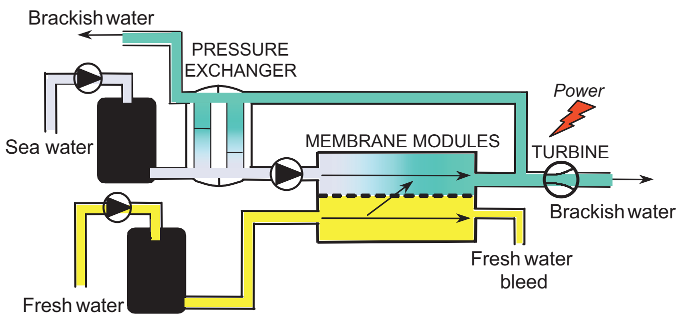



Figure 1: Simplified diagram of the PRO process.

### References

[1] Aaberg, R.J. (2003) REFOCUS The International Renewable Energy Magazine **Nov/Dec**, 48-50

# Sea Testing and Optimisation of Power Production on a Scale 1:4.5 Test Rig of the Offshore Wave Energy Converter Wave Dragon - (WAVEDRAGON 1:4.5)

*Soerensen, H.C.[1], Christensen, L.[1], Hansen, L.K. [1], Friis-Madsen, E.[2], Kofoed, J.P.[3], Frigaard, P.[3], Dunce, D.[4], Bree, T. [5], Holmén, E.[6], Knapp, W.[7], Riemann, S.[7], Nedkvintne, J.[8], Nöhrlind, T.[9], Raulund, A. [10] Praest, J. [11] Panhauser, W.[12]*

[1] SPOK ApS, Denmark, consult@spok.dk ; [2] Löwenmark F.R.I, Denmark; [3] Aalborg University, Denmark ; [4] Armstrong Technology Ltd, UK; [5] ESB International Engineering, Ireland; [6] Veteran Kraft AB, Sweden; [7] Technical University Munich, Germany; [8] Balslev A/S, Denmark; [9] Nöhrlind Ltd, UK; [10] NIRAS AS, Denmark; [11] Promecon A/S, Denmark; [12] Kössler Turbines Ges.m.b.H, Austria

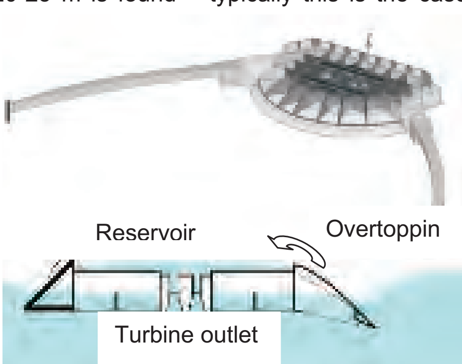


| | |
|---|---|
| Contract No : ENK5-CT-2002-00603 | Project duration : 10/2002 – 06/2005 |
| Project budget : € 2 629 642 | EC contribution : € 1 532 999 |
| Website : www.wavedragon.net | |



**Objectives**

The primary objective of the project is to establish the scientific knowledge base needed for deploying a full-scale prototype of the overtopping wave energy converter Wave Dragon. This will be obtained through long-term field-testing on a test rig with all systems installed. The scale model has an installed power of 20 kW corresponding to 4 MW in full-scale with full turbine deployment. The 4-11 MW Wave Dragon is a slack moored device that can be deployed in large parks wherever a sufficient wave climate and a water depth of more than 20-25 m is found – typically this is the case in the North Sea and in the Atlantic, offering significant economic and environmental benefits for the EU.

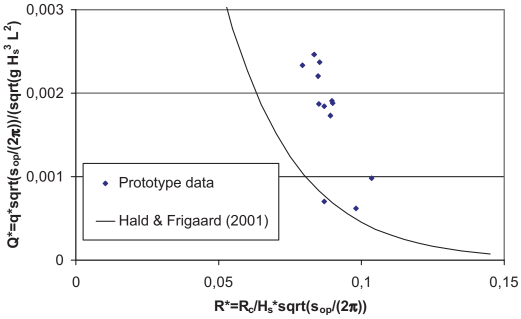



A successful deployment of the Wave Dragon will then contribute to the EU goals on:

- Increased use of renewable energy sources.
- Reduced price of wave energy produced electricity to 0.04 EUR/kWh by 2016.
- Reduced emission of green house gases.
- Higher competitiveness of hydro turbine manufactures, as mass production of simple hydro turbines can be foreseen.
- Job creation in areas of the EU where job opportunities are scarce, primarily within industries such as shipyards and construction industries.
- Contribution to the assessment of standards applicable to offshore wave energy converters within structural design and environmental impacts, and recommendations for future pre-normative research needs.

As the know-how required is trans-disciplinary and not easily reproducible, successful technological development and commercialisation will give European industries a strong and long lasting competitive advantage on the world scene, as has been the case for the wind power industry. The project will during the project lifetime contribute to the European strategic goal of securing a self-sufficient, diversified and low-cost renewable energy supply.

### Results




After one year of testing, the following results have been obtained:

- Wave Dragon has proved its ability to survive in real sea [1].
- Wave Dragon has been delivering electricity to the grid as the first offshore wave energy converter in the world [1].
- The remote control system has been tested and is now used to run the anticipated test series [2].
- The 6 turbines have been installed in open sea and the process for operation and maintenance has been documented [4].
- The results from measurements of forces have shown figures of the same magnitude as expected from the test of a scale 1:50 model [3].
- The overtopping results and by that the expected power output are indicating higher values (more power) than expected from previous tests of a scale 1:50 model [2].

### Potential exploitation by end users

The project opens up for large-scale exploitation of offshore wave power, which will contribute to improving European self-sufficiency and diversification of energy supply.

According to a modest estimate [5] ocean wave energy has a potential for covering more than half the world's electricity consumption 15,000 TWh [6]. For decades, utilization of wave energy has been the subject of research and development but until recently with little prospects of a commercial solution.

On the basis of a well-proven design and documentation of the technical viability through long term field testing a power production price of 0.11 EUR/kWh will be documented at project finalisation with a long-term production price of 0.04 EUR/kWh foreseen

The deployment of Wave Dragon will establish a completely new industry like the wind industry offering job potentials for employees from the declining the European oil and gas offshore industry. The long-term employment in Europe is foreseen to 6,000, with an installed power of 2,400 MW expected by 2016. The large-scale serial production of Wave Dragon type turbines is also expected to open up for an increase in small hydropower installations due to a 20% reduction in costs. During the project, dissemination and exploitation activities will be targeted at dissemination of scientific results, dissemination towards the public, commercialisation of sub-technologies and at finding investors for a first generation full-scale prototype.

### References

[1] Soerensen, H.C. et. al. (2003) Fifth European Wave Energy Conference, Cork
[2] Frigaard, F. et. al. (2004) ISOPE 2004, Toulon
[3] Friss-Madsen, E. et. al. (2002) IMAM 2002, Crete
[4] Knapp, W. et. al. (2003) Hydro 2003, Croatia
[5] World Energy Council (1994) New Renewable Energy Resources, p.234
[6] IEA Statistics (2003) Renewable Information, 188 pp.

# OPERATIONAL FORECASTING

# Acoustic Communication Network for Monitoring the Underwater Environment - (ACME)

*J.-M. Passerieux[1], S. Fischer[2], P. van Walree[3], A. Adams[4], S. Coatelan[5]*

[1] Thales Underwater Systems, France; [2] Ministry of Transport, Public Works and Water Management, Netherlands, [3] TNO Physics and Electronics Laboratory, Netherlands; [4] University of Newcastle upon Tyne, United Kingdom; [5] ORCA-Instrumentation, France

| | |
|---|---|
| Contract No : EVK3-2000-000039 | Project duration : 12/2000 – 11/2003 |
| Project budget : € 2 857 833 | EC contribution : € 1 617 711 |
| Website : http://flipper.ncl.ac.uk/acme | |

## Objectives

- To develop robust communication and protocol algorithms for an underwater acoustic communication network operating in coastal environment,
- To make a real time software implementation of the methods and algorithms, and to make a hardware implementation of a network prototype of acoustic modems,
- To test and evaluate the network prototype in configurations needed for applications of direct social interest (monitoring of pollution, measurement of current, other water management related parameters, etc.)
- To verify the value of a robust acoustic communication network in practice by integrating the prototype with the existing measurement infrastructure in the Westerschelde shipping lane, and to actually monitor the current during a time span of weeks.

## Results

Main results of the ACME project are:

- An evaluation/comparison of modulations for underwater acoustic communication in coastal environment, including most often used of modulations (MFSK, spread spectrum, BPSK), with bitrate from 100 bps up to 1 kbps. Cf. [3,4]
- The definition and implementation of the ACMENet protocol, which successfully allowed (during at sea experiment) multi-nodes synchronisation, data retrieval and transmission via a relay mode. Cf. [1,2].
- The realisation of the whole ACME network prototype, including one master node (near the shore) and three slave nodes (located on the sea bottom), connected with sensors and with RWS existing measurement network.
- The final in situ evaluation of the ACME network prototype, which allowed to gain very valuable insight on the difficulties which may arise when operating complex system as ACME network prototype.

In other respects a data base, maintained at IFREMER/SISMER, with environmental data and hydrophonic data (for various acoustic modulations).This data may be useful to other parties for the development and testing of transmission algorithms for underwater communications. The data bank is available on the ACME data management website at IFREMER: http://www.ifremer.fr/sismer/program/acme/index.htm

## Potential exploitation by end users

The obtained results are of special interest to any end user interesting in data retrieval in underwater coastal environment when a link to the shore by cable or via radio network is difficult or impossible (because of associated costs, environmental conditions or human activities, e.g. dredging, fishing, navigation, etc.).

## References

[1] G. Acar and A.E. Adams, A Master-Slave protocol for the Underwater Acoustic Communication Network, 7th Conf. On Underwater Acoustic, ECUA 2004, Delft (NL), July 2004
[2] Martin Nelisse, Networking Considerations for Acoustic Communication with Multi-Node Underwater Sensors Networks, 7th Conf. On Underwater Acoustic, ECUA 2004, Delft (NL), July 2004
[3] J.-M. Passerieux, Experimental evaluation of DS-CDMA modulations for use in shallow water acoustic communication network, 7th Conf. On Underwater Acoustic, ECUA 2004, Delft (NL), July 2004
[4] M.K. Robert and P. van Walree, High bitrate BPSK signals in shallow water environment, European Conf. On Defense Technologies, Malmö (SW), June 2003

# Atlantic Network of Interdisciplinary Moorings and Time-series for Europe - (ANIMATE)

*Send, U.[1,*], Villagarcia, M.[2], Lampitt, R.[3], Meinecke, G.[4], Valdimarsson, H.[5], Müller, T.J.[1], Karstensen, J.[1]*

[1]Leibniz-Institut für Meereswissenschaften, Germany; [2]Instituto Canario de Ciencias Marinas, Spain; [3]Southampton Oceanography Centre, UK; [4]Marum, Germany; [5]Hafrannsóknastofnuninni, Iceland; *usend@ifm-geomar.de

| | |
|---|---|
| Contract No : EVR1-CT-2001-40014 | Project duration : 12/2001 – 11/2004 |
| Project budget : € 2 977 631 | EC contribution : € 2 258 676 |
| Website : www.soc.soton.ac.uk/animate | |

## Objectives

The open ocean component of a real time earth system monitoring framework is particular demanding through the often harsh conditions at sea. As a first step three preoperational mooring sites have been deployed in late 2002 in the North East Atlantic that collect hydrographic and biogeochemical data. Typically sensors are mounted at depths of up to 1300m and measure Carbon Dioxide, Nutrients, Temperature, Salinity, Pressure, Current Speed and Direction, and Phytoplankton Concentration. Part of the data is send to shore in near real time and is accessible via the World Wide Web. The near real time data can be used by a range of scientific disciplines. The difficult conditions throughout the year make the site locations ideal for trials on the technology and systems required to send real-time data and to record the delayed-mode data.

## Results

After a preparation period of about 6 to 8 month all three mooring site where made operating in late 2002 and sent physical data (temperature, conductivity and pressure) from down to 1300m depth in near real time [1, 2]. In late 2002 the real time data access of Carbon Dioxide (pCO2) could be established at one site.

Further refinements planned include: Adding other sensors to near real data submission procedure, improvement to mooring design and maintenance strategies.

## Potential exploitation by end users

The near real time data provides the eulerian subsurface observational base for the global ocean data assimilation experiment (GODAE) especially important for model validation. The ANIMATE moorings contribute to and are continued with the FP6 Project MERSEA. This opens the assimilation of observed biogeochemical data into a new set of regional and global hydrographic and biogeochemical assimilation models.

## References

[1] Send, U. et al. (2003) ANIMATE first annual report, 203 pp.
[2] http://www.soc.ac.uk/animate/data

# Development of the Black Sea Nowcasting/Forecasting System - (part of ARENA)

*E. Cordoneanu, V. Dorofeev, V. Fomin, G. Korchev, A. Kordzadze, G.Korotaev, K. Korotenko, A. Kubryakov, T. Oguz, Yu. Resnyansky, D. Trukhchev, H. Slabakov*

ARENA MODELLING TEAM

EC project ARENA has started last year. One of the project goals is to develop pilot nowcasting/forecasting system in collaboration with the Black Sea GOOS and other international project ongoing in the basin. The elaborated strategy of the Black Sea nowcasting/forecasting system is based on the evaluation of the available resources in the region. There is extended initial observing system in the basin operating in the near-real time. It includes remote sensing data of AVISO altimetry, IR AVHRR data, JPL/QUIKSCAT scatterometry and NASA SeaWiFS/MODIS sea color data together with international surface drifting buoys and NICOP/ONR profiling floats programs and NCEP atmospheric model data. The Black Sea basin-scale circulation model of Marine Hydrophysical Institute National Academy Sciences of Ukraine assimilates now remote sensing data for the near-real time nowcasting of three-dimensional temperature, salinity and current fields. The following development of the Black Sea nowcasting/forecasting system on basin scales assumes the extension of the regional atmospheric models supported by Hydro-Meteorological Institutes of Bulgaria and Romnia in frame of Meteo-France ALADIN project to the Black Sea area and improvement of the sophisticated ecosystem model of Institute Marine Science (Turkey) to three-dimensions and the near-real time operation. The use of high-resolution regional atmospheric model makes possible medium-range forecasting of the Black Sea circulation. The special efforts are planned for the accurate nowcasting/forecasting of circulation at the coastal zone. The set of ongoing efforts such as regional modeling of Burgas Bay (Bulgaria), Poti region (Georgia), Black Sea North-Western Shelf and Karkinit Bay (Ukraine) will be coordinated by ARENA project and nested to the basin-scale models. Additionally to the open sea boundary conditions and atmospheric forcing from the basin-scale models, coastal measurements should be collected and distributed by Russian Hydrometeoroogical Center. Two types of thematic models supported by Hydro-Meteorological Institutes of Bulgaria and Romania are also planned to be coupled with the basin-scale circulation model: wave model forecast and oil spill surveillance model. Pilot nowcastin/forecasting system could be evaluated in the near-operational mode in case of the availability of relevant Internet resources in the region.

# Arctic-Subarctic Ocean Flux Array for European Climate: North - (ASOF-N)

*E. Fahrbach, A .Beszczynska-Möller*

Alfred-Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, e-mail: efahrbach@awi-bremerhaven.de

| | |
|---|---|
| Contract No : EVK2-CT-2002-00139 | Project duration : 01/2003 – 01/2006 |
| Project budget : € 3.780.000 | EC contribution : € 1.890.000 |
| Website : http://www.awi-bremerhaven.de/Research/IntCoop/Oce/ASOF/index.htm | |

**Objectives**

The high latitude oceans form a sensitive and important component of the global climate system and the climate of the European sector is especially vulnerable. Annual-mean temperatures in Northwest Europe and Scandinavia are considerably higher than they should be for their latitude because a vast amount of heat (about 1 billion MW) is carried northward by the large scale circulation in the ocean. There is concern that predicted by models "global warming" will be accompanied by regional cooling across Northwest Europe and Scandinavia due to weakening of this thermohaline circulation in the ocean.

Three components of ASOF (North, East, West) aim to measure and model the variability of fluxes between the Arctic Ocean and the Atlantic Ocean with the implementation a longer term system of critical measurements needed to understand the high-latitude ocean's steering role in decadal climate variability. ASOF-N is focused on the northern boundaries where warm and salty waters enter the Arctic Ocean and cold and fresh water as well as sea ice are advected from the Arctic Ocean into the Nordic Seas. Its main objective is to design and start the installation of the appropriate components of the global observing system in choke points of the Nordic Seas. The aim is to provide the necessary long term data sets to determine the variability of the freshwater and heat fluxes between the Arctic Ocean and the North Atlantic in order to understand and predict their response to climatic forcing and to provide the necessary tools to assess the risk of abrupt changes. ASOF-N aims to understand the processes which control the volume, heat and salt transports between the Nordic Seas and the Arctic Ocean by a combination of field work and modeling:

- The field work includes the installation of moorings in the passages, their recovery, the deployment of floats and hydrographic surveys.
- The variability of the measured fluxes will be quantified and better understood in the framework of the model simulations.
- An innovative design of cost effective measurement arrays will be a first step towards an Arctic component of the global ocean observation system.

The results will permit to establish a well calibrated array as a European contribution to a global observing system.

ASOF-N is organized into the Workpackages which are carrying out the research tasks in the regional order: *Workpackage 1:* Atlantic water pathways, *Workpackage 2:* Fluxes across the western Barents Slope, *Workpackage 3:* Heat Flux through Fram Strait, *Workpackage 4:* Freshwater Fluxes through Fram Strait, as well as they comprise Data Management *(Workpackage 5)* and Integration and Synthesis *(Workpackage 6).*

The partners in the project consortium come from 7 institutions in 5 European countries (Germany, Norway, France, Poland and Finland), each having a well established working-records in the Arctic and Subarctic regions.

**First Results**

It was shown that a warming of the two main Atlantic water inflows to the Arctic Ocean was accompanied by the amplifying of NAO [1,2]. The heat and volume fluxes calculated from the hydrographic measurements between 1980 and 2001 showed a net southward volume transport through Fram Strait indicating the presence of another inflow passage, likely the Barents Sea inflow. This southward flow has increased for the recent years. The transport of Atlantic water through the Barents Sea Opening was found to be forced by the local atmospheric circulation with a strong minimum in winter. The modeled fluxes in the western Barents Sea are strongly variable on the daily time scale. The Atlantic water pathways into the Barents and Fram Strait can be also recognized with use of the Iodine tracer. In Fram Strait results of both moorings measurements and hydrographic sections reveal the strong barotrophic character of the flow. The last results show that West Spitsbergen Current splits into two branches at the Spitsbergen slope. The increase in the heat flux through Fram Strait was found in late nineties with a potential to cause a warming of the Arctic Ocean intermediate layer [3]. The heat flow through Fram Strait is stronger in winter due to stronger volume flux of Atlantic Water. A half of the interannual change is due to the temperature change and another half is a result of the changing volume flow. There is also a correlation between the volume and heat transports in Fram Strait and a large scale atmospheric circulation (NAO index). The net outflow of freshwater from the Arctic Ocean increased in the last years. Monthly averages of the ice thickness reveal large seasonal and interannual variability. The measured volume flux of ice through Fram Strait showed a massive peak in 1994-5. The sea ice velocity in East Greenland Current was found to be highly correlated with the sea level pressure difference across Fram Strait [4]. There is a working hypothesis that the changes in the East Greenland Current in 1990swere related to the strength of the front between EGC and Greenland Sea gyre.

During ASOF-N the array of 17 moorings has been deployed across Fram Strait. Besides the earlier used current meters and TS sensors the new moorings were equipped with new technology devices like ADCPs, pressure bottom recorders, inverted echo sounders and pop-up buoys with memory units. Especially designed tube moorings are used in the ice covered western part of the strait. A new open ocean algorithm was developed for the ice thickness measurements. The sound sources were installed at selected moorings in Fram Strait and Barents Sea Opening and two deployments of floats took place since the beginning of ASOF. Hydrographic monitoring of the key sections is continued with introducing of the new measuring techniques (e.g. profiling by Lowered ADCP).

**Contribution to social and economical objectives**

The ASOF project is a tool to assess the variability of the ocean circulation between the high Arctic and the North Atlantic as a key to evaluate the likelihood of abrupt changes in the Atlantic Thermohaline Circulation and in the climate of NW Europe. The significant changes of the natural conditions in the Arctic will have dramatic consequences for the socio-economic conditions (e.g. shipping routes, changes in fish-stocks). ASOF combines an appropriate set of measurements and models to understand the most relevant processes which control the variability of a system with a clear potential to abrupt change.

ASOF-N will provide a substantial contribution to the development of European Marine Research Area. It is also important European contribution to the global observing system. ASOF-N time-series and other data will be available in a timely way to managers e.g. for the Arctic Monitoring and Assessment Programme AMAP, the annual statement on the Climatic Status of ICES waters, or the WCRP CLIVAR or ACSYS/CliC programmes. Successful tests of innovative technologies in the moorings will significantly improve the position of the involved companies on the market.

**References**

[1] Dickson et al. (2000) Journal of Climate, 13.
[2] Karcher et al. (2003) Journal of Geophysical Research, 108(C2).
[3] Schauer et al. (2004) Journal of Geophysical Research, accepted.
[4] Widell et al. (2003) Geophysical Research Letters, 30(19).

# *Coordinated European Surface* Ocean Palaeo-estimation Collaboration (CESOP)

Jansen, E., Balino, B.

Bjerknes Centre for Climate Research, University of Bergen, Norway



| | |
|---|---|
| Contract No: EVR1-2001-40018 | Project duration: 12/2001 – 11/2004 |
| Project budget: 1 774 317 € | EC contribution: 1 390 171 € |
| Website: www.bjerknes.uib.no/research/CESOP/ | Contact: eystein.jansen@bjerknes.uib.no |



CESOP intends to significantly improve our ability to reconstruct oceanic climate variability beyond the instrumental period (>100 years). It will provide critical data for testing/validating climate models over time scales decisive for climate prediction. State-of-the-art palaeo-observation methods will be improved and CESOP will build upon a unique European world class network of collaborating laboratories. The partners will be treated as an Integrated System of Infrastructures to jointly utilise the specific strengths of each facility. The project will develop highly accurate methods with a major improved accuracy based on the Mg/Ca palaeothermometry technique. The technique will be calibrated against modern ocean variables, standardised analytical methods will be developed and checked against alternate methods. The technique will be applied to produce new climatic time series and time slices with highly improved accuracy.

**Overall objectives**

- To produce a standardised quality checked methodology based on Mg/Ca ratios in foraminiferal calcite from deep sea sediments for estimating past Sea Surface Temperature (SST) and Sea Surface Salinity (SSS) for the world oceans with a major improved accuracy compared with more traditional approaches.
- To use this much improved methodology to produce reconstructions of surface ocean parameters that successfully can be integrated with climate model experiments, for model development, model validation and model output analysis.

***Results***

- An integrated method is being developed, utilising the Cambridge laboratory as a hub for training researchers and students from the other partners.
- Subsequently similar facilities are being established at the other partners.
- The differences between the new method and other approaches are being explored

***Potential exploitation***

- A joint European method is emerging, which will be very valuable for FWP 6 projects on climate dynamics and natural climate variability.
- CESOP is training a new generation of scientists in the most up-to-date methods and
- CESOP promotes a broadly based and unified framework for facilitating and integrating disciplinary research efforts.

## *The consortium*

CESOP comprises 6 principal contractors from universities and national research institutes in, France, Norway, UK, Germany, the Netherlands and Spain. The consortium represents a wide range of experience in palaeoclimate research and geochemistry.

1. University of Bergen, Bjerknes Centre for Climate Research, Norway (Coordinator)
2. Dept. of Earth Sciences, Cambridge University, UK
3. Laboratoire des Sciences du Climate et de l´environnement, CNRS, Gif sur Yvette France
4. Department Paleoecology & Paleoclimatology, Faculty of Earth and Life Sciences, Vrije Universitetet, The Netherlands
5. Geowissenschaften, Bremen University, Germany
6. Dept. of Environmental Research CSIC, Barcelona, Spain

**CLIWOC: A database for the world's Oceans 1750-1850.**

**R. García-Herrera, D. Wheeler, G. Konnen, M.R. Prieto and P.Jones on behalf of the CLIWOC team.**

From the earliest days of deep sea sailing mariners have kept logbook accounts of their voyages. By 1750 the keeping of logbooks was almost universal amongst the officers of European ships. Although not prepared with this purpose in mind, the logbooks and the detailed observations that they contain are today of great scientific value. One of the factors that a ship's officer needed to take into account in the successful navigation of his vessel was the weather. It required that wind force and wind direction be carefully recorded, the data being then used to determine the drift, or 'leeway', made by the ship. Mariners tended also to keep a careful note of other weather phenomena such as rain, thunder, fog and snow even though they had little direct influence of navigation.

Many logbooks failed to survive the rigours of life at sea, but tens of thousands have been preserved to the present day. Some date from as long ago as the seventeenth century, and they become more abundant as time goes by. Most frequent amongst the survivors are the logbooks of vessels in the state service and in particular those of the armed services. These have now been gathered together in a number of important national archives. Those of the UK, France, Spain and the Netherlands all possess notable collections. The observations in the ship logs of these four countries comprise in the pre-1850 period the bulk of the observations that have been taken over the world oceans.

CLIWOC is a project funded by the European Union with partners from Spain, the UK, the Netherlands and Argentina. Its principal objective is to produce a database of daily oceanic weather observations between 1750 and 1850. It has been completed by December 2003. Currently, the CLIWOC database is ready for integration with the I-COADS world database of meteorological observations 1784-present. This will significantly augment I-COADS in its early period.

The CLIWOC database utilises daily observations from logbooks that represent all the World's major oceanic areas, the North and South Atlantic, the Indian and he Pacific Oceans. The original data are being processed and presented using terms that conform to present-day usage and understanding. Information is based on the most frequently recorded elements of wind strength and direction, but data will also be provided on a wider range of commonly recorded phenomena that include rain and snow, thunder, fog and even the incidence of sea ice cover. A meta-database will also allow enquirers to consult the original sources. Around 300,000 will be included in the final version of the database, and constitute the dataset at this presentation, which will describe the space coverage reached so far, as well as the first results obtained in the quality control process. Particular attention will be paid to the consistency of the observations from ships of the same and different nationalities and the comparison with present day climatology.

# The European Directory of Initial Ocean-observing Systems - (EDIOS)

*Verduin, J.J.*

Institute of Hydrobiology and Fisheries Science, University of Hamburg, Germany

| | |
|---|---|
| Contract No: EVR1-CT-2001-20005 | Project duration: 10/2001 – 09/2004 |
| Project budget: € 1 195 551 | EC contribution: € 1 195 551 |
| Website: www.edios-project.de | |

**Objectives**

The central objective of the EDIOS project is the construction and implementation of a meta-database (computerised directory) that includes information on all European ocean-observing systems (sites and devices) in routine and repeated operation. EDIOS represents a much-needed tool in operational oceanography and will fill a gap in the presently available European oceanographic meta-databases. EDIOS will help EuroGOOS to build a European ocean-observing system by providing a comprehensive European catalogue of instruments and sensors in continuous use. The EDIOS user-friendly visual interface will give easy access to the information contained in EDIOS and is aimed at users from different sectors without the need for extensive database knowledge. Regular update of the EDIOS Directory will ensure up to date information and inclusion of most European ocean-observing systems operating on a continuous level.

**Results**

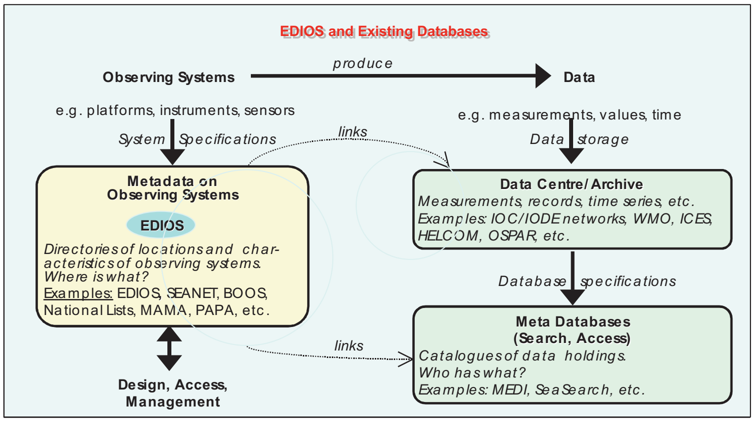
EDIOS meta-database contains information on geographic co-ordinates, parameters measured and frequency of measurement, access to the data, technical information of the data collection methods (e.g. instruments, sensors, ships, platforms, nets), presents applications of the sampled data including derived products, details of institutes responsible for each instrument or sensor, and links to data-holding institutes. The database will be continuously updated and used to define the Initial European Ocean-observing System.

EDIOS includes links to all existing European directories as well as to the data-holding agencies and institutes. Therefore it is expected to contribute to networking and data sharing among European oceanographic organisations, agencies and institutes. It will be complementary to and supportive of existing meta-databases that contain archived records of projects, scientific cruises, and archival data centres. (For the functional positioning of EDIOS in relation to other directories and (meta) databases see Figure 1). Strong user involvement at each step in the directory's design (e.g. meta-data entries, user interface) has ensured that the requirements and priorities of a variety of users will be met. The visual user interface is designed to be compatible with existing international meta-databases, such as SeaNet and EDMED.

## Potential exploitation by end users

The EDIOS visual user interface ensures the usefulness of EDIOS to all oceanographic sectors, commercial and non-commercial. Such accessibility will warrant that the use of EDIOS is not just confined to operational oceanographic centres and agencies. Scientists, entrepreneurs and students from all sectors will be able to locate meta-data from ocean-observing systems in Europe.

***Figure 1.*** *Functional types of Databases: EDIOS is a Meta-Database on Ocean-observing Systems that networks with existing databases and meta-databases (links)*




Furthermore, EDIOS represents a much needed management and design tool that will permit the scientific and logistic design of a long-term marine observing system, combining operational agencies and research projects as sources. Scientists and forecasters testing, developing, and designing ocean data assimilation for numerical models will use EDIOS for identifying the geographic sources of data and examining different designs of the systems. EDIOS will enable rapid combination and co-ordination of national ocean-observing systems to improve monitoring and modelling around European seas, and develop and refine observations. It will also allow assessment of the performance of the ocean observing and forecasting systems, and set European standards for ocean-observing technology by developing a classification scheme for the performance of ocean-observing systems. This will eventually lead to a much needed compatibility and high standard of ocean-observations throughout Europe and help reducing the overall costs of the national operational oceanographic programmes. Furthermore, EDIOS will provide market data to instrument and equipment manufacturers, who can see where there are sales potentials. Finally, EDIOS will encourage trans-national wide-ranging scientific use of the data generated by the ocean-observing systems included in the directory, benefiting efforts to predict, assess, and formulate response options to global change.

# Underwater Communications using Electromagnetic Waves - (EMCOMMS)

*Lucas, J.[1], Al-Shamma'a, A.[1], Seim, J.[2], Loehr, W.[3], Puchbauer,G.[4], McGregor, D.[5]*

[1] University of Liverpool, UK; [2] NUI, Norway; [3] FSA, Germany; [4] Bonn Elektronik, Germany; [5] Stenmar, UK



| | |
|---|---|
| Contract No : EVK3-2001-0078 | Project duration : 01/2002 – 12/2004 |
| Project budget : € 1 480 410 | EC contribution : € 950 002 |
| Website : www.liv.ac.uk/eee/emcomms | |



## Objectives

The nature of the ocean environment and its vast size has necessitated the development of sophisticated equipment and techniques for various underwater applications including diver-to-diver communications, ROV/AUV docking, communications and oil and gas explorations. To facilitate scientific exploration a wide variety of systems and vehicles have been developed to operate within the shallow continental shelf region or in deep oceans. For successful underwater electromagnetic (EM) wave operation, knowledge is required of the wave transmission properties of seawater over all distances both short and long. This information is required for such activities such as: sensor systems, imaging, position fixing, measurement of speed, obstacle detection and avoidance, guidance, communication of data/voice and remote control.

To investigate, for the first time, electromagnetic wave propagation through seawater for high carrier frequencies (1 – 5MHz) up to a distance of 1km. The objectives are:

- To transmit and recover digital data at high bit rates (1Mbits/s).
- To transmit text and video images at standard camera frame when using data compression.
- To compare EM wave communications systems with the capabilities of an acoustic system.

## Results

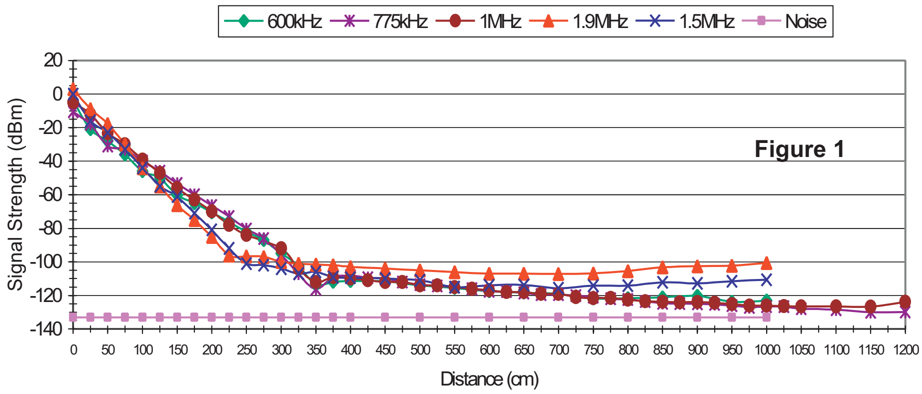
The outcome from the theoretical studies indicated that seawater has a molecular dipole lossy dielectric structure as well as a conductivity of approximately 4S/m. In the near field, because of the proximity of the electrodes, conduction currents exist whilst in the far field the influence of the electrodes is minimal and under these conditions dielectric molecular dipole displacement (nullification) currents exist. Conduction is a continual loss process whilst nullification is a single and much smaller loss process in response to a change of electric field. Its magnitude is given by the Debye equation [1].

| Frequency f (MHz) | Losses for 1000m propagation (dB) | | | Total Signal Loss (dB) |
|---|---|---|---|---|
| | Near Field Optimised | Far Field Diffraction | Far Field Attenuation | |
| 0.1 | - 60 | - 52 | 0 | - 112 |
| 1 | - 60 | - 62 | 0 | - 122 |
| 5 | - 60 | - 69 | - 2 | - 131 |
| 10 | - 60 | - 72 | - 8 | - 140 |
| 20 | - 60 | - 75 | - 31 | - 166 |

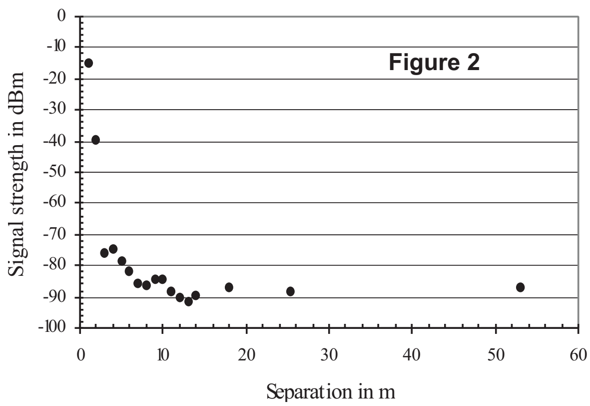
Table 1 Propagation capabilities of EM waves

Table 1 shows the estimated attenuation in both the near and far fields with allowance for diffraction losses. For example at 1MHz, a signal loss of –122dB will be attained mainly through near field loss and the far field diffraction loss. The through water attenuation is only estimated to be a few dBs.

Experimental investigations have been carried out with various techniques and methods of propagating an EM waves through seawater have been studied. In addition various types of antennae have been investigated including loop, dipole, folded dipole at different sizes. The results of our study, figures 1 and 2, show that EM waves propagation in seawater within Liverpool Marina Dock is possible at frequencies higher than that in the acoustic techniques and in the range of MHz [2].




## Potential exploitation by end users




There is a strong requirement to avoid using divers to undertake sub-sea activities. The preferred role is intervention by using autonomous robotic systems, both vehicles and manipulators. The obtained results will allow EM waves to be used for the first time to transmit data and images through seawater. By establishing high-speed data rates, the actions of the robot can be up quickly undertaken thus ensuring a safe working environment. Once these techniques are perfected then it is possible to establish deep water systems to recover oil and gas at depths well below the dive limit of 200m. Even within the dive limit, the ability to remotely control sub-sea equipment will reduce the burden on the diver hence allowing longer missions to be undertaken with less physical effort being expended by the diver.

As well as high-speed data communications, EM waves can also be used for a wide range of activities for which ultrasonic waves have previously been used. These include such techniques as range finding and anti-collision navigation of sub-sea vehicles. Additional systems for pollution monitoring can be developed based upon RF transmission.

## References

[1] Thuéry, J (1992) Microwaves: industrial, scientific and medical applications, ISBN 0-89000-448-2.
[2] Shaw, A (2004) IEEE Transactions on Antennas and Propagation, to be publish in April.

# The European Marine Seismic Metadata and Information Centre: gateway to marine geological survey data - (EUROSEISMIC)

*Stevenson, A.*[1]

[1] British Geological Survey, United Kingdom agst@bgs.ac.uk



| Contract No : EVR1-CT-2001-20004 | Project duration : 01/2002 – 12/2004 |
|---|---|
| Project budget : € 2 036 664 | EC contribution : € 2 036 664 |
| Website : www.eu-seased.net | |



## Scientific Objectives and Approach

An understanding of the nature of the seabed is an important factor in strategic marine management. The seabed is the focus of complex interactions between many oceanographic, biological and sedimentary processes, which directly affect the social and economic development of the European Community. The basis for management of the marine environment for sustainable use is the construction of a pan-European knowledge base of existing seabed information.

The European Commission 5th Framework project EUROSEISMIC has developed a central metadatabase for data derived from acoustic and sonar surveys of the European Seas. In combination with metadata for seabed samples and cores compiled during the EC-funded EUMARSIN (European Marine Sediment Information Network) and EUROCORE projects, users will have 'one-stop' access to a significant amount of publicly available marine geological information held by European organisations. The 23-member partnership includes the marine departments of the geological surveys of the EU Member States and the Newly Associated States plus oceanographic institutes from France, Romania and Bulgaria.

## Results

EUROSEISMIC will present metadata for over 2 million line kilometres of survey information held by the project partners and, when possible, other organisations such as universities and government research departments. An Internet-based, GIS interface to the metadata has been developed (Figure 1). A series of tools are provided to allow users to identify the surveys present in their area of interest and combine the search results with samples/cores from the same area. Search areas may be selected either by defining a box on the main map or by entering the co-ordinates of the area of interest.

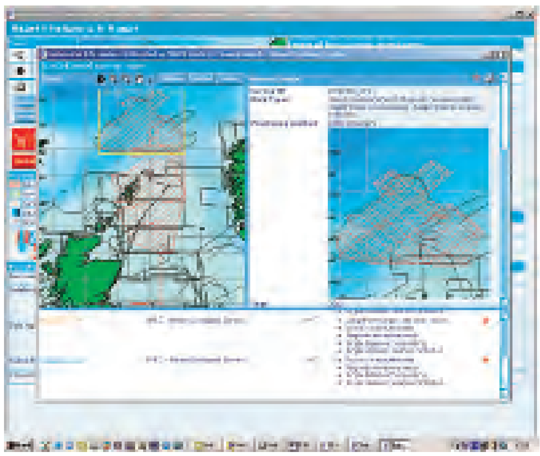


Figure 1: Example from the EUROSEISMIC metadatabase showing search results from an area northeast of the United Kingdom.

**Potential exploitation by end users**

- improved access to available geophysical survey data for all European seas;
- overviews of metadata information required for strategic marine management;
- improved exchange of data and information at a pan-European level;
- increased public awareness of the marine environment;
- improved input for environmental research and fundamental scientific research.

# European Sea Level Service - Research Infrastructure (ESEAS-RI)

*Plag, H.-P.*[1] *and the ESEAS-RI Project Team*[2]

[1]Norwegian Mapping Authority, Geodetic Institute, Honefoss, Norway,
[2]See http://eseas.org/eseas-ri/

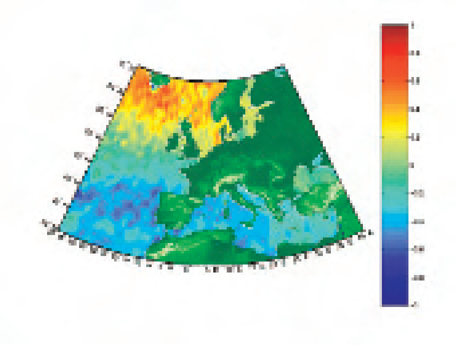
| | |
|---|---|
| Contract No: EVR1-CT-2002-40025 | Project duration: 11/2002 - 10/2005 |
| Project Budget: EUR 3 426 000 | EC contribution: EUR 2 300 000 |
| Web site: http://eseas.org/eseasi-ri/ | |

**Objectives**

The European Sea Level Service (ESEAS) has brought together the formerly scattered sea level research infrastructure in Europe and has developed into a major research infrastructure for all aspects related to sea level, be it in the field of climate change research, natural hazards and marine research. The primary objective of the ESEAS-RI project is to support the ESEAS research infrastructure and to facilitate the transnational coordination. Key technological goals are the upgrading of selected observing sites and the standardisation of the network, operational routines, databases and quality-control. The primary scientific objective of the project is to study sea level variations at inter-annual to multi-decadal time scales and to quantify potential future changes in mean sea level. In order to reach the objective, the ESEAS-RI project comprises four Work Packages (WP) addressing the following issues:
(1) quality control of the hourly tide gauge data accessible through the ESEAS;
(2) determination of vertical land movements at tide gauges in order to decontaminate the relative sea level records for this bias;
(3) determination of sea level variations on inter-decadal time scales in the North Atlantic and the semi-enclosed European seas as well as assessment of secular relative sea level trends for the European coasts;
(4) improvement of the network of ESEAS Observing Sites through upgrading of selected tide gauges and co-location of gauges with continuous GPS.

**Results**

With respect to WP1, progress has been made towards a standardised quality control of hourly and sub-hourly sea level data, Moreover, a concept for a distributed database of the observations and meta information from ESEAS Observing Sites has been developed, which maintains the link between the data originator and the data sets throughout the chain to the final user.
A major achievement for WP2 is the specification and pre-validation of a GPS analysis strategy and a time series analysis strategy which together will result in an accuracy of vertical land movement at tide gauges staisfying the needs of climate studies.
The initial task for WP3 is the analysis of the global monthly mean sea level data from mainly coastal tide gauges in order to determine the spatial and temporal patterns of inter-annual to multi-decadal sea level variations, and the preliminary results indicate significant spatio-temporal modes on these time scales, which, however, appear to change over time. If this transient nature is confirmed, then this would warrant a long-term monitoring of the spatio-temporal pattern of inter-annual and longer term sea level variation as an important climate indicator. Correlation of the sea level patterns with forcing factors is used to relate the sea level variations to climatic processes. As an example, the correlation of sea level with the NAO index reveals a dominate latitude-dependent pattern in the correlation over the North Atlantic and the Mediterranean Sea (see the Figure).
The upgrading of the physical sea level observation network in the frame of WP4 has resulted in improved higher data quality for crucial locations particularly in the Mediterranean and Black Sea regions. Co-location of several ESEAS Observing Sites with CGPS has closed significant gaps in the network of sites for long-term observations of absolute sea level variations.



**Correlation of sea level and NAO index.**
*The correlation is computed for the time interval 01/19923 to 11/2001. Sea level is determined from Topex/Poseidon observation with a spatial and temporal resolution of 1 degree and 1 month, respectively. Monthly values of the NAO index are taken from the CRU of the University of East Anglia, Norwich, U.K. A trend and an annual harmonic constituent have been removed from both the NAO index and the individual sea level time series prior to the correlation. The plot was provided by Niel Kjær, KMS, Denmark.*

Already after an initial phase of slightly more than a year, the project has stimulated the integration of a significant part of the European sea level monitoring and research community both through direct participation in the projects as well as in the frame of the ESEAS. The considerable progress towards standardisation of the observational network and the operational routines (including quality control) facilitates significant knowledge transfer between participants from different geographical regions. The integration of the project through ESEAS into a larger international context supports the progress in the project and provides significant feedback for relevant organisations and programmes such as GLOSS, JCOMM, GMES, EuroGOOS, EUREF, IGS and IGGOS.

**Potential exploitation by end users**

Sea level is an environmental variable important for studying climate processes in the coupled atmosphere-ocean system. Moreover, sea level data has a large market in both scientific and non-scientific applications. Having an unique access to a quality-controlled, European-wide database of tide gauge and ancilliary observations as well as derived products will ease many practical application requiring sea level information as well as scientific studies and coastal zone applications. In particular, the improved high-frequency European database will allow improved estimates of extreme sea levels, and further develop the techniques to predict them and their return frequency, and thus allow to assess better the economic cost of coastal development. Likewise, and in combination with observations of vertical land motion, this database will facilitate the improvement of estimates of local subsidence rates, changing tidal conditions, and better assessments of long-term hazards, leading to improved management of flooding hazard as well as improved products for climate change research.

The research carried out in the project is going to result in an empirical model of sea level variations, which provides a important basis for future studies of climate processes at decadal to inter-decadal time scales, particularly the North Atlantic Oscillation, as well as a coherent description of the occurrence of extreme sea levels. Climate fluctuations on inter-annual time scales affect human activities at sea (such as fishery and off-shore ingeneering) as well as on land (such as agriculture). Having available an empirical model describing the sea level variations during the last hundred years will be valuable for validation of models for seasonal to inter-annual climate prediction, which may help to mitigate the effects of these climate variations on human activities.

Improvements of the sea level observation network contribute to better data availability in near-real time for operational oceanography as well as on the longer term for climate monitoring. This opens for contributions particularly to GMES. The project provides already input to the development of the future GMES, particular with respect to obstacles for the exploitation of existing multi-national databases in terms of e.g. technical aspects, data quality and policy, legal and organisational issues.

# Establishment of a European radar altimeter calibration and sea-level monitoring site for JASON, ENVISAT and Euro-GLOSS – (GAVDOS)

*MERTIKAS, S. P.[1], PAVLIS, E. C.[2], TZIAVOS, I. N.[3], BANKS, A.[4], DRAKOPOULOS, P.[4,11], PESEC, P.[5], SUENKEL, H.[5], FORSBERG, R. [6], KAHLE, H.-G.[7], EXERTIER, P.[8], SKLAVIDIS A.[9], GIDSKEHAUG, A. [10].*

[1]Technical University of Crete, Greece, mertikas@mred.tuc.gr, [2]Joint Center for Earth Systems Technology, USA, [3]Aristotle University of Thessaloniki, Greece, [4]Institute of Marine Biology of Crete, Greece, [5]Space Research Institute, Austria, [6]National Survey and Cadastre, Denmark, [7]ETH Hoenggerberg, Switzerland, [8]Observatoire de la Cote d'Azur, France, [9]Hellenic Navy Hydrographic Service, Greece, [10]University of Bergen, Norway. [11]Technological Educational Institute, Athens, Greece.



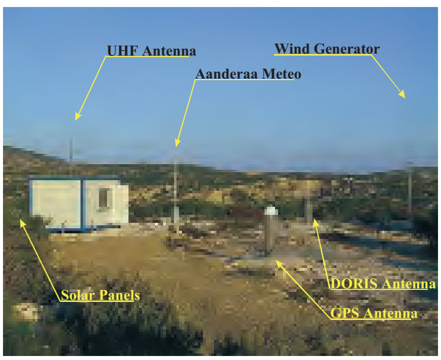
| | |
|---|---|
| Contract No: EVR1-2001-00010 | Project duration: 12/2001 – 11/2004 |
| Project budget: 2,291,961 € | EU contribution: 1,128,969 € |
| Website : www.gavdos.tuc.gr | |



**Objectives**

Climate change on a global scale is a serious concern for all countries, especially for those with extensive coastlines, near major bodies of water. The reason of course is the effects of this global change on the environment, and in this particular case, the change in the mean sea level (MSL) with the obvious consequences on human activities near coastlines. Radar altimeter-carrying satellites are used to observe the oceans from space, so that we can monitor the short-term and long-term trends.

Unfortunately, these satellites have a limited lifetime, and a long-term record of MSL changes can only be established, if observations from all of these missions are reliably linked to each other over many decades. To maintain such a global observing system by combining research and observations on the surface and from space, we need to “connect” the results from each of the previous missions (e.g., SEASAT, GEOS-3, TOPEX/Poseidon) to the current (e.g., Jason-1, GeoSat Follow-On (GFO), Envisat, etc.), and the future ones for as long as possible. Thus, the radar instruments for each satellite need to be calibrated in a standard fashion so that the MSL observations are independent of the mission that produced them.




The main objectives of this project are: (1) To establish an absolute sea-level monitoring and altimeter calibration facility on the isle of Gavdos, south of the island of Crete, Greece; (2) To monitor deformations of the earth's surface at the tide gauges in the area; (3) To develop a detailed regional geoid and Sea Surface Topography (SST) model; (4) To integrate this project in International programs such as, Euro-GLOSS: Global Sea Level Observing System; The European Union Operational Forecasting cluster; WEGENER: Working Group of European Scientists for the Establishment of Networks for Earthquake Research; TIGA: GPS Tide Gauge Benchmark Monitoring--Pilot Project; (5) To integrate it with the global geodetic reference frame, maintained by the International Earth Rotation and Reference Systems Service (IERS), and the International GPS Service (IGS) activities in this region.

**Results**

The current results of the GAVDOS project are as follows:

- An initial evaluation of the absolute bias for JASON's altimeter, based on the comparison of the tide gauge data with the JASON altimeter Geophysical Data Records from only two cycles (#52 and #53), indicate a 127 ± 78 mm bias. This value is in very good agreement with the generally accepted value of 130 mm obtained at elsewhere with data covering over 60 cycles.
- Precise observation of the tectonics and precise determination of the regional geoid with in situ and data collected with dedicated airborne gravity and sea surface topography flights, allowed the establishment of a successful calibration site in an otherwise unsuitable area (significant tectonic activity and very steep geoid).
- A high-resolution (1min of arc) gravity database and a geoid model (accuracy of 5 cm) have been constructed for the area using all available land, marine and airborne data combined with satellite altimetry heights of the sea surface.
- Radiometer and spectrometer data have been used to validate satellite-independent information on atmospheric water vapor and its temporal variation.
- GAVDOS is registered with EUMETSAT and will soon start public dissemination of the weather and sea-level observations for immediate use in weather and oceanographic forecasting.

**Potential exploitation by end-users**

The results obtained are of special interest to the Jason-1 and Envisat missions because the altimeter biases and drifts for each of these missions and among different missions will be determined reliably and consistently. Simultaneously, an absolute MSL-monitoring site is established with the local tectonic deformation field in the region of southern Crete, Greece precisely monitored. These observations are of great interest for geodynamic applications in an area (next to the Hellenic trench) that is well known to often generate large magnitude earthquake events.

This integrated facility, due to its nature and its open ocean location, is appropriate and will make its data and products available for use in forecasting the weather of eastern Mediterranean and monitoring long-term climate changes. Also, the system will be capable for monitoring extreme events (storm surges, etc.) in the proximity. The proposed facility underpins research relevant to the European component of the global observing systems for climate and oceans and operational forecasting of environmental constraints on offshore activities.

# GOOS Regional Alliances Network Development - (GRAND)

*Drago, A[1], Vallerga, S.[2]*

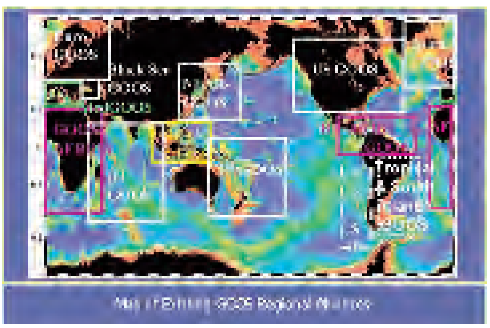
[1] IOI-Malta Operational Centre, MedGOOS Secretariat, University of Malta. [2] Consiglio Nazionale delle Ricerche - IAMC Sezione di Oristano, Italy.

| | |
|---|---|
| Contract No : 505360 | Project duration : 01/2/2004 – 31/1/2006 |
| Project budget : € 536000 | EC contribution : € 520000 |
| Website : www.capemalta.net/GRAND | |

The "GOOS Regional Alliances Networking Development" (GRAND) is a project funded under the RTD 6th Framework Programme of the European Commission. The aim is to improve the international cooperation for ocean monitoring and forecasting. In particular it will disseminate European know-how and best practices established within the MAMA project (FP 5) to the GOOS Regional Alliances (GRAs). The project will build on the European contribution to the global environmental monitoring systems defined by GMES-Global Monitoring for Environment and Security. Under the co-ordination of the MedGOOS Secretariat within the IOI-Malta Operational Centre at the University of Malta and the CNR institute for Coastal and Marine Environment in Italy, it will create a European-led worldwide forum for the GOOS regions and define a regional strategy for GOOS.

The Global Ocean Observing System (GOOS) is an international programme sponsored by IOC, WMO and ICSU to foster the introduction of routine in-situ and remote ocean observations for nowcasting and forecasting. Numerical models will be used to make assessments and develop added-value products in many user sectors. GOOS will monitor the health of the sea and assist in understanding global climatic changes. It also aims to provide knowledge for sound decision-making, to sustain ocean governance, and improve marine services.

It is expected that the 21st century will see a great advance in the value of marine information, thanks to the technological advances in telecommunications, rapid access to data and improved techniques to merge and transform data. Observations and scientific knowledge are crucial for building models and preparing future scenarios. The models increasingly integrate economics and ecology as a contribution to testing management options, and thus provide a key contribution for sound decision-making and governance.



The GOOS is largely being developed through regional initiatives involving alliances of marine organisations active in the regional seas. Early examples were EuroGOOS, MedGOOS and NearGOOS. Now there are there are 13 GOOS regional alliances. They are members of the GOOS Regional Forum, established by the Intergovernmental Committee for GOOS (the I-GOOS of UNESCO/IOC).

These GOOS Regional Alliances have different capacities, resources and activities. GRAND capitalises on the European scientific, technological and organisational capabilities to provide a forum for GRAs to disseminate best practice, transfer technology, build capacities and share knowledge and experiences to implement effective and efficient observing and forecasting systems. The GRAND activities are articulated into three workpackages:

**WP1 GRAND Information –** Targeting to obtain information and evaluate on a regional basis: (i) the nature and extent of key marine environmental issues in the various GOOS regions, and (ii) the capabilities and assets currently deployed in terms of ongoing initiatives, methodologies and practices, technological infrastructures and equipment, resources and funding to address these issues.

**WP2 GRAND Empowerment –** The aim is to empower the GRAs to participate with local expertise to, and benefit from GOOS, building a strong inter-regional network of local experts, and set the basis for a long term training scheme. High-level training workshops for GRA managers will be organised to address issues of common interest, tackle specific needs, furnish an insight on the application of 21st century technology in ocean observations and modelling, and provide European know-how and experience. A demonstrator based on the "*What-if? Prediction"* concept and an advanced ecosystem model is being developed to provide scientific advice to decision-makers for sound planning and remedial actions

**WP3 GRAND Strategy –** Aiming to prepare a regional strategy for GOOS and initiate a series of GRAND publications to serve as a common reference for the GOOS regions. The strategy will be constructed on four main inputs:

- (i) link up regional activities in operational oceanography to GMES and GOOS;
- (ii) introduce modern technologies to achieve the regional goals of GOOS;
- (iii) identify the needs for capacity building at a regional level; and
- (iv) review how to achieve these goals in the context of UN Convention on the Law of the Sea.

The legacy of GRAND for the EC and the global GOOS is the goal of the Regional GOOS Strategy. It will contribute to the international aspects of GMES and support the Member States of I-GOOS to harmonise the development of an effective network of GOOS Regional Alliances through the GOOS Regional Forum.

# Greenland Ice and Climate Experiment - (GreenICE)

*Wadhams, P.[1], Doble, M.J.[1], Toudal, L.[2], Gudmansen, P.[2], Mikkelsen, N.[3], Haas, C.[4], Gill, R.S.[5], Forsberg, R.[6]*

1 Scottish Association for Marine Science, Scotland; 2 Danish Technical University, Denmark; 3 Geological Survey of Denmark and Greenland, Denmark; 4 Alfred Wegener Institut, Germany; 5 Danish Meterological Institute, Denmark; 6 Danish Survey and Cadastre, Denmark

| | |
|---|---|
| Contract No : EVK2-2001-00280 | Project Duration : 12/2003 – 11/2005 |
| Project budget : € 2,426,337 | EC contribution : € 1,842,258 |
| Website : www.greenice.org | |

**Objectives**

The objective of GreenICE is to measure the changes in structure and dynamics of sea ice that have occurred in a critical region of the Arctic Ocean as a result of a switch in Arctic atmospheric circulation, and to relate these changes to the long-term record of variability (2000+ years) in the region.

GreenICE will assess the extent (and causes) of natural variability in this strategically important region north of Greenland. Proxy measurements of environmental changes from the sediment cores will extend GreenICE's investigation at least another 2000 years into the past, placing the modern-day variation into its longer timescale variability setting. Ultimately GreenICE aims to establish whether the recent observed changes in circulation are a previously unseen or unusual occurrence, or whether they have been a recurrent feature of the past climate. Results from GreenICE will be available to the wider community in order to clarify the threat, identified by many recent models, of rapid climatic cooling in the North Atlantic region due to a weakening of the thermohaline circulation. GreenICE therefore forms an essential component of any wider study of change in the North Atlantic and Arctic region..

**Results**

The project combines several techniques to measure the sea ice thickness on local to basin scales. In the local area, simple drilling (using power augers and a hot water drill) is combined with electromagnetic induction (EM) techniques, using the instrument mounted inside a sea-kayak. For larger scales (100-500 km), a helicopter-borne EM is co-ordinated with a scanning laser profilometer to obtain thickness and freeboard along the aircraft tracks.

A novel wave-based measurement method holds the promise of measuring the modal multiyear ice thickness along the whole path from the open ocean to the measurement site using simple tiltmeter systems. These identify the dominant frequency of the ubiquitous "ice swell", present throughout the Arctic Ocean, and combine it with the frequency of waves excited by wind blowing across the ice. The technique allows the estimation of ice thickness without using hard-to-measure mechanical parameters such as Young's modulus.

The surface and airborne measurements are combined with satellite remote sensing imagery (primarily ENVISAT ASAR) to understand ice thickness and deformation signatures. Images are also used to analyse ice motion throughout the area of interest during the modern satellite era and are combined with information from the International Arctic Buoy Programme (IABP) and buoys deployed by GreenICE.

A pilot experiment took place aboard the F/S Polarstern in April 2003, north of Svalbard. The objective was to practise the acquisition of co-ordinated aircraft, ground and satellite data. The cruise also gave an opportunity for development and optimisation of the wave instruments.

The main experiment takes place in May 2004, operating from the Canadian military base at Alert and setting up a ten day ice camp on the southern slope of the Lomonosov Ridge. In addition to the methods used on Polarstern, we will be taking sediment cores through the ice using a custom lightweight coring system and performing a drifting seismic survey to place these in context. An array of five wave instruments will be deployed on a 200km scale and left to examine the development of the wavefield over a complete seasonal cycle.

**Potential exploitation by end users**

Through the combination of sedimentology, sea ice physics and modelling the GREENICE project is in a strong position to assess the potential for abrupt climate change over the past 2000 + years. The results of this project will include data and model results on the quantitative role of Arctic sea ice in the climate system. The implications of climate change affect all human activities both socially and economically and thus results from GREENICE will be disseminated to scientists, commercial institutions and the wider public. During the years after the end of the project, the partners will seek to ensure that results continue to be disseminated.

Regarding scientific applications, the partners will collaborate with colleagues to bring about such follow-on activities as :-

• Insertion of the models into current GCMs, and their use in regional climate modelling for the Arctic. The use of such embedded specialised models, developed under separate research programmes and then used to improve large global models, has been pioneered by the Hadley Centre, Bracknell, UK, and the German Climate Computing Centre in Hamburg, using results from previous EU programmes.

• Continued monitoring of the Arctic, using the techniques and algorithms developed in this project. There is a vital need to obtain longer time series of ice, ocean and atmospheric parameters, in order to improve models further, and so the monitoring and measurement routine established in this project will be continued using national or other international funds.

Engineering applications which will be pursued in a similar way include further technological development of remote sensing algorithms and methods for comparing satellite data output with ice thickness data and further development of ice drift buoy technology.

# Developement of a real time in situ observing system in the North Atlantic Ocean, by an array of Lagrangian profiling floats - (GYROSCOPE)

Y. Desaubies[1], Project Coordinator,
on behalf of the GyroScope Consortium[1]

[1]Laboratoire de Physique des Océans,
UMR 6523, CNRS – Ifremer

The GyroScope project was funded under FP5 (2001-2003) with the objective to contribute to the international ARGO programme (a global array of autonomous ocean profilers). In the course of the project an array of 84 floats were deployed in the North Atlantic, from the Canaries Basin to the Labrador and Irminger Seas. They report temperature and salinity profiles every 10 days. Data management is done at the Coriolis Data Centre, where they are received, processed, and delivered in real time to users (including operational models that assimilate the temperature and salinity profiles).

At the end of the project, 61 floats were still active, some in operation for over 30 months, with a data return of 85%. Procedures for delayed mode data quality control have been developed and implemented. The results show that a data set of excellent quality is delivered by the system.

Several studies have been conducted on the information content of the array, in terms of time and space resolution, and complementarity to satellite altimeter data. The significant impact of float data on ocean assimilation models has been demonstrated, as well as the potential of such data to detect climate change in water masses.

Real time estimation of ocean circulation has been obtained through implementation of a finite difference inverse model. New results on the seasonal variability of large scale ocean circulation, heat transport, and water masses have been obtained.

GyroScope has contributed to the development of a European capability in global in situ ocean observations, and to improvement of the efficiency with which the data are used for ocean research and in support of operational oceanography.

[1] M. Bell (UKMetOffice), E.Duporte (SHOM), J.Font ICM/CSIC), A.Hernandez (ULPGC), B.King (SOC), P.Y. Le Traon (CLS), G.Parrilla (IEO), U.Send (IFM/Kiel),

# Integrated Observation and Modelling of Arctic Sea ice and Atmosphere – (IOMASA)

*Melsheimer, C.*[1], *Heygster, G.*[1], *Pedersen, L.T.*[2], *Andersen, S.*[3], *Schyberg, H.*[4], *Landelius, T.*[5]

[1]University of Bremen, Germany (melsheimer@uni-bremen.de); [2]Technical University of Denmark; [3]Danish Meteorological Institute; [4]The Norwegian Meteorological Institute; [5]Swedish Meteorological and Hydrological Institute

| Contract No: EVK-CT-2002-00067 | Project duration: 11/2002 – 10/2005 |
|---|---|
| Project budget: € 1 795 000 | EC contribution: € 1 358 000 |
| Website: www.uni-bremen.de/~pharos/iomasa | |

**Objectives**

The polar regions belong to the regions of which the least information is available about the current and predicted states of surface and atmosphere. Because of sparse observations, we only have at a rough quality weather forecasts for northern Europe, and ice charts for the ice frequented waters of the European Arctic.

The objective of IOMASA is to improve our knowledge about the Arctic atmosphere by using satellite information which is continuously available, but currently not optimally exploited. This progress will be achieved through an integrated approach involving:

1. remote sensing of the atmospheric parameters humidity, cloud liquid water and temperature over sea ice and land ice
2. improved remote sensing of sea ice with more accurate and higher resolved ice concentrations (percentage of ice-covered sea surface)
3. improving numerical weather prediction (NWP) models by assimilating the results of the points 1 and 2
4. in order to prove the usefulness of this concept, a real time processing set-up and a user interface will be demonstrated

**Scientific Achievements**

Data streams for the direct measurements of AMSU-B radiances, redistributed by EUMETSAT, as well as for the OSI SAF (Satellite Application Facility on Ocean and Sea Ice) ice concentration measurements have been set up. A near-real-time data stream for providing co-located AMSU measurements and interpolated HIRLAM profiles and surface data has been set up. The assimilation system for the numerical weather prediction (NWP) model HIRLAM (High Resolution Limited Area Model) has been extended and prepared for the assimilation of humidity and temperature information from AMSU data. A new heat flux scheme is being implemented in HIRLAM. Development of the sea ice emissivity model and of the algorithms to retrieve total water vapour, cloud liquid water, temperature profile, and sea ice concentration from the remote sensing data is ongoing.

**Relevance for Society**

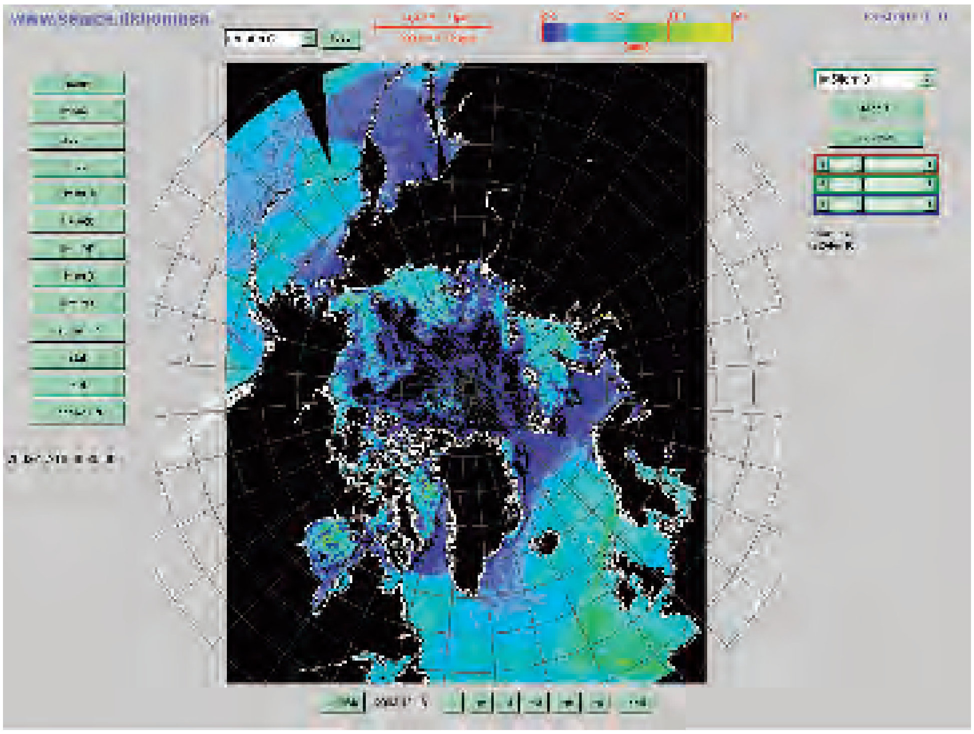
If brought to operational application the results should improve operational weather forecasts and sea ice charting in Northern Europe, helping to improve the living conditions in Northern Europe and especially human off-shore activities in the Arctic region, such as navigation, fisheries, tourism, and exploitation of marine mineral resources. In addition, reliable forecasts are the first step in risk management and disaster control whether in the marine environment, the atmosphere or on land. It is important in making decisions on capital expenditure regarding investments in industry and infrastructure. The assimilation of AMSU-B data will also enhance value of data of meteorological European satellites because sensors similar to AMSU-B are planned on future METOP satellites. The new surface heat flux scheme should lead to improved weather forecasts for Northern Europe and especially of clouds in the Arctic, which is important for climate models.

**Results and Exploitation**

The main results expected towards the end of the project include

- Retrieval algorithm for total water vapour over the Arctic from data of microwave sounder AMSU-B on the NOAA satellites
- Retrieval algorithm for the cloud signature (mainly liquid water path) over the Arctic from data of the microwave imager SSM-I on the DMSP satellites
- Real time assimilation scheme of humidity and temperature information from satellite microwaves radiometers into the HIRLAM NWP model; assessment of improvement potential for NWP
- Emissivity and backscatter model of sea ice in the microwave range
- Synergistic retrieval scheme of sea ice concentration from passive (SSM/I) and active (QuikSCAT) satellite microwave sensors

In addition, a near real time data distribution system has been set up at DTU (Technical University of Denmark) to present IOMASA results to all interested parties (http://www.seaice.dk/iomasa). The Java-based web interface is shown in the figure below.



*User interface for the data distribution system, showing column water vapour retrieved from AMSR data.*

# Ice ridging information for decision making in shipping operations - (IRIS)

*Kaj Riska*

Ship Laboratory, Helsinki University of Technology, Finland

| | |
|---|---|
| Contract No : EVK3-CT-2002-00083 | Project duration : 01/2003-12/2005 |
| Project budget : € 3166168 | EC contribution : € 2008432 |
| Website : http://www.hut.fi/Units/Ship/Research/Iris/Public/ | |

## Objectives

The three overall targets of the IRIS project are

1. Include ridging parameters into ice forecast models, develop methods of determining the parameters from satellite imagery, and verify the results by ground truth experiments.
2. Determine the effect of ridging to ship transit, use this knowledge to describe the ship passage in variable ice cover, and develop tools that can used in route selection and assist decision making in shipping operations.
3. Include ridging parameters to ice charts and ice model forecasts, supply this ice information to ships and display it with a terminal software, implement the routeing tools as an integral part of the software, and verify the applicability by routine ship operations.

The targets of the first project year were.

1. Complete the numerical implementation of ridging description to ice forecast models and complete the first versions of algorithms retrieving ridging parameters from satellite images.
2. Implement the first version of terminal software to selected ships and set up the required ice information chain.
3. To realise the field experiments and application test cases planned for the 1st ice season of the project, and analyse and report the collected data sets

## Results

Scientific achievements:

Equations governing the time change of ridging parameters (ridge height and ridge density) were formulated and implemented to numerical forecast models of Finnish and Swedish ice services. The test runs proved that the approach is succesful and that tests of operative ridging forecasts delivery can be taken by the ice services.

A campaign measuring ice thickness and ridging parameters with a helicopterborne electromagnetic sounder was accomplished in the Baltic. For the first time thickness distributions from all areas of Gulf of Finland and Gulf of Bothnia were obtained. The results showed that the thickness of ridged ice types is often two times larger than the values shown in ice charts.

Better understanding of ship performance in ridged ice cover was obtained using theoretical studies, ice tank tests, transit simulations, and fulls scale data. It can be used to link ridging parameters to the average speed of and ice going ship.

Terminal software that can be used as an onboard decision support tool was tested during routine voyages of ships. The software can receive relevant information from different sources, including ice and ridging information from ice services, and display it in an integrated manner. In the next phase routing routines using the information will be implemented as parts of software. These will make suggestions on the optimal route especially in ridged ice cover.

Socio-economic relevance and policy implications:

The work done is a step towards the integration of ice information to routing and navigation assisting systems. The presence of ice ridges is the most important factor introducing uncertainty to wintertime travel time estimates. The work will reduce this uncertainty and, on the other hand, express quantitatively the uncertainty that always remains in ice navigation. This will enable better advance planning of shipping operations and reduce travel times, and thereby increase the cost efficiency of wintertime navigation.

**Status after 12-months: 31 Dec. 2003**

Quantitative parameters of ridging are included to ice information delivered by ice services and used on board ships. Ridge parameter resolving forecast models and SAR classification algorithms are developed and parameters are included to ice charts. Ground truth experiments are conducted. Methods to assist route selection in ice are developed, based on physical modelling of ship ice resistance and simulation of ship progress. These are implemented to a terminal applied to present ice charts and SAR images on board. The work is validated by routine ship operations. The end result is a system of ice information presentation, delivery and application, structured to facilitate the continuing assimilation of results.

**Conclusions:**

The results of the first year suggest that the above overall targets of the project will be attained.

# The Mediterranean network to Assess and upgrade Monitoring and forecasting Activity in the region - (MAMA)

*Vallerga S.*[1], *Drago, A.*[2]

[1] Consiglio Nazionale delle Ricerche – IAMC Sezione di Oristano, Italy; [2] IOI-Malta Operational Centre, MedGOOS Secretariat, University of Malta, Malta.



| | |
|---|---|
| Contract No: EVRI-CT-2001-20010 MAMA | Project duration: 01/2002 – 12/2004 |
| Project budget: € | EC contribution: € |
| Website: www.mama-net.org | |



**WHAT IS MAMA?**

The Mediterranean network to assess and upgrade the monitoring and forecasting activity in the region (MAMA) is funded under the Energy, Environment and Sustainable Development (EESD) section of the 5th Framework Programme (FP5). MAMA brings together experts from 28 marine institutions, representing all the Mediterranean Countries and three international organisations, IOC, UNEP-MAP and EuroGOOS.

The main objective of MAMA is to build the basin-wide network for ocean monitoring and forecasting, participated by all the Mediterranean countries. Strategic objectives are: (i) the identification of gaps in the regional capabilities for operational oceanography; (ii) the empowerment of all partners; (iii) the design of the initial shared observing system; (iv) awareness and demonstration of the benefits.

A coordinated and sustained ocean monitoring and forecasting system is an effective tool to manage the resources and protecting the marine environment. Such a system will provide a wide range of marine services for maritime transportation and safety, fisheries, coastal protection, mitigation of risks as well as information to assess climatic changes and long-term variability of the marine ecosystem.

The achievements in MAMA as a full scale Mediterranean cooperation are contributing the international role of the European Union, specifically for the implementation of the Mediterranean policy. MAMA is also contributing to foster the leading role of Europe in the development of operational ocean forecasting and in the implementation of GOOS.

**PROJECT ACHIEVEMENTS**

MAMA has completed two successful years of activity building a strong cohesive partnership, supported also by the exchange of personnel. The first comprehensive assessment of the basin-wide infrastructures to support research and services for ocean forecasting in the Mediterranean is completed, showing a wealth of activities for the future initial observing system basin wide. A profile for each country provides the global picture for the region, including the economic importance of the maritime sector. The ongoing analysis is identifying needs and strengths.

A pilot network for data and information exchange is now in place, providing the base for a broad MedGOOS networking interface. The Mediterranean directories of institutions and operational activities are now on the MAMA web page. Awareness meetings on the benefit of ocean forecasting, of the GOOS and on the MAMA achievements, are conducted in each country. They are supported by informative materials and brochures targeted at policy makers. One interesting brochure produced in Arabic will be translated into English for the benefit of all MAMA members. The prototype of the demonstration product to support integrated coastal management CEROSPIG, is now available for the MAMA participants to test.

The MAMA members feel the co-ownership of the achievements and the role of MAMA, the MedGOOS first project, as an example for other regions. The success of the SSA GRAND, extending the MAMA approach to the GOOS Regional Alliances of the world has been fully appreciated by the partnership. The Advisory Board is providing a great support to address emergent scientific problems, and most importantly for the planning of the future activity: MAMA-WIP (What-if? Prediction). MAMA is providing the infrastructure to move to the implementation phase of MAMA-WIP.

The MAMA Project has catalysed co-operation between ALL Mediterranean coastal countries, including Israel and the Arab states of North Africa and the Middle East, thereby demonstrating the capacity of scientific research to promote peace and security in the Mediterranean Basin.

MAMA website (http://www.mama-net.org)

# Rogue Waves – Forecast and Impact on Marine Structures -(MAXWAVE)

*Rosenthal, W.*

GKSS Research Center, Germany



| | |
|---|---|
| Contract No: EVK:3-CT-2000-00026 | Project duration: 12/2000 – 11/2003 |
| Project budget: € 4 683 950 | EC contribution: € 2 569 337 |
| Website: http://w3g.gkss.de/projects/maxwave | |



**Objectives**

A major goal of MaxWave was to investigate the occurrence and the properties of low frequency wave fields, abnormal individual waves and wave groups in deep and shallow water. Special attention was given to regions for which abnormal waves or low frequency waves were reported more frequently. In addition an attempt was made to draw conclusions on the impact of rogue waves for ship- and offshore platform design. Further the needs of coastal engineers and port designers and operators in terms of the influence and impact of extreme ocean waves were addressed. The core tasks were to better understand and describe the occurrence and impact of extreme waves and apply this knowledge to the design of vessels and offshore constructions. Strong emphasis was put towards the socio economic evaluation of the results, which resulted in intensive working contacts with shipyards and with ship designers in general.

**Results**

The project has made substantial progress in the description and observation of abnormal waves as well as the determination of their frequency of occurrence. Furthermore their impact on structures has been investigated in great detail, which led to discussions concerning future design criteria. The impact depends not only on the height but also on shape and speed of the forward front of the abnormal wave. Investigations in this direction have been published [1].

The mathematical description of linear superposition of elementary waves to non dispersing water mountains has been developed and demonstrated. These phenomena can only be modeled in a two-dimensional environment. The phase velocity of the water fronts is usually larger than the phase velocity derived from the one dimensional dispersion relation with the observed frequency. This again leads to increased impact when obstacles are hit, which may lead to modification of the Morrison formula.

At the beginning of the project the observation or measurement of individual waves in space and time was not possible. Within MaxWave several methods have been developed to extract individual waves from tower based and ship borne marine radar systems [2, 3] as well as from space borne synthetic aperture radars [4].

The occurrence of abnormal waves was estimated from several weeks of satellite borne radar data [5]. Every day ~1000 radar images are acquired of which each images 5 km x 10 km of the ocean surface. It was possible to raise the interest of the space industry and in particular the European Space Agency which makes available a large historical data set, which will be analyzed to find more abnormal waves on the global ocean. Another activity was the investigation of ship accidents by bad weather impact that lead to conclusions on the occurrence of abnormal waves. Global maps were plotted that identify areas of high occurrence of extreme waves.

The impact on structures was investigated in the project in several work packages. A few model tank experiments were carried out for structures that had encountered an extreme wave [6]. Model tests in the physical wave tank serve as validation for the calculations. The analysis reveals that the maximum response is directly related to the freak wave height. But fortunately, the response increase is clearly lower than the increase in wave height.

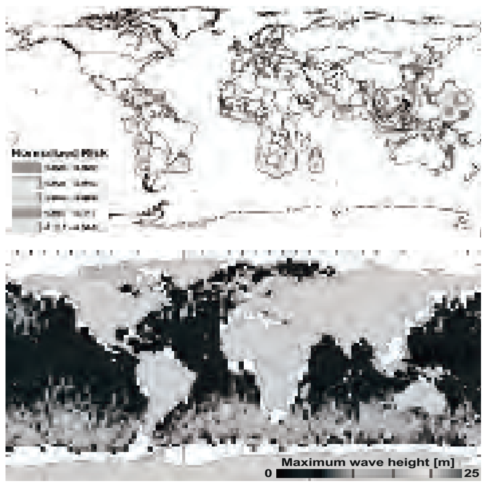
The research lead to the discussion on critical bending moments, modifications in hatch cover strength for bulk carriers and modification proposals for the construction of bridge window panes [7, 8].

### Potential exploitation by end users

By having a consortium that combined oceanography, ship design and its opera-tional application MaxWave had a strong socio-economic component. The results in-dicate the possibilities to reduce the number of ship accidents by considering the exis-tence and probability of extreme waves.

The main results which can be developed for exploitations by the end users are:

- Risk maps and global distribution of areas with high waves based on the investigation of 650 ship accidents reported as being due to heavy seas.
- Global distribution of sea state with respect to high waves based on satellite retrieved wave parameters. Eventually a nowcast warning service may be possible for online and satellite observed monster waves
- A procedure to calculate the design wave induced structural loads on ships, e.g. bending moments, considering time series of wave elevation with abnormal waves.




Normalized ship accident risk map resulting from the MaxWave project (upper panel). Maximum wave height measured from space borne radar data acquired over three weeks in the southern winter of 1996 (bottom panel).

### References

[1] H. Dankert, J. Horstmann, S. Lehner, W. Rosenthal (2003) IEEE Trans. Geosci. Rem. Sens., Vol. 41(6), pp. 1437-1446.
[2] H. Dankert, W. Rosenthal (2004) J. Geophys. Res., in press.
[3] J.C. Nieto-Borge, G. Rodríguez, K. Hessner, P. Izquierdo-González (2004) J. Atmos. Oc. Tech., in press.
[4] J. Schulz-Stellenfleth, S. Lehner (2004) IEEE Trans. Geosci. Rem. Sens., in press.
[5] S. Lehner, W. Rosenthal, J. Schulz-Stellenfleth, A. Niedermeier, J.C. Nieto-Borge (2003) in Proc. of Offshore Mechanics and Arctic Engineering.
[6] G.F. Clauss, K. Stutz, C.E. Schmittner (2004) Offshore Tech. Conf., in press.
[7] C. Guedes Soares, Z. Cherneva, E.M. Antão (2004) Appl. Oc. Res., in press.
[8] W. Pastoor, J. Helmers, E. Bitner-Gregersen (2003) in Proc. of Offshore Mechanics and Arctic Engineering.

# Marine EnviRonment and Security in the European Area - (MERSEA) Strand-1

*Johannessen, J.A.[1], Pinardi, N.[2], Robinson, I.S.[3], Le Traon, P.-Y.[4], Nittis, K.[5]*

[1] Nansen Environmental and Remote Sensing Center, Norway, (johnny.johannessen@nersc.no), [2] Instituto Nazionale di Geofisica e Vulcanologia, Italy, [3] Southampton Oceanographic Centre, United Kingdom, [4] Collecte Localisation Satellites, France, [5] Nationale Centre of Marine Research, Greece



| | |
|---|---|
| Contract No: EVK3-CT-2002-00089 | Project Duration: 01/2003 – 07/2004 |
| Project Budget: 3035779,- | EC contribution: 1699737,- |
| Website: http://www.nersc.no/~mersea, http://www.mersea.eu.org/ | |



**Objectives**

Based on integration of existing spaceborne observations with data from in-situ monitoring networks through ocean modelling and data assimilation system the objectives are to: a) deliver information products (physical, chemical and biological) needed by users concerned with European marine environment and security policies; b) report on the problems met and lessons learnt in supplying this information, and c) contribute to improved knowledge, methods and tools required for monitoring, information production and delivery to users occupied with marine environmental monitoring, management and security.

**Scientific breakthroughs and relevance for society**

MERSEA Strand-1 operates both global ocean systems producing assimilated analysis of the ocean state and forecasts, and regional to coastal finer resolution systems producing more user-oriented products (see http://www.nersc.no/~mersea).

The four core data assimilation systems TOPAZ, MERCATOR, FOAM and MFS are forced with atmospheric data from numerical weather prediction models and they assimilate, or plan to assimilate, satellite derived sea-level anomaly (SLA), sea surface temperature (SST), sea ice fields and ocean colour measurements. In addition the Argo profiling float system (now exceeding 1000 floats) measuring T and S profiles is essential for constraining the subsurface hydrography in the open ocean, as is regular XBT observations from VOS.

Daily mean products and forecasts from the four data assimilation systems are routinely distributed through an OPeNDAP server where the information products (http://www.mersea.eu.org) are analysed, intercompared and assessed for the Atlantic Ocean and Mediterranean Sea. Furthermore, regional and local high resolution (~ 4 km) models considered for specific application to (harmful) algal bloom, eutrophication and oil spill include MIPOM, met.no OD3D, BOOS, NORWECOM, POSEIDON, CYCOFOS and POLCOMS/ERSEM. These models are also dependent on atmospheric forcing field while specification of the 3D current fields at the open boundaries come from the core system.

The reliability and utilization of these integrated systems depend not only upon the performance of the models and assimilation tools, but also on the availability and quality of the observations, telecommunication networks, data processing and distribution, data access, and rapid information integration, flow and services. The systems are more mature for ocean physics, while they are still at the research level for pollution and ecosystem simulations. In general the validation capabilities are constrained by lack of data.

Monitoring and protection of the marine environment in Europe concerns a wide range of international bodies, treaties, conventions and organisations at regional and national levels. Following the introduction of the International Convention of the Law of the Sea in 1982, the

International Convention for the Protection of Pollution by Ships (MARPOL 73/78), the Framework for prevention of dumping of pollutant material (London Dumping Convention 72), conventions such as the OSPARCOM, HELCOM, BARCELONE and the Framework for oil pollution response (OPRC, 90) were established. Recently, the European Maritime Safety Agency (EMSA) in Lisbon, Portugal has moreover emerged to advance the systematic monitoring and reporting of the marine environment and its living resources. The overarching goal is to establish a sound balance between economic and social benefit on one hand and acceptable environmental impact on the other hand. MERSEA Strand-1 contributes to the provision of marine environmental information that is needed to establish this balance. It moreover undertakes the necessary preliminary measures towards implementation and operation of a European global operational oceanography system in the context of GMES by 2008.

**Exploitation of Results**

The preliminary conclusions and recommendations highlight the current capacity of European ocean monitoring and modelling system for environment and security. In short they emphasize the following need and shortcomings.

Sustainable satellite observations from a multi-satellite system for continuous high resolution and high inclination altimetry; high resolution SST measurements from combined use of passive microwave and infrared radiometers; high resolution measurements of chlorophyll derived from ocean colour data, blended from different missions; spaceborne SAR data for detection of oil spills both from illicit vessel discharges and major accidents (e.g. Prestige case).

Sustainable in-situ observations from Argo profiling floats, VOS and Ferry-boxes; rapid data transmission; establishment of observatories; build up of coastal HF radar network; development of biogeochemical sensors; and advances in monitoring of river discharges.

Provided the above observation methods and network are implemented and sustained the modelling capacity will advance in parallel with the CPU capacity to improve: forecast skill and assessment capabilities; downscaling; coastal modelling; and ecosystem modelling. Only with this in place can we claim to have an adequate marine GMES system operational by 2008.

National appointed representatives of conventions, employees of the European Environmental Agency, members of the marine board of the European Science Foundation and additional national and international candidate end users have gradually been made aware of the preliminary results of MERSEA Strand-1. By the termination of the project in June 2004 a user consultation meeting will be arranged to promote further awareness and secure dedicated user involvement in the MERSEA Integrated Project that will be kick-off in April 2004.

# Development of a European system for operational monitoring and forecasting of the ocean physics, biogeochemistry and ecosystems, on global and regional scales. - (MERSEA)

By the MERSEA Consortium[2]

MERSEA (Marine EnviRonment and Security for the European Area) is an Integrated Project funded by the EC under the FP6, Space thematic priority for GMES[3], Ocean and Marine Applications. Forty agencies and industrial partners participate in the project whose aim is to provide an integrated service of global and regional ocean monitoring and forecasting to intermediate users and policy makers in support of safe and efficient offshore activities, environmental management, security, and sustainable use of marine resources. The system to be developed in this 4-year project (2004 –2007) will be the Ocean and Marine services element of GMES to be established in 2008.

At the core of the system is the collection, validation and assimilation of remote sensed and in situ data into ocean circulation models that allow for the self consistent merging of the data types, interpolation in time and space for uniform coverage, now-casting (i.e. data synthesis in real-time), forecasting, and hind-casting, and delivery of information products.

The project will lead to a single high-resolution global ocean forecasting system shared by European partners together with a co-ordinated network of regional systems for European waters which will provide the platform required for coastal forecasting systems. During the project the main pre-operational systems will be transitioned towards operational status and three of the centres will converge on a single ocean model framework suitable for both the deep ocean and shelf-seas.

The project will federate the resources and expertise of diverse institutes, agencies, and companies in the public and private sector, in the fields of satellite data processing, in situ ocean observing systems, data management, ocean and ecosystem modelling, ocean, marine and weather forecasting. A global high resolution model (1/12°) will be developed, as well as improved systems for the Arctic, Baltic, Mediterranean and NE Atlantic. Down-scaling to regional systems will be implemented by nesting methods.

Specific applications to be developed include bio-geochemical variability in European regional and shelf seas (European Atlantic margin shelf including North and Irish Seas) and experiments on forecasting the ocean-atmosphere on daily to seasonal time scales. User products in support of offshore oil exploration and production, wave forecasts and ship routing, and oil drift fate prediction will also be developed.

The overall scope of the project will be described, including the opportunity for the delivery of ocean fields and products in support of research and application developments.

---

[2] The MERSEA project is steered by an Executive Committee comprising : Y.Desaubies (Ifremer) , P.-Y. Le Traon (CLS), U.Send (IFM/Kiel), H.Roquet (Météo-France/CMS), P.Bahurel (MERCATOR – Océan), G.Manzella (ENEA), J.Verron (CNRS/LEGI), C.Le Provost (CNRS/LEGOS), M.Bell (UKMetOffice), E.Buch (DMI), N.Pinardi (INGV), R.Rayner (Ocean Numerics), J.Johannessen (NERSC).

[3] GMES : Global Monitoring for Environment and Security.

# Mediterranean ocean Forecasting System: Toward Environmental Predictions - (MFSTEP)

*Pinardi, N., Coppini, G. and MFSTEP partners*

Istituto Nazionale di Geofisica e Vulcanologia, Italy



| Contract No: EVK3-CT-2002-00075 | Project duration: 03/2003 – 3/2006 |
|---|---|
| Website: www.bo.ingv.it/mfstep | |



***Objectives***

The implementation, development and operational testing of the basin and regional scales forecasting system for the Mediterranean Sea has been organized in the past eight years. The first Project, called Mediterranean Forecasting System Pilot Project, MFSPP, was supported by the European Union (IV Framework Program – Energy, Environment and Sustainable Development, action for "Sustainable Marine Ecosystems").

MFSPP lasted 3 years and ended in 2002 and achieved the following goals: 1) the first basin scale real time observing system was set up and operated with satellite, VOS-XBT and moored buoys observations; 2) the real time forecasting system assimilated all these observations and produced a 10 days forecast every week; 3) regional and shelf models were nested and calibrated within the MFS basin scale model; 4) biochemical flux models were calibrated and validated with data assimilation components for several open ocean and shelf areas in the Mediterranean.

A new initiative started which is called Mediterranean Forecasting System Toward Environmental Predictions-MFSTEP and it is supported by the European Community (V Framework Program – Energy, Environment and Sustainable Development, action for "Sustainable Marine Ecosystems"). This project aims at the further development of the operational ocean forecasting system developed in MFSPP. MFSTEP is based upon three main components: a) the Near Real Time Observing system; b) the numerical forecasting systems (Figure 1) at basin scale and for regional areas; c) the forecast products dissemination/exploitation system. The problems to be solved in MFSTEP belong to three major categories:

1) Technology developments, connected to the new instrumentation for NRT monitoring and the provision of NRT protocols for data dissemination and quality control procedures;

2) Scientific developments, connected to the understanding of the sampling scheme for different measuring platforms, the design and implementation of data assimilation schemes for different spatial scales, the ecosystem modelling validation/calibration experiments for the basin and the coastal scales and the development of data assimilation techniques for biochemical data;

3) Exploitation developments, consisting of the development of software interfaces between forecast products and oil spill modelling, general contaminant dispersion models, relocatable emergency systems, search and rescue models, and fish stock observing systems. In addition, the study of forecast economic value and impact will be carried out.

***Results***

The Mediterranean ocean Forecasting System (MFS) has started operational activities in January 2000. Presently it produces daily analyses and weekly 10-days forecasts of currents and temperature and salinity fields for the entire Mediterranean at approximately 10 km

resolution.
The Mediterranean Forecasting System is operational since December 1999 and its products are weekly available on MFSTEP central website: www.bo.ingv.it/mfstep.

***Potential exploitation by end users***
MFSTEP is current developing a set of application related to the exploitation of the Mediterranean forecasting activities, the main application are oil spill modelling, general contaminant dispersion models, relocatable emergency systems, search and rescue models, and fish stock observing systems. Detailed information about MFSTEP products are available at the project web site.

***Acknowledgements***
This work has been funded by MFSTEP (Supported by the European Community, V Framework Programme, Contract No: EVK3-CT-2002-00075). All the partners of this project are thanked for the invaluable contribution to the material of this abstract.

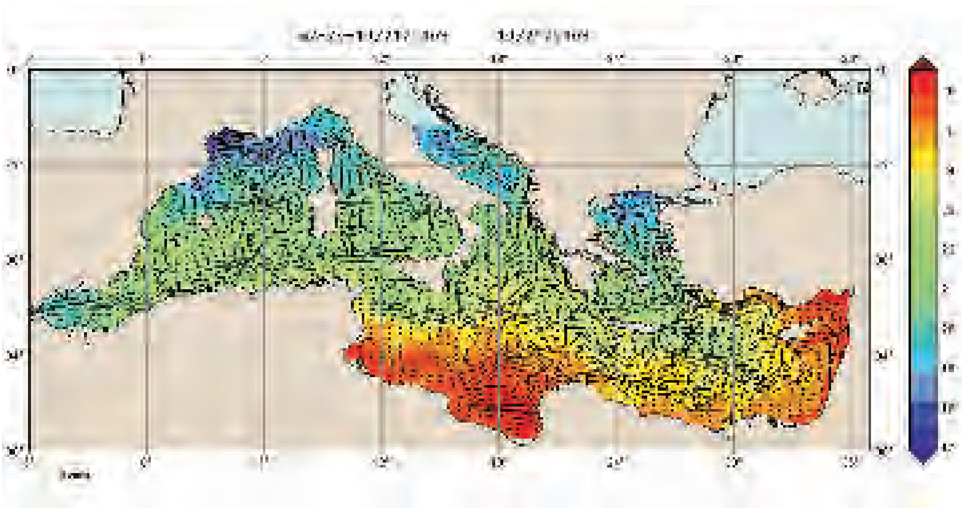


**Figure 1**: MFSTEP Basin scale bulletin MFS surface temperature and currents velocity for day 10/22/03-10/23/03 (available at www.bo.ingv.it/mfstep)

# Meridional Overturning Exchange with the Nordic Seas - (MOEN)

*Østerhus, S., Balino, B.*

Bjerknes Centre for Climate Research, University of Bergen, Norway

| | |
|---|---|
| Contract No: EVK2-CT-2002-000141 | Project duration: 12/2002 – 11/2005 |
| Project budget: 1 730 000 € | EC contribution: 1 590 000 € |
| Website: www.bjerknes.uib.no/research/MOEN/ | Contact: beatriz.balino@bjerknes.uib.no |

**Overall Objectives**

- To contribute to a better long-term observing system to monitor the water mass exchanges between the North Atlantic and the Nordic Seas.
- To assess the effect of anthropogenic climate change on the Meridional Overturning Circulation

The objectives of MOEN are based on three fundamental premises: (i) the importance of the fluxes, (ii) the need to monitor fluxes by direct measurements, and (iii) the need to link the observations to model simulations.

The specific objectives are to:

- Measure the total flux and characteristic of Atlantic water passing into the Nordic Seas across the Greenland-Scotland Ridge
- Measure the flux and characteristic of the eastern component of the overflows from the Nordic Seas to the North-Atlantic
- Estimate the contribution of meso- and small-scale processes to these fluxes
- Model the fluxes and reconstruct their variability since the onset of the 20th century
- Relate strengths and variability of the fluxes to local and remote forcing mechanisms as well as to internal modes of oscillations.

**Results**

Measured transport values for the Atlantic inflows to the Nordic Seas give a total flux of 7.5 Sv [1],[2],[3]. These are the first truly comprehensive flux measurements, while previous estimates were based on budget or geostrophical calculations.

A novel method for flux calculations has been developed, particularly useful in the absence of hydrographic measurements of water mass characteristics [4].

A large overflow event was observed on the Wyville-Thomson Ridge, cascading into the Rockall Trough [5]. This calls for a re-evaluation of the significance of passage in the overall overflow to the Atlantic scheme, particularly on the short temporal scale.

New in sights into mesoscale meandering around the Faroe-Shetland Channel will improve the general flux estimations in the area [6].

Modelling experiments show that the oceans "memory" play an important role in the general circulation of the Nordic Seas.

**Potential exploitation**

Results from MOEN will facilitate testing and calibration of regional and global climate models.

Novel observational methods applied during the project will contribute to the future development of low cost monitoring platforms.

The project will exploit more thoroughly existing hydrographic data sets to reconstruct fluxes over the past century, making use of MOEN´s dynamical insights gained by the numerical modelling.

MOEN promotes a broadly based and unified framework for facilitating and integrating disciplinary research efforts.

**The consortium**

MOEN comprises 7 principal contractors from universities and national research institutes in Denmark, Norway, England, Germany, Iceland, Sweden and 2 sub-contractors from the Faroe Islands and Scotland. The consortium represents a wide range of experience in observational oceanography and numerical modelling, as follows.

- University of Bergen, Bjerknes Centre for Climate Research, Norway (Coordinator)
- The Scottish Association for Marine Science, Oban, Scotland, UK
- Marine Research Institute, Reykjavik, Iceland
- Danish Meteorological Institute, Copenhagen, Denmark
- University of Hamburg, Institute für Meereskunde, Germany
- Dept. of Meteorology/Physical Oceanography, Stockholm University, Sweden
- University of Copenhagen, Niels Bohr Institute for Astronomy, Denmark
- The Faroe Fisheries Laboratory, Torshavn, Faroe Islands (Sub-contractor)
- Fisheries Research Services Marine Laboratory, Aberdeen, Scotland (Sub-contractor)

**References**

[1] Jónsson and Briem (2003). ICES Marine Science Symposia, **219**, 326-328
[2] Hansen et al. (2004). Progress in Oceanography (in press)
[3] Turrell et al. (2003). ICES Marine Science Symposia, **219**, 111-120
[4] Hátún et al. (2003). Journal of Atmospheric and Oceanic Technology (in press)
[5] Turrell & Sherwin (2003). ICES Annual Science Conference CM 2003/T:08
[6] Williams et al. (2004). Deep-Sea Research (submitted)

# Improving satellite ocean color data processing by the use of neural networks - (NAOC)

*Crepon M.[1], Thiria S.[1], Bricaud A.[2], Mangin A.[3], Doerffer R.[4], Fell F.[5], Morales J.[6], D. Cornford[7].*

[1] IPSL-LODYC, UPMC, Paris, France; [2] LOV, CNRS Villefranche , France; [3] ACRI, Sophia-Antipolis, France; [4] GKSS, Geesthaatch, Germany; [5] FUB, Berlin, Germany; [6] CICEM, Huelva, Spain; [7] Aston University, Birmingham, England



| | |
|---|---|
| Contract No : EVG1-CT-2000-00034 | Project duration : 02/2001 – 02/2004 |
| Project budget : € 1 522 580 | EC contribution : € 1 109 514 |
| Website : http://www.ipsl.jussieu.fr/NAOC/ | |



**Objectives**

Spaceborne ocean color sensors, which are now operational or under preparation, have a large number of spectral bands. NAOC, which is an EC FP5 supported program, was aiming at using advanced neural methodology which are well suited to deal with this multi-spectral information for retrieving ocean constituents.

**Results**

First NAOC has performed classification of the satellite signal at the Top Of the Atmosphere (T.O.A) according to specific criteria (energy, pattern of the spectrum) by using Topological Neural network Algorithm. This allows us to extract information on aerosol and on water type, which will be used for atmospheric correction and ocean constituent retrieval.

Second NAOC has determined improved algorithms for atmospheric and oceanic constituent retrieval. As atmospheric correction is sensitive to ocean parameter for case 2 waters, NAOC has developed specific Multi-Layer-Perceptron (MLPs) for processing atmospheric correction and ocean constituent retrieval for case-1 and case-2 waters.

Besides NAOC has determine specific Neural Network algorithms for retrieving ocean pigments from ocean color absorption spectra.

At last NAOC has developed an advanced inversion algorithm based on the Spectral matching method of Gordon (1997). This algorithm inverts the radiative transfer equations both in the atmosphere and the ocean by using a combination of variationnal and Neural method. As it takes into account both atmospheric and oceanic parameters, it is well suited to deal with absorbing aerosols.

**Potential exploitation by end users**

These algorithms are more accurate and faster to run than the standard ones. They are accessible to end users via the NAOC toolbox which is a friendly software.

# Harmonised Monitoring, Mapping and Assessment of Illegal Oil Discharges in European Seas - (OCEANIDES)

*Shepherd I.[1], Bauna T[1], Carreau P[1], Tarchi D[1], Fokuhl I[2], Indregard M.[3], Solberg R.[4], Solberg A[4], Husøy P-O[4], Trieschmann O.[5], Tufte L.[5], Bolding K.[6], Burchard H.[6], Clayton P.[7], Reichenbach D.[8], Haapasaari H.[9] Navickas, T[10]*

[1]Joint Research Centre (Ispra), [2]GAUSS (Germany), [3]Kongsberg Satellite Services (Norway), [4]Norwegian Computing Centre, [5]German Federal Institute of Hydrology, [6]Bolding & Burchard Hydrodynamics, [7]QinetiQ, [8]German National Pollution Control Authority, [9]Finnish Environment Institute, [10]Helcom; contact iain.shepherd@jrc.it +39 0332 789489



| | |
|---|---|
| Contract No : EVK2-CT-2002-00177 | Project duration : February 2003 – July 2005 |
| Project budget : € 2 580 000 | EC contribution : € 1 290 000 |
| Website : http://oceanides.jrc.cec.eu.int | |



**Objective**

OCEANIDES aims at establishing the scientific basis for a more effective monitoring of European waters for oil slicks by aircraft and satellites

**Results**

Information on observations of oil slicks from aircraft has been collected on an operational basis by national authorities and aggregated on a sea-basin scale through regional agreements in the case of the North Sea (Bonn agreement) and the Baltic Sea (HELCOM). In addition a number of completed and ongoing research projects funded by national bodies, the European Commission and the European Space Agency have analysed synthetic aperture radar (SAR) images for oil slicks. We have collected all this information and normalised it into a common data structure – valid for both aircraft and satellite observations – and made it available to the public through an on-line dynamic map. The data from the regional bodies, although not always stored in a uniform manner, was relatively forward to collect. But much information from research projects is not archived in an easily-retrievable format and there is no formal obligation for the responsible researcher to make it available. Data from the ENVISYS, CLEAN SEAS and OILWATCH projects has still not been included in our database. The coverage of data on slicks in the Baltic, North Sea and Mediterranean is good but there is great uncertainty in the monitoring effort. Aircraft flight-paths have not generally been recorded and, in some cases - because the mission also includes border monitoring which is considered a matter of national security - are completely unavailable. Data on satellite monitoring effort is generally easier to obtain although we have to be sure that we include data of images on which no slicks were found in our anlaysis.

During the 2003 monitoring campaign satellite images of the Baltic Sea and the North Sea – from both RADARSAT-1 and ENVISAT-ASAR – were analysed in real-time at the Kongsberg Satellite Services' ground station in Tromsø and aircraft sent out to check the results. The image analysis was subsequently checked by three different organisations using three different methods – operator inspection (two different operators), semi-automatic and fully automatic. In each case the objective was to locate the slicks and assign a confidence that they were not false positives. The operator analysis applied a set of rules to classify the slicks into "low", "medium" and "high" confidence.

Of 18 oil slicks found by one operator - in the real time analysis - that were verified as such by aircraft, 15 were detected by a second operator, 12 by the semi-automatic method and 14 by the fully automatic method. An offline expert analysis using all available information from the satellite images and aircraft flights compared the satellite analysis against the aircraft observations. Although the statistical sample was small, the overall rate of false positives was low for high and medium confidence slicks (23%) and higher for low confidence slicks (56%). (Table 1) A difference in the performance between RADARSAT-1 and ENVISAT was also observed with better results obtained from RADARSAT-1. The difference might be due to the fact that ENVISAT is a quite new sensor and experience of using it for oil slick detection is still quite limited compared to RADARSAT-1.

Table 1 verification by aircraft of slicks identified by expert analysis on satellite images

| | Radarsat | | | | Envisat | | | |
|---|---|---|---|---|---|---|---|---|
| **a-priori confidence** | High | medium | Low | Total | high | medium | low | total |
| **Verified slick** | 4 | 11 | 8 | 23 | 1 | 1 | 9 | 11 |
| **false positive** | 0 | 1 | 13 | 14 | 1 | 3 | 9 | 13 |
| **percentage false positive** | 0 | 8 | 62 | 38 | 50 | 75 | 50 | 54 |

Work is underway to derive a deposition rate of oil from the observed slicks. A first step is to calculate density functions which indicate the number of slicks likely to be observed in a given area at a certain time taking account weather conditions. A preliminary analysis of German aerial observations indicates a progressive reduction in the number of slicks observed per flight hour between 1986 and 2002 – from 0.25 to 0.1.

Converting the density of slicks observed to the number deposited requires knowledge of the persistence of the spill on the surface of the water which in turn depends on the volume and type of oil and the weather and sea state conditions. Both the volume and type of oil are impossible to estimate from current satellite sensors and very difficult from aircraft so we will need to extrapolate from rather patchy in-situ sampling.

Volume and type of oil are also crucial to determining the environmental impact. A slick model that includes convection, dispersion and evaporation has been added to an existing oceanographic model of the Baltic. The objective is to determine what fraction of the deposited oil reaches the coast. During 2004 different assumptions will be fed into the model which will then simulate the sea over timescales of years using past weather conditions and different assumptions about the quantity and type of oil deposited.

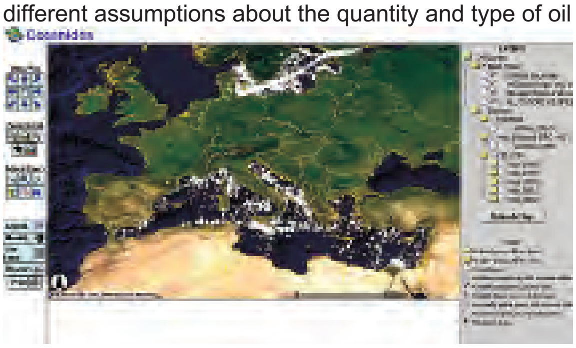


Figure 1 on-line dynamic map linked to harmonised database of oil-slick observations

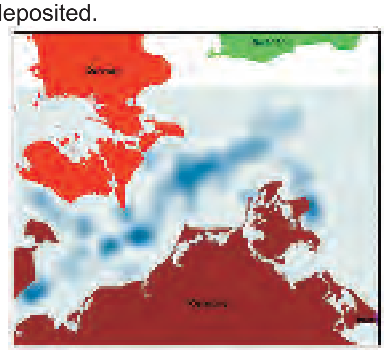


Figure 2 Oil slick density estimation (not standardized) based on the German HELCOM data 1998-2002

**Potential exploitation by end users**

The project should deliver a better assessment of the current quantity and impact of illicit oil spills in European waters. If it is considered that such pollution constitutes a risk to European marine ecosystems then the assessments and analysis provided by OCEANIDES will allow a measurement system and sampling strategy to be developed that will allow those concerned with formulating policies on marine pollution to assess whether or not remedial measures are working.

# Optimal Design of Observational Networks - (ODON)

*She, J.[1] and ODON consortium[1-5]*

[1] Danish Meteorological Institute, Denmark (js@dmi.dk); [2]The Management Unit of the North Sea Mathematical Models, Belgium; [3]Proudman Oceanography Laboratory, United Kingdom; [4]Swedish Meteorological and Hydrological Institute, Sweden; [5]Bundesamt fuer Seeschiffahrt und Hydrographie, Germany.



| Contract No : EVK3-2001-00218 | Project duration : 01/2003 – 12/2005 |
|---|---|
| Project budget : € 2 267 413 | EC contribution : € 1  410 730 |
| Website : www.noos.cc/odon/index.html | |



## Objectives

The objective of this project is to investigate/develop quantitative methods for the optimal design of observing systems for nowcasts/forecasts in coastal/shelf seas and demonstrate these techniques on SST and T/S profile observing networks in the Baltic and North Sea. State-of-the-art ocean models will be run for a one-year period to generate a 'proxy ocean' at the highest presently possible resolution and quality of forcing. With the proxy ocean, sampling distances are optimised based on characteristic scales in T/S fields and sampling locations by using local information content. Quality of the various sampling strategies is then tested by using Observing System Simulation Experiment (OSSE) and cost-benefit analysis is performed for these observing networks.

## Results

In 2003, ODON aims to build up a comprehensive observation database in the Baltic and North Sea, to develop SST and T/S profile data assimilation methods and to evaluate existing T/S observing systems in the Baltic and North Sea.

An observation database has been established for year 2001, including satellite SST (SAF O/I, NOAA AVHRR 12, 14 and 16), In-situ SST and CTD profiles (Fig. 1, including GTS, buoys, ferrybox, monitoring/research cruises, undulated profilers, shown in Fig.1), currents, water level, waves, bathymetry and daily river run-off.

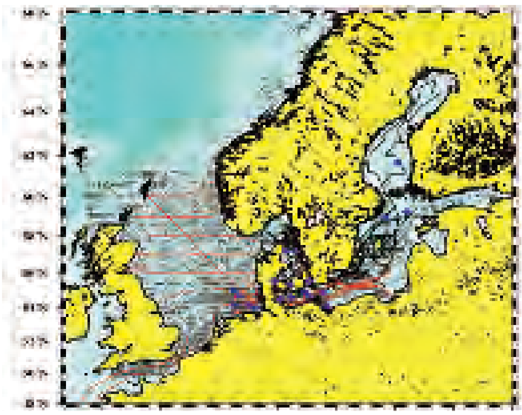


**Figure 1. In-situ SST and CTD stations in 2001**

Multi-level quality control method, spatial-temporal covariance models and multi-platform optimal spatial-temporal interpolation programs have been developed and a high resolution (10km, twice daily) gridded SST product has been generated.

An Optimal Interpolation assimilation method and a simplified Kalman Filter method have been implemented in 3D ocean models to assimilate SST observations, respectively.

Existing observing networks have been assessed in terms of effective spatial-temporal data coverage, signal-noise level, characteristic scales and technological synergy. Here we give results on SST as an example:

- Data coverage

For SST, data coverage has been investigated for both satellite and in-situ networks for different spatial-temporal box sizes. The results show that 3 satellites (NOAA-AVHRR 12, 14 and 16) gives 80% data coverage but only about 55% with 2 satellites (12 and 16) for (3day-20km-20km) box. In-situ data have a coverage of 5% in the Baltic Sea and 10% in the North Sea. The largest data gaps were found in the eastern and northern Baltic Sea.

- Signal-noise analysis

In northern North Sea, the largest SST signal is in inter-annual scale, intra-semi-annual scale can be neglected (with a variance <0.5$^{o}$C). In the Baltic Sea, the largest SST signal is in annual and semi-annual scale (with a variance up to 7$^{o}$C) while intra-semi-annual scale is also important. The noise level due to instrument error is about 0.6C for satellite and up to 0.2C for in-situ.

- Characteristic scale analysis

Spatial distribution of spatial-temporal correlation scales are calculated for SST in intra-semi-annual scale. The results show that temporal correlation scale ranges from 0.5days (in the northern North Sea due to noise and Jutland coast) to 3 days (northeast Baltic Sea and mid-west North Sea). The spatial correlation scales ranges from 50km (in the northern North Sea) to 250km (in eastern Baltic and mid-west North Sea).

*After integrating the analysis results from data coverage, variability and characteristic scales, a preliminary recommendation is made for generating daily gridded SST maps in 20km resolution in the Baltic-North Sea: 1) 3 satellites are to minimum requirement; rationalise existing SST observing network, 2) more observations should be made available in the eastern Baltic and coastal upwelling area, Ferrybox lines from Riga – Helsinki and from Klaipeda – Sassnitz are cost-effective instruments for this purpose. More quantitative comments can be made after further investigations.*

**Potential exploitation by end users**

Major ODON deliverables are optimal design methods, cost-benefit assessment of existing T/S observing system, an ODON database, 3D ocean models with data assimilation, a high resolution proxy ocean, quality evaluation and cost-benefit analysis of dozens of designed Baltic-North Sea T/S observing systems. They have wide implication on marine economy and scientific and technological prospects. The optimal design methods and evaluation of existing T/S observing networks will be very useful for monitoring agencies in the Baltic and North Sea to improve their existing monitoring networks. The ODON database can perform a test base for validating ocean models as well as research works. ODON SST data have already been used by BOOS SST group. The ODON 3D ocean models (COHERENS and HIROMB) are currently used by hundreds of institutions/ firms. Data assimilation schemes and optimisations to these models will definitely improve the ocean modelling level in this region. ODON results will also be unique information for design new observing systems, such as Eastern Baltic Sea Monitoring System, funded by World Bank. Europe is now launching a Global Monitoring for Environment and Security (GMES) program, aiming to build up an operational and autonomous monitoring system in 2008. ODON methods and results can be used by the program in assessing and optimising existing satellite and in-situ monitoring networks. Other users in observing system design include HELCOM, OSPARCOM and EuroGOOS.

# From GEOSTAR to ORION: toward ocean networking - (ORION-GEOSTAR-3)

*Favali P.*[1], *Beranzoli L.* [1], *Clauss G.* [2], *Gasparoni F.* [3], *Gamberi F.*[4], *Gerber H.* [5], *Flueh E.* [6], *Marvaldi J.* [7], *Nicot M.* [8]

[1] Istituto Nazionale di Geofisica e Vulcanologia, Italy; [2] Technische Universitaet Berlin, Germany; [3] Tecnomare-ENI SpA, Italy; [4] Ismar-CNR, Italy; [5] Technische Fachhochschule, Germany; [6] GEOMAR, Germany



| Contract No: EVK3-CT2001-00067 | Project duration: 05/2002 – 04/2005 |
|---|---|
| Project budget:Euro 3 371 710 | EC contribution: Euro 2 435 082 |
| **Website: http://geostar.ingv.it/orion** | |



## Objectives

The ORION-GEOSTAR-3 project has the aim to develop and operate a long-term network of multiparameter seafloor observatories in acoustic communication each other and in acoustic-radio/satellite communication with an on shore site. The demonstration of the possibility to operate ORION nodes within the ASSEM network is the objective of a specific task of the ORION work-plan.

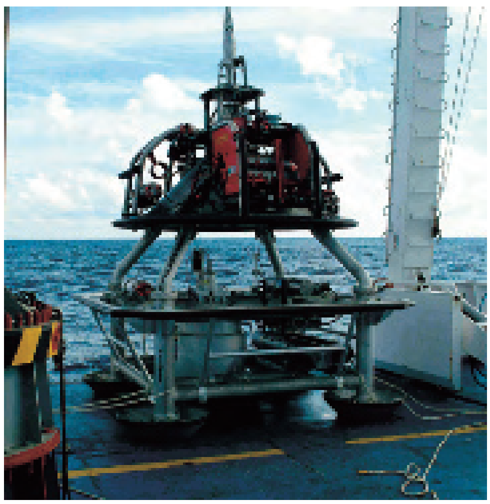
The ORION satellite nodes support also a burial system for seismometers, ASTRA, developed and tested inside the project.

## Results

The following ORION main subsystems were enhanced/developed:

- Main node (Node 1), that is the GEOSTAR observatory managed by MODUS vehicle hosting a subsystem with the functions of a virtual satellite node (Node 2);
- First satellite node (Node 3), also managed by MODUS and designed to support also ASTRA system for seismometer burial;
- Second satellite node (Node 4) to be integrated within the ASSEM network (FP5 project) in the Corinth Gulf pilot experiment;
- Surface buoy for acoustic, satellite and radio communication between the seafloor network and land sites;
- Shore station to receive the network data on land via radio link.

ORION Node 3 on deck before the deployment



The shore station will also integrate the ORION network in the land based operating networks.

The ORION network has been deployed in December 2003 in the Tyrrhenian Sea (3300 m w.d.) by means of the R/V Urania at the base of the Marsili underwater volcano, and will operate till summer 2004 with the following configuration:

- Node 1 (GEOSTAR) + Node 2
- Node 3
- Surface Buoy (radio and satellite links)
- Shore station (Gibilmanna INGV observatory, Northern Sicily).

The recovery mission is foreseen after 7-8 months from the deployment.

**Potential exploitation by end users**

ORION network provides opportunities for

- oil industry (e.g., pipeline monitoring)
- SMES (e.g., test and validation of new long-term underwater sensors/equipments)
- environmental and civil protection authorities (e.g., hazard warning)
- research institutions (e.g., long-term deep-sea time series).

# Programme for a Baltic network to assess and upgrade an operational observing and forecasting system in the region - (PAPA)

*Buch, E., Huess, V.*

Danish Meteorological Institute, Denmark. Email: ebu@dmi.dk

| | |
|---|---|
| Contract No : EVR1-CT-2002-20012 | Project duration: 11/2002 – 10/2005 |
| Project budget: € 1.619.512 | EC contribution: € 1.619.512 |
| Website: www.boos.org/papa | |

## Objectives

PAPA is a thematic network with the objective to build a basin-wide network for ocean monitoring and forecasting among all the Baltic countries.

This will include:

- identifying gaps in the monitoring systems in the Baltic Sea, and in the capability to measure, model and forecast the ecosystem
- building capacities for expertise in setting up and running observing platforms, and modelling and forecasting systems
- designing an effective observing and forecasting system
- raise awareness on the benefits of ocean forecasting

## Results

Within the first year of the PAPA project the following main results have been achieved:

- The network has been well established, and all partners have installed a FTP box system, and observations and model forecasts are exchanged among the PAPA partners via the FTP boxes.
- The capacity building has been initiated by a successful visiting programme.
- A status report about the present capabilities in operational oceanography in the Baltic Sea (see [2]).

## Potential exploitation by end users

The overall goal of the PAPA project is to provide high quality marine services to all users of the Baltic Sea. This will result in a large variety of improvements; examples are improved forecasts of marine navigation, better protection of the environment, and improved marine warnings for the public in general.

## References

[1] BOOS Plan - Baltic Operational Oceanographic System 1999 - 2003. *EuroGOOS Publication No. 14.*

[2] Present Status of Operational Oceanography in the Baltic Sea. Word document under www.boos.org/papa "Project reports".

# A Mobile Lander for Autonomous Monitoring and Sampling - (SEABEE)

*Bach, Fr.-W.*[1], *Walter, C.* [1], *Marty, P.* [2], *Wernerus, F.*[3], *Pinto, I.*[4], *Bordalo, F.*[4], *Meyer, Th.*[5]

[1] Institute of Marine Sciences, Hanover University, Germany; [2] Cybernetix, France; [3] Corsecologie, France; [4] Centre of Marine and Environmental Research, University of Porto, Portugal, [5] MariLim, Germany



| Contract No : EVK3-CT2001-00050 | Project duration : 02/2002 – 12/2005 |
|---|---|
| Project budget : € 2 031 192 | EC contribution : € 1 379 606 |
| Website : http://www.seabee-auv.com/ | |



## Objectives

The SEABEE system is an autonomous system to combine monitoring and sampling during the same survey. The basic System is an Autonomous Underwater Vehicle (AUV) with the ability to land on the sea floor. This normally requires inspection prior to landing and is solved by development of an onboard landing control system including video inspection of the landing site.

The project consists of two consecutive phases: the technological phase for development and integration of all components (core sampler, in situ measurement systems) into a functional tool and the scientific phase for testing and demonstration through a series of surveys addressing major applications with respect to the wide variety of European marine ecosystems.

## End user requirements

SEABEE aims at the needs of the majority of potential end users involved in marine environmental research. Recent surveys by the EuroGOOS working groups revealed the most important data needed by researchers and marine environment actors (see Table 1).

| In situ measured physical or biochemical parameters | Used by N% of Responders |
|---|---|
| Temperature-depth-salinity (CTD) | 86 |
| Current velocity and direction | 57 |
| O2 | 57 |
| Turbidity and Fluorescence | 29 |
| Chlorophyll, Nutrients, Sediment sampling | 14 |

Table 1

Furthermore, the surveys show that most data needed are related to the coastal area and the continental shelf (including estuaries) and about 70% of the respondents indicate the need for a spatial resolution of 0.5 to 1 km. Regarding sediment sampling, half of the respondents requested core lengths of less than 30 cm, 2/3 need core diameters of less than 20 cm. Likewise, the majority uses water samples of less than 2 litres and nobody expressed the need to filter water in situ. Comments emphasised the problematic sampling operation during bad weather conditions also causing inaccurate positioning. All these requirements and uses are taken care of by the SEABEE AUV system.

**Results:**

Fig. 1: Test assembly

Tests at IW investigated the ground suction effect on the sea floor. A tank was built, filled with different sediment types tested with two models of the AUV skis (Fig. 1). : a single-tube-ski with 20 cm diameter and a double-tube-ski with 12 cm diameter each. The ski models were lowered onto the sediment with a robot arm measuring the force required to remove them from the sediment surface. The tests indicated that a significant ground suction effect exists for pure clay sediment. The results are now used for the design of the landing section and a concept for a soft buoyancy system has been designed.

Due to a change in the consortium (replacement of the AUV - partner), which led to a delay of one year, the produced results have to be adapted to the ALIVE AUV from Cybernetix (Fig.2) which will be used in future. Currently the components are reviewed to integrate the conceptual design and designed components (e.g. core sampler, in situ measurement systems).

Fig. 2: ALIVE AUV

**Relevance for Society:**

The autonomous SEABEE vehicle reduces the need for divers and survey vessels and will thus improve the safety in obtaining marine data including so-called undisturbed sediment samples. The data taken by SEABEE will be of a higher quality than using traditional sampling techniques. Coastal zone monitoring and survey programmes will benefit from this approach maintaining a high quality. Using SEABEE, pollution of coastal waters and sediments can be detected and quanqtified in an automated way; SEABEE can take and analyse water and sediment samples determining bathing water quality as well as the contamination of specific coastal regions with TBT after oil spills or other chemical hazards. Also the safety of underwater sewage outlet plums or pipelines can be controlled in a cost effective manner making more frequent inspections affordable. Thus, dangerous substances in the sea can be detected earlier and their harmful effects can be dealt with more quickly and efficiently.

Regular automated geological examinations of the sea floor are useful to detect changes in the coastal structure. This enables the early prediction of future shoreline damage and allows to take precaution measures before the damage is too severe.

The spreading of harmful or foreign plants (like *Caulerpa taxifolia* in the Mediterranean) or of algae blooms can be closely monitored. The effects of sea-cables, pipelines or sewage outlets on flora and fauna can be determined in a similar way.

The SEABEE project contributes to a clean, safe, autonomous and cost-efficient technology to the expanding market of oceanographic equipment. The scientific surveys included in the project will create market opportunities for the participants by demonstrating combined autonomous sampling and continuous monitoring technology. This new combined sampling and monitoring strategy is not available on the market today.

# Pan-European network for ocean and marine data & information management - (SEA-SEARCH)

*Schaap, D.M.A.[1] ,et al*

[1] Marine Information Service (MARIS), The Netherlands

| | |
|---|---|
| Contract No: EVR1-2002-20009 | Project duration : 11/2002 – 10/2005 |
| Project budget : € 2 329 995 | EC contribution : € € 2 329 995 |
| Website : www.sea-search.net | |

**Objectives**

The primary goals of Sea-Search are to provide users with a central overview and access to ocean and marine data & information in a wider Europe and to harmonise quality standards and create improved conditions for data exchange and wider use in multidisciplinary applications. Sea-Search is a Pan-European cooperative network of 33 national oceanographic data centres and marine information services from 30 coastal states, riparian to all European seas.

**Results**

The 33 partners operate and further develop a network of partner websites and a joint European website (www.sea-search.net). This portal site hosts an array of catalogues, overviews and links and acts as central gateway to ocean and marine information & data resources in Europe, e.g:

- online directories of marine datasets (EDMED), marine research projects (EDMERP) and sea-going cruise summary reports (CSR) with input of all research institutes in the countries, riparian to the European seas
- a Common Data Index database to enable users to get highly detailed and up-to-date insight in the availability and geographical spreading of marine data across the different Sea-Search partners and possibly beyond. The Index database is under development, and will make use of XML for easy exchange and comply with ISO-19115 metadata standard.

**Potential exploitation by end users**

Sea-Search provides improved overview and access to oceanographic *in situ* data for a very broad spectrum of uses, encompassing operational oceanography, physical modelling, ecosystem modelling, marine biodiversity, algal bloom studies, amongst others. Sea-Search supports not only research and education, but also coastal zone management, policy making, offshore engineering, fisheries, aquaculture, and recreational users. Sea-Search is very relevant for the execution of international protocols, conventions and agreements, that have been signed by coastal states for protection of the seas, like OSPAR, HELCOM, Barcelona and Black Sea Conventions. Sea-Search is also very relevant for implementation of Europe's environmental policy concerning Integrated Coastal Zone Management (ICZM) and the Water Framework Directive.

In addition, Sea-Search provides a support infrastructure for organizations and projects, dealing with ocean and marine data & information, for indexing, disseminating and promoting their data & information resources to a wide user community.

**Reference: www.sea-search.net**

# Developing a facility to re-use seismic data - (SEISCANEX)

*Miles, P.R.*[1], *Schaming, M.*[2], *Casas, A*[3], *Marchetti, A.*[4], Wardell, N.[4], Sachpazi, M.[5], Sakellariou, D.[6]

[1]Southampton Oceanography Centre, UK; [2]EOST-ULP/CNRS Strasbourg, France; [3]University of Barcelona, Spain [4]OGS, Trieste, Italy; [5]Geodynamic Institute, NOA, Greece; [6]HCMR, Institute of Oceanography, Greece.



| | |
|---|---|
| Contract No : EVR1-CT-2001-40016 | Project duration : 12/2001 – 11/2004 |
| Project budget : € 1 270 792 | EC contribution : € 684 147 |
| Website : www.soc.soton.ac.uk/SEISCANEX | |

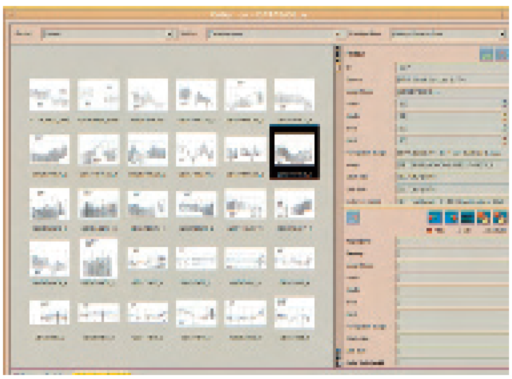


**Objectives**

To develop the existing free-to-use seismic record rescue facility by providing wider data access, new processes for digital conversion and training. This principally addresses the old paper seismic records laying dormant in many European institutions. It permits archive and processing that can enable re-use, generate new value and avoid re-acquisition. The project-wide hardware and software suite would expand to develop the existing WebViewer seismic record thumbnail index for give greater user access. The addition of a mobile scanning capability in Athens would improve data access to those institutions unwilling to move their records. A user driven need of the scientific community for digital reconstruction of the images to SEG-Y would be met through software availability and free training. This would create new opportunities within Europe and Associated States. The facility would continue to provide cost free scanning for the region as a unique opportunity to rescue their research investment, while retaining IPR and confidentiality. The value of these data can then be unlocked for re-use at the discretion of the owners.

**Results**

The free services provided by the project's 4 scanning stations have created and returned over 10,000 images of seismic records from 11 EU countries. This represents more than 1.5M line km of 'at risk' paper seismic records that would cost ~40M Euros to re-acquire today. This legacy of earlier research investment can now be re-used, realise new commercial value and contribute to contemporary regional planning while avoiding unnecessary re-survey with consequent costs, environmental impact and political sensitivity.



Each scanned image is uniquely identified and linked to metadata as thumbnails (left). The images are managed within the project software at 2 databases and made available through the open access WebViewer. This enables the existence of the data to be publicised, identified and referred to owner, creating potential new value.

Although the facility is not a database – the responsibility of data ownership is deferred to data owners – it has aided seismic archiving and data management at research institutions in Bulgaria, UK, France, Spain, Italy, Greece, Germany, Belgium, Turkey, The Netherlands and Russia. The project generation of metadata skeletons alone provides inventorial value.

We have also collaborated with Canada, Australia, Seychelles and New Zealand in seismic re-use applications related to EEZ submissions.

Many of the seismic records were collected using magnetic tape storage facilities that are now obsolete. So the paper record is all that remains of this research investment. This does mean the loss of the original signal bandwidth. However modern transcription techniques can reconvert the images back to digital form for re-processing, interpretation and display – but commercially this is too expensive for research budgets.

The project has therefore developed a transcription software package – ***SeisTrans*** –that converts seismic traces on paper into SEG-Y digital files**.** This is a Linux/UNIX based software module made available through the project in a technology transfer at marginal cost to bring digital re-use, processing and interpretation to research and regional interpretation. The result is a SEG-Y file compatible with all contemporary processing and interpretation systems. We also provid free training in the use of our software and facilities to personnel from any collaborating institution so that the academic user can benefit from the results. We refer large-scale processes to commercial associates – SeiScan GeoData at Robertson research International.

**Potential exploitation by end users**

This data technology project is recognised world-wide as relevant to the *quality of life, safety and preserving the environment* through securing information that can be relevant to long term risk analysis in offshore mapping and submarine instability.

The facility is not only a prime example of making 'at risk' information available to the European *information society* but also to international programmes such as IODP. It provides a user-friendly interface for potential academic or commercial users and for EEZ exploitation.

The new development of low cost ***SeisTrans*** SEG-Y conversion software brings real data re-use to academia. The **free training** improves the socio-economic database by encouraging new commercial opportunities in data technology in the marine environment. This is achieved by providing in-house access or with support from training grants. We also contribute to schools work experience and web-based learning in IT and marine geoscience. In *preserving the environment the a*voidance of seismic re-acquisition is environmentally attractive.

Seismic information is fundamental to any marine resource or hazard assessment. Japan, India and the USA are assessing the impact of methane hydrate through systematic re-interpretation of existing seismic data.

This project makes a contribution to ensure that the seismic research investment of the 20$^{th}$ century remains available for reference and re-use during the 21$^{st}$ century.

# Satellite-based Ocean ForecasTing (SOFT)

Moneris, S.[1], Tintoré J.[2], Alvarez A.[2], Beckers J.-M.[3], Barth A.[3], Challenor P.[4], Onken R.[5]

[1] SAFEGE CETIIS, France; [2] IMEDEA, Spain, [3] GHER, Belgium, [4] NERC, Great Britain, [5] SACLANTCEN, Italy

soft@cetiis.fr

| | |
|---|---|
| Contract No : EVK3-CT-2000-00028 | Project duration : 01/2001 – 06/2004 |
| Project budget : € 1613807 | EC contribution : € 925000 |
| Website : www.cetiis.fr/web/soft/index.htm | |

**Objectives**

The main objective of the SOFT project is to develop a new ocean forecasting system by combining satellite data acquisition, evolutionary prediction techniques and numerical ocean models.

Satellite are the only way to monitor continuously the space-time variability in the ocean. Moreover, satellite data contain information that can be extracted using some prediction algorithms to forecast future state of the upper ocean layers.

Numerical ocean models are by far the most used tools for ocean prediction. The integration of predicted data into a numerical model through assimilation techniques will improve the enormous predictive potential of numerical techniques on oceanic three-dimensional structures which can not be directly sensed from space.

The two main objectives of the SOFT project are :

(1) The development and validation of a new methodology to obtain an accurate and manageable ocean forecast system using satellite data (sea surface temperature, sea surface height and ocean colour);

(2) The integration of predicted satellite data into a three-dimensional numerical model through assimilation techniques in order to develop a new hybrid forecasting system.

**Results**

The SOFT prediction system has been applied for a two-dimensional problem with real sea surface temperature (SST) data issued from satellite images of the Ligurian Sea [1]. One-week-ahead predictions of the SST fields have been considered in December 1999. Comparisons have been performed between the SOFT prediction model, the persistence model (which assumes that the best prediction of next week is the SST of this week) and the real SST field obtained from satellites data acquisition. Results show that a good performance is not expected from the persistence model. The SOFT predictor correctly estimates the drop in temperature observed in the coast of France.

Results obtained for one-weak-ahead predictions indicate a good performance of the SOFT system in predicting the SST fields.

The ocean general circulation model developed by the GHER institute has been applied to the Mediterranean Sea [2]. The model has been implemented with three nested models of different domains and resolutions. The highest-resolution model of 1' is centred to the Ligurian Sea. Forecasted time-series of sea surface data have been assimilated into this model. The results show that assimilation of predicted SST improves the model by a amount comparable to the assimilation of observed SST. The results obtained indicate the usefulness of the assimilation of predicted SST and the improvement of the numerical model forecasts.

**Potential exploitation by end users**

The final objective of the SOFT project is to develop an ocean forecasting system complex enough to provide accurate information of future states of the ocean but simple enough to be distributed among a wide range of end-users.

For this reason, a friendly and easy-to-use graphical interface has been developed for end-users to predict future ocean states from satellite data.

Basically, SOFT can provide predicted sea surface temperature structures, sea surface height and offshore currents associated to the dynamic height, eddies, fronts, propagating waves, biological activities associated to chlorophyll fields and other parameters not directly sensed by satellite and obtained from numerical modelling (currents…).

Since half of the European population lives in the coastal line of 50 km wide, it is expected that the SOFT project will have a significant impact on coastal activities such as :

- environmental control : pollution monitoring, waste management, control of anthropogenic activities in coastal and open ocean areas, bathing water quality, water temperature;
- prevention from coastal erosion or wave damage;
- planning and safety of offshore activities;
- safety and optimisation of marine transport (ship-routing, sailboat races);
- determination of fish zones and management of ocean resources;
- data for research (climate change, oceanography, modelling);
- ...

The SOFT project will be of special interest to coastal managers, cities, managers in pollution monitoring, tourism, offshore activities, fisheries, fish research, marine commerce, national navies, fundamental or applied research…

Continuous monitoring of coastal zones by remote sensing and ocean state prediction will become necessary for economically and environmentally sustainable development

**References**

[1] Alvarez A., Orfila A., Tintore J., (in press), J. Geophys. Res.
[2] Barth A., Alvera-Azcarate A., Rixen M., Beckers J.-M., (accepted), Progress In Oceanography

# AUTONOMOUS UNDERWATER MULTI-PROBE SYSTEM FOR COASTAL AREA / SHALLOW WATER MONITORING - (**SWARM**)

*Vainio, M.[1], Halme A.[1], Troshin I.[1],Stipa, T.[2], Seppälä, J.[2], Pollehne, F.[3], Bauerfeind, E.[3], Haardt, H.[4], Brault, P.[5], Seube, N.[6], Smerdon, A.[7], Caine, S.[7], Swale, B.[8], Hakala, A.[9]*

[1]Helsinki University of Technology, [2]Finnish Institute of Marine Research, [3]Baltic Sea Research Institute Warnemunde, [4]Dr.Haardt Optik-Mikroelektronik, [5]Martec Serpe-IESM, [6]Ecole Nationale des Ingenieurs des Etudes et Techniques d' Armements, [7]Aquatec Group / Aquatec Telemetry LTD, [8]Swale Oceanographic, [9]Sofimation LTD

Email: antti.hakala@sofimation.com


| | |
|---|---|
| Contract No: EVK3-CT-2002-30002 | Project duration: 02/2003 - 01/2005 |
| Project budget: 1916250 EUR | EC contribution: 949086 EUR |
| Website: www.seaswarm.com | |

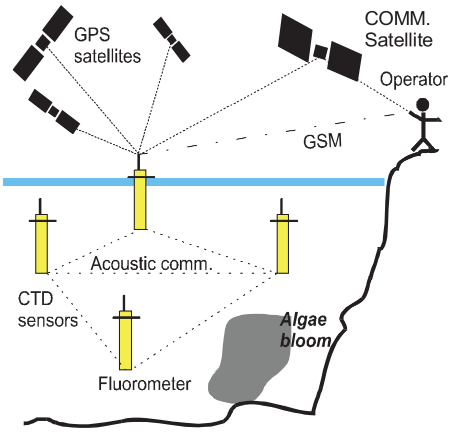

**Objectives**

The value of services provided by the coastal seas, including estuaries, to the human welfare can be estimated to be higher than those of terrestrial or open ocean systems. Coastal waters supply food via fisheries, renewable and non-renewable resources like sand and hydrocarbons, sites for recreation, and sites for waste disposal, and especially for effective nutrient cycling. Human activities have modified the aquatic ecosystems in multiple ways. As an outcome most fish stocks are overexploited, contaminants and habitat loss affect the survival of many species, and eutrophication has influenced the functioning of food web. Thus, the ecologically and economically sustainable use of coastal areas is threatened in many ways.

The relevant spatial and seasonal scales for biological variability are often related to hydrophysical events; these are mostly unpredictable and practically impossible to cover by traditional monitoring with sparse sampling. Current sampling limitations thus restrict our understanding of the role of environmental conditions for ecosystem functioning. Quantitative diagnostics of the factors affecting e.g. the phytoplankton distribution and productivity requires that these will be sampled at relevant scales.

The overall objective of this project (SWARM) is to develop a detection platform, that can measure biological and physical variability at the scale relevant for a single spatial event. Better understanding of the physical, chemical, and biological coupling of coastal ecosystems, provides a better opportunity for water resources management, e.g. key processes and key locations for possibly Harmful Algal Blooms (HAB) can be detected and tackled.

The specific scientific objective of SWARM is to design, implement and test a novel highly redundant underwater monitoring system for shallow water areas. The system consists of multiple, homogenous, small size, reasonably priced, robust and easy to use underwater robotic probes that can perform two-week missions autonomously. The probes control their buoyancy but move otherwise freely with the water flows. They communicate with each other and with the control station (acoustic modem / GSM modem / satellite modem), and localize themselves in 3D based on this information and GPS.




In addition to measuring the standard variables (pressure, temperature, conductivity) the system observes certain algal groups with a novel type fluorometer. Forecasts of algal blooms, their appearance areas and dispersion patterns are extremely difficult. There exists no proper monitoring system capable of covering the critical areas continuously and widely enough. In this project a platform that can measure biological and physical variability at the scale relevant for single event (metre - kilometre and second-day scale) will be developed and tested in the Baltic Sea.

**Results**
At this point of the project, the subsystems design and testing is nearly completed and the construction of the first unit prototype has been started. Additionally, simulation studies related to underwater positioning and navigation issues have been successfully performed. The actual field tests for a complete unit will start in May-June 2004 and they will continue till late autumn. The final results from the SWARM project will be available during the second half of 2005.

**Potential exploitation by end users**
The quality of waters within Europe can clearly be considered as one of the common European resources and the quality of this resource is naturally important to all of the surrounding countries and beyond. Only through common EU decisions and constant monitoring of these decisions can a long and lasting development of these resources be achieved. The target of SWARM is to introduce a system that can be widely used for this monitoring. Further research is needed to develop additional applications, such as systems for lakes, reservoirs, fish farms, estuaries, etc. in order to increase the number of potential users.

# GLOSSARY OF TERMS

| | |
|---|---|
| BONUS | for Baltic Sea Science – Network of Funding Agencies (ERA-Net project) |
| BOOS | Baltic Ocean Observing System |
| CYCOFOS- | Cyprus Costal Ocean Forecasting and Observing System |
| CZM | Coastal Zone Management |
| ECORD | European Consortium for Ocean Research Drilling. |
| EFARO | European Fisheries and Aquaculture Research Organisations (network) . |
| EFMSTS | European Federation of Marine Science & Technology Societies. |
| ELOISE | European Land-Ocean Interaction Studies (EU Initiative on ICZM; research projects). |
| ERA | European Research Area |
| ESEAS-RI | European Sea Level Service Project – Research Infrastructures (research project). |
| ESF-MB | European Science Foundation – Marine Board. |
| ESFRI | European Strategy Forum for Research Infrastructures. |
| ESONET | European Sea Floor Observatory Network (Network of Excellence). |
| EuroGOOS- | European Global Ocean Observing System |
| EuroROSE- | European radar ocean sensing (research project) |
| FAO | Food and Agriculture Organisation |
| FOAM- | Forecasting Ocean assimilation model |
| GEOSS | Global Earth Observation System of Systems |
| GMDSS System | Global Maritime Distress and Safety |
| GMES- | Global Monitoring for Environment and Security |
| GOOS- | Global Ocean Observing System |
| HERMES | Hotspot ecosystem research on the margin s of European Seas (research project). |
| ICZM | Integrated Coastal Zone Management |
| IOC | Intergovernmental Oceanographic Commission |
| IMO | International Maritime Organization |
| IPs | Integrated Projects |
| LIFE | EU Life Programme |
| MAMA- | Mediterranean network to Access and upgrade Monitoring and forecast Activities (research project) |
| MarinERA | Co-ordination of National and Regional Marine RTD Activities in Europe |
| MAST – | Marine Science and Technology Programme |
| MB-ESF | Marine Board, European Science Foundation |
| MCFA | Marie Curie Fellowship Association |
| MedGOOS- | Mediterranean Global Ocean Observing System |
| MERCATOR- | Ocean forecasting model |
| MERSEA- | Marine Environment and Security in the European areas (research project) |
| MFSPP- | Mediterranean Forecasting system Pilot Project (research project) |
| MFSTEP- | Mediterranean Forecasting System Towards Environmental Predictions (research project) |
| MPERSS | Marine Pollution Emergency Response and Support System |
| MOON | Mediterranean Operational Oceanography Network |
| NoEs | Networks of Excellence |
| OMARC | Ocean Margin Research Consortium |
| PHARE | EU PHARE Programme |
| POSEIDON- | Monitoring and forecasting system for Greek Seas (research project) |
| REMPEC | Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea |
| RTD | Research, Technology & Development |
| SME | Small to Medium Sized Enterprise |
| SPICES | Science and Policy Integration for Coastal Ecosystems (proposal consortium) |
| STREPs | Specific Targeted Research Projects |
| TOPAZ- | Towards an operational prediction sys for North Atlantic European coastal z (research project) |
| WaMoS | Wave and Surface Current Monitoring System. |

Celebrating European Marine Science

Building the European Research Area

Communicating Marine Science

**Galway (Ireland) 10 – 13 May 2004.**

## EurOCEAN 2004 .

## The Galway Declaration

**To ensure that recognition is taken at Member State and European Community Level of:**

- **The crucial role of the oceans in climate, carbon cycle and Life on Earth.**
- **The major contribution maritime industries can make to the achievement of the objectives outlined in the Lisbon Agenda.**
- **The essential role of marine science and technology in generating the knowledge needed to fuel this economic achievement in harmony with the environment.**
- **The critical role the European Research Area / 7th Framework Programme must play in supporting world-class excellence in marine science & technology.**

Marine Institute
Foras na Mara

Marine Board

## Annex I

# EUROCEAN 2004

# THE GALWAY DECLARATION

The seas and oceans have historically played a formative role in the development of many European coastal states. From the utilisation of fish as a food source, to the development of international trade, commerce and maritime transport, European society has thrived and prospered from its partnership with the sea. Much of this prosperity can be traced back to the application of science and engineering. Critical developments, underpinned by science and technology, which gave European countries dominance over international trade in the middle ages included shipbuilding and the development of navigational aids.

In May 2004, over 500 leading marine scientists, policy-makers and representatives of the marine industry sector, from all corners of the European Union (EU+25), gathered in Galway (Ireland). Their objective - to determine how marine science and technology can contribute to the achievement of European Union objectives as stated in the Lisbon, Gothenburg and Barcelona Declarations. Namely, *to make the European Union the most competitive knowledge-based economy in the world*, based on the application of science and technology and the principles of sustainable development.

### The EurOCEAN 2004 Conference Noted That:

- The European Union has a significant marine dimension, with over 50 % of the territory under the jurisdiction of its Member States being underwater. This territory extends from the Baltic through the Atlantic to the Mediterranean and Black Sea.  .

- The ocean plays a crucial role in planetary/ecosystem function. It influences climate, the carbon cycle and supports an impressive diversity life forms.

- The European seas and oceans are of major strategic importance to the economic and social development of Europe as well as its security.

- The application of science and technology to our seas and oceans presents new and exciting opportunities for economic growth and innovation in the maritime sector.

- New and emerging scientific knowledge and technologies are providing unprecedented access to marine resources. The flip side of this coin is that increased exploitation (e.g. over Fishing, environmental impacts of oil exploration, urban expansion, etc) is having a negative impact on the sustainability of marine resources.

- The participation of European researchers and the European Union in global research partnerships is vital if we are to truly understand earth ecosystem function.

- The development of mutually supportive and complementary links between the marine industry sector (particularly SMEs) and the research community is essential in order to develop new exploration technologies, support the sustainable development of marine resources and to ensure the transfer, utilisation and commercialisation of research results.

- The European Union Framework Research Programmes, supporting marine science, coupled with national marine research programmes, have created a strong element of co-operation and a truly "*European Marine Science Community*".

**Future Challenges Include:**

- The implementation of an ecosystem-based approach to sustainable development and improved stakeholder input to management decisions;

- Integrating the exciting new discoveries in marine science (e.g. the role of the picoplankton, deep sea extremophiles and sub-seafloor micro-organisms, etc.) to our understanding of marine ecosystem function and their possible commercial application.

- Development of renewable ocean energy to diversify energy sources and contribute to our Kyoto commitments on $CO_2$ reduction;

- Development of coastal shipping as an environmentally friendly and economic mode of bulk transport whilst improving safety and reducing negative environmental impacts;

- The development of the ocean component of a Global Earth Observation (GEO) System as advocated by the Johannesburg Conference and the G8 Summit;

- Conserving marine biodiversity, whilst utilising its unique biodiversity for social and economic purposes (e.g. new bioactive compounds for medicinal, pharmaceutical and industrial purposes);

- The exploration of the deep ocean and continental margins, one of the last frontiers of our planet, in order to uncover its mysteries and assess its resource potential;

- Responding to the implications of global climate change and its impacts on marine and coastal environments and communities;

- Developing a new paradigm to promote inter-institutional co-operation in the context of an expanded Europe (EU +25).

## Responding to the New Challenges Will Require:

- Recognition of the actual and potential value of the marine resource in EU development policies / strategies;

- A partnership approach between Member States and the European Commission in developing and implementing a European Marine Resource Development Strategy;

- Recognition of the critical supportive role of marine science and technology in the sustainable development of our shared marine resource.

## More Specifically, the EurOCEAN 2004 Conference:

- Calls for the recognition of marine science and technology as a clearly identified component of the European Research Area.

- Welcomes the Commission's draft proposals on the structure of the 7th Framework Programme (2007 - 2011) with its six axes: Collaborative

Research, Competition in Basic Research, Technology Platforms, Human Resources, Research Infrastructures and Enhanced Coordination.

- ○ Undertakes to advise, through its National Authorities, how these new structures can best be utilized to support marine research and its contribution to sustainable development and economic growth.
- ○ Welcomes the draft DG Environment Marine Strategy with its emphasis on an ecosystem approach to sustainable development as well as the evolution of fishery and security policies.

- Notes that the Marine Science Community must:

  - ○ Impress on their respective National Authorities the important contribution that marine science can make to the realisation of the Lisbon, Gothenburg and Barcelona Agendas, such that this message is brought by the Member States to the Council of Ministers and the European Commission;

  - ○ Improve its communication skills in explaining the contribution that its work can make to economic and social development;

  - ○ Increase its efforts and capabilities to quantify, in social and economic terms, the actual value of maritime industries & marine resources;

  - ○ Develop procedures to ensure that data collected under publicly funded schemes is made available to the private sector who in many cases are more able to develop value added products and services.

- Notes that long-term ocean observations, such as are proposed under the GEO and GMES initiatives, are critical if we are to implement an ecosystem-based approach to resource management – and that it is the responsibility of the EU <u>AND</u> the

Member States to find appropriate ways, including Public-Private Partnerships, to finance the operational aspects of these observations.

- Notes that young researchers are the backbone of research and the lifeblood of the future. Accordingly, better career structures must be put in place if we are to secure the best researchers in the marine sector.

## What Must We Do Now?

- Working through our respective National Authorities, to ensure that recognition is taken at Member State and European Community Level of:

- The crucial role of the oceans in climate, carbon cycle and Life on Earth.

- The major contribution maritime industries can make to the achievement of the objectives outlined in the Lisbon Agenda.

- The essential role of marine science and technology in generating the knowledge needed to fuel this economic achievement in harmony with the environment;

- The critical role the European Research Area / 7th Framework Programme must play in supporting world-class excellence in marine science & technology.

(www.esf.org/marineboard) as an Irish EU Presidency Event and contribution to the sustainable development of the European Marine Resource.

**For further information on the**

**EurOCEAN 2004 Conference see www.eurocean2004.com**

**DG Research**
**European Commission**
**Directorate-General for Research**
**European Commission**
**B-1049 Brussels**
**Tel: +32.2. 299.11.11 (switchboard)**
**E-mail: research@cec.eu.int**

**Marine Institute**
**Galway Technology Park**
**Parkmore**
**Galway**
**Ireland**
**www.marine.ie**

**Marine Board**
**European Science Foundation**
**1 Quai Lezay-Marnésia**
**67080 Strasbourg Cedex**
**France**
**www.esf.org/marineboard**

European Commission

**Proceedings of the EurOCEAN 2004**
**European Conference on Marine Science & Ocean Technology**

Luxembourg: Office for Official Publications of the European Communities

2007 — xvi, 420 pp. — 17.6 × 25 cm

ISBN 92-894-7727-X

## How to obtain EU publications

Our priced publications are available from EU Bookshop (http://bookshop.europa.eu), where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents. You can obtain their contact details by sending a fax to (352) 29 29-42758.

KI-NA-217-98-EN-C

DG Research
European Commission
Directorate-General for Research
European Commission
B-1049 Brussels
Tel: +32.2. 299.11.11 (switchboard)
E-mail: research@cec.eu.int

Marine Institute
Galway Technology Park
Parkmore
Galway
IRELAND
www.marine.ie

Marine Board
European Science Foundation
1 Quai Lezay-Marnésia
67080 Strasbourg Cedex
France
www.esf.org/marineboard

Publications Office
Publications.europa.eu

ISBN 92-894-7727-X
9 789289 477277