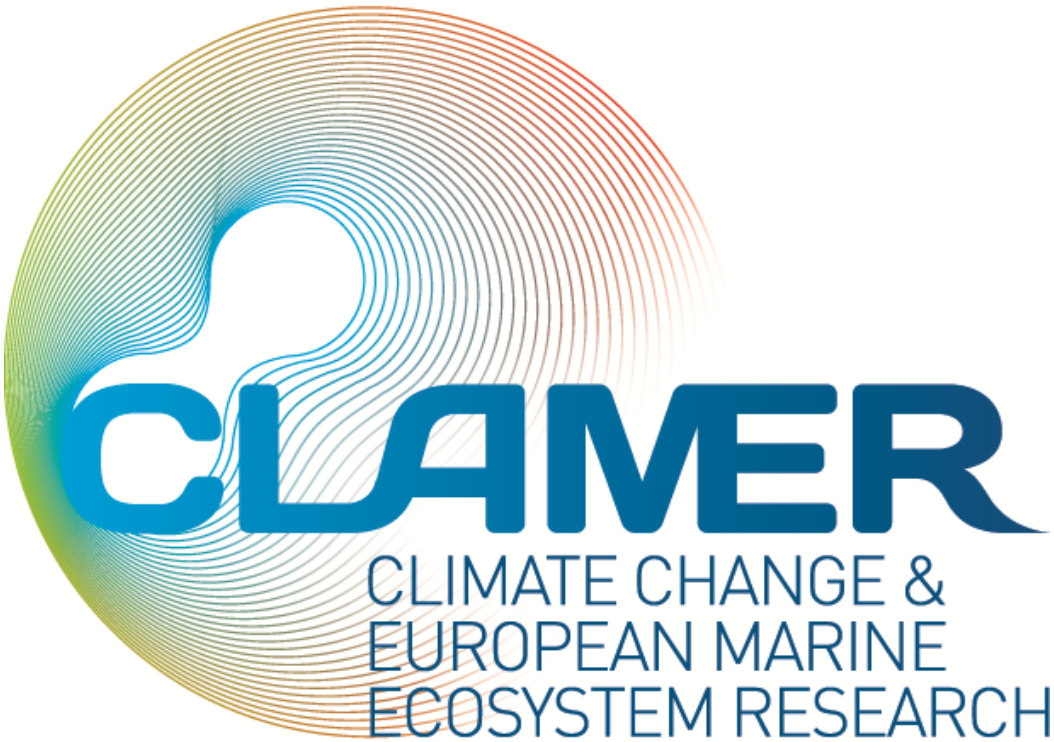

DELIVERABLE NUMBER: 1.1

DELIVERABLE NAME: Inventory report of relevant research and their outputs

DELIVERABLE LEADER: Marine Board-ESF

CONTRIBUTING BENEFICIARIES: Royal Netherlands Institute for Sea Research (NIOZ); University of Brest (UBO-IUEM); Danish Meteorological Institute (DMI); Plymouth Marine Laboratory (PML); Università Politecnica delle Marche (UNIVPM); Hellenic Centre for Marine Research (HCMR); National University of Ireland, Galway (NUIG); Royal Netherlands Academy of Arts and Sciences (NIOO-KNAW); Natural Environment Research Council (NOCS-NERC); University of East Anglia (UEA); University of Tromsø (UoT)

FIRST DRAFT DATE: 04-10-2010

FINAL DRAFT DATE: 01-07-2011

DISSEMINATION LEVEL: Public

SEVENTH FRAMEWORK PROGRAMME
ENV.2009.1.1.6.3
FP7-2009-1-244132

Climate Change Impacts on the Marine Environment: Research Results And Public Perception

Climate Change and Marine Ecosystem Research Results

Deliverable No. 1.1

Inventory report of relevant research and their outputs

Part of Task 1.1

Identification of relevant research and their outputs

Report prepared by: Jan-Bart Calewaert, Marieke Desender, Dina Eparkhina and Niall McDonough for Marine Board-ESF

Contents

Introduction

The CLAMER project and its core objectives

The CLAMER project builds upon the concept that there is a gap between what is known through research and what policy makers and the public know and understand about the impacts of Climate Change on the Oceans; and that this gap needs to be filled to help catalyse the formulation and acceptance of necessary mitigation and adaptation measures for the marine environment.

The overarching aim of the CLAMER project is to raise the awareness of citizens to EU research results on the impacts of climate change on the marine environment, including the socio-economic consequences of such impacts. The core objectives of the CLAMER project are:

1. To assess and summarize state-of-the art knowledge and public perception of EU research on climate change impacts on the marine environment, including the socio-economic consequences;
2. To organize an international conference to promote and exploit EU research results related to climate change impacts on the marine environment and address public perception;
3. To organize additional outreach events and activities to obtain wide and balanced information and participation from affected European countries and beyond.

Why this inventory report?

This report constitutes the first deliverable of the CLAMER project. It provides an overview of primarily European research projects that have significantly contributed to (or are expected to in the future) our understanding of the impacts of climate change on the marine environment. Such an overview does not yet exist. Various catalogues and databases are available which document EU-funded research on climate change in general or which provide information on marine science research specifically, but not in conjunction. A project that aims to valorise European research efforts to close the gap between what is known by science and what the public perceives and understands about climate change impacts on marine ecosystems needs to start with a good overview of past and ongoing research efforts on this subject.

This report is important, firstly as a basic information source in support of other tasks and deliverables within the CLAMER project by identifying relevant European projects and research results. The information it provides is particularly useful for the development of the CLAMER Synthesis Report (Task 1.2) and the evaluation of the successes and/or failures of earlier 'outreach' programmes (Task 2.1). Secondly, this report also provides relevant information for anyone interested in climate change research particularly with respect to its impacts on the marine environment, including scientists, policy makers/advisors, industry stakeholders and the public at large. For this reason, the report will be made available on the project website and widely disseminated through the CLAMER partner networks for all interested stakeholders.

Approach and Methodology

This report contains information on past (dating back to 1998 to include FP5 and FP6) and current research with a focus on EU funded projects and programmes. Important non-EU funded pan-European (e.g. as funded by ERA-NETs and projects under the ESF-EUROCORES scheme), regional and international initiatives of relevance are also included in the overview.

The list of research projects and initiatives in this inventory was collated using an electronic questionnaire inviting correspondents to provide key information on relevant projects such as project title, acronym, geographic and thematic scope and funding source. Aside from CLAMER project partners and stakeholders identified by the consortium, the Marine Board-ESF (Partner 2), sent the questionnaire by e-mail to its extensive listing of pan-European contacts at national funding organizations (many are direct members of the Marine Board or ESF) and to relevant EC contacts. In total, the inventory questionnaire was sent out to 409 contacts (including 30 Marine Board-ESF Delegates, 17 Project Partners and 362 external contacts) which yielded 31 positive returns. This resulted in an initial list of 225 unique research projects and initiatives which was subsequently complemented with information gathered using desktop research and drawing from all available information sources. Those information sources consulted included EC and other project databases (e.g. EurOcean webportal http://www.eurocean.org/ and MarinERA database), EC reports and research catalogues (e.g. FP5 and FP6 catalogues on Climate change research) and output reports and web-portals of the identified research initiatives. A total of 286 unfiltered unique research initiatives of relevance were identified (8 ERA-NET funded projects, 1 ESF EUROCORES, 24 FP5 projects, 52 FP6, 25 FP7, 25 International projects, 3 INTERREG projects and 133 National research initiatives).

Box 1. Additional online European research project information sources

- Cordis: http://cordis.europa.eu/
- Eurocean webportal and MarinERA database: http://www.eurocean.org/
- European Directory of Marine Environmental Research Projects (EDMERP): http://www.seadatanet.org/Metadata/EDMERP
- VLIZ Integrated Marine Informations System (IMIS): http://www.vliz.be/imis
- Website of European Commision DG Environment: http://ec.europa.eu/environment/index_en.htm
- Website of European Commision DG Research and Innovation: http://ec.europa.eu/research/index.cfm?pg=dg
- Open Access Infrastructure Research for Europe (OpenAIRE): http://www.openaire.eu/

Many of the projects identified through the questionnaire or reviewed in the catalogues were not directly relevant to the CLAMER context or had only a very a minor marine or climate change component. Thus to aid the compilation of this inventory report, each project was reviewed and a selection was made based on the following criteria:

1) Research scope: initiatives with research results that contain some aspect of impact, adaptation and/or mitigation related to the impacts of climate change on the marine environment and/or their socio-economic consequences
2) Time scope: only research from 1998 onwards (up to and including research ongoing in 2010)
3) Geographic scope: research with a regional or European scope, or major global and international remit if European researchers participated

As a result, this inventory report contains summary information and contact details about a total of 92 pan-European projects (79 of which were funded by EU Framework Programmes 5, 6 and 7) and 5 international initiatives. The EU-funding contribution of the Framework Programme projects in this inventory alone totals well over 300 million euro. These projects range from smaller one partner projects (e.g. for Marie Curie Actions) to large scale collaborative research projects with up to 74 partners from 20 different countries. Germany, France and United Kingdom are most frequently providing coordinatorship of these EU project.

Information on projects which did not meet the above mentioned criteria and were thus not included in this inventory, was nonetheless retained on file and is available to the project consortium through internal dissemination mechanisms. In addition, links to more information for 48 indirectly relevant research initiatives or research projects that were expected to start soon after the report was completed are given at the end of the report.

Limitations and future improvements

This report provides summary information on research projects and initiatives and their results which were identified as relevant in the CLAMER context. A thorough analysis of the collected information was beyond the scope of this task. Nevertheless, the inventory report provides valuable insight into the European effort and funding dedicated specifically to research on the impacts of climate change on the marine environment in the last decade, and it would be it would therefore be of interest if the European Commission DG Research would systematically compile and regularly make available (e.g. every 3-4 years) a similar overview of research it is funding in relation to climate change impacts on the marine environment. This would amongst others allow to follow up if the identified research gaps are adequately filled over time.

In many cases and for various reasons it proved difficult to source project information. For example, when a project was described in a project catalogue, the information was often incomplete or outdated. Additional information from project websites was often difficult to find, in particular in relation to project outputs and results and final project reports. Some notable exceptions include the FP Projects EUR-OCEANS, CARBOOCEAN, HERMES/HERMIONE and international programmes such as CLIVAR and GLOBEC which maintain very informative project sites and which make project reports and other material readily available for download. However, in many cases, key information and final reports were not freely accessible from project websites or from CORDIS, even for projects which had been long completed (e.g. FP5). For example, the CORDIS website often contained only very basic information, if any, or often provided several different returns on a search for the same project, each providing different types of information. At the same time, many project websites do not provide essential information such as the start or end date of the project so that it is not clear whether the project is still running or not; others websites do not even mention the funding source.

Where information was not available through databases and websites, the project Coordinator was contacted, but again with mixed success. In some cases, the project coordinator provided final project reports and additional information products. Moreover, several projects which have been completed for some time no longer support a website that is accessible or maintained. It would be beneficial if EC project coordinators were contractually obliged to maintain project websites, including gathered data, reports and dissemination products, for at least five years following completion of the project, after which the European Commission should secure its long term availability.

The CLAMER project is meant to reach out to the wider public and bridge the gap between scientific research and the public at large (in this case in relation to climate change and marine ecosystem research in Europe). We can conclude that while there are many good examples of project websites and available information sources, often project results are not even available (or only fragmented) to other scientists. It is clear, therefore, that there is a poor flow or transfer of knowledge and findings from EC funded projects to end users, and in particular to the public at large. This has been identified as a major constraint which needs to be addressed as a matter of urgency.

Box 2. Key Recommendations resulting from the development of the CLAMER Inventory Report

- Systematically and regularly compile and make available an overview of research funded by the European Commission DG Research and Innovation on climate change impacts on the marine environment.
- Develop a clear, compulsory and formal mechanism for submitting and making available foreground information resulting from EU-funded research projects. This is needs to improve upon the current system of making available project information and outputs.
- Create one single well-branded report series which regularly publishes EU-project descriptions and research results and task a responsible entity to manage it, either within or under supervision of the European Commission. Coordinators should be contractually obliged to provide contributions for the report series.
- Develop and manage a unique project referencing system which can be used by project researchers when they publish their results. This would create more visibility for the projects and EU-investments while allowing research outputs associated with projects to be tracked more easily.
- Set-up and widely advertise a self-regulating/updating EU-Project-WIKI as a new tool to submit, update and consult relevant EU-funded project information.
- The European Commission DG Research and Innovation needs to set the minimum information that is required on project websites and contractually oblige project coordinators to include this information. We recommend that project websites should contain at least key project data such as that provided for individual projects in this report (start/end of the project; funding source and amount; duration; project coordinator; etc.), the list of project partners with contact details of the researchers involved; and a description of the project with specific reference to its outputs. It is strongly recommended that all project deliverables should be made directly available on the project website.
- Contractually oblige project-coordinators to maintain a project website, including gathered data, reports and dissemination products, for at least five years following completion of the project.
- Improve the coordination and thoroughly streamline potential new (e.g. EU-project WIKI) and the many already existing tools (project websites, catalogues, research magazines, project databases, etc) to generate a more efficient flow of information from EU-funded research to all stakeholders including other researchers, as well as research managers, policy makers and the public at large. This is needed to avoid duplication of effort and fragmented availability of the EU-funded research initiatives and their outputs.

Disclaimer

This report was compiled using various electronic and printed information sources. For some projects and initiatives the consulted sources provided different and occasionally conflicting summary information and results. In these cases, information from the most official source was retained (EC CORDIS website or project websites). However, users of this inventory report should be aware of its limitations and keep in mind that the some of the summary information presented might not be fully up to date, complete or accurate depending on the available information.


FP5

6C - Carbonate chemistry, carbon cycle and climate change

Summary information

Funding source:	FP5 – Research project
Total Cost:	€ 2.389.796
EC contribution:	€ 1.652.751
Start – end date:	1/11/2002 – 31/10/2006
Duration:	48 months
Project Coordinator:	Jelle Bijma (jbijma@awi-bremerhaven.de)
Organisation:	Alfred Wegener Institute for Polar and Marine Research (AWI) – Germany
CLAMER thematic focus:	Ocean acidification
Project keywords:	Carbonate chemistry; Climate change; CO2; Carbon Cycle; Isotopes; Trace elements; Biomarkers

Project Website:
http://www.awi.de/en/research/research_divisions/biosciences/projects/c6/

Project Partners

1 Alfred Wegener Institute for Polar and Marine Research - Germany
2 University of Southampton – United Kingdom
3 University of Cambridge – United Kingdom
4 Universitaet Muenster - Germany
5 Royal Netherlands Institute for Sea Research - Netherlands
6 Université de Liège – Belgium

Background information

Project Summary

Problems to be solved
The mechanism(s) responsible for lower atmospheric pCO_2 during the Last Glacial Maximum (LGM) and possible feedbacks with climate change are still unresolved. Without a properly implemented natural relationship between the global carbon cycle and climate change, model predictions of future climate scenarios due to anthropogenic CO_2 release are doomed to fail.

Abstract
Among the most important challenges remaining to be addressed by Quaternary paleoceanographers is the mechanism responsible for lowering pCO_2 during the Last Glacial Maximum (LGM) and possible feedback mechanisms with climate change. Our main objective is to use a multi-proxy approach in order to reconstruct the oceanic carbonate chemistry over the past 130,000 years. In combination with numerical models this will allow us to (1) distinguish the mechanisms that control the operation of the oceanic carbon cycle; (2) identify water masses as sinks or sources of atmospheric CO_2; and hence (3) better constrain the role and the impact of the carbon cycle on climate oscillations. Knowledge of the nature and amplitude of *natural fluctuations* in the past are a precondition to assess the stability of modern subsystems and their potential range of variations in the future.

Objectives
The overall objective of 6C is to hind-cast the processes that control the natural inter-relationship between the variation in atmospheric pCO_2 and climate change on glacial-interglacial (G-IG) time scales (by reconstructing temporal and spatial changes in the ocean carbonate chemistry) and to quantify and predict changes in atmospheric pCO_2 on anthropogenic time scales (by quantifying the negative feed-back of pelagic calcifiers).

Project Outputs

Scientific Achievements
During the course of 6C, the project researchers used a multi-proxy approach to reconstruct the oceanic carbonate chemistry and understand the natural relationship with the global carbon cycle. One important component was the development of new tools for reconstructing environmental parameters. The other was to combine analytical records of the sedimentary archive (combining several proxies) in combination with numerical models in order to (1) distinguish the mechanisms that control the operation of the oceanic carbon cycle; (2) identify water masses as sinks or sources of atmospheric CO_2; and hence (3) better constrain the role and the impact of the carbon cycle on climate oscillations. Knowledge of the nature and amplitude of natural fluctuations in the past are a precondition to assess the stability of modern subsystems and their potential range of variations in the future.

The development of the envisioned “foram paleobarometer” did not work because the organic matter contained in fossil foraminifera did not include symbiont specific compounds. In addition, the project did not reach the desired precision and accuracy for “single shell boron isotope analysis” required to reliably approximate bottom water pH. However, one should be optimistic that this will be possible in the near future.

The project has combined multiple proxies (boron isotopes, B/Ca, Mg/Ca, Cd/Ca and alkenones) to study sediments from the northern Arabian Sea and was able to demonstrate that the magnitude of CO_2 degassing from this area increased significantly at ~18 ka, and may thus have played an important role in initiating the rise in atmospheric CO_2 levels at the start of the last deglaciation.

It is generally accepted that the oceans were instrumental in regulating glacial-interglacial changes in atmospheric CO_2, but there is uncertainty over past changes in the location and magnitude of oceanic sources and sinks of CO_2. Our reconstructions indicate that the northern Arabian Sea has been a source of CO_2 to the atmosphere since 30 ka. The $\delta^{11}B$ and B/Ca proxies further suggest that this source (and the intensity of upwelling) increased in intensity from the last glacial maximum to the Holocene. This hypothesis accords with findings from most other studies of the region that suggest the summer monsoon was less intense in the LGM as the Tibetan plateau was heated less strongly at this time. Around ~18 ka the change from relatively low pCO_2 values to higher pCO_2 values is coincident with the start of the rise in atmospheric CO_2 during the last deglaciation. In this context it is noteworthy that it has been observed that the mean effective moisture levels from the Asian monsoon margin started to increase between 18.5 and 17 ka, suggesting that this may represent onset of the summer monsoon after the LGM. Hence, intensification of upwelling in the Arabian Sea and degassing of CO_2-rich surface waters may well have played a role in the increase in atmospheric CO_2 that was further enhanced by increased La Niña-type conditions in the equatorial Pacific between ~14-16 ka.

Although much progress has been achieved with regard to all 3 objectives stated above, we cannot answer objective 1 and 3 as detailed as we had hoped at the beginning of the project. Addressing these objectives requires to fully reconstruct the carbonate chemistry of the global ocean. Hereto, planktonic foraminiferal proxies would constrain the chemistry of the surface water and benthic foraminifera would be used to determine the bottom water chemistry. However, several proxies turned out to be influenced by more environmental parameters than just the target parameter. For instance, the project proposed to use “size normalized weight” (SNW) of planktonic foraminifera as an estimator for bottom water carbonate ion concentrations. Unfortunately, the project results lead to the conclusion that “cryptic speciation” in planktonic foraminifera may mask the true bottom water values and that SNW is therefore not a reliable proxie. In addition, the project did not reach the desired precision and accuracy for single shell boron isotope analysis

required to reliably approximate bottom water pH. Both of these drawbacks made it impossible to reconstruct the bottom water carbonate chemistry. Since "down core" bottom water carbonate chemistry estimates along depth transects of critical ocean areas are the only means to distinguish between the processes that gave rise to the observed changes (physico-chemical carbon uptake or release versus the organic carbon pump or the alkalinity pump) and since, it is also the only way to reconstruct lysocline dynamics, we are currently unable to fully address two of the main objectives that remain the "Holy Grail" for future climate change predictions.

The project proposed and investigated the possible feedback of decreased calcification potential of planktonic calcifiers to increased anthropogenic CO_2 production and hence ongoing ocean acidification. Although, the impact will be relatively small on short time scales, it has to be taken into account on longer timescale (Ridgwell et al., 2006).

Socio-economic relevance and policy implications
The results and conclusions at the end of the project aid us in the understanding of the natural controls and feedbacks between the carbon cycle and global climate change. Eventhough, we were not able to reconstruct the complete carbonate chemistries as initially anticipated, is the increased understanding of the natural inter-relationships (a prerequisite to project possible future climate change scenarios) a relevant issue to society as a whole and for policy makers in particular. It is anticipated that through personal contacts with writers of the IGBP reports our results and conclusions will diffuse to policy makers.

Conclusions
The project has experienced some drawbacks and a one year no-cost extension has been granted. Despite the extra time, however, several proxies turned out to be unreliable (SNW), impossible (paleobarometer) or could not be developed with sufficient accuracy and precision ($\delta^{11}B$ on single benthic foraminiferal shells). Therefore it was impossible to meet all deliverables set out in the original proposal. Yet, significant variations of the carbonate system have been documented (e.g. surface water pH), and as the data sets are completed, this project has contributed to a better knowledge of the natural inter-relationship between the marine carbon cycle and climate change. Finally, it should be noted that several new new programes and many new project have been initiated by the consortium and that 6C keeps on producing new and exiting results.

Project results
A list of publications can be found on the project website (see above) and several abstracts are available from the cordis website at http://cordis.europa.eu/.

AICSEX - Arctic Ice Cover Simulation EXperiment

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 2.424.255
EC contribution:	€ 1.700.000
Start – end date:	1/01/2001 – 1/03/2004
Duration:	38 months
Project Coordinator:	Ola M. Johannessen (ola.johannessen@nrsc.no)
Organisation:	Nansen Environmental and Remote Sensing Center, Bergen (NERSC) – Norway
CLAMER thematic focus:	Temperature changes; ice melting; freshwater inflow; socio-economic impacts
CLAMER regional focus:	Arctic; Baltic Sea

Project Website:
http://www.nersc.no/AICSEX/

Project Partners

1 Nansen Environmental and Remote Sensing Center – Norway
2 University College London, Centre for Polar Observation and Modeling – United Kingdom
3 University of Cambridge, Department of Applied Mathematics and Theoretical Physics - United Kingdom
4 Université Paul Sabatier - France
5 Finnish Institute of Marine Research - Finland
6 Foundation for Research in Economics and Business Administration - Norway

Background information

Project Summary

Objectives
The overall aim of AICSEX is to compare the natural variability and trends during the last century, for selected observed climate sensitive variables and coupled global/nested climate models, in order to assess the model capabilities for prediction of climate changes in the Arctic, Nordic and Baltic Seas in this century. In the last period, the project focused on completing the simulations and assessing the performance of the models used. Furthermore, the economic impact of a melting Arctic ice cover was assessed for fisheries, shipping, offshore and hydroelectric energy industries through a project dedicated industrial users reference group.

Project Outputs

Scientific achievements
The work on AICSEX has resulted in the following achievements:

- New data sets for surface air temperature and multiple sea ice parameters in the Arctic and its regional seas, as well as new data sets for snow cover and river runoff in Eurasia.
- New knowledge of the spatial and temporal variability of temperature and sea ice, through analyses of these new data sets.

- A new high-resolution coupled Atmosphere Ocean General Circulation Model (AOGCM) for the Arctic and its regional seas.
- A new coupled model (physics-biology-geochemistry) for carbon cycle simulations for the Arctic and its regional seas.
- An assessment of the economic impact of climate change on important sectors such as fisheries, offshore industry and energy market.

In addition a number of journal papers have been submitted to refereed journals. The list of publications can be found on the project website.

A list of publications can be found on the project website. The project brochure and other materials are protected by login and password.

Socio-economic relevance and policy implications
Improvements in our ability to detect and predict regional climate and environmental change patterns improve our understanding of the various possible impacts on economic activity following changes in climatic conditions. In a long-term perspective, climatic changes will indirectly or directly bare consequences for all economic activity on a global scale. Such changes will impact consumer and producer behaviour in a wide range of markets. Change in weather conditions will give rise to change in housing requirements etc. However, the impact may first be seen in markets and economic activity directly related to the geographic areas where the changes are most distinctive. The impact will probably be first seen in economic activity in the north-east Atlantic. Several European economic activities are dependent upon the climatic conditions in this area: fisheries, marine transport and energy resources, including hydroelectric power production.

AICSEX has been dedicated to the determination of variability and trends for climate sensitive variables. Furthermore, we have used models for prediction of variables in order to assess if abrupt changes of the sea ice cover of the Arctic and Baltic Seas will occur in this century. Climate change is an international issue of great relevance and significance across Europe and beyond. Climate and ocean phenomena and their variability transcend national boundaries, as do their effects on the environment. European climate is associated with regional atmosphere-ocean variations. The inter-relationships between these phenomena and the variability of e.g. sea ice and run-off are certainly manifested on a regional scale. Climate changes are anticipated to be heterogeneous across Europe. Because of positive feedback mechanisms in the Arctic, the northern European regions are expected to be more affected by climate change and their marginal environment more susceptible to its effects.

AICSEX's contribution to European policies is manifold. First, it contributes towards expanding European scientific expertise in global climate change research in Arctic and sub-Arctic regions. It provides more definitive and convincing evidence ("fingerprints") of natural variability and anthropogenic climate change for the high latitudes of the Northern Hemisphere. Europe needs to have a clear view of what is happening with global warming in global climate change policy-making, e.g. input to IPCC and Kyoto type protocols. Second AICSEX contributes towards determining, understanding, assessing and predicting climate change patterns that influence the European environment, which impact on e.g. fisheries, marine transportation, water resources and off-shore oil industry in the Arctic and sub-Arctic region. Therefore the results of AICSEX are useful for European policy makers.

Conclusion:
A number of major publications from the project have been completed. The main conclusions are:

First, we theorise that the Arctic warming in the 1920s-1930s and the subsequent cooling until about 1970 are due to natural fluctuations internal to the climate system. Second, we believe there are strong indications that natural processes alone can explain neither the warming trend nor the decrease of ice extent and volume over the last two decades. Third, the state-of-the-art ECHAM4 (WP6) and HadCM3 coupled climate models both predict a dramatic decrease of the ice cover, which could result in a nearly ice-free Arctic Ocean during summer at the end of this century.

Though a climate change may shorten the ice season in the Baltic Sea, the natural variability will still be large. Even in the future in terms of decades, there is a need to be prepared for severe ice conditions. The overall tendency towards milder ice winters in the northern Baltic Sea does not necessarily mean that every winter would be mild and, in terms of winter navigation, easy. Considerably year-to-year variability in ice conditions are still to be expected.

Over the last 20 years passive microwave satellite data exhibit significant decreasing trends in snow extent found in Eurasia and North America, especially after 1988. The computed linear trends show a marked difference between North America and Eurasia, with a larger decrease in Eurasia than in North America. This tendency is confirmed when analysing the trends in the spring timing of the snow pack disappearance. Spatio-temporal variability is pronounced during the spring melt period. In most parts of Eurasia and the central and western parts of North America, the tendency has been for earlier snow melt. However, a large region in North-Eastern Canada exhibits a cooling trend with the spring snow pack disappearing later now than 20 years ago.

In situ and satellite-derived estimations of the Ob' river discharge at Salekhard (Russian Federation) has been compared and it is shown that Topex/Poseidon data can be successfully used for hydrological studies. The accuracy of the water discharge is good enough to estimate the daily, monthly discharges and annual water flow with an average error of 5%. For mean monthly discharges, the average errors increase to 15%, mostly due to the scarcity of valid Topex/Poseidon observations during some periods and cater discharge overestimation during the water depletion period in August-October. The introduction of new re-tracking algorithms for computing the river level will significantly increase the accuracy of the discharge estimates.

The Arctic is extremely vulnerable to observed and projected climate change and its impacts. The Arctic is likely to experience more rapid and severe climate change than any other region on Earth. Over the next 100 years, climate change is expected to contribute to major physical, ecological, social and economic changes, many of which have already begun. Changes in polar climate will also affect the rest of the world through rising sea levels and increase warming of lower latitudes. Reduced sea ice cover will increase shipping opportunities and access to resources. Marine and terrestrial animal species' diversity, ranges, and distribution are likely to change, some dramatically. Also, the production of hydropower will change with changed patterns of precipitation and temperatures.

A partial equilibrium model for the Nordic electricity market has been developed. The model comprises 9 regions of which 6 are endogenous Nordic sub-markets (2 Norwegian, 2 Danish, 1 Swedish and 1 Finnish) while 3 are exogenous regions (Russian Federation, Poland and Germany). All explicit production takes place in the internal regions while the external ones only exchange power with internal regions at fixed home market prices. There are no other limits set to the external supply than the transport capacities. The model operates at regional wholesales level, and simulates a full year production and consumption with the year divided into 24 periods, covering 12 months with two load sessions (high and low) for each. The model has been successfully tested in a plain, unconstrained version, but further work is needed to handle cases where water constraints are imposed.

AICSEX has contributed to a better understanding of the climate in the Arctic and its regional seas, by synthesising and analysing new and comprehensive data sets for key parameters like surface air temperature, sea ice thickness and extent, snow cover and river runoff. AICSEX has also improved the climate prediction capabilities by developing new high-resolution atmosphere-ocean-sea ice and coupled models for carbon cycle simulations.

ASOF-N - Arctic Sub-Arctic Ocean Flux array for European Climate: North

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 3.773.650
EC contribution:	€ 1.885.078
Start – end date:	1/01/2003 – 31/03/2006
Duration:	39 months
Project Coordinator:	Eberhard Fahrbach (efahrbach@awi-bremerhaven.de)
Organisation:	Alfred Wegener Institute for Polar and Marine Research (AWI) – Germany
CLAMER thematic focus:	Ocean current changes; deep circulation changes; freshwater inflow
CLAMER regional focus:	Arctic; North Atlantic

Project Website:
http://www.awi.de/en/research/research_divisions/climate_science/observational_oceanography/projects/asof_n/

Project Partners

1 Alfred Wegener Institute for Polar and Marine Research - Germany
2 University of Hamburg, Institute of Oceanography, Center for Marine and Climate Research - Germany
3 Institute of Marine Research - Norway
4 Finnish Institute of Marine Research - Finland
5 Polish Academy of Sciences, Institute of Oceanology - Poland
6 Université Pierre et Marie Curie, Laboratoire d'Océanographie Dynamique et de Climatologie - France
7 Norwegian Polar Institute - Norway

Background information

Project Summary

Objectives
The main ASOF-N objective is to establish the components of the global observing system in choke points of the Nordic Seas to determine the fluxes between the Arctic Ocean and the North Atlantic and to understand and predict how they respond to climatic forcing. To achieve this goal long time series are needed. For this purpose the main tasks were to perform the field measurements with a special focus on setting up of the long term measuring arrays of moored instruments and floats:

- WP 1 'Atlantic water pathways' - measurements of the track lines of Atlantic water flow by floats and mapping horizontal distributions of the Atlantic water properties;
- WP 2 'Fluxes across the western Barents Sea' - measurements by the mooring array in the Barents Sea opening and carrying out the hydrographic sections;
- WP 3 'Heat flux through Fram Strait' - currents and temperature measurements by the mooring array in the eastern and central Fram Strait and the high resolution vertical section of temperature and salinity across the strait;
- WP 4 'Freshwater flux through Fram Strait' - currents and temperature measurements by the mooring array in the western Fram Strait and the high resolution vertical sections of temperature and salinity across and along the strait.

The tasks included analysis of data sets, obtained during field measurements in WP1, WP2, WP3 and WP4 in the first year of the project. The objective of WP5 'Data Management' was to provide access to the project data and the actual status of field and modelling work and to organize the data flow to the project data centre from all partners. The WP6 'Integration and Synthesis' aimed to develop the adequate water mass classification for Fram Strait including a description of time evolution of the water mass properties and regional correlations between the observed variables.

Project Outputs

Scientific achievements

The field work carried out provided repeated hydrographic surveys including vertical sections of temperature and salinity in the observation area (Barents Sea, Greenland Sea, Fram Strait). The ASOF-N mooring arrays maintained during the project provided time series of fluxes in the Barents Sea opening and across Fram Strait. The analysis of the data obtained during ASOF-N in combination with data measured before ASOF-N permitted to describe the longer term variability of the oceanic conditions in the ASOF-N area. On this basis time variability of the water mass properties, heat and volume fluxes were estimated for the three-year long period and beyond. In combination with historical data a nearly decadal time series of fluxes resulted. The variability of volume, heat and freshwater fluxes was analyzed on different time scales from daily to interannual and nearly decadal ones. The contributions of local and remote forcing to the temporal and spatial changes of flow and temperature fields were estimated, giving the insight into the relationship between variability of forcing and of fluxes. High resolution numerical models for the western Barents Sea (NPI) and the Greenland Sea, Fram Strait and Arctic Ocean (AWI) were implemented and runs covering the ASOF-N period were completed. A refined water mass classification for Fram Strait was derived and the possibility was explored to compute the time evolution of heat and salt fluxes through Fram Strait. Variable assessment of the observational system performance during the deployments resulted in a data return of about 90% during the final phase of the project.

A list of publications can be found on the project website.

Socio-economic relevance and policy implications

Variability of the ocean circulation and the water mass distribution in the Nordic Seas lead to changes in the volume, heat and freshwater fluxes between the Arctic Ocean and North Atlantic. Changes in these fluxes can have a strong influence on the role of the ocean in the climate system which includes the potential of abrupt climate changes. The climate variability in particular in the northern North Atlantic has a strong impact on the living conditions in Northwest Europe. This includes energy consumption, sea traffic and marine living resources. Therefore a reliable prediction system is of high value to maintain the present living conditions. Prediction requires understanding and modelling of the relevant processes and monitoring key parameters to validate and constrain the models. Since variability of the relevant time scales can be only studied on the base of the long-term time series, ASOF-N aimed to pave the way towards an observing system consisting of a cost effective array of instruments in the key areas for the exchanges between the North Atlantic and Arctic Ocean. The results of ASOF-N will help to design such a system, to give advice for its implementation and consequently contribute to maintain the quality of life in Northwest Europe.

Results from ASOF-N gave background information to the scientific report from the Arctic Climate Impact Assessment (ACIA) published in 2005 which is a project of the Arctic Council and the International Arctic Science Committee (IASC) a high level intergovernmental forum. The ASOF-N results are included into reports to ICES (the International Council for the Exploration of the Sea), which gives advice to the member countries and helps them manage the North Atlantic Ocean and adjacent seas. ASOF results are a contribution to the formation of the EU-Integrated Project DAMOCLES standing for Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies. ASOF results underline the need for a sustained observing system in the Arctic and Subarctic regions in the framework of the Global Ocean Observing System (GOOS) and the Global Climate Observing System (GCOS) which can be maintained beyond the time of individual research projects.

Conclusion

The evaluation of the available historical data together with the results of the ASOF-N field measurements and modelling results revealed a significant warming of the Atlantic Water propagating through the ASOF-N region and an increased heat flux into the Arctic Ocean. The data indicate that variations of the fluxes between the North Atlantic and the Arctic Ocean occur on a wide range of time scales and are interlinked between the main passages. The volume and heat fluxes are also controlled by local and remote atmospheric forcing. Both in the Barents Sea Opening and Fram Strait variability of temperature is independent of the variations in the volume flux. The former is dominated by advective processes and depends mostly on the upstream conditions while the latter is related to the local atmospheric forcing. Observed variations in the Atlantic Water pathways (namely intensification/ weakening of the branches of the Norwegian-Atlantic Current) result in the redistribution of the Atlantic Water in Fram Strait and strongly influence the heat transport into the Arctic Ocean. All these changes occur over long time scales and only quasi-continuous measurements over a decade and more give a chance to identify the nature of these fluctuations. Lacking spatial resolution is a problem in spite of the fact that the major parts of the transports occur in relatively narrow boundary currents. Technical problems with the present day equipment lead to redundancy of equipment. New technology available to replace conventional instruments on an operational basis is under development and a design of optimized observational array has been worked out on the basis of the ASOF-N experience.

ASOF-W - Arctic Sub-Arctic Ocean Flux array for European Climate: West

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 1.987.679
EC contribution:	€ 1.333.081
Start – end date:	1/02/2003 – 1/08/2005
Duration:	30 months
Project Coordinator:	Jens Meincke (meincke@ifm.uni-hamburg.de)
Organisation:	University of Hamburg, Institute of Oceanography – Germany
CLAMER thematic focus:	Ocean current changes; deep circulation changes; freshwater inflow
CLAMER regional focus:	Arctic; North Atlantic

Project Website:
http://www.ifm.zmaw.de/projectsites/eu-finanziert/beginn-2003/asof/project-summary/?no_cache=1&sword_list%5B%5D=ASOF-W

Project Partners

1 University of Hamburg, Institute of Oceanography - Germany
2 The Marine Research Institute of Iceland, Division of Oceanography and Ecology - Iceland
3 The Scottish Association for Marine Science, Dunstaffnage Marine Laboratory - United Kingdom
4 Department for Environment, Food and Rural Affairs, Cefas Lowestoft Laboratory - United Kingdom
5 Finnish Institute of Marine Research - Finland

Background information

Project Summary

Abstract
This project centred on the fact that the climate of NW Europe, the Nordic Seas and Scandinavia is already abnormally warm for its latitude, and is correspondingly sensitive to change in the factors that are responsible for it. We expect that the changes of climate in this sector may be both rapid and radical as we move from the most extreme development of the atmosphere driving in the 1990s to what must surely be the most extreme anthropogenic contribution to climate change in the next Century. Learning how to mitigate the socio-economic effects of these changes requires the development of believable predictive models of the main processes at work. A central requirement for model improvement is the availability of time series measurements of the oceanic heat and freshwater exchanges between the Arctic and the North Atlantic.

Objectives
The spread of warmth to high latitudes in the Atlantic sector is due to a complex ocean-atmosphere interaction, which includes a vast amount of heat (about 1015 W) carried northward by the ocean's Thermohaline Circulation (THC). There is growing concern that "global warming" will be accompanied in our sector by strong regional cooling across Northwest Europe and Scandinavia due to slowing of this THC loop. This disruption is likely to take effect through the processes that control the deep overflows of dense water, which drive the THC, and the surface freshwater fluxes from the high Arctic that are supposed to shut it down. The North Atlantic Oscillation (NAO) as the main mode of recurrent atmospheric behaviour in our sector is

heavily implicated in these changes and is predicted to amplify with future greenhouse gas forcing. For this reason, the ASOF-W Project has been designed to meet the following overall objective:

To measure the variability of the dense water and freshwater fluxes between the Arctic Ocean and the North Atlantic in the critical location off Southeast Greenland with a view to understanding and predicting their response to climatic forcing, especially to the NAO.

Clustering of ASOF-W with the two parallel EU FP 5-projects ASOF-N and ASOF-E has assured, that the time-series measurements cover all of the fluxes through the Nordic Seas in a synoptic manner. This effort on the European side has prompted parallel field activities in North America for covering fluxes from the Arctic through the Canadian Archipelago into the North Atlantic.

The approach:
Time series measurements have been carried out on the shelf and the slope off Southeastern Greenland by means of two arrays of sensors for currents, temperature and salt to obtain fluxes and flux-variability of the dense Denmark Strait overflow and the freshwater export from the Nordic Seas to the North Atlantic. The overflow measurement array over the slope has been successfully installed during the EUVEINS project and has been extended to a decadal record by this project. The measurement of the freshwater flux on the shelf in the liquid phase has never been achieved directly before the start of this project. Novel instrumentation has been developed and was deployed in a shelf array to measure the profiles of water speed, temperature and salinity from the drift ice covered surface layer to the bottom.

Project Outputs

Major results:
The need to resolve the problem of fluxes and flux-variability arises from the fact, that it is now that the atmospheric driving of the northern North Atlantic has seen the strongest signals ever recorded in the time scale range from interannual to decadal. The response to these signals is presently propagating through the high-latitude oceanic-system and has just begun to affect the headwaters of the deep limit of the Atlantic THC. If we had not instrumented the key locations along the paths of these changes, we would have lost the rare opportunity of measuring the oceans response to atmospheric forcing in a phase of an elevated level of signal to noise ratio. This project and its European and North American partners have therefore provided benchmark observations needed to improve coupled climate models. Also provided was the necessary experience for longer-term measurements in high latitude ocean areas in the context of a future ocean observing system. Major results from ASOF-W are listed as follows:

Despite losses of equipment imposed by the hazardous nature of the East Greenland shelf, a prototype ASOF-W freshwater flux array has been established and maintained beneath a highly variable ice cover. A first liquid freshwater flux estimate yielded a mean value of 2.000 km^3/yr with a standard deviation of the daily mean estimates of 1.200 km^3/yr. This number fitted well into a newly compiled estimate of freshwater fluxes in the Arctic and Subarctic Seas, based on the most recent data available to the project. The freshwater array is continued beyond the duration of the actual project to provide this much needed time series to the upcoming International Polar Year 2007-9 with its activities on the role of the Arctic in the hemispheric water cycle.

The project continued the time series of direct transport measurements of the dense Denmark Strait overflow with a "picket fence" array of 6 to 8 current meter moorings over the East Greenland slope at 64° N. This array was paired with a bottom-mounted acoustic profiling current meter maintained at the Denmark Strait sill some 500 km upstream. In addition, coupled ocean circulation models with realistic atmospheric forcing were run. The mean transport value from altogether 9 years of array data was calculated to be $4.0 \pm 0.4 \times 10^6$ m^3/s with no trend on the decadal time scale and with no correlation to the parallel transport fluctuations of the overflow branches east of Iceland. Significant temperature and salinity signals were recorded with the moored sensors, notably in 1999 and 2004. They could be traced from upstream in the Nordic Seas to downstream to the Labrador Sea, providing information on how atmospherically induced surface anomalies in the high latitudes are advected into ocean depths exceeding 2.500 m in the Subpolar seas to the southwest of the Greenland-

Scotland Ridge, i.e. the deep headwaters of the THC. As with the freshwater array, the dense overflow array will be continued through the IPY.

From a total of 9 years of hydrographic sections worked between the Denmark Strait and the southern tip of Greenland we could provide time series of the downstream development of geostrophic transports of the dense overflow and changes of its water mass characteristics. The transport estimates agree well with the results from the moored array. From the water mass analysis the persistence of stratification along the overflow plume indicates lesser entrainment rates with the ambient waters than assumed so far.

The project included a component for the final development, the testing and the field use of a profiling temperature-salinity probe, operated from a bottom mounted winch. Despite considerable engineering progress with the system and ample field campaigns, no scientifically usable data could be obtained. The prototype continues to be improved. Once operational this instrument is considered ideal for under-ice profiling of shelf waters.

In a synthesis of the project data the observed variability set the local data into the context of the large-scale climatic signals passing between the Nordic Seas and the deep Atlantic. One of the principal results from our array over a decade of continuous observations is the finding that although the transport time series show distinct interannual variability, there is no obvious evidence for any long term trend in the deep overflow west of Iceland. Models with realistic forcing confirm this. Likewise the recent analysis by the ASOF-E group of the deep overflow east of Iceland over the full record from 1995 to 2005 shows neither evidence for any long term downturn in transport nor an inverse relation to the overflow transports west of Iceland, which is in contrast to earlier reports. Thus we find no evidence yet that deep overflow-transport is directly implicated in the recent reported slowdown of the deep limb of the Atlantic Thermohaline Circulation. Our observations of long term changes in the temperature and salinity properties of the overflows are a different matter and may well be involved in the circulation changes as reported for the lower latitudes. They are certainly involved in the observation of Atlantic-wide changes in salinity. Whereas for our Subarctic region we have analysed a decadal freshening of the ocean fluxes from the Arctic to the Atlantic, there is a corresponding salinification of the upper ocean in the subtropical and tropical regions. This indicates a significant role of the coupled ocean/atmosphere freshwater cycle in linking the high latitude ocean basin with the global ocean. Since this is one of the priority topics during the upcoming International Polar Year 2007-9 the ASOF measurement arrays and data sets provide an important platform to build on for the climate research projects of the next decade.

Project Outreach:
The overall aim of ASOF was to implement a longer term system of critical measurements needed to understand the high latitude ocean's steering role in decadal climate variability. This cannot be achieved on a regional basis but can only be met by studying the complete system of oceanic exchanges through the subarctic seas. This need was acknowledged from the outset and it was an extra workpackage added to the ASOF-W project with three main successes: (i) The three components of the European ASOF cluster (ASOF-W, ASOF-N and ASOF-E) were closely integrated by instituting task-groups for planning across all of the Nordic Seas and for establishing a system-wide Numerical Experimentation Group. (ii) An international ASOF programme was developed between the EU-groups and relevant North American groups financed through NSF and NOAA, enabling a true pan-Arctic approach to the ASOF-aim. International Steering Committee Meetings, a regular Newsletter and a website have brought together a scientific programme, which has made ASOF the largest ocean-observing network in the hemisphere for the time being. (iii) In anticipation of the upcoming International Polar Year 2007-9, a larger scale context for the ASOF effort itself was achieved by compiling a Science Plan for a pan-Arctic integrated Arctic Ocean Observing System (iAOOS), which was endorsed by the relevant international scientific organizations and accorded lead-status by the International Council of Scientific Unions Joint Committee for the International Polar Year Partners.

BALANCE - Global Change vulnerabilities in the Barents region: linking arctic natural resources, climate change and economies

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 3.471.724
EC contribution:	€ 2.872.872
Start – end date:	1/12/2002 – 1/11/2005
Duration:	39 months
Project Coordinator:	Manfred A. Lange (langema@uni-muenster.de)
Organisation:	University of Münster, Institute for Geophysics – Germany
CLAMER thematic focus:	Ice melting; temperature changes; biological impacts; socio-economic impacts
CLAMER regional focus:	Arctic; North Atlantic

Project Website:
http://balance1.uni-muenster.de/

Project Partners

1 University of Münster, Institute of Geophysics - Germany
2 SINTEF Fisheries and Aquaculture Coastal and Ocean Engineering- Norway
3 Institute of Marine Research - Norway
4 University of Utrecht, Department of Physical Geography - Netherlands
5 Royal Swedish Academy of Sciences - Sweden
6 University of Turku, Department of Biology - Finland
7 University of Cambridge, Scott Polar Research Institute - United Kingdom
8 Natural Environment Research Council - United Kingdom
9 Umea University, Department of Social and Economic Geography - Sweden
10 University of Tromsø, Norwegian College of Fishery Science - Norway
11 Max-Planck-Institute of Meteorology - Germany
12 University of Münster, Institute of Geoinformatics - Germany
13 University of Lapland, Department of Social Studies - Finland
14 University of Kuopio, Department of Social Sciences - Finland
15 UNEP-World Conservation Monitoring Centre - United Kingdom

Background information

Project Summary

Objectives
The main goal of BALANCE lies in a comprehensive, integrated assessment of the impacts of climate change on environmental and societal components of the Barents region, followed by an assessment of vulnerabilities of the various ecosystems and economies to climate change. This is pursued on the one hand through the construction of an integrated assessment model, and on the other hand through an integrated network of individual expert models that cover the different components of the Barents system (climate, marine

ecosystem, terrestrial ecosystems, economies based on natural resources). Linkages between models had to be identified and feedback runs, and subsequently expert model outputs shall enable feed-back runs of the climate model in order to assess the impact of changing vegetation and sea surface temperature on the projected climate. Major attention had been paid to data integration via Spatial Data Service (SDI), and to the development of the Stakeholder Portal (Assessment and Decision Support System), presupposing close cooperation and efficient data exchange. In order to make findings accessible results shall be broadly disseminated by various means.

Project Outputs

Scientific achievements

Based on the B2 IPCC-SRES scenario two transient climate change runs in 0.5° horizontal resolution had been carried out. As BALANCE aims to project the climate on a detailed regional scale, results from the expert models serve as input for the off-line feedback run of the climate model. Two feedback climate change runs has been performed: one based on data of projected vegetation changes from 1961 to 2099, the second one based on data of projected sea surface temperatures (SST) and on information on sea ice changes from 1995 to 2055. The vegetation feedback run showed that an increased greenhouse gas concentration by the IPCC-B2 scenario leads to a strong warming for the future Barents Sea climate (2080-2099) of about 7°C. The annual mean precipitation shows a clear positive trend and increased about 18.4% for the period 2080-2099 relative to the earlier period 1981-2000. The increase is stronger in winter than in spring and autumn. In summer the precipitation shows a high temporal variability. The definition of linkages between the individual models and their quantification and the specification of vulnerabilities of environmental and socio-economical components of the Barents System comprised elements of the applied methodology. The results of the off-line feedback climate change run with updated SST data indicate that the climate signal is minor compared to the absolute value of the signal. Nevertheless it was shown by the fish model that the projected changes of the marine ecosystem will result in the changing migration and spawning patterns of Cod and Capelin, which in turn can have implications of the fishery sector. An increase in river runoff by 25 % as a result of altered snow cover and precipitation distributions will have a bearing on near-coastal marine processes. In addition the terrestrial models project an increase in boreal needle leaved evergreen forest, as well as northwards and upwards extensions, and an increase in total biomass production. Shade-intolerant broadleaved deciduous trees will migrate also northwards and upwards. Shrublands will be replaced by forests, and tundra Plant Functional Types (PFT) will disappear in the Scandinavian mountains. Tundra in Russian Federation will be found further north. Projected future warmer climate will lead to slightly changing timber stocks of Norway spruce and Scots pine, but will result in an increase of potential insect impact, which subsequently will influence future tree composition. Whether or not the Barents Sea Region will become a net sink or source for CO_2 cannot be conclusively deduced. A detailed study on a number of bird species indicates that climate change will lead to a loss in habitat and thus a decline in population numbers in the Barents region.

Socio-economic relevance and policy implications

Regarding the investigations on climate impact on economies in the European North the results show the following:

- Forestry: Single extreme whether event, like a storm can have a much larger impact on forest exploitation than a gradual change in climate. This may also have implications on the forest labour market and thus on the regional development. However, the vulnerability to climate change is determined to a significant extent by the adaptive capacities, which in the case of forestry might be high, because of an increasing availability of technology and infrastructure, thus, resulting in a small vulnerability of forest economy to climate change.
- Fishery: Among the fishery resources, cod fisheries dominate the economic exploitation of the Barents Sea ecosystem. Northern Norway is highly dependent on fish resource utilisation. The results form the modelling efforts regarding aquaculture and fishery show, that the socio-economic relevance in terms of adaptation to the impacts of global warming is small compared to technological means of aquaculture and fisheries management, e.g. the selection of a specific management regime.
- Reindeer herding: This sector is probably the most directly vulnerable in terms of climate change. However, our studies show that traditional adaptation strategies are still pursued

and have resulted in relatively modest vulnerabilities to environmental factors. In the countries of Fennoscandia the vulnerability of reindeer herding to climate change is less than expected in Russian Federation. This again is mainly based on the fact that the fennoscandian herders have access to means of adaptation, thus decreasing the vulnerability. Stakeholders, when asked about their view on climate change largely consider it but one (mostly less important) factor determining their future. BALANCE, through its involvement of stakeholders and through the Assessment and Decision Support System makes contributions to the transfer and sharing of knowledge, encouraging and enabling an active rather than a passive adaptation to wider processes of environmental change, and thus improving life qualities of communities in the European North.

Dissemination and exploitation of the results

The results of BALANCE have been published in scientific journals, numerous scientific reports and on the Internet through various websites. It should be highlighted that there will be a special issue of the journal "Climatic Change" that will be exclusively comprised of findings from the BALANCE project. The project and its rationale have been presented at scientific conferences and stakeholder meetings on many occasions. Moreover, a dedicated Stakeholder Portal provides hands-on information and offers ample opportunities for stakeholders to engage in the process of refining adaptation measures derived. An exhibition is showed in municipalities of Finland, Norway and Sweden. It is accompanied by a film. All material is to be found at the project web site.

Project related publications and deliverables are available on the project website.

CONVECTION - Greenland Sea Convection Mechanisms and their Climatic Implications

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 3.649.465
EC contribution:	€ 2.500.000
Start – end date:	1/11/2000 – 1/11/2003
Duration:	36 months
Project Coordinator:	Peter Wadhams (pw11@cam.ac.uk)
Organisation:	Scott Polar Research Institute, University of Cambridge - United Kingdom
CLAMER thematic focus:	Sea level rise; ice melting; ocean current changes; deep circulation changes
CLAMER regional focus:	Arctic

Project Website:
http://www.ifm.zmaw.de/projectsites/eu-finanziert/beginn-2000/convection/

Project Partners

1 University of Cambridge, Department of Applied Mathematics and Theoretical Physics - United Kingdom
2 Danish Technical University - Denmark
3 University of Hamburg, Institute of Oceanography - Germany
4 National Research Council, Institute of Atmospheric Sciences and Climate - Italy
5 Alfred Wegener Institute for Polar and Marine Research - Germany
6 Norsk Polarinstitutt - Norway
7 Danish Meteorological Institute - Denmark
8 French Research Institute for Exploitation of the Sea - France
9 University of Iceland - Iceland
10 National Reserach Council - Italy

Background information

Project Summary

Abstract
CONVECTION aims to assess open ocean deep-water production in the Greenland Sea by a combination of operational remote sensing, modelling, and field requirements. We seek to understand the physics underlying convection and how this process links with global climatic factors. The field measurements comprise work in two winters and three summer cruises. Winter convection will be mapped by an acoustic shadowgraph array, moored yo-yo CTDs and transects by an AUV, while ice production and movement will be mapped by in site measurements and buoy deployments, with support from ice tank experiments. Passive microwave, SAR, wind scatterometer and airborne data will be combined with *in situ* data to feed a model that calculates salt flux distribution over the region. When combined with a large-scale ice-ocean model and a small-scale convection model the final package will explain the convection process and its variability under extremes of forcing.

Project Outputs

Scientific Achievements

Previous studies and research programmes in the central Greenland Sea led to a consensus about how and why the Greenland Sea is such a favourable location for deep convection. This was based on a combination of hydrographic properties and ice formation. The upward doming of the deep waters in the centre of the gyre, which brings the deep waters close to the surface and makes them more easily accessible to surface forcing, has been the main hydrographic feature of the region. The local formation and advection of ice, with net brine release and the establishment of descending plumes, is then believed to lead to deep convective events. Salt flux modelling, backed up by experimental studies of pancake ice formation and brine drainage, supports the concept of ice formation as an important source of negative buoyancy in winter. The field studies planned and executed within the project reflected this basic view by the inclusion of an acoustic experiment for the detection of active plumes and an AUV survey underneath the ice cover. Mesoscale non-hydrostatic modelling studies demonstrate the mechanism by which such plumes can be produced and shows how they could develop. The experimental results from the project, however, have caused this general picture to be revised through two discoveries.

Firstly, the doming in the Greenland Gyre has been superseded in recent years by a pronounced and persistent two-layer structure with a density-salinity step at a depth which has steadily increased to 1.600-1.800 m. The upper part seems to be completely ventilated each winter, regardless of ice formation or its lack. This leads to the expectation that there might be convection processes different from plume convection, and within the project another main ventilation type has indeed been identified which leads to different, often contrasting effects. A warming of the ventilated layer by winter convection, for instance, was not thought possible before the project, but the new field data show that this can result from a mixed layer-like ventilation mechanism. 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 no single main driving mechanism for deep convection, and ice formation is not a necessary prerequisite for it.

The second discovery was of a deep convective chimney near the gyre centre at 75°N 0°W, extending to a depth of 2.500 m and thus penetrating through the density step described above. The chimney was discovered 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 such feature yet observed in the ocean. A second chimney was discovered during the spring 2003 survey, which was comprehensive enough to demonstrate that 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 observed to be in anticyclonic rotation at a rate of f/2 out to a radius of 10 km 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. Until we can carry out further experimental observation and theoretical modelling of chimney structure we cannot be sure whether they are playing 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.

A question addressed by the project is whether it is possible to identify conditions which are especially supportive of deep convection. Possible local candidates would be strong winds, cold winters, ice formation, or a low inflow of Atlantic Water (AW). Investigations with 1-d model (which is small enough to be run repeatedly with different forcings and initial conditions) revealed that the vertical density structure of the upper water column is the most discriminating factor. The heat content of the AW represents no hindrance, ice formation is helpful but not essential, and moderate heat losses in winter can suffice for deep convection. The vertical density structure of the upper layers is determined not solely by the lateral fresh water input (low saline Polar

Waters in the upper few tens of metres) but also by the convection history. This stems from the fact that plume convection usually results in an overall stability increase because of the varying final depths reached by the individual plumes. After winters with plume convection it is usually markedly more difficult to ventilate the affected layer again. A mixed layer-like convection type has the opposite effect by mixing efficiently through large depth intervals. Thereafter, very low stabilities in, say, the upper 1.300 to 1.800 m facilitate a reventilation during the next winter. A switch back to plume convection, which needs a fresher surface layer, can be caused by a fresh water (Polar Water, ice melt) input. This, again, is naturally sensitive to meteorological forcing.

The larger scale picture of how convection fits into, and is affected by, the larger scale pattern of oceanic and atmospheric circulation in the Greenland Sea – Arctic Ocean system, was addressed by the AWI modelling group. They were assisted by the enormous mass of historical oceanographic and sea ice data collected as another aspect of the project, which is included in this report on a CD-ROM. This provided data to test hindcasts of ice extent, ocean structure and convection back through the century. Remote sensing data, interpreted using innovative algorithms for young ice types and for wave energies, gave new insight into the behaviour and movement of ice within the whole experimental region.

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 longlived chimneys, the investigation of how two modes of convection may prevail in different years, the innovative 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. The synthesis of these discoveries into a new way of thinking about the Greenland Sea is now in fertile progress, and is already insistently leading to a need for new studies. 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.

Socio-economic relevance and policy implications
Much publicity has become attached to the hypothesis that the shut-off of convection in the Greenland Sea will lead to a decline in the vigour of the Gulf Stream and Atlantic Thermohaline Circulation (THC) and a consequent cooling to the climate of NW Europe, estimated in models to take over from global warming as an absolute declining trend by 2100. From the discoveries in CONVECTION it appears that convection in the Greenland Sea is not shutting off, but is taking place in a variety of forms which offer some resistance to a warming trend. This has major implications for modifying our view of how European (and global) climate is set to change over the next few decades, suggesting that the expected shut-off of the THC and cooling of European climate may well not occur and that the models predicting them are too simplistic.

The improved understanding of the physics of convection means that we can return to the models of carbon expert and air-sea CO_2 fluxes developed during the earlier EU ESOP project and derive improved estimates of the role of the central Greenland Sea gyre in CO_2 sequestration (moderating global warming) and in the carbon budget of the Nordic Seas, of vital importance for fisheries.

The success of the AWI large-scale ice-ocean model of the Greenland Sea – Arctic Ocean system in hindcasting sea ice extent over the past century implies that improved forecasting of sea ice extent in the Nordic Seas over the forthcoming years is now possible. This will allow improved planning for fisheries expansion and for the growth of new trade and oil/or exporting routes from stretches of the Greenland and Svalbard coasts currently inaccessible through sea ice.

CRIMEA - Contribution of high-intensity gas seeps in the Black Sea to methane emission to the atmosphere

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 1.497.155
EC contribution:	€ 1.020.802
Start – end date:	1/02/2003 – 31/01/2006
Duration:	48 months
Project Coordinator:	Marc de Batist (Marc.DeBatist@UGent.be)
Organisation:	University of Gent– Belgium
CLAMER regional focus:	Black Sea

Project Website:
http://www.crimea-info.org/

Project Partners

1 University of Gent - Belgium
2 Ca' Foscari University of Venice - Italy
3 Sapienza University of Rome - Italy
4 Swiss Federal Institute of Environmental Science and Technology - Switzerland
5 Centre for International Marine Exploration - United Kingdom
6 Bulgarian Academy of Sciences, Institute Of Oceanology - Bulgaria
7 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
8 National Institute of Marine Geology and Geoecology - Romania
9 Democritus University of Thrace - Greece
10 International Bureau for Environmental Studies - Belgium

Background information

Project Summary

The CRIMEA Project studied and quantified the transfer of methane that is released at submarine high-intensity methane seeps and methane outbursts in the Black Sea as it ascends through the water column and reaches the atmosphere. This has been done by focussing on the following aspects: (i) characterisation and mapping of the active high-intensity seeps at the sea floor; (ii) characterisation of sub-sea-floor methane sources and migration pathways; (iii) quantification and physical, chemical and microbiological characterisation of fluids and gasses in the shallow sub-sea floor and at the sea floor in active high-intensity seeps; (iv) characterisation of the physical, chemical and microbiological processes controlling the fate of methane in the water column; and (v) establishment of a budget of methane release to the atmosphere from submarine outbursts and assessment of the possible impact of this methane on atmospheric composition.

The research activities of the CRIMEA Project were carried out in two main study areas:

1. The Dnepr paleo-delta area: located at the shelf edge in the NW Ukrainian part of the Black Sea and characterised by the presence of thousands of active seeps. In this area, three specific venting sites are studied in more detail: a site at 100 m, a site at 250 m and a site at 600 m water depth.
2. The Sorokin Trough area: in the deep parts of the Black Sea, at a water depth of about 2.000 m, characterised by the presence of active mud volcanoes. Focus was on the area of the active gasreleasing Dvurechenskiy and Vodyanitskiy mud volcanoes.

Project Outputs

Scientific achievements

Methane is produced in vast amounts by microbial activity in the sediments all across the Black Sea. Transfer of this methane from the sea floor into the overlying water column is strongly controlled by the process of anaerobic methane oxidation and associated sulphate reduction that occur commonly in the shallow sub-sea floor and that form an effective barrier minimising (or even eliminating) the transfer of dissolved pore-water methane into the sea water. Methane transfer takes therefore mainly place by means of gas bubbles, i.e. in bubble-releasing seeps.

The Dnepr paleo-delta area is probably one of the most prolific bubble-releasing seep areas in the World Ocean. Over 2.500 seeps in water depths between 100 and 725 m release gas bubbles, consisting mainly (> 80 %) of methane, into the water column. The methane is produced microbially at burial depths of 30-300 m in this lowstand paleo-delta depocentre. Upward migration of methane and the location of the seeps are controlled by sedimentary factors (i.e. stratigraphy and sediment properties) and by morphology, although locally deep-rooted faults may act as an additional migration pathway and cause advection of minor portions of deep-sourced gas. Below ~725 m water depth, the presence of hydrates forms an efficient barrier against upward methane migration. Bubble-release from these seeps is highly variable and not continuous in time, but taking into account the observed variability, the total flux of methane released from the sea floor in the Dnepr paleo-delta area can be estimated as 1-2 x 107 m^3/yr (at STP conditions).

In the Sorokin Trough area, the distribution of seeps is mainly controlled by the deep structural-geological context and by the presence of migration pathways under the form of mud volcanoes. The high temperature of the entrained fluids allows methane to by-pass the hydrate-stability zone and be released at the sea floor. Gas released at mud volcanoes is a mixture of biogenic and deeper thermogenic methane with source depths of > 6 km. Upward migration of the fluids is focused along the feeder channels of the mud volcanoes, possible involving an intermediate mud and fluid chamber at about 300-600 m depth. Gas outbursts at the Dvurechenskiy and neighbouring mud volcanoes, involving > 1.300 m high reaching gas bubbles, have been shown to be able to last for several years. The release intensity gradually builds up in the beginning and decreases at the end of the outburst period. No short-term variations (within days or hours) have been observed.

Upon their release at the sea floor, gas bubbles will start to dissolve as they rise through the water column. The released methane will therefore be transported through the water column either as dissolved methane or as bubble methane. Bubbles can migrate upwards through the water column by themselves or as part of a bubble plume, which involves also the upward movement of water.

Single-bubble methane transport: The bubble and site characteristics determine the bubble rise velocity, the rates of methane dissolution into the surrounding water and, thus, the height of methane transfer. Modelling shows that single-bubble transport is, in fact, highly ineffective. Significant methane transfer to the atmosphere by single-bubble transport is only possible from very shallow water depths, i.e. less than 100 m. For deeper waters, unrealistically large bubbles would have to be released at the sea floor to still contain methane up to the sea surface. This is supported by surface-water methane concentrations, which show elevated concentrations only above seep areas at the shelf (< 100 m), even though the amount of sediment-released methane from the deeper (i.e. 250 m) seeps is about 100 times larger.

Bubble-plume methane transport: Plume transport allows for the gas bubbles to rise much higher in the water column than what would be possible by single-bubble transport. The formation of a plume can be driven by

various mechanisms, such as a mud-volcano “eruption”, water entrainment via the release of a very large number of bubbles, or the release of pore water together with the bubbles that has a higher temperature or lower salinity than the surrounding sea water. In the Dnepr paleo-delta area, no evidence was found for the existence of plumes. In the Sorokin Trough there are indications that plumes exist that could be driven by the intermittent release of slightly warmer water from the mud volcanoes. A plume could explain the anomalous rising height of the bubbles (> 1.300 m) observed above the mud volcanoes; alternatively, this could also be explained by the formation of a hydrate rim on the bubble surface while rising within the hydrate-stability zone. Nevertheless, there are no indications that the observed plumes are indeed capable of transporting methane up to the upper water column above the Sorokin Trough mud volcanoes.

Dissolved methane transport: Dissolved methane is gradually consumed by microbial processes (involving Archaea and Bacteria), but is also transported through the water column by diffusion and by water mixing processes. The Black Sea is a strongly stratified system with various interfaces (e.g. surface mixed layer, oxycline, thermocline, pycnocline, as well as other less well-delineated boundaries), which all have the potential to influence migration of dissolved methane. For example, the base of the oxycline is a level of strong lateral currents, hereby forming also a physical boundary to the upward migration of methane. Transport across these boundaries takes place via mixing but is slow, so that the methane concentration in the water column can be regarded as in steady state. The entire Black Sea water column represents a very important pool of dissolved methane. There are indications that there is potential for overloading of the steady-state system during a large-scale bubble release episode.

All in all, the Black Sea water column acts as a very efficient buffer against methane transport from the sea floor to the sea surface.

The final transfer of methane from the water column to the atmosphere can take place by diffusion of dissolved methane across the water-air interface or by the direct migration of bubbles (if still containing methane) to the water surface. For the first mechanism, only seeps located in shallow water (i.e. < 100 m water depth) have a measurable impact with slightly higher flux densities than the background value. Modelling of direct bubble transfer has shown the potential for effective transfer even from seeps located in water depths up to 250 m (but not from deeper waters). A direct comparison of the two mechanisms –diffusion versus bubble-transfer– shows that the bubble-transfer mechanism may contribute up to 4 orders of magnitude more methane to the atmosphere above the shallow (< 250 m) seep areas, provided that these bubbles had the right properties when released to still contain sufficient methane at the sea surface. There appears to be no transfer to the atmosphere at all above the observed gas outburst at the Sorokin Trough mud volcanoes.

The methane fluxes from the Black Sea to the atmosphere above the investigated high-intensity seeps have only a negligible impact on the regional atmospheric background concentration of methane. On the other hand, calculations performed for hypothetic episodic events (i.e. a catastrophic mud-volcano eruption, or a sudden exposure of the methane-charged deeper water column) suggest that in those cases the dispersion of methane gas that reaches the atmosphere may result in very large enhancements in the methane concentrations near the sea surface downwind the release point. Photochemical and radiative transfer modeling over a representative mesoscale (10 km < length < 1.000 km) spatial and temporal window pointed that episodically raised methane concentrations can in some cases have a significant impact on the atmospheric composition and radiative forcing. However, mainly due to the limited temporal duration of such catastrophic eruptions, their influence is considered unimportant in the atmospheric system.

Socio-economic relevance and policy implications

CRIMEA addresses a problem that is of wide European interest and that can only be approached by a large, multidisciplinary team at the European level. It contributes to the formation of young scientists and to the transfer of knowledge and of scientific skills throughout Europe, towards pre-accession states and NIS partner countries, and produces data that can be directly used in global climate prediction models to better understand natural versus human influence on global warming. The project thus aids in the European Community’s policy implementation on greenhouse gas emissions and pollution abatement.

EPICA - European Project for Ice Coring in Antarctica

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 7.058.344
EC contribution:	€ 2.406.164
Start – end date:	1/05/2001 – 1/05/2004
Duration:	36 months
Project Coordinator:	Heinrich Miller (hmiller@awi-bremerhaven.de)
Organisation:	Alfred Wegener Institute for Polar and Marine Research – Germany
CLAMER thematic focus:	Sea level rise; ice melting
Regional focus:	Antarctic

Project Website:
http://www.awi.de/en/research/research_divisions/geosciences/glaciology/projects/epica/

Project Partners

1 Alfred Wegener Institute for Polar and Marine Research, Department of Geophysics - Germany
2 Natural Environment Research Council, British Antarctic Survey - United Kingdom
3 French National Centre for Scientific Research, Laboratoire de Glaciologie et de Géophysique de l'Environnement - France
4 Norwegian Polar Institute, Antarctic Section and Polar Climate Group - Norway
5 Utrecht University, Institute for Marine and Atmospheric Research - Netherlands
6 University of Berne, Physikalisches Institut - Switzerland
7 Université Libre de Bruxelles, Département des Sciences de la Terre et de l'Environnement - Belgium
8 Stockholm University, Department of Meteorology - Sweden
9 University of Copenhagen, Niels Bohr Institute of Astronomy, Physics and Geophysics - Denmark
10 Alfred Wegener Institute for Polar and Marine Research, Logistics Department - Germany
11 University of Milano–Bicocca, Dipartimento di Scienze dell' Ambiente e del Territorio - Italy
12 Institut Francais Pour la Recherche et la Technologie Polaires - France
13 Italian National Agency for New Technologies, Energy and Sustainable Economic Development - Italy

Background information

Project Summary

Abstract
The overall objective of EPICA is to reconstruct a continuous, highly resolved history of global climate and environmental changes from centuries to several hundred thousand years. For this, two ice cores are drilled in East Antarctica, one in the central part at Dome C (75°06'S, 123°21'E), the other in the Atlantic sector at Kohnen station in Dronning Maud Land (75°00'S, 00°04'E). The scientific objectives of the two complementary ice-core records are twofold:
• To achieve the best possible characterisation of the rapid changes during glacial and also during interglacial epochs.
• To provide a basis for understanding the mechanisms driving both global climate and the coupled biogeochemical cycles, and give a perspective for assessing current changes and associated feedbacks. The

longest records from Antarctica will be recovered from central areas of East Antarctica and will be especially suitable for examining the forcing mechanisms driving the principal climatic cycles throughout the most recent geological period. Evidence on the associated responses of the ice sheet will also be obtained, which have implications for global sea-level changes.

Project Outputs

Scientific achievements

The project recovered the planned two deep ice cores at Dome C and in Dronning Maud Land (DML). The age of the ice cores, which do not yet reach the bottom of the ice sheet, covers appr. 810.000 (the oldest ice core recovered so far) and 180.000 years, respectively. The preliminary δD record along the entire Dome C core provided the key climate profile to develop its chronology in combination with numerical modelling. Down to 3.139 m the core represents 740.000 years, including all of the interglacial marine-isotope stage (MIS) 11, which was not completed in the Vostok record, and running through a further three complete 100-kyr cycles. We first note a clear change in the amplitude of glacialinterglacial changes before and after MIS 12, and by consistently lower maxima. As in the marineisotope records, the most striking feature is this greater amplitude of glacial-interglacial change in the period after termination V (appr. 430.000 ago). The variations of the atmospheric CO_2 and CH_4 concentrations were also reconstructed through this termination. The overall characteristics of the DML and Dome C stable isotope records look very similar. The difference in $\delta_{18}O$ or δD values between Last Glacial Maximum and the Holocene optimum is comparable, whereas the variations in the glacial are larger in the DML core than in the Dome C core, indicating the influence of the South Atlantic. Temperatures for the Dome C site and the precipitation source area were reconstructed resulting in different trends during the glacial.

The low frequency deuterium-excess fluctuations are strongly influenced by earth obliquity and show a remarkable similarity with a high-resolution southeast Atlantic sea-surface temperature record. By comparing the Dome C isotope record with Vostok and Dome Fuji records, it was found that the East Antarctic climate was homogeneous over the last 80.000 years. The new EPICA ice core records clearly indicate that each of the Dansgaard/Oeschger events found in the GRIP ice core has an Antarctic counterpart. This is also confirmed by CH_4 data, which even show that those events were also characteristic for the previous glacial epoch. The relationship between many of the chemical parameters (and hence the environmental parameters they represent) and Antarctic temperature stayed similar over 740.000 years, but some subtle differences emerge. A comparison of calcium (representing dust, and hence a crude proxy for iron) with CO_2 data for Dome C across warm events A1 to A4 within the last glacial period puts a limit on the extent of iron fertilization in the Southern Ocean. Use of highresolution sulfate profiles to tie the Vostok and Dome C cores together shows that the ratio of the snow accumulation rate at the two sites varies between glacial and interglacial periods. This unexpected result calls for a re-examination of the hypothesis that accumulation rates are determined only by the site temperature.

The synchronisation of the EPICA cores with the Taylor Dome core using CO_2 concentrations shows that there are accumulation rate changes on some Antarctic locations. Significant advances were made in explaining the meaning of sea salt concentrations in ice cores. The sea ice surface, rather than open water, is a significant source of the sea salt seen in the cores. This opens up the possibility that, on long timescales, the sea salt concentration in ice cores can indicate changes in sea ice productivity. An interpretation of sea salt in the DML core has allowed an estimate of the persistence of the Antarctic Circumpolar Wave to be made over a 2000 year time period. For the greenhouse gases CO_2, CH_4, and N_2O detailed records between 220.000 and 200 years BP are available in unprecedented resolution and precision. The CO_2 record over the transition from the last glacial epoch to the Holocene is so detailed that it provided important information about the mechanisms responsible for the CO_2 increase. Further remarkable are the reconstruction of the CH_4 minimum at 8.200 years BP. It was also possible to evaluate a more precise interpolar gradient of the atmospheric CH_4 concentrations. The Dome C record for $\delta_{13}C$ on CO_2 exhibits, besides a general increase of about 0.15 ‰ over the Holocene, three millennial scale variations of the order of a few tenths of a permil, which are unexpected, based on model calculations. It appears that the $\delta_{13}C$ results are much less affected by fractionation during incomplete gas extraction than CO_2 concentration measurements. The record suggests that $\delta_{13}C$ could be correlated to the atmospheric $_{14}C$ concentration.

The $\delta_{15}N$ measurements on N_2 provide information on the thickness of the diffusive firn layer. As has been observed in other cores from low accumulation sites, the $\delta_{15}N$ trend from Dome C for the transition from the last glacial to the Holocene epoch is opposite from that predicted by firn models. The pore space of snow, firn and ice was reconstructed by X-ray micro-computer tomography showing that the original grain size determines the densification rate of polar firn. The grain-size profiles of the two cores show a strong correlation with climate as a result of grain boundary pinning by insoluble (dust) particles. A line scanning system documented the stratigraphy of the ice cores. Scanning electron microscope studies revealed the complexity of impurity distribution in the ice. The climate record on a depth scale from ice cores, has to be transformed to an age scale. As the DML core is drilled on a flank position, effects of horizontal advection have to be taken into account. With a newly developed 3-D thermo-mechanic nested ice flow model the DML core was dated by Lagrangian backtracing carried out by consecutive cubic spline interpolation of a particle's location using the reversed 3-D velocity field obtained from forward experiments. According to the model results the last three glacial cycles are contained within the uppermost 97% depth. The general properties of atmospheric transport towards Antarctica under varying climatic conditions were studied by analysing tracer transit time climatologies based on the concept of tracer age in a LMDZ general circulation model. A state of the art regional atmospheric climate model has been used to model the climate and mass balance over Antarctica for the period 1957-2002.

Socio-economic relevance and policy implications

This project has contributed to a comprehensive study of how climate has changed over the last 740.000 years. This, and the detailed studies that underlie it, will provide critical input to improving climate models that will be used to predict future climate. One output that directly relates to policy has been an assessment of the role of iron fertilization in past CO_2 change, clearly suggesting that iron fertilisation is likely to have only a limited role in mitigating future CO_2 increases. EPICA has a triggering impact to the international collaboration within the Antarctic Treaty system.

Conclusions

Most parts of the project reached or even surpassed the promised milestones and deliverables. Good quality ice cores older than 800.000 years are available. The measuring methods are well developed. Important inferences about the nature of climate changes have already emerged and this project will contribute significantly to our understanding of linkages between components of the climate system.

Dissemination of results

The results were presented at national and international scientific conferences, including Euresco-Conferences, and published in peer-reviewed scientific journals. 62 papers were published, 30 are in press and another 17 presently submitted. National and international press releases and press conferences attracted the interest of the public media, which reported frequently about EPICA and paleo-climate studies with ice cores. Selected data are stored in public accessible databases dedicated to paleo-climate or ice cores.

A list of EPICA related publications is available at
http://www.phys.uu.nl/~wwwimau/research/ice_climate/epica/publications/home.html

ESEAS-RI - European SEA level Service Research Infrastructure

Summary information

Funding source:	FP5
Total Cost:	€ 3.426.209
EC contribution:	€ 2.299.786
Start – end date:	1/11/2002 – 31/10/2005
Duration:	36 months
Project Coordinator:	Bjoern Engen (bjorn.engen@statkart.no)
Organisation:	Norwegian Mapping Authority, Geodetic institute – Norway
CLAMER thematic focus:	Sea level rise

Project Website:
http://www.eseas.org/eseas-ri/

Project Partners

1	Norwegian Mapping Authority - Norway
2	Danish National Space Center - Denmark
3	Proudman Oceanographic Laboratory - United Kingdom
4	University of Nottingham, Institute of Engineering Surveying and Space Geodesy - United Kingdom
5	Spanish Institute of Oceanography - Spain
6	Puerto del Estado - Spain
7	Royal Naval Observatory of Spain - Spain
8	Institut Mediterrani d'Estudis Avanoats - Spain
9	General Command of Mapping - Turkey
10	Environmental Agency of the Republic of Slovenia - Slovenia
11	Institute of Meteorology and Water Management, Maritime Branch - Poland
12	Hydrographic Institute of the Republic of Croatia - Croatia
13	University of Zagreb, Andrija Mohorovicic Geophysical Institute - Croatia
14	Darmstadt University of Technology, Institute of Physical Geodesy - Germany
15	Vilnius Gediminas Technical University, Research Institute of Geodesy - Lithuania
16	Universidad Politecnica de Cataluna - Spain
17	Hellenic Navy Hydrographic Service, Oceanography Division - Greece
18	National Institute of Oceanography - Israel
19	Southampton Oceanography Centre, James Rennell Division - United Kingdom
20	Polish Academy of Sciences, Space Research Centre - Poland
21	National Research Council, Istituto Talassografico di Scienze Marine - Italy

Background information

Project Summary

Abstract
Sea level is an environmental variable important for studying climate processes in the coupled atmosphere-ocean system. In Europe, the physical network for observing sea level at coastal sites is well developed in most geographical regions. However, in some crucial parts (particularly the Arctic Sea, the Eastern Baltic Sea, the Mediterranean, and the Black Sea), the network needs upgrading of the gauges to modern standards. Augmentation of the observing sites with equipment to monitor the stability of the tide gauge and vertical land movement is another urgent issue.

Currently, access to more than 50 individual sea-level databases in European countries is still severely hampered due to national diversity in operation, uneven technological developments, non-standardised products, and different levels of quality assurance.

The European Sea Level Service (ESEAS) is in the process of building up one integrated virtual sea-level information source comprising most of the sea level observing and research resources in Europe. The network of ESEAS Observing Sites will be improved and access to the scattered sea level database standardised. The extensive tide gauge database will be utilised to study sea level variations on decadal to century time scales. An empirical model describing decadal to inter-decadal sea level variations will be derived through combination of tide gauge and satellite altimetry observations. The factors causing these variations will be identified and their contribution quantified. Particular emphasis will be on the North Atlantic Oscillation. A statistical description of the variability of extreme sea levels will be given for the entire European coasts in order to assess future risks.

The ESEAS-RI project is established by ESEAS to support the research infrastructure of ESEAS and facilitate full scientific exploitation of European sea level observations.

Objectives and approach:
The European Sea Level Service (ESEAS) has made the initial step in bringing together the formerly scattered sea level research infrastructure in Europe. ESEAS is developing 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 technological objective of the ESEAS-RI project is to support the ESEAS research infrastructure and to facilitate the transnational coordination, the upgrading of the network of observing sites and the standardisation of the network, the operational routines, the databases and the quality-control as a prerequisite for a full scientific exploitation of the present and future sea level observations.

The primary scientific objective of the project is to study sea level variations at inter-annual to century time scales and to quantify potential future changes in mean sea level. In order to reach this objective, the following main steps are necessary:

- Quality control of the hourly tide gauge data accessible through the ESEAS;
- Determination of vertical land movements at tide gauges in order to decontaminate the relative sea level records for this bias;
- 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;
- Improvement of the network of ESEAS Observing Sites through upgrading of selected tide gauges and co-location of gauges with continuous GPS.

Expected impacts:
The availability of a quality-controlled database of hourly tide gauge data, and the successful upgrading of the ESEAS network are major milestones. The project is expected to result in a major improvement of the research

infrastructure comprised in the ESEAS. The research carried out in the project will result in an empirical model of sea level variations, which provides a unique 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.

The project will stimulate the integration of the European sea level research community into a larger network and thus promote coordinated research. The work in the project will directly result in contributions to environmental assessment reports and will also give information with respect to obstacles for the exploitation of existing multi-national databases in terms of e.g. technical, data quality and policy, legal and organisational issues.

GREENICE - Greenland arctic shelf ice and climate experiment

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 2.426.334
EC contribution:	€ 1.842.255
Start – end date:	1/12/2002 – 1/06/2006
Duration:	42 months
Project Coordinator:	Peter Wadhams (P.Wadhams@cam.ac.uk)
Organisation:	University of Cambridge - United Kingdom
CLAMER thematic focus:	Sea level rise; ice melting
CLAMER regional focus:	Arctic; North Atlantic

Project Website:
http://www.greenice.org/index.html

Project Partners

1 University of Cambridge - United Kingdom
2 Geological Survey of Denmark and Greenland - Denmark
3 Danish Ministry of the Environment, National Survey and Cadastre - Denmark
4 Danish Technical University - Denmark
5 University of Bergen - Norway
6 Alfred Wegener Institute for Polar and Marine Research - Germany
7 University of Iceland, Science Institute - Iceland

Background information

Project Summary

Abstract
The overall aim of the project was to study the structure and dynamics of the sea ice cover in a critical region of the Arctic Ocean, north of Greenland, and to relate these to longer-term records of climate variability retrieved from sediment cores.

The ice cover in the region is among the thickest in the Arctic, as the sea ice is forced against the north coast of Greenland and the Canadian Archipelago by the transpolar drift stream. This thick and heavily deformed ice prevents access by even the most powerful icebreakers and has resulted in an almost complete lack of ice, ocean or geological data from the region. The challenge was to determine in what way ice conditions are changing as part of the overall pattern of retreat and thinning seen elsewhere in the Arctic, and at the same time to determine from seabed coring whether such a heavy ice regime, deep inside the ice limits, was ever free of ice during the past two glacial cycles.

The project was an integrated programme of measurements, remote sensing and modelling. Three winter field measurement campaigns were carried out:

Fieldwork in 2003 was aimed at trialling systems and methods for the main ice camp the following year. Efforts centred on the AWI vessel *Polarstern*, specifically during a two-week period when she was moored to a drifting ice floe in the Yermak Plateau area. Aerial campaigns were conducted with the AWI helicopter-borne electromagnetic induction system (HEM) and the KMS swath laser profilometer, mounted on a Twin Otter aircraft. Activities on the ship included intensive ground-truthing using *in situ* thickness measurements, both by drilling (ice augers, hot water drill) and sledge-borne EM. The drift also allowed the development of thickness monitoring buoys based on the measurement of the spectrum of flexural-gravity waves in the ice. Concurrent data were obtained from an ice camp (APLIS) north of Alaska, providing long-range comparisons of waves necessary for testing the buoy concept.

2004 saw the project team install and occupy an ice camp in the Lincoln Sea, north of Greenland, using Twin Otter aircraft. The camp was a novel, low-cost, lightweight effort, which provided an excellent platform for science in this otherwise inaccessible region. The camp was placed 280 km north of Alert (85°N, 65°W), and occupied by 10 scientists for two weeks in May. Activities at the camp included geological investigations of the seabed and sub-seafloor, a co-ordinated aerial thickness measurement campaign, *in situ* measurements of ice thickness and properties, and the deployment of an array of buoys designed to measure both path-integrated ice thickness and drift, hence deformation over the lifetime of the project and beyond.

The opportunity was taken to repeat the HEM and laser measurements north of Alert with a limited campaign in 2005, to examine temporal as well as spatial ice thickness variability in the region.

Project Outputs

Scientific achievements

GEUS/UB

The geology team designed and built a custom lightweight (air-transportable) winch and piston corer to extract sediment samples from the seafloor. Ice camps provide a superb platform for such investigations, as they drift slowly across the ocean beneath and the low-noise environment allows high quality seismic studies to be conducted with relatively simple equipment. The gravel-rich nature of the seabed prevented many samples from being obtained, but seven cores were obtained in all, of which two proved to be very high quality. The cores contained high abundances of sub-polar plankton species which suggest that the study area was ice-free during the last interglacial. This open water area may have occurred as a polynya or may reflect a generally reduced sea ice cover of the interior Arctic Ocean. This is a striking result, since at present the study area is heavily ice-covered, and forecast models of future shrinking Arctic sea-ice cover suggest that this area is one of the least sensitive to warming in the Arctic. The geological results obtained from the GreenICE project challenge this view. The camp also produced the first seismic survey of the shallowest part of the Lomonosov Ridge, across 62 km of drift track. Results show that the top of southern Lomonosov Ridge is bevelled (550 m water depth) and only thin sediments (< 50 ms) cover acoustic basement. About 1 km of sediments is found at the western entrance to the deep passage between southern Lomonosov Ridge and the Lincoln Sea continental margin.

AWI

The helicopter-borne EM system was used extensively during the project to map the spatial variability of ice thickness in Fram Strait (2003) and in the Lincoln Sea. A small additional campaign from Alert in 2005 also allowed the investigation of interannual variability. Priority was given to flying lines co-incident with the Twin Otter-mounted laser, to examine the relation between freeboard and thickness, though poor weather during the 2004 ice camp severely limited the number of helicopter flying days. Modal thickness of multiyear ice in the Lincoln Sea appeared to increase from 3.9 m in 2004 to 4.2 m in 2005, with snow thickness also increasing, from 0.18 m (2004) to 0.28 m (2005). A much higher fraction of thick, deformed ice was seen in 2005, compared with 2004. Mean thickness tends to be underestimated by the HEM, since the bird cannot 'see' the full depth of ice keels, due to footprint and porosity effects. Profiles from the HEM and laser data were used to

improve the parameterisation of ridging in the AWI sea ice model. Model outputs were compared with field measurements and the optimised model used to examine how ridging, ice thickness and ice drift patterns varied with different atmospheric forcing, representative of past scenarios.

SAMS

The utility of long period wave measurements in the ice covered Arctic Ocean was examined, with the aim of using the measurements to diagnose the path-integrated ice thickness between the source of the waves (the open ocean beyond Fram Strait) and the measurement point, in this case to the north of Greenland. Autonomous wave measuring buoys were developed and successfully deployed for over two years. Considerable practical and theoretical problems were encountered with the resonant wave theory, however, leading to the evaluation of alternative formulations to extract ice thickness. Viscoelastic parameterisations seemed most promising, and the evaluation of this method is currently underway as part of a follow-up project. The buoys also allowed the drift and dynamics of the ice to be determined. Drift was dominantly southwards, with the ice exiting the region through Nares Strait, between Greenland and Ellesmere Island. Ice draft profiles from a United Kingdom submarine cruise under the GreenICE camp area are also presented. Although this effort was not funded under GreenICE, it provides a useful comparison with the HEM and laser results. Preliminary analysis was carried out from analogue data, as we are still awaiting the detailed digital data to be released.

DNSC

The Danish National Space Centre (previously KMS) carried out extensive surveys of the sea ice north of Greenland using a ski-equipped chartered Air Greenland Twin-Otter, fitted with a downward-looking swath laser profilometer. This measured ice freeboard on scales of 500 km and efforts focused on relating this to the ice thickness measured by the HEM and *in situ* drilling, as well as submarine draft profiles. The relation is critical for future satellite missions, which seek to measure ice thickness using freeboard alone. Comparisons between HEM and laser measurements yielded good agreement, though generally higher thickness values are estimated by the laser scanner system. This may be caused by underestimation of the thickest ice, especially ridges, by the HEM system. Laser scanner results in 2003 agreed with *in situ* observations within the expected accuracy. Comparisons with the submarine are also encouraging, though the laser data tend to have thinner modal thickness. Direct comparisons were also made with the laser measurements from the NASA ICESat satellite. Through the GreenICE airborne campaigns it has been demonstrated that the airborne laser scanner measurements are an effective way to measure sea ice thickness and freeboard over large scales (100 to 1.000 km). Coincident EM measurements, and *in situ* measures of the freeboard/draft ratio, will continue to be useful to quantify the inherent errors in the freeboard to thickness conversion.

DTU/DMI

DTU were largely responsible for the acquisition and analysis of satellite remote sensing data. They provided both near-real-time support for the field observations (giving a large-scale overview for aerial and on-the-ground operations) and later, offline, analysis of satellite datasets in comparison with field data. Images were dominantly radar views, from both ENVISAT ASAR and RADARSAT, though extensive use was also made of the optical MODIS images and passive microwave (SMMR, SSM/I) instruments. ASAR data was compared with co-incident laser overflights to establish relations between backscatter and ice freeboard/thickness. Historical data were also used prior to the ice camp to estimate and plan its track. Recent images were used to match submarine tracks, acquired a month earlier, to subsequent laser overflights for draft-freeboard comparisons. Small scale ice dynamics was also examined using high-resolution ASAR data, comparing results with the drift of both *Polarstern* in 2003 and the buoys in 2004.

Conclusions

The project yielded major discoveries about the periodically ice-free nature of the central Arctic Ocean. In addition, methods of ice thickness determination were inter-compared in an area of high thickness and roughness, and a novel technique of thickness monitoring was found not to function in the way described by its progenitor. The project produced extensive co-operation between groups and demonstrated the valuable insights that a multi-platform approach can achieve. The techniques and rationale developed by the project are finding continued application under follow-up projects such as the European DAMOCLES and CRYOVEX programmes, which will continue to track the evolution of ice thickness in this critical area in coming years.

GYROSCOPE - Development of a real time *in situ* observing system in the North Atlantic Ocean, by an array of lagrangian profiling floats

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 4.896.326
EC contribution:	€ 2.930.769
Start – end date:	1/01/2001 – 31/12/2003
Duration:	36 months
Project Coordinator:	Yves Desaubies (yves.desaubies@ifremer.fr)
Organisation:	French Research Institute for Exploitation of the Sea – France
CLAMER thematic focus:	Ocean circulation changes
CLAMER regional focus:	North Atlantic
Project keywords:	Global Change; Climate and Biodiversity; Development of new long-term observing capacity

Project Website:
http://www.ifremer.fr/lpo/gyroscope/

Project Partners

1 French Research Institute for Exploitation of the Sea - France
2 Spanish National Research Council - Spain
3 Université de Bretagne Occidentale - France
4 Secretary of State for Defence - Ministry of Defence - United Kingdom
5 Collecte localisation satellites SA - France
6 Etablissement principal du service hydrographique et océanographique de la marine - France
7 Natural Environment Research Council - United Kingdom
8 Spanish Institute of Oceanography - Spain
9 University of Las Palmas de Gran Canaria - Spain
10 French National Centre for Scientific Research - France

Background information

Project Summary

Problem to be solved
Progress in numerical modelling, the availability of satellite-borne sensors, and global ocean observation programmes, have led to the understanding of large fluctuations in the coupled ocean-atmosphere system. The possibility of seasonal forecasting of the coupled ocean-atmosphere system could have considerable economic benefits, but it cannot be done without appropriate ocean models and observations. In several countries, operational ocean–atmosphere models are being developed to enable nowcasting and forecasting. Ocean observing systems are required in support of those operational objectives, as well as for ocean models assessment and validation; for understanding and modelling the ocean role in climate; monitoring ocean changes; and enabling long-term trends prediction. GyroScope aims to develop a key component of such a

system, that will provide, for the first time, basin-wide *in situ* ocean observations with a sampling appropriate to resolve seasonal and inter-annual variability. The detection of longer time scale climate signals will require that such observing systems be maintained permanently.

Scientific objectives and approach

The overarching objective of the GyroScope project is to develop a European component of a global *in situ* observing system of ocean variability in the North Atlantic, based on autonomous, freely drifting profiling floats, which can measure vertical profiles of temperature and conductivity (from which salinity can be deduced) at regular intervals. The data are transmitted by satellite to a receiving station. The first objective is to deploy a pilot array of about 80 autonomous profiling floats, as a contribution to the international ARGO programme. This array will transmit in real time data to Data Centre Ifremer, that will quality control, and distribute it on the Global Telecommunication System for use by National Weather Services, and operational agencies. The data will be used to estimate the time varying ocean circulation, temperature and salinity fields, and the balance of heat in the North Atlantic. Some of the estimations will be done in real time; others will include complementary data sets (satellite altimetry) to obtain the most accurate estimates and assess the information content of the float data (resolution, accuracy). Recommendations will be made for future implementation of an *in situ* ocean observing system. This project involves a combination of field work, data processing and evaluation, numerical modelling of ocean circulation, and studies of ocean circulation and ocean atmosphere interactions at large scales.

Expected impacts

The project goal is to develop a fully operational, low resolution array of profiling floats in the North Atlantic. A real time data stream operating continuously will deliver quality controlled data to operational meteorological and oceanographic services. Data synthesis obtained at two week intervals will give for the first time an opportunity to monitor the state of the ocean in real time. The data provided by this project will allow, in combination with satellite data and numerical models, improved long range weather forecasts by the National Weather Services, as well as more realistic ocean models for operational users, and a much improved understanding of the role of the ocean in climate. The data will contribute to a unique database for future climate research. It is hoped that the results of the project will enable the implementation of permanent *in situ* ocean observing systems for operational and scientific needs, much as those that have been in place for decades in the atmosphere.

HOLSMEER - Late Holocene shallow marine environments of Europe

Summary information

Funding source:	FP5
Total Cost:	€ 2.082.589
EC contribution:	€ 2.010.563
Start – end date:	1/01/2001 – 30/06/2004
Duration:	42 months
Project Coordinator:	Paul Storey
Organisation:	University of Wales - United Kingdom
CLAMER regional focus:	North Atlantic
Project keywords:	Meteorology; Forecasting; Resources of the Sea; Fisheries; Environment

Project Website:
http://notendur.hi.is/jeir/holsmeer.html

Project Partners

1 University of Wales – United Kingdom
2 Instituto Geologico e Mineiro – Portugal
3 University of Bremen – Germany
4 University of Bergen – Norway
5 University of Plymouth – United Kingdom
6 Stockholm University – Sweden
7 University of Aarhus – Denmark
8 The Scottish Association for Science – United Kingdom
9 University of St Andrews – United Kingdom
10 University of Iceland – Iceland
11 University of Vigo – Spain
12 Geological Survey of Norway – Norway

Background information

Project Summary

Modelling predictions of the climate system's response to anthropogenic forcings are severely inhibited by inadequate understanding of natural climate variability. HOLSMEER proposes to improve our understanding of this natural variability through the search for, interpretation, and quantification of, climatic variability in high-resolution shallow marine records from Atlantic Europe covering the last 2000 years. Long-term instrumental time series of marine and atmospheric parameters will be used in a new way to calibrate the marine palaeoclimate observations, extending the marine record to the period before systematic recording of environmental parameters was undertaken, and therefore providing a basis for establishing the natural variability of the oceanic component of the climate system in the critical North Atlantic region prior to significant anthropogenic forcing of the environment. These data will validate numerical models of the climate system.

IRONAGES - Iron Resources and Oceanic Nutrients - Advancement of Global Environment Simulations

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 2.324.197
EC contribution:	€ 1.582.774
Start – end date:	31/03/2000 – 30/09/2003
Duration:	42 months
Project Coordinator:	Hein de Baar (debaar@nioz.nl)
Organisation:	Royal Netherlands Institute for Sea Research - Netherlands
Project keywords:	Ocean ecosystems; global carbon cycle; climate system; Ocean Biogeochemical Climate Models (OBCM's)

Project Website:
http://www.nioz.nl/nioz_nl/d0e54483aa31c55b01a9fb11c0c23df4.php

Project Partners

1	Royal Netherlands Institute for Sea Research – Netherlands
2	University of East Anglia, School of Environmental Sciences - United Kingdom
3	The University of Liverpool, Oceanography Laboratories - United Kingdom
4	Institut fuer Meereskunde an der Universitaet Kiel - Germany
5	Max Planck Institute for Meteorology - Germany
6	University of Plymouth, Department of Environmental Sciences - United Kingdom
7	Universite de Bretagne Occidentale, Institut Européen Universitaire de la Mer - France
8	French National Centre for Scientific Research, UMR 1572 - France
9	Commissariat à L'Energie Atomique - France
10	Alfred Wegener Institute for Polar and Marine Research - Germany
11	University of Groningen, Biological Centre – Netherlands
12	Universite Libre De Bruxelles, Groupe de Microbiologie des Milieux Aquatiques - Belgium
13	Universite Pierre et Marie Curie, Laboratoire de Physique et Chimie Marine - France

Background information

Project Summary

Abstract
The functioning of ocean ecosystems and their interaction with the global carbon cycle and the climate system is not very well known. Ocean Biogeochemical Climate Models (OBCM's) are still too simplistic to adequately describe observed changes in ocean biology and chemistry in space and time. Therefore large uncertainties remain concerning the carbon up-take by the ocean that also limits the predictability of the future carbon up-take.

Scientific objectives and approach

The work outlined seeks to better model marine ecosystems and the sources and sinks of C, N and other elements within those systems, assuming that a number of factors (notably light, N, P, Si, Fe) are co-limiting plankton blooms. This goal will be achieved through a combination of laboratory experiments, fieldwork and modelling. Laboratory work will target the predominant algal species of the major taxonomic groups and determine their growth as a function of multiple stresses, such as limitations of iron, light and macronutrients. This data will then be used to refine and improve ocean ecosystem models, with the aim to more accurately replicate observations of the natural system. New realistic OBCM' s will be developed for budgeting and exchanges of both CO_2 and DMS, implementing: (I) co-limitation by 4 nutrients of 5 major taxonomic classes of phyto-plankton, (II) DMS (P) pathways, (III) global iron cycling, (IV) chemical forms of iron and (V) iron supply into surface waters. Input from below of iron from anoxic sediments of coastal margins will be assessed along a 2-D vertical section from Europe into the centre of the north Atlantic. Input from above of Fe (II) dissolved in rainwater from Sahara dust blown over the central Atlantic will be quantified at sea, and related to observed plankton production, CO_2 gas exchange and dimethylsulfide (DMS) emission. Different chemical forms of iron will be analysed and rigorous certification of all Fe in seawater data will be ensured. For 2 major DMS-producing algal groups the life cycle, Fe limitation, export production, CO_2 uptake and DMS emissions will be synthesised from existing literature and laboratory experiments. Experimental data will be fed into an ecosystem model. Also DMS (P) pathway modelling will be carried out being expanded with 3 other groups of algal and DMS (P) pathways. The extended ecosystem model will provide reliable output for CO_2/DMS gas exchange being implemented into two existing OBCM's. Then climate change scenarios notably changes in Fe inputs, will be run, with special attention to climatic feedback (warming) on the oceanic cycles.

Project Outputs

Scientific achievements

Iron input into the oceans, iron originating from reduced Fe(II) from anoxic sediments of coastal margins (iron from below), as well as from aeolian input from above of Fe(II) dissolved in rainwater from Sahara-derived dust blown over the central Atlantic (iron from above) was quantified. These fluxes were related to observed phytoplankton production, CO_2 gas exchange and DMS emission. Moreover, the different chemical species of Fe were determined. Finally, these field data were used to construct a simple global Fe cycling model. The physiology, life cycle, Fe limitation, export production, CO_2 uptake and DMS emissions for the two major DMS producing colony-forming Phaeocystis spp. and calcifying *Emiliania huxleyi* as well as three other major classes of marine phytoplankton (diatoms, N_2 fixing diazotrophs and the small picoand nanoplankton) were synthesised from existing literature in combination with additional laboratory experiments. The ensuing know-how was fed into below ecosystem modelling, as well as into the DMS(P) pathway modelling. The existing phytoplankton ecosystem model (SW AMCO) was expanded with the 3 other taxonomic groups and also the DMS(P) pathways simulation. Expansion of the global iron model as well as the SW AMCO model were used for improvement of the Ocean Biogeochemical Climate Model (OBCM's), with as ultimate aim of IRONAGES to run climate change scenario's, notably changes in Fe inputs, with special attention to climatic feedbacks (warming) on the oceanic cycles and fluxes.

Results

Field data on iron fluxes from sediments as well as from atmospheric input, collected during several cruises, were made available. A Fe certification exercise ensured reliable measurements of ultra-low iron concentrations. A global Fe cycling model was constructed. Reviews of five major taxonomic groups of marine phytoplankton were made available. Additional laboratory experiments filled gaps in physiological knowledge on these groups. An ecosystem model SWAMCO, was expanded using the scientific knowledge on the 5 taxonomical groups. The simple Fe cycling model, as well as the SWAMCO model, were used to improve Ocean Biogeochemical Climate Modelling.

An IRONAGES data product CD is available upon request from the coordinator institute (see website).

Socio-economic relevance and policy implications

The results from IRONAGES helps to address the issues of quality of life and health and safety by constructing tools with which, future climate forecasts will have a greater degree of certainty than is currently available. The

results of this work directly enable EU policymakers and planners to propose new policies that deal with the impacts of climate change with the highest possible confidence. The development of the marine ecosystem models creates a tool to test the sustainability of such systems under conditions of climate change or anthropogenic perturbation. This allows then for ecosystem conservation and management resource policies to be developed with reduced uncertainty about the possible changes in climate and the ramifications arising from that. Any policy decision on reduced CO_2 emissions will implicitly affect the longer-term availability of natural resources: petroleum, natural gas and coal.

Conclusions

The improved OBCMs developed within IRONAGES enable studying the influence of potential climate change on the biogeochemistry in the oceans and possible feedbacks to climate. Changes in mixed layer depth and temperature driven by climate change will influence the composition of phytoplankton, leading to changes in the biogeochemical cycling of a number of compounds, such as DMS that influence climate. Changes in DMS production have the potential to offset climate changes due to increasing CO_2 levels, especially singe anthropogenic sulphur emissions to the atmosphere have been reduced strongly in recent time.

MAIA - Monitoring the Atlantic Inflow toward the Arctic

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 2.393.050
EC contribution:	€ 1.183.500
Start – end date:	1/01/2000 – 1/01/2003
Duration:	36 months
Project Coordinator:	Thomas McClimans (thomas.a.mcclimans@sintef.no)
Organisation:	SINTEF Fishery and Aquaculture, Trondheim – Norway
CLAMER thematic focus:	Ocean current changes; temperature changes
CLAMER regional focus:	Arctic; North Atlantic
Project keywords:	Forecasting; Meteorology; Resources of the Sea; Fisheries; Environmental Protection; Measurement Methods

Project Website:
http://www.bodc.ac.uk/projects/european/maia/

Project Partners

1 Institute of Marine Research - Norway
2 Natural Environment Research Council – United Kingdom
3 Swedish Meteorological and Hydrological Institute - Sweden
4 Université Pierre et Marie Curie - France
5 Scottish Office Agriculture and Fisheries Department - United Kingdom

Background information

Project Summary

Abstract
The overall objective of MAIA is to develop an inexpensive, reliable system for monitoring the inflows of Atlantic water (AW) to the northern seas. The method employs a geostrophic balance between the Coriolis force on the flow and the pressure (sea-level) difference across the flow for variations that are much slower than a day. Due to the Coriolis effect, the poleward flow causes the surface to rise to the right toward the coast. The flow of AW through the Norwegian Sea comprises an offslope baroclinic transport and a barotropic shelf slope jet. The inflow past the Faroes contains a combined barotropicbaroclinic jet. MAIA aims to monitor the inflow of AW and associated velocities on the continental shelves to an accuracy of 15% of the total values and a time resolution down to 5 days. This accuracy and resolution, using the proposed method, has been earlier demonstrated for shelf slope currents. The 5-day averaging eliminates the effects of tides and synoptic meteorological effects. The region of interest extends from the Rockall Trough in the southwest to the Kara Sea in the northeast. In the north, the project focuses on monitoring the flows through the Barents Sea. The effects of the inflows on the ice fronts in the north are studied. There are several variables to take into account when using the MAIA concept. From earlier work, the buoyancy of the coastal water and the atmospheric pressure (inverse barometer) near the tide gauges are taken into account. This gives the coastal signal of the AW inflow, but both *in situ* data from 1975 to 2000 and satellite altimetry have revealed several other physical aspects of

the ocean circulation that must be considered. These include significant motions in the deeper layer, wind, a buoyant surface layer outside the AW front, variable density of the AW inflow and a variable external water level. The original paradigm was based on a simple 2-layer flow off Norway, where the barotropic slope jet and the baroclinic frontal jet are geographically separated. The distribution to the north of the Faroes is more complicated, with a mixed barotropic baroclinic slope jet. For this region, it has been possible to resolve the modes using EOF. Here, there appears to be a relatively constant, but noisy, division between baroclinic and barotropic parts throughout the year. This is believed to be a result of the topographical constraints imposed by the Iceland-Faroe Ridge. Algorithms for computing the inflow were developed in MAIA WP3 (2002) on the basis of historical data from 1975 to 2000. A major result of the historical analysis is the demonstration of disparate, latitude-dependent seasonal phases for the baroclinic and barotropic flows. The algorithms in MAIA WP3 (2002) were linear regressions.

Results from a validation experiment from June 2000 to November 2001 are used to validate the earlier algorithms and to resolve several issues. In general, the early algorithms had very limited predictive capability. In this experiment both currents and bottom pressures are used to estimate the inflows, and drifters and tracers are used to gain insight into the influence of the outer domain. The results have resolved, in part, the seasonal disparities. In the newer work we have made improvements in the algorithms by accounting for the quadratic relation between baroclinic transports and water level rise across the current, by including satellite altimetry closer to the shelf slope and by accounting for the effect of winds near the coastal stations. Based on these findings, revised algorithms are proposed and recommendations are made for improvements in the method to capitalise on the available monitoring data. A time series of estimated monthly averaged Atlantic water inflow toward the Arctic is presented for the period 1978-2002. We have reduced the noise level for predicting flows on the basis of coastal water level data by employing more monitoring data. To reduce the noise further, it is recommended to expand the monitoring by employing telemetering bottom pressure sensors at strategic locations. Bottom pressure sensors located in regions with significant baroclinic flows need the support of inverted echo sounders and seasonal hydrography to record the actual water level. This report and all other MAIA deliverables are included in the MAIA CD-ROM that is issued by BODC.

Use of MAIA results

The potential results of MAIA for predicting sea surface temperature and ice-front position over weeks, based on transports of warm Atlantic Water to the region of interest, could enhance long-term weather forecasting.

For the petroleum industry MAIA can provide a means to calculate the long-term variability of the Atlantic inflow to put short-term measurements into perspective. This will lead to more reliable estimates of extreme current speeds in areas where it is an important design parameter. MAIA can also provide more reliable boundary conditions for numerical models of the shelf seas from the North Sea to the Kara Sea, north of Siberia, and improve their value as a forecasting tool for operational purposes, as well as a tool for establishing longterm data series of ocean currents. The results can also provide a correlation between easily observable oceanic parameters and the ice extent in the Barents Sea, which can be used for ice cover forecasts on a time scale of months to seasons.

Commercial fisheries are pursued in sea areas influenced by the Atlantic inflow to the Arctic by the European Community, Nordic and Russian Federation nations. These fisheries are of great socio-economic importance and have in the past been managed by international agreements based upon annual scientific stock assessments and population predictions. There is a growing impetus towards introducing multi-species interactions and environmental influences to fisheries management.

As for the environment, the transport routes for Atlantic water toward the Arctic will provide valuable information for assessing the fate of pollutants in northern European shelf seas. The results of MAIA are directly relevant to the World Climate Research Programme's climate studies: Arctic Climate System Study (ACSYS) / Climate and Cryosphere Programme (CliC) and Climate Variability (CLIVAR).

The European component of the Global Ocean Observation System (EuroGOOS) is concerned with identifying the potential synergy from a range of measurements. It has a strong and continuing interest in measuring the

strength of the thermohaline circulation, monitoring deepwater formation, convection, and northward transport. MAIA represents first and foremost added value to existing measurement/monitoring programmes.

Project Outputs

BODC had responsibility for assembling and fully documenting all data collected during the validation experiment. The data set consists of 859 CTD casts, 18 moored ADCPs, 43 current meters, 6 bottom pressure recorders, 2 inverted echo sounders, 8 RAFOS floats and 1 Iodine experiment.

The full MAIA data set was published on CD-ROM by BODC in March 2003 complete with user interface and documentation (see project website for more information and to obtain a data CD).

MOEN - Meridional Overturning Exchange with Nordic Seas

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 1.727.606
EC contribution:	€ 1.590.709
Start – end date:	1/12/2002 – 30/11/2005
Duration:	36 months
Project Coordinator:	Svein Østerhus (svein.osterhus@gfi.uib.no)
Organisation:	Bjerknes Centre for Climate Research – Norway
CLAMER thematic focus:	Ocean circulation changes
CLAMER regional focus:	Arctic; North Atlantic

Project Website:
http://www.bjerknes.uib.no/pages.asp?kat=74&lang=1

Project Partners

1 Bjerknes Centre for Climate Research - Norway
2 The Scottish Association for Marine Science - United Kingdom
3 Marine Research Institute - Iceland
4 Danish Meteorological Institute - Denmark
5 University of Hamburg, Insitute für Meereskunde - Germany
6 Stockholm University, Department of Meteorology - Sweden
7 University of Copenhagen, Niels Bohr Institute for Astronomy, Physics and Geophysics - Denmark
8 The Faroese Fisheries Laboratory - Denmark
9 Fisheries Research Services Marine Laboratory - United Kingdom

Background information

Project Summary

Abstract
The mild climate of north Western Europe is, to a large extent, governed by the influx of warm Atlantic water to the Nordic Seas. Model simulations predict that this influx and the return of flow of cold deep water to the Atlantic may weaken as a consequence of global warming. MOEN will assess the effect of anthropogenic climate change on the Meridional Overturning Circulation by monitoring the flux exchanges between the North Atlantic and the Nordic Seas and by assessing its present and past variability in relation to the atmospheric and thermohaline forcing. This information will be used to improve predictions of regional and global climate changes. MOEN is a self-contained project of the intercontinental Arctic-Subarctic Ocean Flux (ASOF) Array for European Climate project, which aims at monitoring and understanding the oceanic fluxes of heat, salt and freshwater at high northern latitudes and their effect on global ocean circulation and climate.

MOEN will contribute to a better long-term observing system to monitor the exchanges between the North Atlantic and the Nordic Seas from direct and continuous measurements in order to allow an assessment of the effect of anthropogenic climate change on the Meridional Overturning Circulation. This will be done by

measuring and modelling fluxes and characteristics of total Atlantic inflow to the Nordic Seas and of the Iceland-Scotland component of the overflow from the Nordic Seas to the Atlantic.

Objectives

• To contribute to a better long-term observing system to monitor the exchanges between the North Atlantic and the Nordic Seas.
• To assess the effect of anthropogenic climate change on the Meridional Overturning Circulation.

Project Outputs

Socio-economic relevance and policy implications

- MOEN has extended the time series of Atlantic inflow to the Nordic Seas and dense overflows through the Faroe Bank Channel by two years. The new measurements have been combined with historical data to construct a decadal long time series of transport of the warm and salty Atlantic water toward the Arctic and the return of cold dense overflow.
- MOEN has developed a model tool capable of describing the observed volume transport.
- MOEN has designed an optimised monitoring scheme for long-term monitoring of the exchange across the Iceland-Scotland ridge. The basic tools for achieving a sustainable monitoring system are moored, ship- space-born instrumentation used to collect the necessary field data.

Conclusions

- The MOEN field phase was successfully terminated in 2005 with a data return close to 100%.
- MOEN modelling results show that the model is able to describe the observed natural variability and exchange variation with high accuracy.
- Ten peer-review articles have been publish including two high impact papers in Science and Nature. The list of publications is available on the project website.

NOCES - Northern Ocean-atmosphere Carbon Exchange Study

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 2.324.197
EC contribution:	€ 1.582.774
Start – end date:	1/04/2002 – 31/03/2005
Duration:	36 months
Project Coordinator:	James Orr (orr@cea.fr)
Organisation:	Commissariat a L'Energie Atomique – France
CLAMER regional focus:	North Atlantic; North Sea
Project Keywords:	Interannual-to-decadal variability of air-sea CO_2 fluxes; northern hemisphere; impact on carbon budgets; models

Project Website no longer available

Project Partners

1 CEA-CNRS Laboratoire des Sciences du Climat et de l'Environnement - France
2 Université de Versailles, Département de Physique - France
3 Met Office – Hadley Centre for Climate Prediction and Research – United Kingdom
4 Institut für Meereskunde, Department of Theory and Modelling - Germany
5 Max Planck Institute for Biogeochemistry - Germany
6 Max Planck Institute for Meteorology - Germany
7 Université de Liège, Laboratory for Planetary and Atmospheric Physics - Belgium
8 Université Pierre et Marie Curie - France
9 Nansen Environmental and Remote Sensing Centre - Norway
10 Sir Alister Hardy Foundation for Ocean Science - United Kingdom
11 University of East Anglia - United Kingdom

Background information

Project Summary

Problems to be solved
Noces will set constraints on interannual-to-decadal variability of air-sea CO_2 fluxes, particularly over the northern hemisphere. An understanding of this variability, associated uncertainties and the mechanisms which drive it will be used to *i)* Evaluate the ocean component of coupled carbon-climate models which predict future atmospheric CO_2 and *ii)* Improve the skill of inverse atmospheric models to distinguish contributions of European, Asian, and North American terrestrial carbon sinks.

Therefore, NOCES will improve current understanding of the variability of air-sea CO_2 fluxes and its impact on carbon budgets. Such will help ameliorate numerical models that are used to evaluate present and future carbon uptake over Europe and other regions of the Northern Hemisphere. Although the Kyoto Protocol is being negotiated internationally, credible carbon budgets have not been established. This must change if

Europe is to verify commitments and be in a proper position during future negotiations. Credible carbon budgets are needed to make all nations accountable. Without accountability, atmospheric CO_2 would be sure to rise far beyond acceptable levels.

Scientific objectives and approach
NOCES has three main objectives: *i)* To assess patterns and uncertainties of interannual-to-decadal variability of air-sea CO_2 exchange by means of diagnostic ocean model comparison and data evaluation *ii)* To evaluate how different prognostic coupled carbon climate models perform for the ocean component on this most relevant time scale and *iii)* To improve constraints on the terrestrial carbon sink over Europe, using simulated air-sea CO_2 fluxes and uncertainties as a priori estimates for inverse atmospheric models.

NOCES is original because *i)* It will be the first to make forced ocean carbon simulations of interdecadal variability, *ii)* It will do so with six diverse ocean models to provide uncertainty estimates and results that are not model specific, *iii)* It will elucidate the mechanisms responsible for this variability (using statistical correlation analysis, comparison with time series data and comparison with another ongoing mechanistic study), and *iv)* It will improve the a priori constraint for air-sea CO_2 fluxes used by atmospheric inverse models and thus reduce uncertainties in terrestrial carbon uptake.

Project Output

Scientific achievements

- Production of standard protocols with which ocean modellers are now able to make comparable simulations of inter-annual to decadal variability. The NOCES/OCMIP-3 protocol document has become a standard in the community.
- Production of a detailed multi-model output archive from the standard ocean model simulations made within NOCES. This legacy from NOCES will serve the community as a standard reference point for many years to come and will be more valuable due to efforts to improve the common protocol guidelines.
- Improved atmospheric inverse modelling approach.
- Improved method to evaluate the variability of air-sea CO_2 fluxes from satellite information.
- Comparison of simulated inter-annual variability of air-sea CO_2 fluxes from ocean models vs. atmospheric inverse models [Peylin *et al*., 2005].
- Improved understanding of what controls tropical Pacific carbon and radiocarbon [see NOCES publication Rodgers *et al*., 2004].
- Improved understanding of temporal trend in observed pCO_2 in the North Atlantic [see NOCES publication Lefèvre *et al*., 2004].
- First evaluation of decadal variability of air-sea CO_2 fluxes in the North Atlantic [see NOCES publication Raynaud *et al*., 2005].
- Better understanding of compensating regional variability of air-sea CO_2 fluxes in the North Atlantic basin. The North Atlantic's subtropical gyre was not the largest contributor to the overall, basin-wide variability, in contrast to previous suggestions. The subpolar gyre and the inter-gyre region (the transition area between the subpolar and subtropical gyres) also contribute to major multipolar anomalies at multiple frequencies: these tend to cancel one another out in terms of the basin-wide air-sea CO_2 flux [see NOCES publication Raynaud *et al*., 2005].
- First accounting for time lag between inter-annual variability of air-sea CO_2 fluxes and driving mechanisms [see NOCES publication Raynaud *et al*., 2005]. Statistical analysis within NOCES have shown that there is indeed a strong correlation between air-sea CO_2 fluxes and the North Atlantic Oscillation (NAO), but only if one takes into account time lags (maximum r = 0.64 for lags between 1 and 3 years) [see NOCES publication Raynaud *et al*., 2005].
- Improved understanding of the effect of increasing atmospheric CO_2 (the anthropogenic perturbation) on total variability. The effect is negligible at inter-annual time scales, whereas at the decadal (13-year) time scale, it increased variability by 30% [see NOCES publication Raynaud *et al*., 2005].
- Serendipitous discovery that during pre-industrial times there was probably a large ocean transport of about 0.8 Pg C yr−1 from the northern to the southern hemisphere, caused by iron limited primary

productivity in the Southern Ocean [see NOCES publication Wetzel., 2004]. This finding resolves a long-standing enigma as to why all other ocean models (none of which featured iron limitation) could not simulate such a large inter-hemispheric ocean transport, as theorized based on supposed pre-industrial atmospheric CO_2 gradients.

- Serendipitous discovery that high-latitude surface waters may become corrosive to CaCO3 minerals such as aragonite by the end of the century, a first in perhaps 25 million years [see NOCES publication Orr *et al*., 2005]. This would seriously threaten marine calcifying organisms such as cold-water corals and some plankton.
- Production of various other related scientific publications from NOCES (see activity reports from each of the work packages).

Socio-economic relevance and policy implications

NOCES addresses how improving our understanding in the variability of the air-sea CO_2 flux in the Northern Hemisphere would (1) reduce uncertainties concerning uptake of atmospheric carbon by the terrestrial biosphere and (2) improve predictions of future atmospheric CO_2. Both improvements are relevant to EU environmental policies, and in particular the Kyoto Protocol, by which EU Member States have agreed to reduce fossil carbon emissions.

The NOCES project built on the current EU investment in several recent or ongoing projects (e.g., CARBOEUROPE, CAVASSOO, PREDICATE) and has helped to set the stage for ocean, global carbon cycle and biogeochemistry research which was initiated within the 6th Framework Programme. NOCES must be carried out at the European level, i.e., its goals cannot be obtained from any of the Member States alone because it requires extensive model comparison and evaluation with a diverse group of models to provide interpretations that are not model specific.

Conclusion

Accomplishments during NOCES came more slowly than originally planned because it proved difficult to elaborate, refine, and agree on all the details necessary to make rigorous comparisons of model simulations of inter-annual variability. Nonetheless, the NOCES modelling groups persisted. This effort has provided an archive of standard model output from multiple models, which will serve as the de facto reference for this type of simulation for years to come.

ORFOIS - Origin and fate of biogenic particle fluxes in the ocean and their interaction with the atmospheric CO_2 concentration as well as the marine sediment

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 2.852.439
EC contribution:	€ 2.122.146
Start – end date:	30/11/2001 – 30/11/2004
Duration:	36 months
Project Coordinator:	Christoph Heinze (christoph.heinze@gfi.uib.no)
Organisation:	National Environmental Research Institute – Denmark
Project Keywords:	Carbon cycle; silicon cycle; CO_2 uptake; Kyoto Protocol; marine biogeochemistry; marine tracer database; general circulation models; water column models; Marine sediment models

Project Website:
http://www.pangaea.de/Projects/ORFOIS/

Project Partners

1 National Environmental Research Institute - Denmark
2 University of East Anglia, School of Environmental Sciences – United Kingdom
3 Hellenic Centre for Marine Research - Greece
4 French National Centre for Scientific Research, UMR 1572 - France
5 Universite de Bretagne Occidentale, Institut Européen Universitaire de la Mer - France
6 Netherlands Institute of Ecology – Netherlands
7 French National Centre for Scientific Research, UMR 6539 - France
8 University of Hamburg, Zentrum fuer Meeres- und Klimaforschung - Germany
9 Commissariat à l'Energie Atomique - France
10 Max Planck Institute for Meteorology - Germany

Background information

Project Summary

Problems to be solved

The simulation of thoroughly backed up surface ocean pCO_2 distributions will narrow the uncertainties of carbon redistribution estimates within the earth system. This knowledge has direct economic consequences because it enables early political measures to react on and prevent undesired climate change evolutions. This knowledge enables a well planned procedure for fulfilling the Kyoto Protocol obligations of member states. Early planning on the basis of solid research results within this context has been shown to be of extreme economic value. The calculation of the fate of particles will be the foundation for valid estimates of removal and storage of hazardous substances within the ocean (coming from land based sources through river runoff

and atmospheric transport as well as from direct marine disposal). The consideration of near shore and shelf systems within a global BOGCM (biogeochemical ocean general circulation model) will provide a first global estimate of shelf/open ocean interaction and related water exchange time scales on a mechanistic basis. The particle flux and sediment "community models" will provide a basis for future operational biogeochemical forecasting of environmental key variables. Thus these models will help to prevent marine areas around EU member states from environmental damage and foster sustainable use of these oceanic areas for fisheries.

Scientific objectives and approach
The main scientific objectives of project ORFOIS are to:

- identify and quantify globally the mechanisms underlying the transformation of biogenic particles to dissolved substances within the ocean water column in order to predict correctly surface ocean carbon dioxide sources and sinks;
- develop a refined particle flux model for operational use in ocean general circulation models which realistically describes particle dynamics in the water column, deposition of material to the sediment, and the interaction with the carbon dioxide partial pressure pCO_2;
- provide a global closed carbon and nutrient budget for modern (preindustrial) conditions including the water column sediment interaction;
- estimate the changes in CO_2 sea surface source sink patterns and vertical redistributions of carbon as well as nutrients for future global climate change, as well as carbon sequestration scenarios including the associated potential economic impacts.

The project's main technological objectives are to:

- establish publically available community models for particle flux dynamics in the water column and early sediment diagenesis which are suited for use in general circulation ocean climate models;
- establish databases for marine carbon and nutrient cycling which will be easily publically available.

The methodology to achieve these goals is based on a combination of a comprehensive observational database on marine carbon cycling to be collated with two BOGCMs.

Project Output

Scientific achievements
Comprehensive predictive models systems, i.e. those who can react to changes in external or internal forcing, for marine biogeochemical cycling (carbon, oxygen, nutrients) were developed including particle dynamics (disaggregation and coagulation): A 1 –D modelling framework was provided which allows quick tests of parameterizations two 3 –D fully fledged coupled biogeochemical-physical ocean general circulation models.
A comprehensive web accessible database for ocean biogeochemical cycling was established with special emphasis on carbon (including pCO_2 data) oxygen, nutrients, and particle fluxes. Process parameterizations for particle fluxes in the water column as well as sedimentary processes (early diagenesis, sediment top layer, reverse weathering) were developed on the basis of observations and modelling. A first step parameterization of river run off in BOGCM's was provided. A socio-economic evaluation clarified the option for inclusion of coastal zones into CO_2 emission trade.

Results from global change scenarios: Inclusion of particle dynamics in BOGCM's indicates that the buffer capacity of the ocean for anthropogenic CO_2 may be lower than expected from models which do not include particle dynamics. Thus the process added to the models here is important for reliable prediction of future atmospheric greenhouse gases concentrations and the respective radiative warming.

Results from iron fertilization: Iron fertilisation as a mitigation option for climate change is not efficient and thus should not be carried out.

Results from glacial ocean: The effect of iron fertilization and dust input however can have contributed significantly to the glacial atmospheric pCO_2 drawdown as observed from ice core measurements.

Results from socio-economic evaluation: Inclusion of ocean zones around countries into CO_2 emission trade can potentially be exploited by a few nations only without doing significant harm to the global community.

Socio-economic relevance and policy implications

Precise knowledge on particle dynamics in the ocean provides the basis for more appropriate prognostic models for oceanic CO_2 uptake from the atmosphere, which can now in fact be optimized also with respect to sediment trap data. As these latter data on the biological fluxes have potentially large systematic errors the model framework in conjunction with a large data set based on dissolved tracers (not sediment trap data) will help to narrow these uncertainties. The socio-economic evaluation showed that inclusion of oceanic areas into emission trade considerations may be tried by a few nations, but that this consideration would have no large global impact (neither on economics or climate).

Conclusions

The model framework including a process related steering of marine particle fluxes for organic carbon, calcium carbonate and biogenic silica is a unique tool in the world of biogeochemical modelling. The dedicated observational database is one of the most comprehensive dedicated databases existing so far.

POP - Pole-Ocean-Pole: global stratigraphy for millennial climate variability

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 3.265.396
EC contribution:	€ 1.773.968
Start – end date:	1/12/2000 – 31/05/2004
Duration:	42 months
Project Coordinator:	Jenny Walsham (jrw46@admin.cam.ac.uk)
Organisation:	Cambridge University, Department of Earth Sciences - United Kingdom
CLAMER Regional focus:	Arctic; North Atlantic
Project keywords:	Deep-sea sediments and ice cores; modelling, climatic change; high-resolution palaeoclimatic records for understanding the climate system

Project Website:
http://www.esc.cam.ac.uk/research/research-groups/pop

Project Partners

1 Cambridge University – United Kingdom
2 French Natinal Centre for Scientific Research, UPR 5151 - France
3 University of Berne - Switzerland
4 Spanish National Research Council, Instituto de Investigaciones Quimicas y Ambientales - Spain
5 French Natinal Centre for Scientific Research, UMR 1572 - France

Background information

Project Summary

Abstract
POP (Pole-Ocean-Pole) was proposed with the overarching objective of developing the methods for linking palaeoclimatic records from the polar ice cores and from deep ocean sediments. By examining sediments from the world oceans it is possible to make very valuable reconstructions of many aspects of the Earth's climate system over the past million years and more. Methods for developing time scales for deep ocean sediment records have evolved over the past 30 years, largely based on work by Shackleton and colleagues in the 1970's. On the other hand the polar ice cores have certain unique advantages. First, they contain bubbles of "fossil" air so that the natural record of changes in greenhouse gases can be obtained. Second, they are capable of yielding a more detailed record (in the Greenland ice sheet even at annual resolution, in the deeper parts of the Antarctic ice sheets better than century resolution) than marine cores that can very rarely yield a resolution better than about 200 years. Third, the factors controlling variations in snow accumulation are easier to understand than those causing changes in the accumulation of marine sediment, so that the conversion from depth to geological age can be carried out in a more refined manner.

Unfortunately Greenland is only able to provide records covering about 110,000 years (one glacial cycle) but these records are of superb quality and provide an ideal template for understanding the details of climatic variability in the North Atlantic region over that time interval. At the time that POP was proposed, the Vostok record from Antarctica provided the longest record, about 400,000 years. Hence the focus of POP was to

develop an accurate and precise age scale for the Vostok record and for marine cores that could be precisely linked to it. There was to be a special focus on those cores that could substitute for the Greenland ice sheet by yielding highly detailed climatic records for the North Atlantic region.

Project Outputs

Scientific achievements
For the last glacial cycle (the last seventy thousand years) POP developed a new age scale for ice cores in both the Greenland and Antarctic polar ice sheets as well as for marine sediments of the North Atlantic Ocean. This also permitted improved calibration of the radiocarbon time which assists in applying a consistent age scale to sedimentary records of rapid environmental change over this time interval in sediment cores from the other ocean basins, and in records that are collected on the continents.

For the 400,000-year time interval that is covered by the Vostok ice core that was collected in central Antarctica POP developed a new age scale that has been applied to the three long cores from central Antarctica that have so far been collected: Vostok, Dome Fuji, and Dome C.

Significant advances were made within POP in obtaining a reliable age scale for the air bubbles that have been analysed within the ice cores, so that we also have a more reliable age scale for the history of natural variations in the concentration of greenhouse gases (carbon dioxide and methane) in the atmosphere.

Records of changing sea surface temperature, and of conditions on the sea floor bathed by the deep ocean water masses, were collected from the subantarctic Indian Ocean, the tropical Indian Ocean, and both the East and the West of the North Atlantic Ocean. These records are extremely detailed and can be linked to the ice cores with unprecedented reliability. This will permit a more detailed understanding of the relative timing of changes in different components of the global climate system. New modelling in the POP project provides a considerably better understanding of the mechanism by which climatic changes propagate through the climate system with delays that can amount to over 1.000 years.

Results

- The project has delivered new sediment cores, new analyses, new methodologies and new theoretical concepts.
- A suite of cores from the North Atlantic off Portugal was collected. Many types of analyses have already been performed on these cores, but they remain as a legacy for future researchers
- A very large number of oxygen isotope analyses; carbon isotope analyses; alkenone-based temperature estimates; fossil microfossil counts and other measurements have been collected. These will provide the basis both for publications by the POP scientists and by the broader community for whom these will constitute valuable data archives. Important new data, particularly regarding the concentration of methane in the air bubbles spanning the last 400,000 years, have been obtained.
- Significant advances have been made in the methods for interpreting records in ice cores. In particular methods for estimating the air temperature actually associated with the bubbles that are subjected to analysis have been refined.
- A new approach to the development of age scales in ice cores has led to a better understanding of the time frame for the records in these cores.
- New model results have been published that advance our understanding of the operation of the so-called ‘bipolar seesaw’ whereby temperature changes in one hemisphere can lead to changes in the opposite sense in the opposing hemisphere.

Socio-economic relevance
The POP findings will help to refine the reliability of the atmospheric and coupled atmosphere-ocean models that are used to predict future trends in global climate that will result from the continuing addition of greenhouse gases to the atmosphere that mankind is causing.

Conclusions

A broad conclusion that may be drawn from the findings of the POP project is that the 'bipolar seesaw' concept does constitute both a valuable means for describing the past record of rapid natural climate variability, and a useful route to making testable predictions that will further consolidate our confidence in climate model predictions.

TRACTOR - TRAcers and Circulation in the NORdic Seas region

Summary information

Funding source:	FP5 - Research project
Total Cost:	€ 2.342.632
EC contribution:	€ 1.887.530
Start – end date:	1/02/2001 – 31/01/2004
Duration:	36 months
Project Coordinator:	Truls Johannessen (truls.johannessen@gfi.uib.no)
Organisation:	University of Bergen and Bjerkens Center for Climate Research – Norway
CLAMER thematic focus:	Ocean circulation changes; deep circulation changes
CLAMER regional focus:	Arctic; North Atlantic
Project keywords:	Resources of the Sea; Fisheries; Environmental Protection; Meteorology; Forecasting

Project Website:
http://www.ices.dk/ocean/project/tractor

Project Partners

1 University of Bergen - Norway
2 University of East Anglia – United Kingdom
3 Göteborg University - Sweden
4 Nansen Environmental and Remote Sensing Center - Norway
5 Norwegian Polar Institute - Norway
6 Marine Research Institute - Iceland
7 International Council for Exploration of the Seas - Denmark

Background information

Project Summary

Primary 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 thermaholine 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.

Specific Objectives
Perform annual hydrographic, chemical and SF6 tracer surveys into the Nordic regions in order to:

- Measure lateral and diapycnal mixing rates in the Greenland Sea Gyre and in the surrounding regions.
- Document the depth and rates of convective mixing in the Greenland Sea using the SF6 and the water masses characteristics.
- Measure the transit time and transport of water from the Greenland Sea to surrounding seas and outflows. Document processes of water mass transformation and entrainment occurring to water emanating from the central Greenland Sea.
- Measure diapycnal mixing rates in the bottom and margins of the Greenland Sea basin using the SF6 signal observed there. Quantify the potential role of bottom boundary-layer mixing in the ventilation of the Greenland Sea Deep Water in absence of deep convection.

Monitor the variability of the entrainment of water from the Greenland Sea using time series auto-sampler moorings at strategic positions i.e., sill of the Denmark Strait, Labrador Sea, Jan Mayen fracture zone and Fram Strait. Relate the observed variability of the tracer signal in the outflows to convection events in the Greenland Sea and local wind stress events. Obtain a better description of deepwater overflow and entrainment processes in the Denmark Strait and Faeroe Bank Channel overflows and use these to improve modelling of deepwater overflows.

Monitor the tracer invasion into the North Atlantic using opportunistic SF6 measurements from other cruises: we anticipate that a number of oceanographic cruises will take place in the north-east Atlantic and the Labrador Sea. It should be possible to get samples from some cruises for SF6 measurements.

Use process models to describe the spread of the tracer to achieve better parameterisation for three-dimensional models. One reason that these are so resistant to prediction is that our best ocean models are as yet some distance from being good enough, to predict climate and climate change.

Project Outputs

Scientific achievements and conclusions
As by spring of 2004[1], the main results of TRACTOR are:

- The vertical mixing rates in the Greenland Sea gyre system have been quantified and found to be much higher than in other regions.
- The main pathways from the Greenland Sea into the ambient oceans have been identified.
- Information on the exchange and exchange rates between basins of the water marked by the tracer have been received from budgeting the tracer patch.
- Two modes of ventilation are identified in the Greenland Sea. The first is the formation of eddies with subsequent ventilation at mid depth during the collapse of the eddies and the second is overturning. The eddy mode seems to play an important role during the tracer experiment with a volume transport estimated to 0.01 to 0.02 Sv while the limited overturning present during the main part of the experiment seemed to contribute to 0.1-0.2 Sv.
- Different pathways from the Greenland Sea dominate during different modes of the North Atlantic Oscillation, the natural variability in atmospheric forcing. In the NAO + mode a bifurcation of the pathways occur with one route from the Greenland Sea through the Jan Mayen channel, along the Jan Mayen Ridge and then into the Faeroe-Shetland channel and the other route along the shelf rise to the Greenland Shelf on route to the Denmark Strait. In the NAOmode waters from the Greenland Sea will mostly select the western path.
- The first appearance of the tracer at the Greenland-Scotland Ridge was in the Faeroe Bank channel after 2.5 years (± 2 months). This is consistent with the different pathways for the water from the Greenland Sea connected to the NAO modes as mentioned above, since NAO + forcing greatly dominated during the experiment.

[1] No later information could be found

- The circulation and mixing characteristics of the 20 km resolution Nansen Centre version of the Miami Isopycnic Coordinate Ocean General Circulation Model (MICOM), lead to greatly improved and a representative time-space distribution of the released SF6. It is concluded that simulated distributions of tracers provide detailed insight into isopycnal and diapycnal diffusion parameterizations, and that a data-model comparison can be used to constrain the strength of the mixing schemes.
- The 40 km, and in particular the 20 km, resolution versions of the model system are able to describe the main features of the observed CFC-11, CFC-12, ^{137}Cs and SF_6 concentrations in a realistic way. In fact, the performed simulations show that OGCMs used in climate research should be evaluated based on some of the key tracers, including SF6, to assess, and by that to improve, the model's ability to reproduce the main features of the key ventilation processes of the ocean climate system.
- The results from the tracer release experiment will be used for a modelling inter-comparison exercise. Preliminary results from a GCM indicate that it seems to accelerate the general circulation relative to what is observed from the tracer field. A clear need for more detailed intercomparison between the tracer field and the most frequently used GCMs are needed to improve these models from which results are frequently used in guidance of policy making (see IPCC-report).
- New information of the transformation of dissolved inorganic carbon along the East Greenland Current, and of the anthropogenic carbon inventory within the Nordic Seas, and a new hypothesis on how ice formation enhances air-sea flux of CO_2.
- During the TRACTOR period an auto-sampler collecting deepwater has been developed. One successful deployment and retrieval of the auto-sampler was done in the Denmark Strait. The water is now being measured for CFC's. The titanium bags used need to be of a larger volume to be able to sample for SF6 and a new design of water collecting bags are under development.

Socio-economic relevance and policy implications

European dimension of the problem

TRACTOR has investigated the circulation of the Nordic Seas. The area has been considered crucial to the general circulation of the oceans, and this interlinked with climate change processes. A better understanding of the processes involved in climate change that affects Europe specifically and the globe in general, and a better predictability of climate change, are important for many aspects of the economy, politics, welfare and cultural and social affairs. Better detection and prediction of anthropogenically forced climate changes, as well as understanding the natural backdrop of changes, will form a better basis for policy making.

Contribution to developing S&T co-operation at international level

The consortium of TRACTOR has brought together skills and analytical methods which are unique in the world. It was built on existing capacities brought together in a scientific task that has not been attempted before. With the contributions from the different partners, a critical mass of personal resources and infrastructure (such as research vessels and computers) was achieved. The project has fostered closer ties between the observational and climate modelling communities in Europe, and laid the ground for further development of European modelling institutions to improve the model skills to describe global ocean circulation and its impact on climate.

Contribution to policy design or implementation

An improved capability to model oceans and oceanic processes will reduce uncertainties in the projected forecasts of the climatic response to greenhouse gas forcing.

- It will form a better basis for choosing the most relevant policies to deal with the problems of climate change and the implementation of the Kyoto protocol.
- The model improvements will specifically address uncertainties related to processes of high relevance for the regional climate; the project has contributed to more reliable regional climate forecasts.
- The improved ocean modelling capabilities is of relevance for the use and management of oceans and ocean resources, in particular living resources.
- The improved ocean modelling capabilities will also be of high relevance for the potential forecasting of water management in Europe.

Quality of life

There is considerable variability in the climate of Europe. Most areas of human activity are affected by climate change in the region. It is necessary to improve our understanding of this variability and the range of the variability in future scenarios. If ocean circulation should change or the decadal variability should tend to shift into a state where one of the NAO modes is dominant, this would impact strongly on life in our part of the globe, in a way which is economically quantifiable. Although parts of this variability may be chaotic and nonpredictive, the project has contributed to a better understanding of the patterns, which may lead to some type of predictability. A better understanding of oceanic processes lies at the heart of this problem.

UVAC - The influence of uvr and climate conditions on fish stocks: a case study of the northeast arctic cod

Summary information

Funding source:	FP5
Total Cost:	€ 1.477.900
EC contribution:	€ 904.000
Start – end date:	1/03/2000 – 28/02/2003
Duration:	36 months
Project Coordinator:	Paal Berg (paal.berg@nilu.no)
Organisation:	Polar Environmental Research Centre – Norway
CLAMER thematic focus:	Biological impacts; socio-economic impacts
CLAMER regional focus:	Arctic; North Atlantic
Project Keywords:	Marine eco-systems; UV radiation; climate change; fishery management

Project Website no longer available

Project Partners

1 Norwegian Institute for Air Research – Norway
2 German Aerospace Centre – Germany
3 University of Tromsø – Norway
4 Azti Fundazioa – Spain
5 Bodo Regional University – Norway
6 Commission of the European Communities – Italy
7 Spanish National Research Council – Spain

Background information

Project Summary

Abstract
The main objective of the proposal was to investigate the impact of solar ultra-violet radiation (UVR) on the Northeast Arctic cod stock. This relation was planned to be investigated as part of a more comprehensive impact system, including both other geophysical factors such as climate, and other (biological) components of the marine ecosystem which are of importance for the cod stock (zooplankton: *Calanus finmarchicus*; phytoplankton). It was envisaged to study the UVR impact 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.

Deliverables
It was expected that the project would provide:

- re-evaluated homogenised biological data series of cod, Calanus finm. and phytoplankton from the Lofoten area over at least a 100-year period
- new data sets on UV radiation conditions (one multi-decadal series, spatially resolved UV maps over a 15-year period) from the Lofoten area
- new field and laboratory experiment results on UV impact on the selected species
- correlation coefficients between geophysical/UVR parameters and biological parameters, especially cod 0-year class size
- an improved cod stock prediction model, considering the impact of UVR and other geophysical parameters

Project Outputs

Project deliverables are no longer accessible via a project-website but can be obtained by contacting Georg H. Hansen, Senior Scientist from the Norwegian Institute for Air Research (NILU) at Georg.H.Hansen@nilu.no.

The project's actual outcome
The UVAC project has yielded most of the deliverables, in some aspects beyond the expectations, in others not to the fully 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 the introduction of trawling in the 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, 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, back to 1934
- meteorological data from Røst (1880-1969, 1979-1997) and Skomvær (1970-1978)
- daily total ozone data (March-May) and derived UVR (5 parameters) and PAR data back to 1940
- 2 independent satellite–derived UVR climatologies (daily and higher level) 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 a negative sign) for cod in its earliest life stage, was not confirmed by the multi-decadal correlation studies. The 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 (for 1-2 out of 20 years), UVR may seriously damage cod eggs and larvae. The positive correlation found instead has not been explained so far. Hence, the envisaged year class size prediction tool based on UVR could not be realised in its planned form. However, the results of the multi-linear correlation between climatic and biological data, and the wavelet analyses of the historical cod and climate

data indicate that there are predictive possibilities on annual and decadal time scales, should the stock recover its biological potential in the next few years.

Exploitation of the results
The scientific results and new data sets produced in the frame of the UVAC project have the potential to be used in a number of future activities:

- 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 as well as on terrestrial ecosystems
- 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.


FP6

ADELIEPENGUINSUCCESS - Long-term foraging success in an Antarctic top-predator, the Adélie Penguin: effect of individual quality, colony size and access to prey

Summary information

Funding source:	FP6 - Marie Curie Actions
EC contribution:	€ 250.231
Start – end date:	1/12/2005 – 30/11/2008
Duration:	36 months
Project Coordinator:	Charles-André Bost (lacalle@cebc.cnrs.fr)
Organisation:	National Council for Scientific Research – France
CLAMER thematic focus:	Biological impacts
Regional focus:	Antarctic

Project Website:
http://www.penguinscience.com/index.php

Project Partners

1 National Council for Scientific Research – France
2 H.T. Harvey & Associates – United States

Background information

Project Summary

Abstract
Polar Regions are highly sensitive to climate change and this raises real concern for the future of polar ecosystems. Some of the most important signals of global climate warming have come from Antarctica, the waters surrounding of which support one of Earth's most productive marine ecosystems. As integrators of food web changes, Antarctic marine top predators are reliable indicators of changes in marine food webs. Hence, the Life Time Reproductive Success (LRS) of top predators integrates environmental variability over large spatial and temporal scales, but is also affected by individual and colonial variability.

As part of an international project on the Adélie Penguin, the ADELIEPENGUINSUCCESS study focuses on:
(1) how individual quality is linked to differences in foraging strategies,
(2) the extent to which colony size influences the LRS, and
(3) how high and low quality individuals cope with years of high environmental stress related to changing climate.

BASIN - Basin-scale Analysis, Synthesis, and Integration: Resolving the impact of climatic processes on ecosystems of the North Atlantic Basin and shelf seas

Summary information

Funding source:	FP6 - Specific Support Action
Total Cost:	€ 133.300
EC contribution:	€ 115.071
Start – end date:	1/07/2006 – 31/03/2008
Duration:	21 months
Project Coordinator:	Michael St. John (michael.st.john@uni-hamburg.de)
Organisation:	Universität Hamburg – Germany
CLAMER thematic focus:	Ecosystem changes
CLAMER regional focus:	North Atlantic

Project Website:
http://www.globec.org/

Project Partners

1 Plymouth Marine Laboratory – United Kingdom
2 Universität Hamburg - Germany

Background information

Project Summary

Abstract
BASIN was a joint EU / North American research initiative designed to elucidate the state of our understanding of the role of the climatically driven mechanisms underlying observed changes in North Atlantic ecosystems and their services as well as to provide the vision necessary to allow us to quantify and understand the consequences of climate and environmental variability and change on the system. The ultimate goal was the development of an understanding of the links between climate and the marine ecosystems of the North Atlantic Basin and the services these ecosystems provide including exploited marine resources, and to use this understanding to develop ecosystem based management strategies that will anticipate the effects of climate change.

Objectives
The project objectives were to report on the status of climate-related ecosystem research in the North Atlantic Basin and associated shelf seas (from Georges Bank to the Barents Sea and the North Sea shelf). As well, the project documented gaps in systematic observations and process understanding of atmospheric and oceanic parameters, necessary to improve forecasting of ecosystems in the North Atlantic and associated shelves. Furthermore the project developed a metadatabase necessary for the future consolidation of long-term observations from EU and international databases necessary for the modelling and in particular short term

prediction of the dynamics of North Atlantic and associated shelf ecosystems. BASIN also reported on the feasibly of developing a joint EU-US-Canadian research program in the field of ocean ecosystems and produced an international science plan. BASIN's final objective was to develop, in concert with representatives from the EU DG Research and program managers from the US National Science Foundation and the Canadian NSERC, an implementation plan for the development of jointly funded EU-North American research programmes.

Methodology
The BASIN SSA funded four workshops to identify and document the state of the art of climate-related ecosystem research in the North Atlantic Basin and associated shelf seas, assess the feasibility of developing a joint EU-North American basin-scale research program focusing on the ecosystems of the North Atlantic, and seek to develop an implementation plan whereby joint research initiatives involving the EU and other nations (e.g. USA, Canada, Japan, China) can be developed and funded. Based on these workshops, two reports on the status of BASIN scale research have been developed and an International science plan has been generated upon which future research in the region can be based. Information has been made accessible to the interested parties via the BASIN web page as well as via reports published in the GLOBEC series.

Project Outputs

BASIN has generated four reports based on the activities in the funded meetings. These reports assess and report on the status of climate-related ecosystem research in the North Atlantic Basin and associated shelf seas. They also identify and document gaps in systematic observations and process understanding of atmospheric and oceanic parameters, including those of climate, necessary to improve forecasting of ecosystems in the North Atlantic and associated shelves. The reports additionally identify the potential for consolidation of long-term observations from US and international databases for the modelling and in particular prediction of the dynamics of North Atlantic and associated shelf ecosystems and their services. Finally the reports provide a science plan upon which future research programs in the region can be based. These results will benefit policy makers, environmental agencies, researchers in the field and the general public.

CARBOOCEAN - Marine Carbon Sources and Sinks Assessment

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 19.230.000
EC contribution:	€ 14.500.000
Start – end date:	1/01/2005 – 31/12/2009
Duration:	60 months
Project Coordinator:	Christoph Heinze (christoph.heinze@gfi.uib.no)
Organisation:	University of Bergen and Bjerknes Centre for Climate Research – Norway
CLAMER thematic focus:	Ocean acidification
CLAMER Regional focus:	North Atlantic, Southern Ocean, European Regional Seas, World Ocean
Project keywords:	Carbon cycle; CO_2 uptake; Kyoto Protocol; marine biogeochemistry; Climate; Atlantic Ocean; Southern Ocean; World Oceans; US partners; Earth Sciences; Numerical ocean modelling; Marine carbon and oxygen observations; Marine carbon data syntheses

Project Website:
http://www.carboocean.org/

Project Partners

1	University of Bergen - Norway
2	Universite Libre De Bruxelles - Belgium
3	Alfred Wegener Institute for Polar and Marine Research - Germany
4	Leibniz Institute of Marine Sciences - Germany
5	Spanish National Research Council - Spain
6	Commisariat à l'Energie Atomique - France
7	Universite Pierre Et Marie Curie - France
8	Royal Netherlands Institute for Sea Research – Netherlands
9	University of East Anglia - United Kingdom
10	Universite de Liege - Belgium
11	University of Bern - Switzerland
12	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften - Germany
14	Technische Universitaet Hamburg - Germany
16	University of Bremen - Germany
17	National Environmental Research Institute - Denmark
18	Universidad de las Palmas de Gran Canaria - Spain
19	French Research Institute for Exploitation of the Sea - France
20	French National Centre for Scientific Research - France
22	Universite de Perpignan - France
23	Marine Research Institute - Iceland
24	Institut National de Recherche Halieutique - Morocco
25	University of Groningen - Netherlands
26	Royal Netherlands Academy of Arts and Sciences - Netherlands
28	Nansen Environmental and Remote Sensing Centre - Norway
29	Norwegian Institute for Air Research - Norway

31 Polish Academy of Sciences, Institute of Oceanology - Poland
32 University of Gothenburg - Sweden
33 Met Office - United Kingdom
34 Natural Environment Research Council - United Kingdom
35 University of Essex - United Kingdom
36 Fastopt Gbr - Germany
37 Intergovernmental Oceanographic Commission of Unesco - France
38 Nilu Polska Ltd. - Poland
39 Philippe Saugier International Educational Projects - France
44 Princeton University - United States

Background information

Project Summary

CARBOOCEAN IP (= CarboOcean Integrated Project) aimed at an accurate scientific assessment of the marine carbon sources and sinks within space and time. It focused on the Atlantic and Southern Oceans and a time interval of -200 to +200 years from now.
CARBOOCEAN was successful in determining the ocean's quantitative role for uptake of atmospheric carbon dioxide (CO_2), the most important manageable driving agent for climate change.
CARBOOCEAN thus created new scientific knowledge as an essential foundation for a quantitative risk/uncertainty judgement on the expected consequences of rising atmospheric CO_2 concentrations. Based on this judgement, it will be possible to guide the development of appropriate mitigation actions, such as management of CO_2 emission reductions within a global context.
CARBOOCEAN combined the key European experts and scientific resources in the field through an integrated research effort. The effort complemented other major research programmes on oceanic, atmospheric, and terrestrial carbon cycling and was linked to these programmes.

The ultimate goal of Integrated Project CARBOOCEAN was to reduce the present uncertainties in the quantification of net annual air-sea CO_2 fluxes. Particular emphasis was placed on the Atlantic Ocean and the Southern Ocean as the main deep water production areas, but also the World Ocean as a whole is considered. The target was to reduce the uncertainties by a factor of 2 for the world ocean and by a factor of 4 for the Atlantic Ocean. The IP delivered a description, process oriented understanding and prediction of the marine carbon sources and sinks with special emphasis on the Atlantic and Southern Oceans on a time scale –200 to +200 years from now. Specific objectives were:

1. Description and quantification of the CO_2 air-sea exchange on a seasonal-to-interannual scale for the Atlantic Ocean and the Southern Ocean
2. Quantification of decadal-to-centennial large-scale Atlantic and Southern Ocean carbon inventory changes
3. Quantification of the carbon sources and sinks at the European regional scale
4. Identification and understanding of biogeochemical feedback mechanisms which control marine carbon uptake and release
5. Integration of carbon observations into an integrated prognostic modelling framework

Project Achievements and Outputs

The CARBOOCEAN achievements represent the cutting edge in marine carbon cycle research in the domains of interest to the project. They are embedded in the international research community and have triggered new collborations and fostered existing collaborations. The record of peer reviewed publications form the CARBOOCEAN IP documents the high standard of the research results (including papers in *Nature* and *Science*). To illustrate this, we give below for each core theme, examples where CARBOOCEAN research has lead to new

knowledge which will also have considerable effect beyond the project end and which are shaping our present research questions as well as new up-coming research directions.

1. At basin wide/regional scale the air-sea CO_2 fluxes are interannually more variable than previously thought (e.g. Schuster et al., 2009; Watson et al., 2009; Metzl, 2009; Le Quéré et al., 2007) especially in regions of vertical downward mixing of water close to saturation with respect to the atmospheric CO_2 concentration. This new knowledge will help to re-design coming ocean observatories for carbon (such as initiated through the the ESFRI programme in ICOS – Integrated Carbon Observing System). This new finding is also fundamental in our general understanding of ocean carbon cycling: The ocean sink is not as reliable and steady, at least at the regional level, as many analysis methods (assuming steady state conditions) expect. In some ways the finding of highly variable air-sea CO_2 fluxes represent a paradigm shift in global carbon cycle research. The analysis of VOS line data for establishing basin-wide fluxes is currently also tested for the Pacific Ocean as CARBOOCEAN supported PhD student M. Telszewski started a post-doc position in Japan. The link between a temporarily decreasing Southern Ocean carbon sink and stratospheric ozone is a completely new aspect of Earth system science underlining the need for truly coupled multi-reservoir Earth system models. CARBOOCEAN researchers are also partners in the newest sea surface fugacity of CO_2 climatology as produced under US lead authorship with many international contributors. The CARBOOCEAN work on the North Atlantic and Southern Ocean ideally complement the work by international colleagues on the Pacific Ocean and particularly the El Nino/Southern Oscillation associated changes in air-sea carbon exchange.

2. The most comprehensive highest accuracy consistent carbon cycle tracer data set for the Atlantic available to date is the CARINA data set, which consists of a large number of pre-CARBOOCEAN data, data sampled during CARBOOCEAN, and many data sets from international colleagues. CARBOOCEAN was instrumental in bringing this data set to life. The data set nicely complements the GLODAP data set compiled under guidance of R.M. Key (Key et al., 2004). Bob Key from Princeton University was also a central figure in the compilation of CARINA. An effort similar to CARINA has now also started in the circum-Pacific Asian-American communities under the name PICES and will lead, together with CARINA, to a world-wide extreme high quality carbon data set. This data set will also have to be updated in the future due to the transient nature of the marine carbon cycle. CARBOOCEAN also provided new estimates on Atlantic inventories of excess carbon due to the anthropogenic carbon perturbation. The high latitude oceans can well have a considerably higher amount of anthrpogenic carbon stored in their water column than previously estimated. Inverse computations of intra-ocean fluxes and air-sea carbon fluxes through international-US efforts were supported by contributions from CARBOOCEAN.

3. The contribution of European regional seas to the Atlantic and European carbon budget was significantly better quantified than through previous efforts. The seasonal analysis of an entire regional seas basin and the systematic seasonal reccoupation of the Strait of Gibraltar hydrographic cross section with marine carbon measurements, can be regarded as milestones towards a systematic quantification of the carbon fluxes along the land-ocean continuum. A series of new process and case studies has indicated new processes through re-mineralisation of shallow organic sediments and associated alkalinity release and new procdures for biogeochmemical pH computations. Borges and Gypens (2010) have shown that in the discussion about ocean acidification, eutrophication in the coastal seas has an even stronger impact on the carbonate system and hence must be taken into account in continental seas carbon cycling. CARBOOCEAN scientists have contributed to the new international text book (Liu et al., 2010) on carbon and nutrient fluxes in continental margins.

4. The dependence of nutrient utilisation by biota on increase in ambient CO_2 partial pressure (and associated pH decrease and decrase in calcium carbonate saturation) as resulting from Riebesell et a. (2007) has triggered a new line of research on non-stoichiometric carbon cycle midelling, where the assumed “Redfield concept” of constant ratios of $P:N:C:\Delta O_2$ in most biogeochemical ocean models is abandoned. It is under discussion, whether the relationship as deduced from mesocosm experiments can be transferred to other situations and regions or not. If yes, it could include a potentially significant feedback to rising CO_2. In any case a process on re-thinking older established concepts in marine biogeochemical understanding has now been started, and has, e.g., lead to a new interface between Earth system models and the marine paleoclimatic sedimentary record (Heinze et al., 2009) which can help to solve the issue in future by looking at past changes of the Earth system. Gehlen et al. (2008) could show how quickly the sea surface signal of ocean acidification is transferred to the deep ocean where high CO_2 water is starting to dissolve marine calcium carbonate sediments. This study

complements nicely earlier studies with coarser models on the long-term negative feedback induced by sediment dissolution carried out by US researcher Archer (2005). Further, a cutting edge summary and description on the term “alkalinity” was published (Wolf-Gladrow et al., 2007) which will enter the scientific literature as a classic paper on this often not unambiguously discussed carbon cycle tracer (see discussions in Rakestraw, 1949; Dickson, 1992).

5. A new isopycnic physical-biogeochemical carbon cycle model was developed based on the existing modules MICOM and HAMOCC (Assmann et al., 2010) and implemented into a new Earth system model (Tjiputra et al., 2010). Next to the isopycnic ocean model version used at GFDL Princeton (GOLD model), this is the only isopycnic ocean Earth system model currently available and hence very useful in intercomparisons such as the CMIP5 programme in view of the 5th IPCC Assessment Report of Working Group 1. Systematic predictive scenarios with 4 comprehensive Earth system models have provided hindcasts (since the onset of industrialisation) and future projections (under assumptions of an SRES A2 emission scenario) for global as well as regional air-sea carbon fluxes which will enter the RECCAP analysis of the Global Carbon Project (Roy et al., to be submitted) in the years to come.

The project achieved a dissemination to policy makers including members of the European Parliament, to schools and to the general public. The project was instrumental in initiating further research projects and coordinating activities (such as the European FP7 project on ocean acidification, EPOCA, and the EU FP7 coordination action, COCOS). The instrumental Integrated Project has worked extremely well for the European carbon cycle community and has contributed to the competitiveness of European research in this field. The international collaboration, in particular with he US through partner Princeton University, was indeed extremely fruitful. Towards the end of CARBOOCEAN, important review/progress overview papers were published together with US partners.

An extensive list with references of cited and other CARBOOCEAN related publications can be found on the project website.

CD-PALEO - Development of Cadmium isotopic measurements by MC-ICP-MS using a double spike approach: Application to marine sediments and paleoceanography

Summary information

Funding source: FP6 - Marie Curie Actions

EC contribution: € 148.021
Start – end date: 1/12/2004 – 30/11/2006
Duration: 24 months

Project Coordinator: Wafa Abouchami
Organisation: Max Planck-Gesellschaft Zur Foerderung Der Wissenschaften e.v. Represented by the Max Planck Institut Fur Chemie – Germany

Background information

Project Summary

Changes in atmospheric CO_2 content are an important index of climate changes and are regulated by oceanic circulation and nutrient distribution. Variations in seawater biologically mediated trace elements, such as Cd, can be directly linked to the carbon cycle, and can thus provide information on past climatic variations. The Cd/Ca "nutrient-like" ratio has been used as a proxy of past ocean thermohaline circulation since it has been shown that Cd/Ca ratios can fingerprint distinct water masses. Recent studies have questioned the use of these ratios as a proxy for reconstructing past oceanic productivity, due to a potential fractionation between Cd and PO4 and/or a possible temperature effect. We propose to develop a method for measuring Cd isotope ratios in marine sediments to assess the potential of Cd isotopes as a proxy of past oceanic changes in oceanic biological productivity and/or temperature during the Quaternary.

This novel approach will be achieved by establishing a chemical separation and a measurement protocol of Cd isotopes using a MC-ICP-MS instrument combined with a double spike technique to correct for instrumental mass bias. Cd isotopic measurements will be performed on variable geological materials to evaluate the extent of natural Cd isotopic fractionation. We will then focus on marine sediments to understand the parameters controlling Cd isotope fractionation in the oceans. Time-series of Cd isotopes in selected marine sediment cores will be used to trace past oceanic circulation and biological productivity during the Quaternary and establish the potential of Cd isotopes as a paleoceanographic proxy.

This project meets the objectives of the Specific Program and the Work Program for the Marie Curie Actions, since it falls within the FP6-2003-Global-2 thematic research program, comprises scientific innovation and analytical development, and will provide the applicant with both the experience and training required to develop as an independent scientist.

CECILIA - Central and Eastern European Climate Change Impact and Vulnerability Assessment

Summary information

Funding source:	FP6 - Specific Targeted Research Project
Total Cost:	€ 3.367.022
EC contribution:	€ 2.749.891
Start – end date:	1/06/2006 – 31/12/2009
Duration:	43 months
Project Coordinator:	Tomas Halenka (tomas.halenka@mff.cuni.cz)
Organisation:	Charles University - Czech Republic
CLAMER regional focus:	Black Sea (hydrology, water quality and water management)
Project Keywords:	Energy Saving; Energy Storage; Energy Transport; Environmental Protection; Fossil Fuels; Innovation; Technology Transfer; Meteorology; Other Energy Topics; Policies; Regional Development; Renewable Sources of Energy; Resources of the Sea; Fisheries; Scientific Research; Social Aspects; Transport; Waste Management

Project Website:
http://www.cecilia-eu.org

Project Partners

1. Charles University - Czech Republic
2. The Abdus Salam International Centre for Theoretical Physics - Italy
3. Météo France - France
4. Danish Meteorological Institute - Denmark
5. Aristotelio Panepistimio Thessalonikis - Greece
6. Czech Hydrometeorological Institute – Czech Republic
7. Institute of Atmospheric Physics of the AS CR – Czech Republic
8. Eidgenoessische Technische Hochschule Zuerich - Switzerland
9. University of Natural Resources and Life Sciences - Austria
10. Administratia Nationala de Meteorologie - Romania
11. Bulgarian Academy of Sciences, National Institute of Meteorology and Hydrology - Bulgaria
12. Institutut National de Hidrologie si Gospodarire a Apelor - Romania
13. Orszagos Meteorologiai Szolgalat - Hungary
14. Narodne Lesnicke Centrum - Slovakia
15. Politechnika Warszawska - Poland
16. Eotvos Lorand Tudomanyegyetem - Hungary

Background information

Project Summary

Abstract
The main objective of CECILIA is to deliver a climate change impacts and vulnerability assessment in targeted areas of Central and Eastern Europe. Emphasis is given to applications of regional climate modelling studies at a resolution of 10 km for local impact studies in key sectors of the region. The project contains studies of hydrology, water quality and water management (focusing on medium-sized river catchments and the Black Sea coast), air quality issues in urban areas (Black Triangle — a polluted region around the common borders of the Czech Republic, Poland and Germany), agriculture (crop yield, pests and diseases, carbon cycle), and forestry (management, carbon cycle). Very high resolution simulations over this region are necessary due to the presence of complex topographical and land use features. Climate change impacts on large urban and industrial areas modulated by topographical and land-use effects which can be resolved at the 10 km scale, are investigated by CECILIA. The high spatial and temporal resolution of dense national observational networks of the CECILIA regional model experiments will uniquely feed into investigations of climate change consequences for weather extremes in the region under study. Comparisons of the results based on statistical downscaling techniques will also be provided. Statistical downscaling methods for verification localization of model output for impact studies will be performed.

Objectives
After the political changes that occurred in countries of the former Eastern Block at the end of the 1980's, climate change started to be taken into account to some extent at the governmental level. In particular, from the scientific point of view, at the beginning of the 90's the access to information and data started to become a reality. Around the mid 90's significant improvements in cooperation were promoted by the US Country Study Programme. Under this framework, many countries from the former Eastern Block obtained access to global climate-change scenarios and longer series of global climatological data. They participated in workshops on the use of this information for the assessment of climate-change impacts on agriculture, forestry, water management and health. Unfortunately, at that time there was very limited equipment to handle large amounts of data and, moreover, not sufficient know-how in this region to start real cooperation efforts in the field of climate-change modelling. However, this knowledge gap has been progressively eliminated and when the regional climate model RegCM appeared through ICTP in several countries of Central and Eastern Europe at the end of the 90's, it proved the feasibility of carrying out regional climate change studies performed by local users in this area. Eventually the adaptation of a commonly used NWP model in LACE countries, i.e. the model ALADIN from Meteo-France, started in 2001 in Czech Republic and now the model, ALADIN-Climate, has taken part in the EC FP6 project ENSEMBLES. Thus, the door has been opened for real climate change impact and vulnerability assessments for central and eastern Europe based on locally provided high resolution regional climate modelling.

During the last decade regional climate models (RCMs) have been increasingly used to examine climate variations at scales that are not resolved by global models. To the extent that they produce realistic climate simulations, such models can be powerful tools in the study of regional climate impacts. Since the field of regional climate prediction is still evolving, the skill of RCMs in simulating climate variability has not been extensively evaluated. This is planned within the framework of the project ENSEMBLES for simulations of 50 to 25 km resolution driven by ERA40 reanalyses. As part of the ENSEMBLES project transient scenario runs of 100 — 150 year's length are also planned under different greenhouse gases (GHG) and aerosol forcing. In this proposal we plan a detailed analysis and use of the results of the project ENSEMBLES for focused initial impact studies in our target region. However, one of the main objectives of this proposal is also to adapt a few of the models used for ENSEMBLES (ALADIN-Climate and RegCM) for very high resolution (grid spacing of 10 km) simulations over selected sub-domains, which will provide additional information related to the complex terrain of the region. The assessment of the role of significant but previously not resolved topographical features and land-use patterns will be provided in these experiments as well as the evaluation of the sensitivity of the simulations to the choice and size of the model domain. Moreover, development of new features in the

parameterization of high resolution physics in the models is expected (e.g. cloud microphysics, chemistry of urban areas etc.). This will provide a connection with the EC FP6 Project QUANTIFY, which aims at quantifying the impact of transportation on climate change. Our project will also provide insights on the validation and relative merits of statistical and dynamical downscaling, in particular as applied to provide local climate information.

Main goal

The main goal of the proposal is to integrate results from different previous and ongoing modelling activities and approaches to provide the basis for very high resolution climate change impact and vulnerability assessment in important human activity sectors and natural ecosystems. It is prohibitive to cover within the STREP all the sectors in their complexity, so that we target our analysis on some key areas of specific interest to the region. For example, the flood and drought conditions which occurred in recent summers over the region highlight the importance of the hydrologic cycle and water management in the Elbe and Danube river catchments in response to changes in the occurrence of precipitation extremes. Impacts on agriculture and forestry influencing the economy of countries in the region will be studied with emphasis on the main productions in the area. The 2003 heat wave demonstrated the importance of studies of the health impacts of extreme conditions that would also lead to considerable changes in air quality, both regionally and in major urban centres. The proposed research will benefit greatly from previous and ongoing European projects and programmes with related objectives, e.g.:

- Modelling the Impact of Climate Extremes (MICE),
- Statistical and regional dynamical downscaling of extremes for European regions (STARDEX),
- Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects (PRUDENCE),
- ENSEMBLE-based Predictions of Climate Changes and their Impacts (ENSEMBLES),
- Quantifying the Climate Impact of Global and European Transport Systems (QUANTIFY),

Aims

The overall aim of this proposal is to assess the impact of climate change at the regional to local scale for the territory of central and Eastern Europe, with emphasis on using very high climate resolution in order to capture the effects of the complex terrain of the region. From the viewpoint of climate scenario production, this goal will be achieved through a strategy of multiple and combined approaches, namely variable resolution models, RCMs and statistical downscaling methodologies. The primary tools, however, will be very high resolution RCMs run locally for targeted areas. From the impact viewpoint, the most important sectors for the economies and welfare of individual countries will be selected. These objectives will be achieved through the execution of the following specific tasks:

- To collect, assess and make available for first local impact studies the scenarios and climate simulations produced in previous relevant projects, especially PRUDENCE, STARTDEX, MICE and ENSEMBLES, where available.
- To adapt and develop very high resolution RCMs for the region (10 km grid spacing) and perform regional time-slice nested simulations driven by ERA40 data and by GCMs for selected GHG change scenarios.
- To verify the model results, compare RCM and statistical downscaling results, analyze and develop the methods for verification, particularly at local scales. To estimate the effect of global climate change on the occurrence of extreme events (heavy precipitation, heat waves, droughts) in the region, including the assessment of the added value of high-resolution experiments for the simulation of the relevant processes and feedbacks.
- To evaluate uncertainties in regional climate change projections by intercomparing results obtained in previous projects (PRUDENCE, ENSEMBLES) and the present ones.
- To assess (based on the high resolution downscaling results) the impacts of climate change on the hydrological cycle and water resources over selected catchments in the region; to study the effects of climate change on the Black Sea.
- To study (based on the high resolution downscaling results) the impacts of climate change on agriculture and forestry, carbon cycle and selected species.
- To study (based on the high resolution downscaling results) the impacts of climate change on health and air quality (photochemistry of air pollution, aerosols).

CENSOR - Climate variability and el niño southern oscillation: implications for natural coastal resources and management

Summary information

Funding source:	FP6 - Specific Targeted Research Project
Total Cost:	€ 3.830.000
EC contribution:	€ 3.000.000
Start – end date:	1/10/2004 – 30/09/2008
Duration:	48 months
Project Coordinator:	Catherine Audebert (catherine.audebert@awi.de)
Organisation:	Alfred Wegener Institute for Polar and Marine Research – Germany
CLAMER thematic focus:	Temperature changes; storm frequency and intensity changes; ocean current changes; freshwater inflow; biological impacts

Project Website:
http://www.censor.name/

Project Partners

1 Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences - Germany
2 Institut de Recherche pour le Développement - France
3 Spanish National Research Council - Spain
4 Universidad de Antofagasta - Chile
5 Universidad Nacional Mayor de San Marcos - Peru
6 Universidad Nacional Agraria la Molina - Peru
7 Instituto del Mar del Peru - Peru
8 Centro Austral de Investigaciones Cientificas - Argentina
9 Universidad Arturo Prat - Chile
10 Zentrum Für Marine Tropenökologie - Germany
11 Center of Oceanography for the Eastern South Pacific - Chile
12 Universidad Nacional del Mar del Plata - Argentina

Background information

Project Summary

Abstract
Marine biodiversity and the sustained exploitation of marine resources are significantly influenced by the ENSO (El Nino- Southern Oscillation) climate variation, which particularly affects the aquatic and terrestrial habitats along the Chilean-Peruvian coast of the Humboldt Current upwelling system. Both its warm phase (El Nino: EN) and its cold phase (La Nina: LN) have drastic implications for the ecology, socioeconomy and infrastructure of the countries impacted. Local artisanal fisheries represent a major activity for the domestic economy of both countries, thus a huge amount of studies (published and unpublished) exist aiming at identifying effects of EN. However, most processes and mechanisms causing these effects have not been analyzed yet. In the sea, especially artisanal fisheries and near-shore invertebrate and fish populations suffer from EN effects. Both EN

and LN, however, also produce positive effects, which are not fully used by local fishermen and human communities.

The aim of the CENSOR project is to enhance the detection, compilation and understanding of EN/LN effects on coastal marine environments and resources. Local artisanal fisheries and many commercial branches connected to them will benefit from the findings. Thus this project is expected to be of high economic and social interest for Chile and Peru, as well as for their environmental policy and social stability. To achieve this goal we propose a multidisciplinary approach, which enables us to build a comprehensive picture illustrating the response of the upwelling ecosystem to EN events. Scattered data on coastal benthic communities, coastal ichthyologic resources, pelagic-benthic processes and riverine input on coastal systems will be compiled and analyzed comparatively under EN and non-EN conditions. Further, aquacultural demands will be addressed. All results of the CENSOR project will be integrated in a database and made available (managers & public at large).

Project Outputs

One major goal of CENSOR was the compilation, integration and dissemination of existing data, including unpublished resources. The concept is to prevent that these data, due to limited distribution outside their place of origin, get lost in the future. Therefore, CENSOR compiled this information with the PANGAEA - Publishing Network for Geological and Environmental Data. Data, including all metadata, are long-term archived and accessible at WDC-MARE, using a persistent identification as provided through the DOI (Digital Object Identifier) system. Metadata, as already defined in PANGAEA, can be downloaded using dynamic links provided on the project website. Specific data sets may be accessed using the PANGAEA search engine PangaVista with the query 'CENSOR' and special search term (e.g. author name, species, area).

CIRCE - Climate Change and Impact Research: the Mediterranean Environment

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 13.730.066
EC contribution:	€ 10.000.000
Start – end date:	1/04/2007 – 30/06/2011
Duration:	51 months
Project Coordinator:	Antonia Navarra (navarra@bo.ingv.it)
Organisation:	National Institute of Geophysics and Volcanology – Italy
CLAMER thematic focus:	Abiotic, biotic and socio-economic impacts
CLAMER Regional focus:	Mediterranean

Project Website:
http://www.circeproject.eu/

Project Partners

1	National Institute of Geophysics and Volcanology - Italy
2	Spanish National Research Council, Instituto de Ciencias de la Tierra "Jaume Almera“ - Spain
3	Fundación Centro de Estudios Ambientales del Mediterráneo - Spain
4	CLU Ltd - Italy
5	Danish Meteorological Institute - Denmark
6	University of Crete, Environmental Chemical Processes Laboratory - Greece
7	Agenzia Nazionale per le Nuove Tecnologie, l’Energia e lo Sviluppo Economico Sostenibile - Italy
8	Fondazione ENI Enrico Mattei - Italy
9	Universidad Complutense de Madrid - Spain
10	Helholtz-Zentrum Geesthacht - Germany
11	Institute of Accelerating Systems and Applications - Greece
12	National Research Council - Italy
13	Potsdam Institut für Klimafolgenforschung - Germany
14	Centre de Coopération Internationale en Recherche Agronomique pour le Développement - France
15	Centre National de la Recherche Scientifique - France
16	Universidad Politecnica de Madrid - Spain
17	World Health Organisation, Regional Office for Europe
18	Fondatation de Recherche pour le Développement Durable et des Relations Internationales - France
19	Natural Environment Research Council – United Kingdom
20	Max-Planck Society for the Advancement of Science - Germany
21	National Observatory of Athens - Greece
22	National Institute of Marine Sciences and Technologies - Tunisia
23	University of Haifa - Israel
24	University of Natural Resources and Applied Life Sciences - Austria
25	European Commission Joint Research Centre
26	Parc Cientific de Barcelona - Spain
27	Azienda Unità Sanitaria Locale Roma E, Department of Epidemiology - Italy
28	Météo France - France
29	MET Office - United Kingdom

30 Università degli Studi della Tuscia - Italy
31 Stockholm Environment Institute, University of York - United Kingdom
32 University of Birmingham - United Kingdom
33 Universidad del Pais Vasco - Spain
34 Universitat Politècnica de Catalunya - Spain
35 Nacional and Kapodistrian University of Athens - Greece
36 Tel-Aviv University - Israel
37 Universidad de Alcala - Spain
38 Zadig - Italy
39 University of East Anglia - United Kingdom
40 Universitat de les Illes Balears - Spain
41 Instituto de Ciência Aplicada e Tecnologia, Universidade de Lisboa - Portugal
42 Universität Hamburg - Germany
43 University of Aegean - Greece
44 Centre for Environment and Development for Arab Region and Europe - Egypt
45 University of Bern - Switzerland
46 Università degli Studi l'Aquila - Italy
47 Freie Universität Berlin - Germany
48 University of Salento - Italy
49 European Climate Forum - Germany
50 Vrije Universiteit Amsterdam – Netherlands
51 The Hebrew University of Jerusalem - Israel
52 Università di Santiago di Compostela - Spain
53 Centro Euro-Mediterraneo per i Cambiamenti Climatici - Italy
54 Institute Pasteur de Tunis - Tunisia
55 Association pour la Recherche sur le Climat et l'Environnement - Algeria
56 International Center for Agricultural Research in the Dry Areas - Syria
57 Hellenic Center for Marine Research - Greece
58 University of Southampton - United Kingdom
59 Ben-Gurion University of the Negev - Israel
60 Paul Scherrer Institut - Switzerland
61 Institute of Communication and Computer Systems - Greece
62 Instituto Nazionale di Oceanografia e Geofisica Sperimentale - Italy
63 Università di Bologna, Alma Mater Studiorum - Italy
64 SEI Oxford Office Limited – United Kingdom
65 The Cyprus Institute

Background information

Project Summary

Abstract
CIRCE aims at developing for the first time an assessment of the climate change impacts in the Mediterranean area. The objectives of the project are:

- To predict and to quantify physical impacts of climate change in the Mediterranean area,
- To evaluate the consequences of climate change for the society and the economy of the populations located in the Mediterranean area,
- To develop an integrated approach to understand combined effects of climate change,
- To identify adaptation and mitigation strategies in collaboration with regional stakeholders.

The project investigates how global and Mediterranean climates interact, how the radiative properties of the atmosphere and the radiative fluxes vary, the interaction between cloudiness and aerosol and the modifications in the water cycle. Recent observed modifications in the climate variables and detected trends are compared.

The economic and social consequences of climate change are evaluated by analyzing direct impacts on migration, tourism and energy markets together with indirect impacts on the economic system. CIRCE moreover investigates the consequences on agriculture, forests and ecosystems, human health and air quality. The variability of extreme events in the future scenario and their impacts are also assessed.

A rigorous common framework, including a set of quantitative indicators developed specifically for the Mediterranean environment are developed and used in collaboration with regional stakeholders. The results are incorporated in a decision support system tool and disseminated to the relevant users. Possible adaptation and mitigation strategies have been identified. The integrated results discussed by the project CIRCE will be presented in the first Regional Assessment of Climate Change in the Mediterranean area.

Objectives
The main objectives of CIRCE are to predict and to quantify the physical impacts of climate change in the Mediterranean, and to assess the most influential consequences for the population of the region. The knowledge yielded by the different specialised investigations are linked in an integrated interdisciplinary approach designed to study the total effect of climate change. CIRCE integrates cutting-edge scientific research with the needs of end-users and communities. Thus, CIRCE is able to quantify the impact of global warming on Mediterranean climate variables, whilst also taking into account the regional social, economic and policy aspects of the process. In this way, CIRCE makes a powerful contribution to the definition and evaluation of adaptation and mitigation strategies.

Recent observed changes in climate variables are documented. Detectable trends and variability are identified and described, and then compared with a series of possible explanations. An optimal mix of plausible forcing factors will be derived as the best explanatory interpretation of ongoing changes. In this way, a comprehensive set of data describing the physical impacts of climate change are developed, and then used to assess the consequences of climate change for human society and ecosystems. CIRCE analyses a number of climate parameters including: temperature, precipitation, atmospheric humidity, wind, waves, sea-level rise, surface radiative fluxes, balance between evaporation-precipitation, saline output to the Atlantic, water vapour export, frequency and distribution of extreme events, nutrient loading into the sea, and sensitivity to water stress. CIRCE builds on the extensive modelling experience already available, but it develops specific modelling scenarios for the Mediterranean, in terms of resolution, process and feedback inclusions, understanding and specific diagnostic studies for the Mediterranean area.

The impacts of climate change are analysed and evaluated in their oceanographic, meteorological, ecological, economic and societal dimensions. Information are provided in terms of economically meaningful variables such as productivity changes, variation of resource stocks, shifts in technology and demand patterns. Economic consequences for agriculture are evaluated through estimation of agricultural productivity, management and profit. Similarly, impacts on forestry and on biodiversity are investigated. CIRCE focuses particularly on the direct economic impacts for four crucial sectors for the Mediterranean region: health, tourism, energy demand, and human migration. The project provides the advances required to meet policy needs in these sectors. To do that CIRCE aims to build a new vision of the interactions between climate factors and socio economic evolutions trying to overcome two classical obstacles faced by a number of research projects on climate impacts.

The first obstacle is often the imbalance between physical and natural science and social sciences. In CIRCE this imbalance has been corrected and social sciences are a strong component of the project. CIRCE brings together the natural sciences community and social community in a new integrated and comprehensive way.

The second obstacle is linked to the first, a “climate all vision of society” that is to put climate as the major constraint of human behaviour to understand adaptation. This bias is sometimes necessary for the needs of modelling but then produces irrelevant elements of analysis for policy making. A more realistic approach is needed to match stakeholders and policy maker’s demands.

Most climate impact assessments so far have focussed on a causal chain from climate change to economic and social impacts, adaptation policies being the direct responses to climate impacts.

CIRCE analyses climate impacts as the "joint product" of climate change and socio economic dynamics/ human behaviour which are most of the time independent of climate change. In this non linear approach, impacts of climate change are analysed with reference to specific socio economic scenarios, with particular attention to relevant sector and policies which can actually emphasize or reduce effects of climate change. On the other side response strategies are not pure "adaptation" responses to climate change but a mix of long trends evolutions, progressive reorientation of sectoral policies which can also have positive or adverse effects on resilience or vulnerability to climate change. CIRCE makes a strong point in producing relevant research for the actors of the region. For that reason it is essential to provide assessments that can be integrated in practical decision making, therefore this more comprehensive method is necessary and more able to represent the reality as many impacts – on health, tourism, migration, etc. – cannot be reliably expressed as a function of climate change alone. The end result of the political economy of economic and social policies of the region are not "climate first" but "development first" for a number of years to come. Keeping that framework in mind give the best chance to reach relevant actors and improve relevant strategies. That is the underlying concept of the CIRCE project

The CIRCE Concept
To integrate the assessment of cross-sectoral impacts of climate change, for selected case-study regions, CIRCE adopts a risk-based approach based on the conclusions developed in the specialized investigations. A rigorous common framework, including a set of quantitative indicators tailored specifically for the Mediterranean environment will be developed and used in collaboration with regional stakeholders and policy makers. The results are incorporated in a decision support system tool and disseminated to the appropriate end-users. Likely adaptation and mitigation strategies are identified using bottom-up (via regional workshops) and top-down approaches. The case-study areas will include North African, Middle Eastern and European locations.

The end products of CIRCE will be published in the open scientific literature and summarised in less technical terms in the Final Report - Regional Assessment of Climate Change in the Mediterranean (RACCM).

The RACCM is produced in close consultation with stakeholders. Meetings of the project were held jointly with carefully-selected stakeholders, who contributed to better-defined and more relevant priorities and issues. Thus CIRCE develops an understanding of the different needs of the European Region, and enhance and develop analysis methods, models and indicators. Under the project, the interactive effects of climate change becomes better understood, and predictions of risk and the prior assessment of policy effects are improved. The project thus provides cutting-edge scientific results that helps to establish:

- The methodology for including stakeholders needs and questions in the scientific discourse,
- The information on possible climate changes for the 21st century in the Mediterranean area,
- A framework for the preparation, reviewing and dissemination of the Regional Assessment Report,
- A set of policy-specific indicators and assessments that can be used to:
- Inform environmental reporting,
- Enable international comparisons in terms of quality of life, environment, economy and health,
- Define a set of objectives and targets, and to monitor trends and progress towards these targets.

Project Outputs

A database of scientific papers and detailed materials (data, documents, scientific publications) ready to be consulted related to CIRCE is available on the website in the 'researcher' area.

A Discovery Service for the CIRCE Metadata Catalogue is also available. The Catalogue includes products and data from CIRCE project.

By the end of the year 2011, the CIRCE project will have accomplished the ambitious Regional Assessment Climate Change in the Mediterranean (RACCM) report which provides a detailed picture of climate in the

Mediterranean region. Composed by 5 parts, CIRCE RACCM Report describes changes in progress in atmosphere and in the basin (Part I) and how these changes affect water availability in the region (Part II). Part III investigates effects on agriculture and ecosystems, and Part IV presents the impacts on social and economical dimensions. The last section (Part V) is devoted to case studies, eleven relevant places and zones in the Mediterranean region that are expected to be particularly affected by the impacts of climate change (i.e. Tuscany region, Athens, and Gulf of Valencia).

DAMOCLES - Developing Arctic Modelling and Observing Capabilities for Long-term environmental studies

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 24.670.000
EC contribution:	€ 16.100.000
Start – end date:	1/12/2005 – 31/05/2010
Duration:	48 months
Project Coordinator:	Jean-Claude Gascard (gascard@lodyc.jussieu.fr)
Organisation:	Université Pierre et Marie Curie – France
CLAMER thematic focus:	Ice melting
CLAMER Regional focus:	Arctic

Project Website:
http://www.damocles-eu.org/

Project Partners

1 Université Pierre et Marie Curie - France
2 Alfred Wegener Institute for Polar and Marine Research - Germany
3 Swedish Meteorological and Hydrological Institute - Sweden
4 Nansen Environmental and Remote Sensing Center - Norway
5 Finnish Institute of Marine Research - Finland
6 Meteorological Institute - Norway
7 Norwegian Polar Institute - Norway
8 Arctic Centre university of Lapland - Finland
9 University of Gothenburg - Sweden
10 Institute of Marine Research - Norway
11 Centre for Environment, Fisheries and Aquaculture Science – United Kingdom
12 Danish Meteorological Institute - Denmark
13 University of Cambridge - United Kingdom
14 University of Bremen - Germany
15 University College London - United Kingdom
16 Stockholm University - Sweden
17 University of Bergen - Norway
18 Foundation for Research and Technology - Greece
19 University of Hamburg - Germany
20 Polish Academy of Sciences, Institute of Oceanology - Poland
21 OPTIMARE Sensorsysteme AG - Germany
22 Finnish Meteorological Institute - Finland
23 The University Centre in Svalbard - Norway
24 French Research Institute for Exploitation of the Sea - France
25 French National Centre for Scientific Research - France
26 Université de Savoie - France
27 Institut Polaire Français - Paul Emile Victor - France

28 Technical University of Denmark - Denmark
29 Danish National Space Center - Denmark
30 State Research Center Arctic and Antarctic Research Institute - Russian Federation
31 Tartu Uelikool - Estonia
32 Russian Academy of Sciences, P.P. Shirshov Institute of Oceanology - Russian Federation
33 The University of Reading - United Kingdom
34 Ecole Nationale Supérieure des Ingénieurs des Etudes et Techniques d'Armement - France
35 Scottish Association for Marine Science - United Kingdom
36 O.A. Sys - Ocean Atmosphere Systems - Germany
37 International Polar Foundation - Belgium
38 Center for international and Environmental Research - Norway
39 Martec Serpe IESM - France
40 Fastopt ralf Giering and Thomas Kaminski GbR - Germany
41 Naxys As - Norway
42 Helsinki University of Technology - Finland
43 Aanderaa Instruments A.S - Norway
44 Aquatec Telemetry Limited - United Kingdom
45 Cerpolex - France

Background information

Project Summary

Abstract
All state-of-the-art climate models predict that the perennial sea-ice of the Arctic Ocean will disappear within a few decades or less. Important questions remain as to whether this expectation is justified, and if so when this change will take place and what effect it will have on climate at a regional-to-global scale. Such a dramatic physical affront to the ocean-atmosphere-cryosphere system in northern latitudes which corresponds to a change in surface albedo from more than 0.8 to less than 0.3 over a surface larger than Europe, is bound to have radical effects on human activities with immediate impacts on the indigenous inhabitants of the circum-Arctic region and the ecosystem on which they depend, and widespread effects on socio-economic activity on hemispheric scale. We propose an Integrated Project for Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies (DAMOCLES) with the following objectives: (1) identify and understand the changes occurring in the Sea-Ice, Atmosphere and Ocean of the Arctic and Sub arctic domain, (2) improve the realism by which these changes are simulated in models, thus extending the lead-time prior to the onset of extreme climate events, (3) determine appropriate adaptation strategies for a range of anticipated socio-economic impacts following the disappearance of the perennial sea-ice. At a time when the International Polar Year (IPY) will focus on the science of the polar regions and on the human dimension of polar change, DAMOCLES will provide a contribution to reflect both the skills of European Sciences and the importance to European interests. DAMOCLES represents the integrated efforts of 45 (Original) + 4 (TTC extension) European research institutions including 10 SMEs distributed among 12 European countries, and coordinated with the USA, Russian Federation, Canada and Japan.

Objectives
The main objective of DAMOCLES is to reduce the uncertainties in our understanding of climate change in the Arctic and in the impacts thereof. To meet this objective DAMOCLES will, following the approach of Numerical Weather Prediction Centers, develop an integrated system for obtaining relevant geophysical observations, transferring them to a central databank, distributing them to the modelling centers, and producing nowcasts and forecasts of the Arctic climate. But since there exists no such thing as an Arctic Ocean Observing System, nor fully validated models for Arctic climate, nor accepted methods for forecasting of climate, a number of specific objectives need to be met in DAMOCLES:

- Synoptic observational coverage of the Arctic Ocean sea-ice cover:

- The variability of sea-ice thickness, extent, concentration, ice-type and drift will be monitored by remote and in-situ systems in near real-time. Sea-ice dynamics and thermodynamics will be scrutinized to better understand their role for the large-scale ice-atmosphere-ocean system
- Synoptic observation and investigation of atmospheric key processes

Aimed at a better predictability of the Arctic weather and climate, key processes are investigated in a combined observational/process-modelling effort:

- the effects of Arctic cyclone on sea-ice in terms of heat and moisture transport, an improvement of boundary-layer physics over ice and ocean, an improvement of the radiative transfers and its interaction with snow and sea-ice
- Synoptic observation of the Arctic Ocean circulation and key processes
- An observational system will be set up with the aim to improve the understanding of the large-scale circulation of the Arctic Ocean and its vertical and lateral exchanges as well as the communication between central basins and the shelves. New techniques will be used to assess synoptically the state of the ocean under the ice and the fluxes of heat, salt and volume across the boundaries
- Integration and assimilation of observations with large-scale models

Model sensitivities will be investigated and performance be improved by model-model and model-data comparison, aiming at an improved predictability. Observations will be enhanced by a set of assimilation activities to deliver reanalysed Arctic variables in time and space. To address the question of potential impacts of climate change in the Arctic the following specific objective of DAMOCLES can be formulated:

- Assessment of impact on environment and humans

The observationally supported model improvements, the model sensitivities and past ranges of variability will be combined with new field data. The aim is to evaluate improved predictability and its consequences, as well as the impact of projected changes on adaptation capabilities and vulnerability of the environment and human activities. DAMOCLES will not work in isolation – it serves the European community. Exploitation and dissemination of the results are key elements of the project. Thus, a 6th specific objective is:

- User-friendly return of information to the community

A website will be available; giving the community updated information about the state of the Arctic (e.g. real-time information of key atmospheric, ice and ocean variables) as well as information about the progress of the science of DAMOCLES. Education will be provided, through workshops and student scholarships.
The main technological objective of DAMOCLES is to develop a prototype for an Arctic Ocean Observing System (AOOS) including major innovations and breakthrough in High Technology instrumentation adapted to a remote and harsh environment such as the Arctic Ocean. The DAMOCLES AOOS prototype system will be composed of very modern and sophisticated instruments for *in situ* measurements involving near real time transmission and remote sensing such as:

- Satellite radar altimetry, Scatterometers (QuickSCAT), passive microwave radiometers (SSM/IS, AMSRE), SAR imagery (ENVISAT, RADARSAT);
- Ice Tethered Platforms equipped with vertical CTD profilers for taking daily profiles of temperature and salinity versus depth;
- Sea-Gliders like autonomous underwater vehicles measuring 1.000s of slanted profiles of temperature and salinity along transects between ITPs and Moorings equipped with acoustic transponders;
- Neutrally buoyant floats drifting at constant depth and equipped with Upward Looking Sonars to measure Sea-Ice draft from underneath;
- Tiltmeters for detecting flexural-gravity waves propagating through the ice and deducing sea-ice thickness over an averaged area.

One of the most important challenges of DAMOCLES is related to multi-faceted applications of underwater acoustic technology such as:

- Upward Looking Sonar (ULS) mounted on neutrally buoyant isobaric drifting floats and/or on moorings for measuring sea-ice draft;
- Long range navigation using Sound Fixing and Ranging (SOFAR/RAFOS) techniques for navigating underwater Floats and Sea-Gliders under sea-ice;

- Short range navigation and data transfer using acoustic modems on all the instruments fixed on moorings (eulerian) or freely drifting (lagrangian) for near real time data transmission;
- Acoustic Doppler profilers measuring vertical profiles of horizontal currents;
- Tomography for measuring temperature along vertical sections after inversion;
- Acoustic based technology will also be used in the atmosphere for measuring winds with sonic anemometers.

DAMOCLES will for the first time achieve a systematic approach to observing, understanding and quantifying climate change in the Arctic through:

- Developing and deploying an advanced observing system that provides for the synoptic, continuous and long-term monitoring of the lower atmosphere, sea-ice and the upper ocean;
- Evaluating and improving global and regional climate forecasting models based on validation by, and assimilation and integration of observed data;
- Designing and testing an integrated ice-atmosphere-ocean monitoring and forecasting system. The ultimate deliverable will be to lengthen the lead-time of extreme climate changes predicted to occur in the Arctic within this century and thus to improve the ability of society to mitigate for their impacts.

DAMOCLES research will provide a substantial step forward from the present state-of the art by:

- improving monitoring capabilities of the Arctic Ocean, ice and atmosphere through innovative technological advances;
- improving the data transfer from instruments to users, through innovative technological advances, the use of an operational databank, and unprecedented data delivery and format agreements between all partners;
- increasing the knowledge concerning dynamics and thermodynamics of the Arctic Ocean Sea-ice cover and the understanding of its interaction with the Ocean and the Atmosphere in the northern hemisphere climate system;
- improving significantly the ability to predict extreme climate events in the Arctic, such as the disappearance of the perennial ice-cover;
- contributing to the development and implementation of observing and forecasting systems to make longterm systematic observations of marine and atmospheric parameters of the Arctic Environment necessary for global change research and management strategies;
- improving the knowledge on the adaptive capacity and vulnerability of human activities and the environment with respect to such an event, and thus enhance the European Union’s preparedness in terms of environmental and societal terms.

Project Outputs

During the project large amounts of various types of data describing the sea ice, atmosphere and ocean have been collected. Proper management of the data flow and access is an essential part of a successful project and for this reason a website has been set up for the optimalisation of data management and distribution. The special website can be accessed via the project website. The project website also contains a list of peer-reviewed publications from DAMOCLES.

During the final symposium, DAMOCLES scientists developed a declaration summarizing the key findings from the project, as well as future projections and scenarios. This declaration can be found on the project website.

DAMOCLES-TTC - Developing Arctic Modelling and Observing Capabilities for Long-term environmental studies - extension

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 422.914
EC contribution:	€ 422.914
Start – end date:	1/11/2006 – 1/11/2009
Duration:	36 months
Project Coordinator:	Jean-Claude Gascard (gascard@lodyc.jussieu.fr)
Organisation:	Université Pierre et Marie Curie – France
CLAMER thematic focus:	Ice melting
CLAMER Regional focus:	Arctic

Project Website:
http://www.damocles-eu.org/

Project Partners

1 Université Pierre et Marie Curie - France
2 National Academy of Sciences, B.I. Stepanov Institute Physics - Belarus
3 Russian Academy of Sciences, Institute Numerical Mathematics - Russian Federation
4 Nansen International Environmental Remote Sensing Center - Russian Federation
5 Research Centre Earth Operative Monitoring - Russian Federation

Background information

Project Summary

Abstract
DAMOCLES IP aims at reducing the uncertainties in our understanding of climate change in the Arctic and their impacts. Over the last 3 decades, the Arctic has warmed more than any other region of the world, and the sea-ice cover has decreased significantly. DAMOCLES is the largest ever effort to assemble simultaneous observations of the Arctic atmosphere-ice-ocean system. The observational time period coincides with the International Polar Year (IPY) and DAMOCLES will be an outstanding contribution, from the European Community to the IPY. The DAMOCLES data set will be assimilated in models for quantitative estimates of circulation and used for:

- Validating and improving numerical models;
- Increasing our understanding of the processes and mechanisms underpinning the Arctic climate system;
- Initialising ensemble forecasts of the future state of the Arctic DAMOCLES Extension (DAMOCLES TTC) programme and will enhance quite significantly 2 major issues of DAMOCLES IP undertaken by 4 new TTC partners.

One of the main objectives of the DAMOCLES Extension proposal is to investigate the Arctic sea ice by means of extensive data archives from Russian satellites and Arctic expeditions, as well as from new observations by Russian satellites and field experiments in 2007 - 2009. Satellite data archive and *in situ* measurements from expeditions, represent a unique wealth of information about the Arctic. Russian and Belarus experts involved in sea-ice, satellite remote sensing and modelling will provide high value data sets and analyses for DAMOCLES.

Objectives

The DAMOCLES Extension (DAMOCLES TTC) programme of activities will enhance quite significantly two major issues of the DAMOCLES Integrated Project undertaken by four new TTC partners. The first major issue concerns DAMOCLES work dedicated to sea-sce which is one of the central and most important themes of DAMOCLES. Three new partners, one from Belarus and two from Russian Federation, will contribute to an extension over 4 different tasks: Sea-ice thickness, Snow characteristics, Sea-ice categories and Sea-ice types, and Sea-Ice thermodynamics. The second major issue concerns DAMOCLES work dedicated to modelling and in particular model sensitivity studies taking into account some oceanic, atmospheric and terrestrial specific effects such as tides for instance, which have not been addressed into the DAMOCLES IP work programme. One new partner from the Russian Academy of Sciences, Institute of Numerical mathematics in Moscow will contribute to dedicated studies of ocean tidal dynamics on long-term development of sea-ice, hydrography and ocean currents. DAMOCLES work will also greatly benefit from Russian ice data to be made available.

The extension work to be performed by the new partners will include:

- Provision of extensive archives of Russian satellite data of arctic sea-ice as well as new high resolution optical and IR images supporting DAMOCLES field experiments;
- Data analysis of ice thickness, density, freeboard, snow cover from previous Russian expeditions needed for validation of satellite altimeter retrievals of ice thickness;
- Investigation of retrieval of thin ice thickness from satellite IR data in combination with models, complementing other ice thickness observing methods performed during DAMOCLES IP;
- Improvement of multiyear ice concentration retrieval using combination of passive microwave and scatterometer data. Use of Okean SLR data with similar capacity as scatterometer to identify MYI, will be investigated;
- Dedicated studies of leads and polynyas by integrating optical, IR and radar satellite data, both with Russian and non Russian data supported by field experiments;
- Investigation of sea-ice thermodynamics using surface temperature retrievals from satellites in combination with *in situ* data from field experiments;
- Performing field investigations of sea-ice and snow cover from the Russian drifting station and expedition by the Russian icebreaker *A. Fedorov* during the International Polar Year (2007-2008);
- Retrieval of snow grain size and snow pollution in the Arctic from optical satellite sensors;
- Improvement of estimation of sea-ice dynamical and thermodynamical properties;
- Improvement for large scale modelling and forecasting capabilities;
- Dedicated studies of ocean tidal dynamics on long-term development of sea-ice, hydrography and ocean currents;
- Model sensitivity experiments including boundary conditions, atmospheric forcing and river run-off, based on a finite-element model including tidal effects;
- Adding value to the integrated DAMOCLES model intercomparison and sensitivity studies by extending the range of parameters;
- Data dissemination according to DAMOCLES IP specifications.

DYNAMITE - Understanding the Dynamics of the Coupled Climate System

Summary information

Funding source:	FP6 - Specific Targeted Research Project
Total Cost:	€ 3.122.214
EC contribution:	€ 1.999.998
Start – end date:	1/03/2005 – 29/02/2008
Duration:	36 months
Project Coordinator:	Helge Drange
Organisation:	Nansen Environmental and Remote Sensing Center – Norway
CLAMER thematic focus:	Temperature changes; ice melting; storm frequency and intensity; biological impacts
CLAMER Regional focus:	Arctic; North Atlantic
Project keywords:	Global warming; North Atlantic Oscillation (NAO); Arctic Oscillation (AO); Coupled atmosphere-ocean/sea ice variability; Coupled atmosphere-ocean/sea ice modelling

Project Website:
http://dynamite.nersc.no/

Project Partners

1	Nansen Environmentaion and Remote Sensing Centre - Norway
2	University of Reading – United Kingdom
3	Centre Europeen de Recherche et de Formation avancee en Calcul Scientifique - France
4	Met Office - United Kingdom
5	French National Centre for Scientific Research - France
6	Chinese Academy of Sciences, Institute of Atmospheric Physics - China
7	Leibniz Institut fur Meereswissenschaften - Germany
8	National Institute of Geophysics and Volcanology - Italy
9	Administratia Nationala de Meteorologie - Romania
10	Vestas Asia Pacific A/S - Denmark
11	Bergenshalvoeens Kommunale Kraftselskap Raadgiving As - Norway
12	Societa Generale di Ingegneria — S.G.I. Spa di Rubano - Italy
13	Vexcel Limited - United Kingdom

Background information

Project Summary

Abstract
Deeper understanding of the intrinsic variability and stability properties of the main climate variability modes is needed to assess confidence in the detection, attribution and prediction of global and regional climate change, to improve seasonal predictions, and to understand the shortcomings of current prediction systems. DYNAMITE will explore the fundamental dynamical mechanisms of two of the most important modes of climate variability:

the North Atlantic Oscillation/Arctic Oscillation (NAO/AO) and the El Nino-Southern Oscillation (ENSO). The project will elucidate key theoretical and practical aspects of the NAO/AO and ENSO through analyses of available observations, application of classical and new theory, and use of idealised and state-of the- art numerical models of the atmosphere, ocean, land-surface, sea-ice, marine biology, and the coupled climate system. Specifically, DYNAMITE will advance the understanding of strongly and weakly coupled processes underlying the natural variability of ENSO and NAO/AO; it will evaluate the representation of the coupled processes underlying ENSO and the NAO in state-of-the-art models used to predict climate change; it will advance understanding of the response of ENSO and NAO/AO to climate change; and it will assess the role of ocean biology in the variability of the tropical coupled climate system, including ENSO. DYNAMITE will be implemented by a partnership of world class climate research institutions, including a candidate country and several SMEs. All of the results and findings gained in DYNAMITE will be transferred to the climate modelling community both in and outside Europe by bi-annual electronic newsletters and a dedicated and open DYNAMITE model workshop at the end of the project. DYNAMITE will improve the European capability to make predictions of the state of the climate system from seasons to centuries ahead, thereby contributing to the competitiveness and sustainability of the European Union.

Objectives
Progress in understanding the fundamental modes of the climate system, in particular the coupled ocean-atmosphere system, is essential to improve the detection, attribution and prediction of global and regional climate change. DYNAMITE will explore the fundamental dynamics of, and the similarities and differences between, two of the most important modes of climate variability: the North Atlantic Oscillation/Arctic Oscillation (NAO/AO) and the El Nino-Southern Oscillation (ENSO).

The project will elucidate key theoretical and practical aspects of NAO/AO and ENSO through a coordinated, focussed and open effort based on analyses of available observations, application of classical and new theory, and use of idealised and state-of-the-art numerical atmosphere, ocean/ sea ice, coupled atmosphere-ocean/sea ice and coupled atmosphere-ocean/sea ice-ecosystem General Circulation Models (GCMs). DYNAMITE will advance understanding of the intrinsic characteristics of NAO/AO and ENSO, and also the response of these modes to enhanced concentrations of greenhouse gases. Based on this, the specific objectives of DYNAMITE are:

- To quantify strongly and weakly coupled processes underlying the natural variability of ENSO and NAO/AO;
- To evaluate the representation of the coupled processes underlying ENSO (wind stress, weather noise, phase synchronisation and locking, tropical scale interactions, wave activity) and the NAO (SST, snow cover, sea ice cover, troposphere/stratosphere coupling) in state-of-the-art models used to predict climate change;
- To identify the response of ENSO and NAO/AO to climate change;
- To quantify the role of ocean biology in the variability of the tropical coupled climate system, including ENSO.

A central part of DYNAMITE is a set of co-ordinated model experiments. Detailed protocols for experimental design, implementation and analysis have been defined with the aim to address:

- How the ocean responds to realistic and idealised NAO-forcing,
- How the atmosphere responds to realistic and idealised SST and sea ice anomalies,
- How the short and long term atmosphere-ocean coupling strength inluence ENSO,
- How NAO and ENSO may change as a result of global warming,
- How the marine biota may influence the coupled atmosphere-ocean climate system,
- How NAO and ENSO are coupled.

Project Outputs

A list of DYNAMITE and related publications is available on the project website.

ECOOP - European COastal-shelf sea OPerational observing and forecasting system

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 11.238.655
EC contribution:	€ 30.000
Start – end date:	1/02/2007 – 1/04/2010
Duration:	39 months
Project Coordinator:	Friedhelm Schroeder (friedhelm.schroeder@gkss.de)
Organisation:	Institute for Coastal Research, KOI; Danish Meteorological Institute – Denmark
CLAMER regional focus:	Baltic Sea; Norht Sea; Mediterranean Sea; Black Sea; North Atlantic
Project keywords:	Policies, Meteorology; Scientific Research; Renewable Sources of Energy; Other Energy Topics; Energy Saving; Resources of the Sea; Fisheries; Forecasting; Energy Storage; Energy Transport; Fossil Fuels; Social Aspects; Environmental Protection; Waste Management; Safety; Transport; Innovation; Technology Transfer

Project Website:
http://www.ecoop.eu/

Project Partners

1 Danish Meteorological Institute – Denmark
2 Bundesamt fur Seeschifffahrt und Hydrographie - Germany
3 Hellenic Centre for Marine Research - Greece
4 French Research Institute for Exploitation of the Sea - France
5 Institute of Marine Research - Norway
6 Institute of Marine Sciences METU - Turkey
7 National Institute of Geophysics and Volcanology - Italy
8 GIP Mercator Ocean - France
9 Met Office - United Kingdom
10 Marine Hydrophysical Institute – United Kingdom
11 Ukrainian National Academy of Science - Ukrain
12 Natural Environment Research Council - United Kingdom
13 Sofiiski Universitet “Sveti Kliment Ohridski” - Bulgaria
14 Italian National Agency for New Technologies, Energy and Sustain. Econom. Develop. - Italy
15 Alfred Wegener Institute for Polar and Marine Research - Germany
16 Fundación Azti, Tecnalia - Spain
17 Bolding and Burchard Hydrodynamics - Denmark
18 Bar Ilan University - Israel
19 Centre for Environment, Fisheries & Aquaculture Science - United Kingdom
20 Collecte Localisation Satellites - France
21 CLU SRL - Italy
22 University College Cork, National University of Ireland - Ireland
23 National Reserach Council, Institute of Atmospheric Sciences and Climate - Italy

24 National Environmental Research Institute - Denmark
25 Danmarks Rumcenter - Denmark
26 Finnish Institute of Marine Research - Finland
27 Mikheil Nodia Institute of Geophysics - Georgia
28 University of Zagreb, Faculty of Science - Croatia
29 GKSS – Forschungszentrum Geesthacht GmbH - Germany
30 HR Wallingford Ltd. - United Kingdom
31 Carl von Ossietzky Universitaet OldenburgI - Germany
32 Spanish National Research Council - Spain
33 Institut National Agronomique de TunisieI - Tunisia
34 Institut National de Recherche Halieutique - Morocco
35 Bulgarian Academy of Sciences, Institute of Oceanology - Bulgaria
36 Israel Oceanographic and Limnological Research Limited - Israel
37 Leibniz Institute for Baltic Sea Research, Warnemünde - Germany
38 Instituto Superior Tecnico - Portugal
39 Mariene Information Service - Netherlands
40 Meteorologisk institutt - Norway
41 Météo France - France
42 Tallinn University of Technology - Estonia
43 Management Unit of the Mathematical Models - Belgium
44 Nansen Environmental and Remote Sensing Centre - Norway
45 Norsk Institutt for Vannforskning - Norway
46 Plymouth Marine Laboratory - United Kingdom
47 Puertos del Estado - Spain
48 Rijksinstituut voor Kust en Zee, Rijkswaterstaat - Netherlands
49 Russsian State Hydrometeorological University - Russian Federation
50 Swedish Meteorological and Hydrological Institute - Sweden
51 State Oceanographic Institute - Russian Federation
52 Techworks Marine Limited - Ireland
53 Delft University of Technology, Department of Civil Engineering and Geosciences – Netherlands
54 Panepistimio Kyprou - Cyprus
55 Universite de Liege - Belgium
56 Institute of Accelerating Systems and Applications - Greece
57 Università di Bologna, Centro Interdipartimentale per la ricerca sulle Scienze Ambientali - Italy
58 Uniwersity of Gdansk - Poland
59 Universitat Politecnica de Catalunya - Spain
60 The University of Reading - United Kingdom
61 French National Centre for Scientific Reserach, Délégation Midi-Pyrénées - France
62 European Commission Joint Research Centre
63 Marine Institute - Ireland
64 Xunta de Galicia – Conselleria de Medio Ambiente e Desenvolvemento Sostible - Spain
65 Noveltis - France
66 Finnish Environment Institute - Finland
67 Chinese Academy of Sciences, Institute of Atmospheric Physics - China
68 Fondazione IMC Centro Marino Internazionale Onlus - Italy
69 National Institute for Marine Research and Development "Grigore Antipa" - Romania
70 University of Bergen - Norway
71 University of Malta - Malta
72 Spanish Institute of Oceanography – Spain

Background information

Project Summary

The overall goal of ECOOP is to consolidate, integrate and further develop existing European coastal and regional seas operational observing and forecasting systems into an integrated pan-European system targeted at (i) detecting environmental and climate changes, (ii) predicting their evolution, (iii) producing timely and quality assured forecasts, (iv) providing marine information services (including data, information products, knowledge and scientific advices) and (v) facilitate decision support needs.

This is to be attained through the following activities:

- Integrate existing coastal and regional sea observing (remote sensing, *in situ*) networks into a pan-European observing system;
- Integrate existing coastal and regional sea forecasting systems into a pan-European forecasting system and assimilate pan-European observation database into the system; Assess the quality of the pan-European observing and forecasting system;
- Advance key technologies for the current and next generation pan-European observing and forecasting system;
- Develop and generate value-added products for detecting environment and climate change signals;
- Integrate and implement a pan-European Marine Information System of Systems (EuroMISS) for general end user needs;
- Develop methodology and demonstrate an European Decision Support System for coastal and regional seas (EuroDeSS) that responds to the needs from targeted end users, as emphasized in the GEOSS and GMES initiatives;
- Carry out technology transfer both in Europe and at intercontinental level, establish education and training capacities to meet the need for ocean forecasters.

ECOOP will achieve its goals by implementing an integration of observations and modelling into a pan-European marine information system of systems (EuroMISS) and design of a European decision support system (EuroDESS) for coastal and regional seas.

Project Outputs

Knowledge developed within the project has been shared and disseminated by various means to partners within the project and outside the project to both the scientific community and the public in general. An extensive overview of project achievements, publications and results is available from the final reports and dissemination plan which can be downloaded from the project website.

ECOTRENDS - Long-term trends on high-diverse benthic communities in the NW Mediterranean Sea: Ecological consequences of climate change

Summary information

Funding source:	FP6 - Marie Curie Actions
EC contribution:	€ 158.219
Start – end date:	1/03/2005 – 28/02/2007
Duration:	24 months
Project Coordinator:	Joaquim Garrabou (garrabou@com.univ-mrs.fr)
Organisation:	National Council for Scientific Research – France
CLAMER thematic focus:	Biological impacts
CLAMER Regional focus:	Mediterranean Sea
Project keywords:	Social Aspects; Scientific Research, Coordination; Cooperation; Regional Development; Information; Media; Education; Training; Evaluation; Biodiversity; population genetics; climate change; conservation; GIS; landscape ecology; Mediterranean benthic communities; underwater images; long-term series

Background information

Project Summary

Abstract
Human activities have extensively altered the global environment, changing biological cycles, transforming land and oceans, and enhancing the mobility of biota. These changes have also altered the biological diversity producing important ecosystem and societal consequences. The need to collect long-term data sets has been stressed by marine ecologists because such data provide baselines to verify trends in marine communities. Long-term approaches produce meaningful data, essential for the conservation of biodiversity and the successful management of marine ecosystems. The Mediterranean coralligenous benthic communities are valuable from the ecological viewpoint, beautiful as seascapes, and unique communities. However, they are among the most endangered Mediterranean ecosystems due to overexploitation of living resources, urban development, anthropogenic effects on water quality, and the increase of diving tourism. In addition to this scenario, the mass mortality event of invertebrates detected in 1999 and 2003 has been associated with elevated seawater temperatures supposedly related to global climate change. Therefore, the aim of this project is to understand the ecological structure and dynamics of NW Mediterranean coralligenous communities, which are considered particularly sensitive to global climate change. To achieve this goal this study integrates complementary approaches to enhance our ecological knowledge and to determine how resilient Mediterranean communities are. This scientific project is based on the analysis of decadal trends of two photographic series of these communities and on population genetics experiments of key species. The expected results will provide the proper scientific context for biological conservation of the diverse Mediterranean coralligenous communities.

ENSEMBLES - ENSEMBLE based predictions of climate change and their impacts

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 22.790.000
EC contribution:	€ 15.000.000
Start – end date:	1/09/2004 – 31/12/2009
Duration:	64 months
Project Coordinator:	Paul Van Der Linden (paul.vanderlinden@metoffice.gov.uk)
Organisation:	Met Office, Hadley Center, Exeter - United Kingdom
Project keywords:	Climate Change, Climate Research, Global Climate Modelling, Regional Climate Modelling, Climate Observations, Climate and Weather Extreme Events, Physical Climate Processes, Climate Scenarios, Climate Projections, Climate Change and Policy, Climate Change Impacts, Energy, Agriculture, Insurance

Project Website:
www.ensembles-eu.org

Project Partners

1 Met Office – United Kingdom
2 Meteo France, Centre National de Recherches Météorologiques - France
3 French National Centre for Scientific Research - France
4 Danish Meteorological Institute - Danmark
5 European Centre for Medium-Range Weather Forecasts - United Kingdom
6 International Institute for Applied Systems Analysis - Austria
7 National Institute of Geophysics and Volcanology - Italy
8 Royal Netherlands Institute for Sea Research – Netherlands
9 University of Bristol - United Kingdom
10 Max Planck Gesellschaft zur Foerderung der Wissenschaften e.v. - Germany
11 National Observatory of Athens - Greece
12 Sveriges Meteorologiska och Hydrologiska Institut - Sweden
13 University of East Anglia - United Kingdom
14 University of Fribourg - Switzerland
15 University of Hamburg - Germany
16 University of Reading - United Kingdom
17 Agenzia Regionale per la Prevenzione e l'Ambiente dell'Emilia-Romagna Servizio Meteorologico Regionale - Italy
18 Aristotle University of Thessaloniki - Greece
19 Bureau of Meteorology Research Centre - Australia
20 Centre Européen pour le Recherche et la Formation Avancée en Calcul - France
21 Cesky Hydrometeorologicky Ustav - Czech Republic
22 Cicero Senter for Klimaforskning - Norway
23 CLIMPACT - France
24 National Research Council - Italy
25 Univerzita Karlova v Praze - Czech Republic
26 Danmarks Jordbrugsforskning - Denmark

27 Università degli Studi di Firenze - Italy
29 Deutscher Wetterdienst - Germany
30 Electricite de France - France
31 Ecole Normale Superieure - France
32 Eidgenoessische Technische Hochschule Zuerich - Switzerland
34 Fondazione ENI Enrico Mattei - Italy
35 Fundación para la Investigación del Clima - Spain
36 Ilmatieteen Laitos - Finland
37 Fachhochschule fuer Technik Stuttgart - Germany
38 Freie Universitaet Berlin - Germany
40 GKSS Forschungszentrum Geesthacht GmbH - Germany
41 Ustav Fyziky Atmosfery AV CR - Czech Republic
42 The Abdus Salam International Centre for Theoretical Physics - Italy
43 Institut fuer Meereskunde an der Universitaet - Germany
44 Instituto Nacional de Meteorologia - Spain
45 The Trustees of Columbia University in New York City – United States
46 Institut Universitaire Kurt Boesch - Switzerland
47 University of Stuttgart - Germany
48 Commission of the European Communities - Directorate General Joint Research Centre - Belgium
49 London School of Economics and Political Science – United Kingdom
50 London School of Hygiene and Tropical Medicine - United Kingdom
51 Meteorological Institute - Norway
52 Meteoschweiz - Switzerland
54 Nansen Environmental and Remote Sensing Center - Norway
55 Institutul National de Hidrologie si Gospodarire a Apelor Bucuresti - Romania
56 Administratia Nationala de Meteorologie - Romania
57 Polish Academy of Sciences, Research Centre for Agricultural and Forest Environment - Poland
58 Potsdam-Institut für Klimafolgenforschung e.v. - Germany
59 Rijksinstituut voor Volksgezondheid en Milieu - Netherlands
60 Societe de Mathematiques Appliquees et de Sciences Humaines - France
61 Finnish Environment Institute - Finland
62 University of Cantabria - Spain
63 Universite Catholique de Louvain - Belgium
64 Universidad de Castilla la Mancha - Spain
65 University of Oslo - Norway
67 Lunds Universitet - Sweden
68 Universität Kassel Germany
69 University of Liverpool – United Kingdom
70 University of Oxford – United Kingdom
73 Université Joseph Fourier, Grenoble - France
74 Met Eireann – Ireland

Background information

Project Summary

Abstract
Prediction of both natural climate variability and human impact on climate is inherently probabilistic, due to uncertainties in forecast initial conditions, representation of key processes within models, and climatic forcing factors. Hence, reliable estimates of climatic risk can only be made through ensemble integrations of Earth - System Models in which these uncertainties are explicitly incorporated. For the first time ever, a common ensemble forecast system will be developed for use across a range of timescales (seasonal, decadal, and longer) and spatial scales (global, regional, and local). This model system will be used to construct integrated

scenarios of future climate change, including both non-intervention and stabilisation scenarios. This will provide a basis for quantitative risk assessment of climate change and climate variability, with emphasis on changes in extremes, including changes in storminess and precipitation, and the severity and frequency of drought, and the effects of "surprises", such as the shutdown of the thermohaline circulation. Most importantly, the model system will be extensively validated. Hind casts made by the model system for the 20th century will be compared against quality-controlled, high-resolution gridded datasets for Europe. Probability forecasts made with the model system on the seasonal and decadal timescales will also be validated against existing data. The exploitation of the results will be maximised by linking the outputs of the ensemble prediction system to a wide range of applications. In turn, feedbacks from these impact areas back to the climate system will also be addressed. Thus ENSEMBLES will have a structuring effect on European research by bringing together an unprecedented spectrum of world-leading expertise. This expertise will be mobilised to maintain and extend European pre-eminence in the provision of policy-relevant information on climate and climate change and its interactions with society.

Objectives
The overall goal of ENSEMBLES is to maintain and extend European pre-eminence in the provision of policy relevant information on climate and climate change and its interactions with society. ENSEMBLES will achieve this by:

- Developing an ensemble prediction system based on the principal state-of-the-art, high resolution, global and regional Earth System models developed in Europe, validated against quality controlled, high resolution gridded datasets for Europe, to produce for the first time, an objective probabilistic estimate of uncertainty in future climate at the seasonal to decadal and longer timescales;
- Quantifying and reducing the uncertainty in the representation of physical, chemical, biological and human-related feedbacks in the Earth System (including water resource, land use, and air quality issues, and carbon cycle feedbacks);
- Maximising the exploitation of the results by linking the outputs of the ensemble prediction system to a range of applications, including agriculture, health, food security, energy, water resources, insurance and weather risk management.

To meet the Project Goal the project is split into a number of scientific and technological objectives with a number of operational goals. The work in the project is conducted through 10 closely connected Research Themes (RTs), each of which has Major Milestones (MMs) which are the means of assessing progress towards the project objectives and operational goals.

ENSEMBLES will be a major step forward in climate and climate change science. Over the next five years the major progress in climate science is expected mainly to take place in six areas:

- The production of probabilistic predictions from seasonal to decadal and longer timescales through the use of ensembles
- The integration of additional processes in climate models to produce true Earth System models
- Higher resolution climate models to provide more regionally detailed climate predictions and better information on extreme events
- Reduction of uncertainty in climate predictions through increased understanding of climate processes and feedbacks and through evaluation and validation of models and techniques
- The increased application of climate predictions by a growing and increasingly diverse user community
- The increased availability of scientific knowledge within the scientific community and to stakeholders, policymakers and the public.

ENSEMBLES will make major scientific contributions in all these areas and, most importantly, will ensure that these six strands are all taken forward in an integrated and co-ordinated way. This will be possible because ENSEMBLES encases each of these elements within a planned and actively managed programme.

All of the major groups in Europe, who would individually be involved in the six elements, are participants in the project. In numerous ways ENSEMBLES will extend the state-of-the-art in the prediction of climate change and its impacts at seasonal to decadal and longer timescales. Foremost in this will be the development of the first global, high resolution, fully comprehensive, ensemble based, modelling system for the prediction of

climate change and its impacts. This will confirm and maintain Europe's position as the world leader in climate change prediction. The integrated system to be developed for this project will deal with issues related to:

- Natural variability of climate in the context of a changing chemical environment,
- Non-linearity in the response both at the global and regional scale,
- Quantitative estimates of uncertainty guided by observations, relevant to policy makers.
- This will require:

Inclusion of the non-linear feedbacks between climate and the impacts of climate change (e.g. water resource management, changes in land use, energy needs). This requires a more integrated approach to the assessment of the impacts of climate change than has hitherto been undertaken within a sophisticated, state-of-the-art earth system model;

- Quantifying uncertainty in individual components of the earth system and in the interaction between individual components, through the use of (i) different model constructions and (ii) ensemble-based "perturbed physics" versions of each model. The incorporation of "perturbed physics" techniques within the modelling framework allows for an exploration of uncertainties associated with the representation of individual processes (particularly relevant for those which cannot be resolved at the model grid-scale), and together with the multi-model approach will provide a much more complete estimate of uncertainty than has thus far been possible;
- Construction of an ensemble of earth system models to provide estimates of climate and other environmental change for the next 10 to 100 years. Model diversity is essential for providing a level of confidence to European predictions of climate change;
- Derivation of an objective method of deriving probability distributions using ensembles of models, weighted according to the ability of an individual model to represent key aspects of observed climate. Evaluation of model skill is an essential part of the process, which will involve the development of new methodologies for diagnosing key processes and phenomena in models and for confronting them with satellite and *in situ* observations;
- Using the probability distributions of the impacts of climate change from the integrated system (including water management, land use, air quality, carbon management and energy use) to determine the social and economic effects and provide a risk assessment for selected emissions scenarios (policies);
- Developing a comprehensive approach to the validation of climate change ensembles and the impacts assessments, which includes the exploitation of seasonal to decadal predictability studies, thereby providing for the first time a sound, quantitative measure of confidence in future scenarios.

Thus, ENSEMBLES will begin to move the state of the art in climate prediction from a small number of deterministic predictions with no quantitative assessment of relative confidence towards an end-to-end multimodel ensemble prediction system (quantitatively validated against recent past climates and against the ability to predict future climate at the seasonal to decadal timescales) which would be able to provide probabilistic estimates of future climate change and its impacts on key sectors, at the European and global scales.

Project Outputs

Final project results and reports are available from the project website.

EPICA-MIS - New Paleoreconstructions from Antarctic Ice and Marine Records

Summary information

Funding source:	FP6 - Specific Targeted Research Project
Total Cost:	€ 5.470.000
EC contribution:	€ 2.500.000
Start – end date:	1/12/2004 – 31/05/2008
Duration:	42 months
Project Coordinator:	Dominique Raynaud (raynaud@lgge.obs.ujf-grenoble.fr)
Organisation:	National Council for Scientific Research – France
CLAMER thematic focus:	Sea level rise; ice melting
Regional focus:	Antarctic

Project Website:
http://www.awi.de/en/research/research_divisions/geosciences/glaciology/projects/epica_mis/

Project Partners

1 National Council for Scientific Research - France
2 Alfred Wegener Institute for Polar and Marine Research - Germany
3 National Interuniversity Consortium for Marine Sciences - Italy
4 Universite Libre de Bruxelles - Belgium
5 Koebenhavns Universitet - Denmark
6 Institut Polaire Francais — Paul Emile Victor - France
7 Utrecht University - The Netherlands
8 Stockholms Universitet - Sweden
9 Norwegian Polar Institute - Norway
10 University of Bern - Switzerland
11 Natural Environment Research Council - United Kingdom
12 University of Cambridge - United Kingdom
13 Commissariat à l'Energie Atomique - France
14 Consorzio per L'attuazione del Programma Nazionale di Ricerche in Antartide - Italy

Background information

Project Summary

Abstract
The objective of the Specific Targeted Research Project EPICA-MIS is to produce palaeoreconstructions and integrated climate analysis through marine and ice core studies. It will contribute to the development of novel palaeoreconstruction methods by providing unique palaeorecords and developing new proxies of critical properties of the climate system. The two Antarctic deep ice cores will be completed and they will for the first time reveal atmospheric records of greenhouse gases like CO_2 and methane reaching 800,000 years back in time. Novel multi-parameter and high-resolution records of climate-relevant parameters like ice isotopes, greenhouse gases, dust and soluble impurities will be produced from the new Antarctic ice cores. They will be compared and correlated with palaeoreconstructions from marine, Greenland and other Antarctic regions. A

key task here is to produce common timescales for the records by comparing the individual datings and by investigating novel tephra and palaeomagnetic correlation methods. The produced multiproxy reconstructions will provide an outstanding platform for understanding and modelling the past and present climate. Because the reconstructions from both ocean and ice cores will be integrated and will use novel indicators for instance for sea-ice, Antarctic insolation, iron or opal isotopes, climatic issues like the carbon cycle, sea surface temperature, and the climatic coupling between the northern and southern hemispheres can be addressed with new perspectives. As strategies for mitigation and adaptation to global change have to be based on predictions on future climate, the EPICA-MIS novel palaeoreconstructions will produce new evidence about climate dynamics and variability necessary to improve and test policy-relevant models. The Research Project goes a step further in integrating the European ice core research groups with marine palaeoclimate research groups, thus forming a strong European Research Area.

Objectives

The Project's strategic objectives can be summarized as follows:

- State of knowledge
- Completion of the EPICA drillings
- Extending the ice record
- Developing novel proxies for paleoclimatic reconstruction
- Paleoreconstruction and integrated climate analysis through marine and ice core studies

ESONET - European Seas Observatory NETwork

Summary information

Funding source:	FP6 - Network of Excellence
Total Cost:	€ 13.990.000
EC contribution:	€ 7.000.000
Start – end date:	1/03/2007 – 28/02/2011
Duration:	48 months
Project Coordinator:	Roland Person (Esonet.Webmaster@ifremer.fr)
Organisation:	French Research Institute for Exploitation of the Sea – France
CLAMER Regional focus:	North Atlantic; Arctic; Black Sea; Mediterranean Sea
Project Keywords:	European seafloor observatory network; oceanographical and phisycal recordings

Project Website:
http://www.esonet-noe.org

Project Partners

1 French Research Institute for Exploitation of the Sea - France
2 Send Off-Shore Electronics Gmbh - Germany
3 Send Signal Elektronik Gmbh - Germany
4 Altran Technologies - France
5 SLR Environmental Consulting Limited - Ireland
6 Dokuz Eylul Universitesi - Turkey
7 Beuth Hochschule Für Technik Berlin-University of Applied Sciences - Germany
8 Medicion Ambiental S.L.N.E. - Spain
9 Norddeutsche Seekabelwerke Gmbh - Germany
10 Sercel S.A. - France
11 SOPAB Brest - France
12 National Council for Scientific Research - France
13 Centro De Investigacao Tecnologica Do Algarve - Portugal
14 Teseo S.r.l. - Italy
15 University of Aberdeen - United Kingdom
16 Sis Sensoren Instrumente Systeme Gmbh - Germany
17 Guralp Systems Limited - United Kingdom
18 Nke S.A. - France
19 Fugro Engineers Bv – The Netherlands
20 Alcatel Submarine Networks SAS - France
21 Bogazici University - Turkey
22 Istanbul Technical University - Turkey
23 Institute of Oceanology, Bulgarian Academy of Sciences - Bulgaria
24 Universite Libre De Bruxelles - Belgium
25 Stiftelsen Norges Geotekniske Institutt - Norway
26 University of Tromsø - Norway
27 Spanish National Research Council - Spain
28 University of Algarve - Portugal
29 University of Acores - Portugal
30 Marine Institute - Ireland

31 Royal Netherlands Institute for Sea Research - The Netherlands
32 Hellenic Centre for Marine Research - Greece
33 Natural Environment Research Council - United Kingdom
34 Tecnomare SPA - Societa Per Lo Sviluppo Delle Tecnologie Marine - Italy
35 Istituto Nazionale Di Fisica Nucleare - Italy

Background information

Project Summary

Abstract
The European GMES programme for Global Monitoring for Environment and Security has identified a need for a subsea component of a proposed surveillance system. This will be directed to monitor the solid earth beneath the sea, processes at the interface between the solid earth and sea and processes in the water column.

ESONET was set up as a concerted action (EVK3-CT-2002-80008) sponsored by the European commission to consider the feasibility of such a system. ESONET is directed to monitoring the submarine terrain around Europe from the continental shelves to the abyss, an area of ca. 3 million km^2. This is comparable in size with the total landmass of Europe and is increasingly important for resources, such as minerals, hydrocarbons and fisheries. Only a small fraction of this realm has been explored and new features, and communities of animals (e.g. cold water corals and mud volcanoes) are discovered every year. The biodiversity probably exceeds that of the European land mass. There are natural hazards such as submarine slides and earthquakes with associated tsunamis. Human impacts on this zone are poorly understood. A prerequisite for management, conservation and protection from hazards of this zone is the establishment of a long- term monitoring capability. ESONET through a co-ordinated approach will provide data to users on time scales from instantaneous real-time hazard warning to long term archiving of data for tracking of global change around Europe.

Remote sensing from aircraft and spacecraft has limited capacity for penetrating through sea water; optical sensors only providing data on the surface layer of the ocean. Monitoring of events on the sea floor or in the water column require *in situ* sensors, power supplies and a data storage or telemetry system. The science of oceanography has developed through the use of instruments such as current meters deployed on moorings or platforms with electrical energy stored in batteries and data archived on various media such as photographic films, hard discs or solid state memory. Data are only available when the system is recovered, there is no real-time capability and the system is limited by the battery life and storage capacity of the data store. Real-time telemetry of data can be achieved either via acoustics through the water, or via radio links to shore or satellite from a surface buoy. These systems are never-the-less limited by the energy available in the observatory and energy costs of data transmission imposes a further energy drain. In contrast, space craft opportunities for use of solar energy are limited to special cases where a sufficiently large array can be mounted on a surface buoy or other structure.

ESONET is complementary to proposed cabled observatory systems being developed in North America (NEPTUNE) and Japan (ARENA) but will use various technologies including noncabled instruments.

Project Achievements

ESONET/CA emphasized the importance of the submarine terrain around Europe from the continental shelves to the abyss, an area of 3 millions km^2, comparable in size with the total landmass of Europe and increasingly important in terms of resources (food, energy, biodiversity). Also, this area is the place of large natural hazards such as submarine slides, earthquakes and tsunamis, whose impact is enormous particularly in coastal areas. Finally, an important part of the processes that are critical to climate change takes place in the ocean system and its monitoring is increasingly important for the sustainability of humankind. The only systematic way to complement existing spatial and coastal devices was seen as the implementation of a group of multiparametric

seafloor permanent observatories, connected directly or indirectly to shore. They were specifically designed to ensure a long term monitoring of chosen critical locations, where the most important biological, chemical or physical processes could be detected or followed up.

ESONET/CA made the first assessment of available European capacity in ocean observatories. It allowed the identification of the potential stakeholders in Europe and elsewhere with interests in the proposed system and it produced a first level configuration of the observatory nodes. It also started systematic connections with similar initiatives in the USA, Canada and Japan, establishing itself as the reference seafloor observatory program.

EUR-OCEANS - EURopean network of excellence for OCean Ecosystems ANalysis

Summary information

Funding source:	FP6 - Network of Excellence
Total Cost:	€ 40.000.000
EC contribution:	€ 10.000.000
Start – end date:	1/01/2005 – 31/12/2008
Duration:	48 months
Project Coordinator:	Paul Tréguer (paul.treguer@univ-brest.fr)
Organisation:	National Council for Scientific Research – France
CLAMER thematic focus:	Abiotic changes; biologic impacts; socio-economic impacts
CLAMER Regional focus:	Arctic; Baltic Sea; Mediterranean Sea; North Atlantic
Project Keywords:	Global change, climate change, anthropogenic impacts on the marine ecosystems, ecosystems end-to-end, marine biogeochimistry, public outreach

Project Website:
http://www.eur-oceans.eu

Project Partners

1 National Council for Scientific Research - France
2 Institut des Sciences de la Mer et de l'Aménagement du Littoral - Algeria
3 Vrije Universiteit Brussel - Belgium
4 Université Catholique de Louvain - Belgium
5 Université Libre de Bruxelles - Belgium
6 Université de Liège - Belgium
7 Centro de Investigación Oceanográfica en el Pacifico Sur-Oriental - Chile
8 Universidad de Concepcion - Chile
9 Danish Institute for Fisheries Research - Denmark
10 National Environmental Research Institute - Denmark
11 University of Aarhus - Denmark
12 Tartu Uelikool, Eesti Mereinstituut - Estonia
13 Finnish Institute of Marine Research - Finland
14 France Innovation Scientifique et Transfert S.A. - France
15 Commissariat à l'Energie Atomique - France
16 Institut de Recherche pour le Développement - France
17 French Research Institute for Exploitation of the Sea - France
18 SOPAB Brest - France
19 Alfred Wegener Institute for Polar and Marine Research - Germany
20 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
21 Leibniz Institute for Baltic Sea Research Warnemünde - Germany
22 Max-Planck-Gesellschaft zur Förderung der Wissenschaften (MPG) - Germany
23 University of Hamburg - Germany
24 University of Bremen - Germany
25 Hellenic Centre for Marine Research - Greece
26 Institute for Coastal Marine Environment of the National Research Council - Italy
27 National Interuniversity Consortium for Marine Sciences – Italy

28 National Institute of Geophysics and Volcanology - Italy
29 National Institute of Oceanography and Experimental Geophysics - Italy
30 Stazione Zoologica 'A. Dohrn' - Italy
31 Latvian Fish Resources Agency - Latvia
32 Institut National de Recherche Halieutique - Morocco
33 University of Groningen – Netherlands
34 Nederlands Institute of Ecology – Netherlands
35 University of Amsterdam – Netherlands
36 Wageningen Universiteit, Department Environmental Sciences – Netherlands
37 Royal Netherlands Institute for Sea Research - Netherlands
38 University of Tromsø - Norway
39 Norwegian Polar Institute - Norway
40 Norwegian University of Science and Technology - Norway
41 University of Bergen - Norway
42 Institute of Marine Research - Norway
43 Institute of Oceanology of the Polish Academy of Sciences - Poland
44 Sea Fisheries Institute - Poland
45 Instituto Nacional de Investigação Agrária e das Pescas - Portugal
46 P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences - Russian Federation
47 University of Cape Town - South Africa
48 AZTI-Tecnalia - Spain
49 Spanish National Research Council - Spain
50 Spanish Institute of Oceanography - Spain
51 Universidad de Las Palmas de Gran Canaria - Spain
52 University of Vigo - Spain
53 Swedish Museum of Natural History - Sweden
54 Göteborg University - Sweden
55 Stockholm University - Sweden
56 University of Bern - Switzerland
57 Faculty of Science of Bizerta - Tunisia
58 Middle East Technical University, Institute of Marine Sciences - Turkey
59 Institute of Biology of the Southern Seas - Ukraine
60 University of Essex - United Kingdom
61 Natural Environment Research Council - United Kingdom
62 Centre for Environment Fisheries and Aquaculture Science - United Kingdom
63 Plymouth Marine Laboratory - United Kingdom
64 University of Southampton - United Kingdom
65 University of Warwick - United Kingdom
66 Scottish Ministers Acting through Fisheries Research Services Marine Laboratory - United Kingdom
67 Imperial College of Science, Technology and Medicine - United Kingdom

Background information

Project Summary

Abstract
EUR-OCEANS aims to achieve lasting integration of European research organisations on global change and pelagic marine ecosystems, and to develop models for assessing and forecasting the impacts of climate and anthropogenic forcing on food-web dynamics (structure, functioning, diversity and stability) of pelagic ecosystems in the open ocean. The NOE will favour the progressive integration of research programmes and facilities of major research Institutes all over Europe. The long-term goal of the NOE is to create a multi-site institute for European research on ocean ecosystems under anthropogenic and natural forcings. The international context is provided by Global Ocean Ecosystem Dynamics (GLOBEC), and the forthcoming

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) of the International Geosphere Biosphere Programme (IGBP). EUR-OCEANS' Joint Programme of Activities (JPA) comprises:

1. Integrating activities on: networking (data and model integration);
2. Jointly executed research, organised around four broad modelling tasks (together with observations and experiments) on: pelagic ecosystems end-to-end, biogeochemistry, ecosystem approach to marine resources and within-system integration;
3. Activities to spread excellence, including training of researchers, and spreading excellence to socioeconomic users and to the European public (through the Association of Aquaria for EUR-OCEANS public outreach);
4. Management Activities. Administrative and Financial Coordinator: Institut Océanographique. Governing bodies: General Assembly (Member Organisations); Executive Committee (incl.Scientific Director and the Deputy); Steering Committee (incl. Work Packages Leaders). Councils: Scientific, Intellectual, Gender Equality, and EUR-OCEANS Institute. Composition: 69 Member Organisations, from 25 states (incl. 7 Third countries); 160 PIs selected for their capacity and excellence. Close cooperation with the USA, Australia, Canada, Namibia and Japan.

Project Outputs

Major achievements

From 2005 to 2008, the EUR-OCEANS Network of Excellence brought together more than 160 Principal Investigators and 350 Associated Scientists, from 61 member research institutes and universities in 25 countries in Europe and beyond. The objectives of the NoE were twofold: scientific progress and networking.

The overall scientific objective was to develop models for assessing and forecasting the impacts of climate and anthropogenic forcing on pelagic ecosystems, in order to define a basis for sustainable development at a global level. The networking objective was to achieve lasting integration of major European organisations research efforts in this scientific field. Additionally, the EUR-OCEANS NoE also aimed to develop international co-operation with non European countries, in particular with the USA.

To achieve the agreed networking and overall scientific objectives the EUR-OCEANS' methodology was to build a Joint Programme of Activity (JPA) structured to favour interactions between the four major components/communities dealt with by the NoE's scientific programme, i.e. climate and anthropogenic forcing, biogeochemistry, ecosystem end-to-end, ecosystem approach to marine resources. The JPA included Integration, Education, Training and Outreach activities as well as Jointly Executed Research activities, distributed amongst 10 work packages. These activities were developed targeting seven distinct Systems (i.e., geographical areas or ecosystem types).

A. Integration, Education, Training, Outreach programmes

The programmes that the NOE designed and implemented to favour networking and integration are as follows.

The PhD Programme (2005-2008): To foster integration, EUR-OCEANS funded PhD projects that were supervised by advisors belonging to two or more Institutes in different countries. The 19 students, selected on criteria of excellence, originated from another country than those where the Institutes were located. The advisors were from France (28%), the United Kingdom (20%), the Netherlands (16%), Germany (14%), Belgium, Denmark, Norway, South Africa, Spain, Switzerland, Greece and Italy. Interestingly, DIFRES (Denmark) and the French Ministry of Research added one scholarship each to the EUR-OCEANS PhD Programme, for a grand total of 21 EUR-OCEANS PhD students. In addition, more than 300 PhD theses in the EUR-OCEANS science field, funded from resources other than the EUR-OCEANS EC grant, have been co-supervised by EUR-OCEANS PIs. A promising output of the PhD programme was, in 2006, the creation of the MENTOR Doctoral Network created by the universities of Brest (France), Bremen and Kiel (Germany), Bergen (Norway) and Southampton (the United Kingdom). MENTOR is leading CALMARO, an Early Stage Training project within the "Marie Curie Actions" of the European Commission.

The postdoctoral programme operated along the same lines. Eleven scientists originating from 7 countries and supervised by 23 PIs from 11 different countries started their projects between late 2006 and 2008.

The Integration Projects: Fourteen projects were selected and funded to favour integration. They involved 22 PIs (on behalf of 80 scientists) belonging to 16 MOs of 11 countries.

The Floating University programme: Two “universities at sea” were organised by EUROCEANS with the help of the universities of Tromsö and Bremen. A total of 17 students (11 male, 6 female) originating from 7 countries benefited from two cruises in the Nordic Sea (on board of R/V Jan Mayen), and in the North Atlantic Ocean (on board of the R/V Marian S. Merian).

The summer school programme: From 2006 to 2008 EUR-OCEANS organised or coorganised 6 summer schools, for both its own and external students. Those summer schools took place in Portugal, Germany, Turkey, Denmark, and the United Kingdom.
The mobility programme: From 2006 to 2008, 120 EUR-OCEANS PIs, associated scientists and students, affiliated to 41 different MOs, benefited from a mobility grant to visit another MO.

The sharing facilities programme: From 2005 to 2008 EUR-OCEANS designed and implemented a database for sharing major facilities (mesocosms, mass spectrometers, equipment at sea, etc.) available in different MOs. One hundred and twelve such facilities have been identified and shared during 6.052 days from 2005 to 2008, which corresponds to a mean of approximately 15 days of sharing per facility and per year.

The data rescue and transformation programme: From 2006 to 2008 EUR-OCEANS developed a programme for rescuing data that were relevant to model development and validation. The 16 funded proposals were from Finland, France, Germany, Greece, Italy, Latvia, Norway, Russian Federation, South Africa, Spain, United Kingdomraine, and the United Kingdom. In addition, four proposals for data transformation (addition of metadata, format and unit changes) were also awarded funds; successful proposals were from France, Germany and the United Kingdom.

The knowledge transfer programme to socio-economic users: From 2005 to 2008, the *Knowledge Transfer Unit* has produced 16 Fact Sheets, delivered to targeted socio-economic users identified in a database (governmental and regional organisations, local fisheries management committees, NGOs, international advisory bodies, etc.). The symposium on "*Coping with global change in marine social-ecological systems*", a socio-economically oriented European conference organised by EUR-OCEANS in synergy with GLOBEC and the FAO, was held in Rome (Italy) from 7 to 11 July 2008.

The Public Outreach Programme: This programme was implemented by a Network of 10 aquaria and scientific centres located in France, Greece, Italy, Monaco, Poland, Spain, Sweden and the United Kingdom. This Network, created by EUR-OCEANS, produced 16 films to illustrate critical issues of the EUR-OCEANS science field domain. This activity was carried out under the control of 44 PIs originating from 21 different MOs of 12 countries involving France, Germany, Norway, Netherlands, Portugal, Poland, South Africa, Spain, Sweden and the United Kingdom. Researchers from Monaco and Peru also participated to this activity. The network of aquaria and scientific centres also developed a specific educational programme for European schools and a film contest (2008) in which 8 European countries participated, and which a primary school from the United Kingdom won. The goal of developing *international cooperation* was met through active cooperation with IMBER and GLOBEC, two active international programmes sponsored by IGBP and SCOR. This included the co-organisation of 40 workshops and summer schools. In addition, in the context of the International Polar Year (2007-2009), EUR-OCEANS took the initiative of the ICED programme (coordinator: BAS, United Kingdom). Concerning research in the coastal upwelling domain, EUR-OCEANS also actively developed collaborations with the Scripps Institution of Oceanography, Peru, BENEFIT, Namibia, Mauritania and Morocco. EUR-OCEANS, together with GLOBEC and IMBER, also took the BASIN initiative. This ambitious programme will bring together researchers from Europe, USA, and Canada to better understand and model the impacts of global change on the marine ecosystems of the North Atlantic basin.

B. Jointly Executed Research:

Developing models for assessing and forecasting the impacts of climate and anthropogenic forcing on food-web dynamics of pelagic ecosystems in the open Ocean: The overall scientific objective of EUR-OCEANS was to develop models for assessing and forecasting the impacts of climate and anthropogenic forcing on food-web dynamics (structure, functioning, diversity and stability) of pelagic ecosystems in the open ocean. This objective has been achieved before the end of the fourth year. The EUR-OCEANS modelling efforts resulted in publications such as Le Quéré *et al*. (2007), Schneider *et al*. (2008), Orr *et al*., Cury *et al*. (2008), Senina *et al*. (2008), Lehodey *et al*., Travers *et al*. (2009), and fed ongoing projects such as MEECE. In 2007, several EUROCEANS researchers (including Thomas Stocker, Corinne Le Quéré, Fortunat Joos and Christoph Heinze) played key roles in the activities of Working Group I (WGI) of the Intergovernmental Panel on Climate Change (IPCC), which released its Fourth Assessment Report AR4. With the development of ecosystem models the NOE has contributed to pave the way for the next report. EUR-OCEANS researchers produced major publications that are milestones on the road of forecasting the impacts of climate and anthropogenic forcing on marine ecosystems. Among these publications are: (1) a paper on how global climate will modify the metabolic balance (production vs. respiration) of the oceans (P.N.A.S., 2006, 103: 8739-8744), (2) a paper on saturation of the Southern ocean CO_2 sink due to recent climate change (Science, 2007: 316, DOI:10.1126/science.1136188, 1735-1738), and (3) a paper dealing with a new field of research for the ecosystem approach to fisheries called ecosystem oceanography (Trends in Evolution and Ecology, 2008, 23: 338-346). More specifically, the following developments can be highlighted:

1. Development of coupled physical - biogeochemical models at global scale

The Dynamic Green Ocean Model: A consortium of ten EUR-OCEANS MOs (>30 scientists from different EUR-OCEANS research groups, also involving Canadian organisations), supported the development of the Dynamic Green Ocean project, which strongly contributed to the EUR-OCEANS integration process. This project develops a comprehensive model of the oceanic compartment of the Earth system.

Earth system modelling*:* The EUR-OCEANS Earth system modelling activity was conducted by three centres of excellence, in Bergen (Norway), Bern (Switzerland), and Gif-sur-Yvette (France). Based on the comparative use of three coupled global AOGCM models, it successfully reached its objectives. The acidification of the ocean due to anthropogenic CO_2 dissolution is a key issue addressed by this EUR-OCEANS modelling group. The changes in the saturation state of seawater with respect to aragonite were investigated in three Earth System Models. According to the results given in two manuscripts submitted to Nature and to Biogeosciences, the impact of ocean acidification is imminent in the Arctic Ocean, which will become undersaturated over the coming decade. The second key issue addressed by this EUR-OCEANS modelling group was the simulation of marine productivity and climate linkages using comprehensive Earth System Models. Interannual variability and a comparison between observation-based and modelled estimates for various productivity related variables has been published in 2008 in Biogeoscience (5: 597-614). A second focus of the analysis was on century scale change in global warming simulations; results have been documented and written-up for the peer reviewed literature.

2. Development of end-to-end ecosystem models

Identifying modelling gaps: EUR-OCEANS reviewed the existing end-to-end models, in order to identify modelling gaps (paper published in 2007 in Progress in Oceanography, 75:751-770).

Making new tools available for ecosystem oceanography: A major output of EUR-OCEANS was to show the synergy between overexploitation and climate change in impacting the exploited marine resources, and demonstrate that full (two-way) coupling of low and high trophic level models, along with the inclusion of key species involved in potential alternative pathways, improves models abilities to reproduce observed patterns and produce scenarios of responses to global change. One notable EUR-OCEANS end-to-end modelling effort consisted in the coupling of (1) the physical ocean general circulation model NEMO which simulates ocean physics and dynamics, (2) the biogeochemical model PISCES which models the biogeochemical processes including two phytoplankton and two zooplankton size-classes (Aumont and Bopp, 2006) and, (3) the ecosystem model APECOSM (Apex Predators ECOSystem Model; Maury *et al*., 2007), a recent spatially explicit size-based model of open-ocean ecosystems describing the flow of energy through the ecosystem from zooplankton to fish. Another significant achievement was the two-way coupling (by a EUR-OCEANS funded PhD student) of a ROMS–N2P2Z2D2 low trophic level model ((Koné *et al*., 2005) and the OSMOSE, individual and

size-based high trophic level model (Shin *et al*., 2004). The following 2005-2008 indicators attest to the impacts of EUR-OCEANS on its research sector:

- Number of funded joint proposals in response to EC FP6/7 calls: 7
- Number of workshops/summer schools in co-operation with IMBER and GLOBEC: 40
- Number of other international co-operative actions, including USA and Canada: 4
- Number of co-tutored PhD thesis: 21 EUR-OCEANS *sensu stricto* + 300 co-tutored by PIs
- Number of international symposia: 3

C. The EUR-OCEANS Consortium

The final step of the EUR-OCEANS NOE toward the achievement of lasting integration of European research organisations on global change and pelagic marine ecosystems was the creation of a virtual multi-site institute called the "*EUR-OCEANS Consortium*". Founded in Brest on 12 July 2008, the consortium is devoid of legal identity and relies on the institutional commitment and in-cash and in-kind contributions of its members; it is based on the principle of subsidiarity and was conceived as a centre of initiative to favour the coordination of cooperative actions among major European players in marine sciences. So far 25 Member Organisations from 14 countries have joined it as core members. The scientific coordination and executive direction of the consortium has been entrusted to IRD. Activities are developed under the scientific perspective of "building scenarios for marine ecosystems under anthropogenic and natural forcing in the XXI Century", notably through competitive programmes for Foresight Workshops, Conferences and Flagships (i.e., joint programmes of activities) targeting hot topics such as submesoscale processes and ecosystem dynamics, rapid change in polar systems, and approaches to develop ecosystem / socio-economic scenarios under global change.

EUROPOLAR - The European Polar Consortium: Strategic Coordination and Networking of European Polar RTD

Summary information

Funding source:	FP6 - ERA-NET
Total Cost:	€ 2.480.000
EC contribution:	€ 2.480.000
Start – end date:	1/03/2005 – 28/02/2009
Duration:	48 months
Project Coordinator:	Paul Egerton (europolar@esf.org)
Organisation:	Institut Polaire Français Paul Emile Victor - France
CLAMER Regional focus :	Arctic

Project Website:
www.europolar.org

Project Partners

1. Institut Polaire Français Paul Emile Victor - France
2. European Science Foundation - France
3. Fonds zur Förderung der wissenschaftlichen Forschung - Austria
4. National Fund for Scientific Research - Belgium
5. Fund for Scientific Research - Flanders - Belgium
6. Belgian Science Policy Office - Belgium
7. Ministry of Foreign Affairs Republic of Bulgaria - Bulgary
8. Ministry of Education Youth and Sport - Czech Republic
9. Danish Polar Center - Denmark
10. Danish Research Agency - Denmark
11. Estonian Science Foundation - Estonia
12. Finnish Ministry of Transport and Communications - Finland
13. Alfred Wegener Institute for Polar and Marine Research - Germany
14. Bundesministerium für Bildung und Forschung - Germany
15. Greenland Home Rule, Department for Culture Education Research and Church - Greenland
16. Ministero dell'Istruzione, dell'Università, della Ricerca - Italy
17. Royal Netherlands Institute for Scientific Research - Netherlands
18. Research Council of Norway - Norway
19. Norwegian Polar Institute - Norway
20. Ministry of Scientific Research and Information - Poland
21. Arctic and Antarctic Research Institute of Roshydromet - Russian Federation
22. Ministry of Education and Research - Romania
23. Ministerio de Educación y Ciencia - Spain
24. Swedish Research Council - Sweden
25. Natural Environment Research Council – United Kingdom

Background information

Project Summary

Abstract
EUROPOLAR ERA-NET is a consortium of 25 Ministries, Funding Agencies and National Polar RTD Authorities from 19 European countries and of the ESF-European Polar Board. With a combined critical mass of over 500 Million Euros per annum, it is the most significant initiative to coordinate European Polar RTD Programmes ever attempted. EUROPOLAR ERA-NET will exert a massive and positive impact on this domain and lead to long-term durable partnerships within Europe and internationally. EUROPOLAR ERA-NET will also encourage and support the closer relationship of National Polar RTD Programme managers in Europe fostering cooperation and leading to joint Programme activities. EUROPOLAR ERANET will also deepen and strengthen the interactions between countries with large Polar RTD Programmes and nations with evolving Polar Programmes in central and south-eastern Europe, encouraging exchange of experiences and best practice on management and financing of Programmes and infrastructures. The presence of key European and international organizations within EUROPOLAR ERA-NET will open up a vast network of human and material capital. The structuring and coordination of European trans-national elements will enable the construction of mechanisms to mobilize joint funding flows and the reciprocal access to research infrastructures. The long-term goal of the European Polar Consortium is the development of a 'European Polar Entity' that will be established through dialogue at a political level beyond the EUROPOLAR ERA-NET and will enable Europe to maximize and direct its critical mass at the global level.

Objectives
Research and technology in the Polar Regions is fundamental to our understanding of the functioning of the earth system especially in relation to climate change, climate variability and its wide economic and societal impact on European and global populations. European nations have played a central role in scientific research in the Polar Regions throughout the last century. The Polar Regions are central to answering questions of global relevance and importance in modern climate research and its effects. Europe has a high capacity in both research and infrastructure terms in the Polar Regions, the combined critical mass of national polar programmes and assets across Europe exceeds 500 Million Euros per annum. There is a clearly identifiable need for Europe to optimize this high-investment and provide an enhanced utilization of research infrastructures, harmonizing scientific, human and technology capacity. Polar research from its very beginning has been a cooperative activity in large part due to the extreme nature of the environments it requires agreements on a national and more often-international scale to implement very large projects with complex logistics.
"….Europe is at the forefront of international efforts in polar research," said Research Commissioner Philippe Busquin at the launch, in Bremerhaven (DE) last February, of several Polar research projects being supported by the European Union. "The poles are unique indicators of climate change processes [making] polar research a key element in our overall research effort on global climate change…." Former European Research Commissioner, Philippe Busquin, 2004.

"The Northern Dimension concept covers a broad and diverse geographic area, stretching from the Arctic and sub-Arctic to the southern shores of the Baltic, and from North-West Russian Federation in the East to Iceland and Greenland in the west. The Northern Dimension also pays special attention to regions with specific needs, such as Kaliningrad and the Arctic region."Former External Relations Commissioner, Chris Pattern, 2004.

The management of national programmes in the Polar Regions is subject to a great deal of variability across Europe, with a complex funding and evaluation architecture, there is a need to simplify and harmonize these systems to produce a coherent set of interlinked and fully networked agencies. The common access to a suite of world class Polar Infrastructures that are dedicated to supporting at a national level a wide range of Scientific programme disciplines. To avoid duplication of research efforts and to better understand the differences in scale of operation for Arctic and Antarctic science campaigns, EUROPOLAR ERA-NET will analyze and compare the structural and management approaches from its partner countries resulting in strategies to harmonize these systems on a trans-national basis. The Landscape of Research in Europe has been dramatically

changed during the 6th framework programme with emphasis placed on the Lisbon Agenda and the development of a 'European Research Area' leading to the Europe's aspirations of becoming the most competitive knowledge based Economy in the world by 2010. EUROPOLAR ERA-NET will establish the unique conditions for a durable cooperation between European research programmes in the Polar Regions. EUROPOLAR ERA-NET will strive to enhance and maintain Europe's premier capacity for research in the Polar Regions by building a framework of sufficient scale and critical mass to facilitate, promote and sustain intellectual interchange in the international research arena. Agreements between National Polar RTD funding agencies and ministries have historically been at a bilateral level and the structures and mechanisms for internal agreement amongst European nations on multinational agreements are still lacking or need testing. This requirement for an enhanced coordination and management at a Pan-European scale in Polar Research, driven by success of programmes such as EPICA (European Project Ice Coring in Antarctica) which has acted as a model for the way in which a group of 10 nations can implement with pooled funding a major scientific research programme which addresses global concerns. This model needs to be applied in a wider context to Polar RTD programmes on the new and exciting frontiers.

The Consortium that forms EUROPOLAR ERA-NET comprises 25 funding agencies, national ministries and Polar Authorities from 19 countries in Europe including key new accession states, candidate states to the EU and external states such as Russian Federation . The composition of the consortium represents every significant actor and European nation with Arctic and Antarctic research programme activities. EUROPOLAR therefore represents the most significant initiative to network European Polar RTD Programmes ever attempted.
General Objectives for the EUROPOLAR ERA-NET comprise:

- Creating the conditions for a gradual deepening of the interaction between National Polar RTD Programmes in order to mobilize and coordinate the existing critical mass of infrastructures, human capital to maximize the impact of European Polar activities.
- Contributing to the establishment of leading edge collaborative Polar Research Centres and supporting the intellectual development of the next generation of Polar Research specialists especially in new and candidate nations of the Union.
- Supporting the EC Northern Dimension Action Plan by creating research opportunities (RTD programmes, researcher mobility and support mechanisms) relevant for the Arctic issues.
- Generating a prototype advisory and policy support mechanism for European Governments in the Polar Regions.
- Enabling the integration of new accession and candidate states to the European Union by the stepwise and agreed mutual opening of Europe's Polar RTD Programmes and strengthening the relationship between Europe and the Russian Federation through cooperation between consortium partners.
- Optimizing the management and utilization of European Polar facilities and assets.
- Providing the focus of European strategic activities in the Polar Regions through the development of a common European planning and research implementation framework.

The principle benefits arising from EUROPOLAR ERA-NET will be:

- Structuring the environment and landscape of Europe's Polar RTD programmes to allow fully trans-national research programmes and enhanced access to Polar Research infrastructures.
- Enabling National Polar RTD Agencies to build strong multilateral partnerships within and outside Europe.
- Enabling the effective integration of new accession and candidate countries of the European Union through involvement in extensive Polar RTD activities.
- Delivering high quality science policy advice in support of European Union Policies.
- Consideration of Polar RTD issues, which are beyond the capacities of individual member states and generate sufficient critical mass Increased awareness of policy issues of relevance to the Polar Regions.
- Contributing to the strengthening of the European research and innovation area.
- The development of common management best practice and European research strategies in the Polar Regions.

EXTALGAE - Biological consequences of global climate change. The effects of salinity and temperature in extremophilic algae

Summary information

Funding source:	FP6 - Marie Curie Actions
EC contribution:	€ 169.323
Start – end date:	4/10/2004 – 3/10/2006
Duration:	24 months
Project Coordinator:	Stefan Falk (stefan.falk@ter.mh.se)
Organisation:	Mid Sweden University (Mitthogskolan), Department of Natural and Environmental Science - Sweden

Background information

Project Summary

Abstract
The overall goal of this project is to investigate the physiological and chemical adjustments incurred by photosynthetic algae to parameters affected by global climate change, namely changes in salinity, temperature and light. Furthermore we are aiming to contribute to European scientific research by filling an important gap in climate modelling systems by examining and potentially enabling the prediction of volatile organic sulphur compounds (VOSC) production in marine algae.

Aquatic phytoplankton have two important roles in global geochemical cycles affecting climate change. First, through photosynthesis they assimilate 40 % of all CO_2 flowing through the global carbon budget. Second, marine algae can contribute to global sulphur fluxes through the product ion of volatile organic sulphur compounds (VOSCs). These processes work in parallel to counteract global warming by fixing carbon while the production of VOSCs counteracts global warming through enhanced cloud albedo. Of these latter compounds, dimethylsul phonioproprionate (DMSP) is the primary source of global sulphur and contributes between 48-100% of the sulphur fluxes in the subpolar North Atlantic waters. The ability to predict the concentration and fluxes of DMSP in the ocean as well as the release of its degradation products into the atmosphere would greatly enhance climate modelling and to our knowledge has not been possible. During this action we wish to advance the understanding of the regulatory mechanisms governing the biosynthesis of DMSP in algae. An extremophile isolated from the water column in a permanently ice-covered Antarctic lake will be used as a highly sensitive test organism for these studies as relatively small disturbances in the environment result in large physiological responses. This research will not only examine the independent effects of changes in salinity, temperature and light on VOSC production but will investigate their synergistic effects.

FEUFAR - Future of European Fisheries and Aquaculture Research

Summary information

Funding source:	FP6 - Specific Support Action
Total Cost:	€ 626.800
EC contribution:	€ 499.680
Start – end date:	1/01/2007 – 31/08/2008
Duration:	20 months
Project Coordinator:	Lucas Van Hoof (Luc.vanhoof@wur.nl)
Organisation:	Wageningen IMARES, Institute for Marine Resources & Ecosystem Studies - Netherlands
CLAMER thematic focus:	Biological impacts: socio-economic impacts
Project Keywords:	Fisheries; Aquaculture research; foresight

Project Website:
http://www.feufar.eu/

Project Partners

1 Wageningen IMARES, Institute for Marine Resources & Ecosystem Studies – Netherlands
2 Marine Board – European Science Foundation
3 Hellenic Center for Marine Research - Greece
4 Norwegian Institute of Fisheries And Aquaculture Research - Norway
5 FUTURIBLES - France
6 French Research Institute for Exploitation of the Sea - France
7 Centre for Environment, Fisheries and Aquaculture Science - United Kingdom

Background information

Project Summary

Abstract
The goal of the FEUFAR project was to define the research required in the medium term (10 years), to enable exploitation and farming of aquatic resources in the context of key challenges and risks for meeting sustainability requirements. The main output of this exercise is a publication outlining the key challenges, strategic options and research needs concerning fisheries and aquaculture in both European waters and waters in which European fleets are operating under European agreements.

The FEUFAR project has applied a foresight analysis using scenarios, building a step by step analysis of the most important factors influencing the future of fisheries and aquaculture. The process of foresight analysis was embedded and founded on two core pillars; the first corner stone was the development of a series of scenarios. These scenarios have been built step-by-step based on an analysis of the main factors influencing fisheries and aquaculture.

The second cornerstone was the involvement of peer experts and stakeholders. In all the steps of the process workshops with stakeholders from the fishing and aquaculture industry and their representative organisations, environmental NGOs and consumer organisations were organised.

Workshops for experts from the fisheries and aquaculture science community were organised, and joint stakeholder and expert workshops were held.

This resulted in a research agenda that is logically argued and based on an analysis by stakeholders and experts in addition to the work of the project team. Hence the priorities described in the research agenda have both a scientific analytical basis and societal reference.

The main output of the whole exercise as reported in the following pages is a document outlining, in the opinion of the core group, the key challenges, strategic options and research needs concerning fisheries and aquaculture in European waters and waters in which European fleets are operating under European agreements.

In terms of aquaculture, the deliberate decision was made at the start of the project to focus on marine aquaculture only. Although acknowledging that freshwater aquaculture is an important issue, we felt that we could not do justice to it within the resource and time constraints of the programme. However, unlike aquaculture, European fisheries focus almost entirely on the marine environment, although a few non-marine (generally anadromous) fisheries resources are important and did find their way into the dialogue, generally as an aside.

A second issue contained in the project's main terms of reference is an acknowledgement that European fishing fleets operate not only in European waters, but also, in some cases extensively, in waters elsewhere in the world under bilateral agreements, some of long standing. Therefore, although the dialogue with stakeholders and other interested parties tended to be focused on Europe rather than operations elsewhere, for reasons relating to their own main interests and experience, core-group dialogue continually drew on knowledge of fishing operations of EU fleets in non-European waters, seeking to discern whether the same principles were relevant and being applied there as at home. Some of the core group have experience of fisheries production and management elsewhere in the world, so could contribute to the dialogue and analyses on the basis of personal knowledge. It was obvious to the whole team that the drivers for and many of the scenarios addressing sustainable and healthy fishing were the same wherever in the world EU fleets operate, and it is therefore essential that the EU not only maintains its commercial and bilateral interests in those countries, but also be seen to be responsive to the need to develop the same principles of optimal and sustainable management as in their own waters. In many cases, fish consumer preferences and aquaculture and product development depend as much on fish imports and EU fleet catches from non-European waters as they do on EU wild fish production itself. Two-way interaction between representatives of those countries in all aspects covered in the project's final report is therefore essential, because without it, the credibility of European commercial interests and managers will be undermined.

Future research needs were also summarised and returns to this issue in detail, addressing EU fisheries and aquaculture operations at home as well as operations of EU fleets and partnerships around the world in the same fields.

As a starting point of the process the project implemented an analysis of existing foresight analyses in fisheries and aquaculture world wide. This analysis has shown both a form of congruency among the studies as well as providing an initial list of topics for future research.

The methodology of the foresight process consists of 6 logical steps. In the first step we defined the system: the boundaries and the horizon of the world of fisheries and aquaculture was set, and split into 7 subsystems.

In the next step, for each part of the system key driving forces and relationships between them were determined. After these drivers had been determined, each driver was documented. For each driver we

determined the most important indicators and described how this driver had developed over the past 20 years. Then, for each driver, a set of different hypotheses, or a number of “possible futures” was elaborated.

Based on the hypotheses for each driver we constructed hypotheses for the development of each of the subsystems. These are called ‘micro-scenarios’, possible developments for each of the subsystems.

Connecting in a logical way the micro scenarios of the different subsystems results in the “macro-scenarios”: possible futures for the entire system. The scenarios developed could be distinguished along 4 perspectives; scale of management, either regulating issues at a global/international scale or at a international-regional scale or even national-local scale; the main objective of production to be centred upon feeding people or mainly on conservation of the marine ecosystem; the extent to which society is based on environmental awareness and the main fabric of the governance system, be it free market or strict government planning and control.

Research priorities have been identified in five main areas:

- Fisheries
- Aquaculture
- Ecosystem approach to marine resource management
- Consumer preference and Market development
- Socio-economics and Governance

In addition three cross cutting themes have been developed:

- Data collection and analysis
- Risk management
- Outreach and extension services

Project Outputs

The main output of the project has been a discussion between the experts in the project team, peer experts and stakeholders on developing research priorities in the field of fisheries and aquaculture. This process has been documented and continuously being disseminated through the project website.

In the process a number of project documents and workshop reports have been made. In addition members of the project team have frequently given presentations on the scope, process and results of the project to an even wider audience.

With the production of the final report a start can be made to further discuss the priorities developed in the project. In order to facilitate this further discussion a simple leaflet presenting an overview of the project and its process and methodology and the final outcome: a research agenda will be prepared and distributed widely both in the research and stakeholder communities.

In addition the draft final report will be send to experts and stakeholders for comments. These comments will be listed in an addendum to the final report.

The results of the project are a starting point for a discussion on the political priorities and the funding of relevant research. A number of topics mentioned above are already part of current national and international research programmes. However, what becomes clear in the analysis is that although attention is already given to fisheries and aquaculture topics, total effort in these fields of research should rather be on the increase then on the decline.

In addition, especially in the fields of management and governance the scenarios present a pressing need for the development of integrated multi-disciplinary and multi-stakeholder tools in order to address (spatial) planning and prioritisation issues. And when tools are developed they are in urgent need of being operationalised.

Also pivotal in the entire research effort has to be an understanding of the position of the consumer and their preferences next to incorporating an understanding of societal view on the sustainable utilisation of marine resources. Utilisation and conservation of marine resources in a sustainable way requires a sustainable management system balancing ecological, environmental and societal aspects. None of the research priorities presented above can be taken up in isolation, but should be considered integrated with the other aspects.

HERMES - Hotspot Ecosystem Research on the Margins of Europe

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 22.730.000
EC contribution:	€ 15.560.000
Start – end date:	1/04/2005 – 31/03/2009
Duration:	48 months
Project Coordinator:	Philip Weaver (ppew@noc.soton.ac.uk)
Organisation:	Natural Environment Research Council, Southampton Oceanography Centre - United Kingdom
CLAMER thematic focus:	Deep circulation changes; sedimentation changes; abiotic impacts; biotic impacts; socio-economic consequences
CLAMER Regional focus:	Arctic; North Atlantic; Mediterranean Sea; Black Sea
Project Keywords:	Biosphere, European deep ocean margin, geosphere, hydrosphere, sedimentary systems, carbon cycle

Project Website:
http://www.eu-hermes.net/

Project Partners

1 National Oceanography Centre Southampton - United Kingdom
2 French Research Institute for Exploitation of the Sea - France
3 Royal Netherlands Institute for Sea Research - Netherlands
4 University of Barcelona - Spain
5 Hellenic Centre for Marine Research - Greece
6 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
7 Institute of Marine Sciences, National Research Council - Italy
8 Alfred Wegner Institute for Polar and Marine Research - Germany
9 University of Tromsø - Norway
10 National University of Ireland Galway - Ireland
11 University of Erlangen - Germany
12 University of Gent - Belgium
13 Spanish National Research Council - Spain
14 National Interuniversity Consortium for Marine Sciences - Italy
15 Max Planck institute for Marine Microbiology- Germany
16 National Council for Scientific Research, CEFREM - France
17 Instituto Hidrografico - Portugal
18 International University Bremen - Germany
19 University of Bremen - Germany
20 University of Wales - United Kingdom
21 Institute of Marine Research - Norway
22 Göteborg University - Sweden
23 University of Southampton - United Kingdom
24 National Institute of Oceanography and Applied Geophysics - Italy

25 University of Birmingham - United Kingdom
26 Netherlands Institute for Ecology - Netherlands
27 University of Aberdeen - United Kingdom
28 University of Liverpool - United Kingdom
29 DEU Institute of Marine Science and Technology - Turkey
30 Scottish Association for Marine Science - United Kingdom
31 University of Aveiro - Portugal
32 GeoEcoMar - Romania
33 UNESCO Intergovermental Oceanographic Commision
34 University of Pierre and Marie Curie - France
35 University Bretagne Occidentale - France
36 Institut Scientifique Rabat - Morocco
37 Challenger Oceanic - United Kingdom
38 Volcanic Basin Petroleum Research - Norway
39 Praesentis - Spain
40 Median - Spain
41 MMCD - Germany
42 Olex AS - Norway
43 ArchimediX - Germany
44 Proteus - France
45 Jobin Yvon - Spain

Background information

Project Summary

Abstract
HERMES is designed to gain new insights into the biodiversity, structure, functioning and dynamics of ecosystems along Europe's deep-ocean margin. It represents the first major attempt to understand European deep-water ecosystems and their environment in an integrated way by bringing together expertise in biodiversity, geology, sedimentology, physical oceanography, microbiology and biogeochemistry, so that the generic relationship between biodiversity and ecosystem functioning can be understood. Study sites will extend from the Arctic to the Black Sea and include open slopes, where landslides and deep-ocean circulation affect ecosystem development, and biodiversity hotspots, such as cold seeps, cold-water coral mounds, canyons and anoxic environments, where the geosphere and hydrosphere influence the biosphere through escape of fluids, presence of gas hydrates and deep-water currents. These important systems require urgent study because of their possible biological fragility, unique genetic resources, global relevance to carbon cycling and possible susceptibility to global change and man-made disturbances.

Past changes, including catastrophic events, will be assessed using sediment archives. We will make estimates of the flow rates of methane from the geosphere and calculate how much is utilised by benthic communities, leaving the residual contribution to reach the atmosphere as a greenhouse gas. HERMES will enable forecasting of biodiversity change in relation to natural and man-made environmental changes by developing the first comprehensive pan-European margin Geographic Information System. This will provide a framework for integrating science, environmental modelling and socio-economic indicators in ecosystem management. The results will underpin the development of a comprehensive European Ocean and Seas Integrated Governance Policy enabling risk assessment, management, conservation and rehabilitation options for margin ecosystems.

Project Achievements

This many highlights of the HERMES project include, among other no less significant results:

- increased knowledge of submarine canyons and the heterogenous habitats they sustain (Tyler *et al*.)
- identification of cold water cascading in the Gulf of Lion, its impact on the shrimp fishing industry, and the susceptibility of the process to climate change (Canals *et al*.)

- the discovery that ecosystem functioning and efficiency on continental margins increases exponentially in deep-sea ecosystems characterized by higher biodiversity (Danovaro *et al*.)
- work on cold-water coral reefs that has shown the importance of the reef mass itself in distributing organic matter (Lavaleye *et al*.)
- many new discoveries about the distribution of cold-water coral reefs, including in the central Mediterranean where they were previously believed to be rare (Freiwald *et al*.)
- measurement of rates of subsurface fluid flow and methane release at some mud volcanoes and cold seeps (Foucher *et al*.)
- identification of a vast heterogeneity of cold seep habitats and faunal assemblages, on scales of tens to hundreds of meters (Vanreusel *et al*.).

Results from all of these studies have contributed to better understanding of ecosystem food webs, which are explored from a modeler's perspective by Soetaert *et al*. One of the great strengths of the HERMES project has been its ability to bridge the gaps among policymakers, nongovernmental organizations, and HERMES scientists. The HERMES project was designed to provide the scientific knowledge base that will support policy decisions concerning the sustainable management of Europe's natural offshore resources and to contribute to the success of a holistic approach to European maritime governance (see Grehan *et al*., this issue). There has been a necessary learning curve for all concerned, with scientists learning to make their research more relevant and policymakers learning to put their problems directly to scientists. A number of discussion sessions involving policymakers, nongovernmental organizations, deep-sea industry representatives, and HERMES scientists have been very successful in identifying some key issues that will need to be taken forward in subsequent projects.

These issues include the need for holistic, long-term research strategies to answer societal needs and to support deep-sea governance. Key knowledge needs for policy and management include interdisciplinary and multisectoral research to fill management gaps, such as integrated management, environmental impact assessments, strategic environmental assessments, spatial planning, marine protected areas, and implementation of a precautionary approach. Research must also be conducted to illustrate for policymakers and stakeholders the impact of good management decisions and practices, and the value of deep-sea ecosystems to society (Armstrong *et al*.). This cross-sectoral community will be important in the development and implementation of the European Maritime Policy and Marine Strategy, and for responding to the EU Habitats directive.

Finally, the research community has a key role in making science visible to the wider public, and raising awareness among the public and policymakers (see De Mol *et al*. and Gunn and Thomsen). HERMES has made a significant start in integrating research across a range of disciplines and across a wide range of European institutions, and in addressing the societal issues mentioned above. Testament to the success of the project is the inclusion of HERMES in the European Commission's list of the Top 40 projects funded under its Framework Six Programme.

IPY-CARE - Climate of the Arctic and its Role for Europe (CARE) – A European component of the International Polar Year

Summary information

Funding source:	FP6 - Specific Support Action
Total Cost:	€ 409.000
EC contribution:	€ 395.000
Start – end date:	1/07/2005 – 31/03/2007
Duration:	21 months
Project Coordinator:	Ola M. Johannessen (ola.johannessen@nersc.no)
Organisation:	Nansen Environmental and Remote Sensing Center – Norway
CLAMER thematic focus:	Abiotic and biotic impacts; socio-economic consequences
CLAMER Regional Focus:	Arctic
Project keywords:	International Polar Year 2007-2008, Arctic Environment and Ecosystems, Arctic Climate Change

Project Partners

1 Nansen Environmental and Remote Sensing Center - Norway
2 Alfred Wegener Institute for Polar Research - Germany
3 Max Planck Institute for Meteorology - Germany
4 The Norwegian Polar Institute - Norway
5 Academy of Sciences Mainz/Institute for Polar Ecology & GEOMAR Center for Marine Geosiences - Germany
6 University of Bergen, The Bjerknes Centre for Climate Research - Norway
7 Pierre et Marie Curie University - France
8 Finnish Institute of Marine Research - Finland
9 Göteborg University - Sweden
10 Scottish Association for Marine Science - United Kingdom
11 Danish Meteorological Institute - Denmark
12 State Research Center Arctic and Antarctic Research Institute - Russian Federation
13 Nansen International Environmental and Remote Sensing Center - Russian Federation
14 National Council for Scientific Research - France
15 Foundation for Research and Technology - Greece
16 National Meteorological Administration - Romania
17 Institute de Ciencia i Tecnologia Ambientals - Spain
18 Institute of Oceanology, Polish Academy of Sciences - Poland
19 International Polar Foundation - Belgium

Background information

Project Summary

Abstract
The overall objective of IPY-CARE is to create, co-ordinate and prepare a Pan-European science and implementation plan for Arctic climate change and ecosystems research programme as contribution to the International Polar Year.

The Arctic has over the last 2-3 decades warmed more than other regions of the world, and the sea ice cover has decreased in the order of 10% in the same period. Climate models furthermore indicate that anthropogenic global warming will be enhanced in the northern high latitudes due to complex feedback mechanisms in the atmosphere–ocean–ice system. At the end of this century, the Arctic Ocean is predicted to be "a blue ocean" during summer time. The Arctic may therefore encounter the most rapid and dramatic changes during the 21st century, with significant consequences for environment and human activities.

The IPY-CARE Specific Support Action will create a coordinated plan for European Arctic climate and ecosystem research programme by organising expert groups who will develop a science and implementation plan for a coordinated pan-European IPY-CARE programme. Expert groups will be established for the following six modules which represent the main components of the programme: M1:Processes determining Arctic climate variability and changes; M2: Marine biological processes in response to climate change; M3: Air-sea-ice meso-scale processes and climate variability; M4: Past climate variability; M5: Remote sensing and new technology for climate data provision, and M6:Assessment of Arctic climate change impacts on climate in Europe including the Mediterranean area and socio-economic consequences for Europe. An important part of the expert groups' activities will be to organize an Arctic climate symposium open for all.

IPY-CARE will require large and multi-disciplinary resources that can only be mobilized by a joint effort of a broad consortium, which includes all the major polar research institutions and groups in Europe. IPY-CARE will build up promotion and outreach activities to rise the awareness of the importance of the Arctic for global climate, resource exploitation, transport and environmental vulnerability. Furthermore, IPY-CARE will develop education and training programmes in the area of Arctic climate research for young scientists in Europe.

Objectives
The overall objective of the IPY-CARE Project is to explore, quantify and model Arctic climate change, its interaction with the climate in lower latitudes and its impact on Arctic marine ecosystems, and to assess the socio-economic consequences for Europe.
Its specific objectives can be summarized as follows:

- To determine the processes responsible for the past and present variability and changes in the Arctic climate system and to improve their representation in regional and global climate models.
- To understand the degree to which recent variability and changes in the Arctic climate system, e.g., shrinking sea-ice cover, thawing permafrost and increased methane emission, are of natural or anthropogenic origin.
- To understand and quantify the response of marine biological processes to climate change and their effects on Arctic marine ecosystems and the air-sea CO_2 fluxes and to improve their representation in ecosystem models and inclusion in global climate models.
- To quantify the Arctic freshwater budget and its linkages to the global thermohaline circulation (THC) and climate, and to assess its potential in causing rapid climate change, sea-level change and sequestration of CO_2.
- To improve capabilities to predict Arctic climate on decadal and longer time scales and design optimal components of an integrated monitoring and forecasting system.
- To assess the impact of climate change in the Arctic on the THC, marine ecosystems and fisheries, transportation, offshore industry and oil and gas production, coastal infrastructures, and on climate in Europe.

Project Outputs

Work performed and results achieved

The main end results of IPY-CARE are the Science Plan and Implementation Plan for Arctic climate research during and after the IPY period (2007 – 2009). The Science Plan describes objectives, approaches, work packages, role of participants and expected results for six main work packages of IPY-CARE: WP1: Processes determining Arctic climate variability and changes; WP2: Marine biological processes in response to climate change; WP3: Air-sea-ice mesoscale processes and climate variability; WP4: Past climate variability; WP5: Remote sensing and new technology for climate data provision, and WP6: Assessment of Arctic climate change impacts on climate in Europe. The Science Plan emphasizes that Arctic climate and ecosystem research requires and interdisciplinary efforts from climate scientists working with the physical environment (atmosphere, sea-ice, ocean, hydrology), biologists, paleoclimatologists, satellite remote sensing and other specialists on observing systems and data transmission. The methodology includes use and update of databases for the Arctic, including archived as well as new data, and implementation of new information technology to make data available in more user-friendly ways. Acquisition and use of satellite data will be coordinated and intensified during IPY. Numerical models and computer resources for running model simulations will be strengthened and coordinated. Dissemination of research results and public outreach will be enhanced using web map technology. The Science Plan has been used to apply for funding at the national and international level. The Science Plan for IPY-CARE was expanded and completed in May 2006 where new partners were included. More than 80 institutions from 17 countries are now on the participant list. The Science Plan has been an important background document for preparing proposals for implementation of various Arctic research projects. The Science Plan is available on the project web site (http://www.nersc.no/CARE/).

The Implementation Plan describes briefly the funded research projects and how they are coordinated with nationally and EU-funded activities. The Plan describes coordination of logistical platforms needed to perform Arctic research, in particular icebreakers and ice-going research vessels, buoys and moorings, drifting ice stations and aircraft. The Implementation Plan has been compiled based on projects that are funded from various sources, in particular EU projects and national projects. In 2006 and beginning of 2007 national IPY programmes announced opportunities and provided funding for projects related to many of the topics in the Science Plan. The document describes field activities and projects that have recently started or will start soon as part of the intensive IPY campaigns in 2007 – 2008.

Coordination with other projects has been done primarily to optimise logistics and field experiments. Several projects cooperate the use of icebreakers, open ocean vessels, aircraft and other infrastructure facilities. This is described in the Implementation Plan. Satellite data acquisition is also coordinated between several projects. Coordination also includes new proposal preparation. In the DAMOCLES project, an extension proposal was prepared involving Russian Federation and Belarus partners to strengthen the satellite ice observation and climate modelling work in the Arctic. The Norwegian IPY programme is funding 20 new projects starting in 2007. Many of these projects are focused on specific topics of the Science Plan.

Promotion and outreach activities have continued, including the official website prepared by IPF (http://www.ipy-care.org/) and the website provide by NERSC (http://www.nersc.no/CARE/). Several presentations of IPY-CARE have been given at conferences, meetings and workshops. Scientific papers have been published, and some training and education activities have been conducted. Specific presentations and meeting have been held for offshore industry and marine transportation and other operators who expect to increase their activities in the Arctic. Presentations have been given to European and global agencies and programmes developing environmental and climate monitoring systems. Promotion and outreach activities were conducted in cooperation with other Arctic climate projects. New results from research projects showing climate change or extreme climate events in Arctic regions have now extensive coverage by the media. New knowledge of the Arctic climate will evolve as a result of the intensified research activities associated with IPY.

Use and dissemination of knowledge

Results of climate research are needed by many user groups and organisations with activities and responsibilities in the Arctic. The partners in IPY-CARE have disseminated knowledge from Arctic climate research to the following user groups:

- Practical operators in Arctic regions, including shipping companies, oil and gas companies
- National agencies and authorities with responsibilities for infrastructure and monitoring services in Arctic regions
- International organisations and programmes for the Arctic, including Arctic Council and its working groups, CliC, GOOS, GCOS, IGOS
- Education and training.
- Technology transfer from science and technology to SMEs
- The general public and media

The approach for dissemination of results includes: Public website with up to date information, publications in scientific & technical journals, presentation of results at conferences related to polar and climate topics, seminars and meetings with specific user groups (e.g. oil industry).

ISOCLIV - Exploring the influence of intraseasonal oscillations on the climate variability in the Indo-Pacific sector during boreal summer

Summary information

Funding source:	FP6 - Marie Curie Actions
Total Cost:	€ 152.242
EC contribution:	€ 92.281
Start – end date:	1/03/2004 – 31/10/2005
Duration:	20 months
Project Coordinator:	Gavin Plumpton (g.m.plumpton@reading.ac.uk)
Organisation:	University of Reading, CGAM, Department Of Meteorology - United Kingdom
Project keywords:	Madden-julian oscilation, ENSO, Asian Summer Monsoon, boreal summer

Background information

Project Summary

Abstract
The sub seasonal activity in the Indo-Pacific region is dominated by the Madden-Julian Oscillation (MJO), which can be defined as a 30-50-day oscillation that moves eastward from at least the Indian Ocean to the Central Pacific Ocean. This intraseasonal oscillation organizes convection on a regional scale and, by modulation of the strength and position of the main tropical heat source, is thought to strongly influence large-scale climatic phenomena, such as the Asian Summer Monsoon (ASM) and the El Nina Southern Oscillation (ENSO). The aim of this project is to identify the mechanisms in this suggested relationship with a focus on the boreal summer season. To that end, we will first analyse the evolution of the coupled Indo-Pacific system during the summer of 2002, which provides an unprecedented example illustrating the influence of the MJO on the ASM and ENSO. The analysis of recent high-quality observational data sets and various sensitivity experiments with forced ocean and atmosphere General Circulation Models (Gems) will allow us to identify the major intraseasonal patterns and build hypotheses on the mechanisms that could link these patterns with the ASM and ENSO. In the second phase, high-resolution coupled Gems will be used to confirm the previous suggested mechanisms and generalize the 2002 case study to various other large-scale Indo-Pacific conditions. An improved understanding of the influence of the intraseasonal activity in the Indo-Pacific sector will have implications in terms of predictability. Indeed, confirmation of the role of intraseasonal forcing on the development of ENSO and ASM activity may imply a limit to long-term predictability of these large-scale phenomena.

MACIS - Minimisation of and Adaptation to Climate Change Impacts on Biodiversity

Summary information

Funding source:	FP6 - Specific Targeted Research Project
Total Cost:	€ 1.210.000
EC contribution:	€ 900.000
Start – end date:	1/11/2006 – 31/10/2008
Duration:	24 months
Project Coordinator:	Ingolf Kühn (ingolf.kuehn@ufz.de,)
Organisation:	Helmholtz Centre for Environmental Research UFZ, Department of Community Ecology – Germany
CLAMER thematic focus:	Biological impacts; socio-economic consequences

Project Website:
http://www.macis-project.net/

Project Partners

1 Helmholtz Centre for Environmental Research UFZ, Department of Community Ecology – Germany
2 Oxford Brookes University - United Kingdom
3 South African National Biodiversity Institute - South Africa
4 Helsingin Yliopisto - Finland
5 University of Turin - Italy
6 Pensoft Publishers - Bulgaria
7 University of Oxford - United Kingdom
8 National Council for Scientific Research - France
9 University of Lausanne - Switzerland
10 Spanish National Research Council - Spain
11 Universite Catholique de Louvain - Belgium
12 University of Lund - Sweden

Background information

Project Summary

Abstract
MACIS will review and meta-analyse the existing projections of climate change impacts on biodiversity. It will assess the available options to prevent and minimise negative impacts for the EU25 up to 2050 and review the state-of-the-art on methods to assess the probable future impacts of climate change on biodiversity. This includes the review of possible climate change adaptation and mitigation measures and their potential effect on future biodiversity. MACIS wants to further develop a series of biodiversity and habitat models that address biodiversity impacts, and are capable of calculating the consequences of the changes in the trends in drivers as specified by the narrative scenarios provided by the IPCC. MACIS will identify policy options at EU, Member State, regional and local levels to prevent and minimise negative impacts from climate change and from climate change adaptation and mitigation measures.

Project Outputs

While not the focus of the project, the impacts of climate change on coastal biodiversity and related adaption and mitigation measures are addressed as part of the project activities. The project deliverables can be downloaded from the project website which also displays a list of project related publications.

MAP - Secondary Marine Aerosol Production from Natural Sources

Summary information

Funding source:	FP6 - Specific Targeted Research Project
Total Cost:	€ 3.050.000
EC contribution:	€ 2.600.000
Start – end date:	15/09/2005 – 14/03/2009
Duration:	42 months
Project Coordinator:	Colin O'Dowd (colin.odowd@cmas.demon.co.uk)
Organisation:	National University of Ireland – Ireland
Project Keywords:	Marine aerosol, climate feedback mechanisms, Meteorology, Environmental Protection, Resources of the Sea, Fisheries

Project Website:
http://macehead.nuigalway.ie/map/workplan.html

Project Partners

1. National University of Ireland - Ireland
2. Netherlands Organisation for Applied Scientific Research - Netherlands
3. Consiglio Nazionale delle Ricerche - Italy
4. University of Helsinki - Finland
5. University of Kuopio - Finland
6. Finnish Meteorological Institute - Finland
7. University of Manchester - United Kingdom
8. University of York - United Kingdom
9. University of East Anglia - United Kingdom
10. Stockholms Universitet - Sweden
11. Ruprecht-Karls-Universität Heidelberg - Germany
12. Max-Planck-Gesellschaft Zur Förderung der Wissenschaften E.V. - Germany
13. Johannes Gutenberg-Universität Mainz - Germany
14. Joint Research Centre – European Commission
15. University Of Crete - Greece
16. Ecotechsystems - Italy

Background information

Project Summary

Marine aerosol contributes significantly to the global radiative budget and consequently, changes in marine aerosol abundance and/or chemical composition will impact on climate change. Various climate feedback mechanisms have been proposed involving the sulphur, sea-salt, iodine and organic sea-spray cycles; however, all cycles and their impacts on aerosol haze and cloud layers remain poorly quantified. MAP aimed at consolidating the current state-of-the-art in the fields of aerosol nucleation and growth and primary marine aerosol (PMA) production to quantify the key processes associated with primary and secondary marine aerosol

(SMA) production from natural sources. MAP focused on the newly identified aerosol formation mechanisms involving iodine oxides, for secondary aerosol production, and the primary production of marine organic matter aerosols produced by plankton and transferred to the atmosphere via the bubble bursting process at the ocean surface. Key processes have been identified, parameterized and implemented in a Global/Regional-scale chemical transport model and in a regional climate model. Combining the knowledge gathered on key processes with satellite-derived information on oceanic and meteorological parameters, an algorithm has been developed to produce a Sea-Spray Source Function (S3F) which was subsequently used in large scale models to quantify the impacts of marine aerosols. The algorithm and its application are a product contributing to GMES/GEOSS. Similarly, an organo-iodine source function will be further developed in the future, building on the foundations laid out in MAP. The impact of marine aerosol on atmospheric chemistry, radiative forcing and climate have been evaluated using the large-scale models.

The Specific MAP Objectives were:

- To elucidate the dominant condensable vapours driving secondary marine aerosol (SMA) formation.
- To quantify the number and size flux of primary inorganic and organic marine sea-spray aerosol (PMA)
- To produce a PMA and iodo-carbon source function using integrated Global Earth Observing satellite data and *in-situ* data.
- To quantify the impact of SMA and PMA on radiative forcing and atmospheric chemistry

Project Outputs

MAP was an ambitious programme of aerosol observations and modelling studies aimed at elucidation of the key formation and transformation processes associated with marine aerosols, and the implementation of these key processes into regional and global chemical transport and climate models in order to quantify regional and global marine aerosol budgets and impacts on the radiative budget. The complexity of marine aerosol characterisation, formation and impacts, and its tight coupling to the marine biological cycle is evident from the new results found in MAP. While MAP was very successful in achieving its goals and objectives, the project raised many new questions as it endeavoured to answer the key questions set out at the start of the project. Significant advances were made in our understanding of marine aerosol formation processes and its complex chemical composition, but the system is far from “well understood” and significantly more work is required to fully address the role of marine aerosol in biogeochemical cycling and climate change. In summary, marine aerosol is perhaps the most significant, albeit most complex, natural aerosol component globally, with significant contributions to the global radiative budget which is tightly coupled to dynamical and biological processes, both of which are expected to change with future climate change. Consequently, as previously suggested, marine aerosol is connected to climate feedback coupling, the magnitude and sign of which, however, still remains to be determined.

Basic advances in knowledge have been, and continue to be, communicated to the community through peer-reviewed publications in international journals and through international conferences and workshops.
In terms of using the knowledge, a number of aerosol formation schemes, for both secondary and primary aerosol production, have been developed and implemented in MAP’s main regional and global models. Further, the sea-spray source function has been supplied to the EUCAARI IP and is being implemented in both regional and global EUCAARI models.

The MAP database is also available for model evaluation, as is the case for GEMS/MACC Integrated Forecast System, and is also currently being used in a range of global models for model performance evaluation.

Although the project is completed, dissemination of results will continue on the basis of opportunity and through the completion of MAP publications which extend beyond the MAP period. A total of 37 scientific papers have been produced to date, and a greater amount of conference abstracts/extended abstracts have been produced.

MARBEF - Marine biodiversity and ecosystem functioning

Summary information

Funding source:	FP6 - Network of Excellence
Total Cost:	€ 8.707.000
EC contribution:	€ 8.707.000
Start – end date:	1/02/2004 – 30/04/2009
Duration:	63 months
Project Coordinator:	Heip Carlo (c.heip@nioo.knaw.nl)
Organisation:	Netherlands Institute of Ecology - Netherlands
CLAMER thematic focus:	Biological impacts; socio-economic consequences
Project keywords:	Marine biodiversity, adaption to climate change, impact of changes including global changes, ecosystem functioning, socio-economic impact, European scale, Network of Excellence

Project Website:
http://www.marbef.org

Project Partners

1 Rijkswaterstaat Waterdienst - Netherlands
2 Wageningen Imares B.V - Netherlands
3 Roskilde University- Denmark
4 Institute of Marine Research - Norway
5 Royal Netherlands Institute for Sea Research - Netherlands
6 University of Pisa - Italy
7 Wageningen University - Netherlands
8 University of Wales - United Kingdom
9 Maastricht University, International Centre For Integrative Studies - Netherlands
10 Göteborg University - Sweden
11 National Council for Scientific Research - France
12 Marine Biological Association of The United Kingdom - United Kingdom
13 Institute of Marine Biology of Crete - Greece
14 National Institute for Coastal and Marine Management - Netherlands
15 University of Gdansk - Poland
16 Centre For Environment, Fisheries and Aquaculture Science - United Kingdom
17 University of Amsterdam - Netherlands
18 French Research Institute for Exploitation of the Sea - France
19 Klaipeda University - Lithuania
20 University of Oslo - Norway
21 Centro Interdisciplinar De Investigação Marinha E Ambiental - Portugal
22 Rivo Netherlands Institute for Fisheries Research - Netherlands
23 Akvaplan-Niva - Norway
24 Syddansk University - Denmark
25 National Research Council - Italy
26 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel –
27 National University of Ireland - Ireland

28 Sir Alister Hardy Foundation For Ocean Science - United Kingdom
29 University of Gent - Belgium
30 Institut Für Ostseeforschung Warnemünde - Germany
31 Danmarks Fiskeriundersøgelser - Denmark
32 Alfred Wegener Institute for Polar and Marine Research - Germany
33 Institute of Oceanology, Polish Academy Of Sciences - Poland
34 Universidade dos Acores - Portugal
35 Max-Planck-Gesellschaft zur Foerderung der Wissenschaften - Germany
36 Ecological Consultancy Services Limited - Ireland
37 Flanders Marine Institute - Belgium
38 Stazione Zoologica "Anton Dohrn" - Italy
39 University Court of The University of St Andrews - United Kingdom
40 Universitat de Les Illes Balears - Spain
41 Technical University of Denmark - Denmark
42 Natural History Museum - United Kingdom
43 University of Southampton - United Kingdom
44 Natural Environment Research Council - United Kingdom
45 Rijksuniversiteit Groningen - Netherlands
46 Plymouth Marine Laboratory - United Kingdom

Background information

Project Summary

Abstract
Knowledge on marine biodiversity in Europe is fragmented within and between disciplines. The approach to understanding the effects of increased anthropogenic pressure on marine biodiversity has hitherto been addressed local. In particular, to understand how marine ecosystems will adapt to climate change, we especially need to address the long-term and large-scale changes in marine biodiversity. This requires an entirely new research framework.
The creation of the network of excellence, MarBEF (Marine Biodiversity and Ecosystem Functioning) aims at integrating research efforts by forming a dedicated group of marine scientists and institutes and creating a virtual European institute with a long-term research programme and dedicated links with industry and the public at large. This involves besides coordination of research, training, exchange and outreach activities in several relevant fields of science, including marine ecology and biogeochemistry, fisheries biology, taxonomy and socio-economic sciences. Better integration of research is also required to support the legal obligations of the EU and its member states and associated states for the Convention for Biological Diversity, Theo SPAR and Barcelona conventions, as well as several EU directives (Birds Directive, Habitats Directive, Water Framework Directive). Society needs this information because a large and growing number of industries depend 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.

Project Outputs

Major achievements:

Biodiversity loss is one of the major consequences of the unsustainable use of the Earth's resources. The aim in establishing a European network on marine biodiversity and ecosystem functioning (MarBEF) was to increase our understanding of large-scale, long-term changes in marine biodiversity. MarBEF has taken a bottom-up approach by bringing together over 700 scientists from around Europe to integrate their research. The skills and expertise of these scientists, from a variety of disciplines within marine science, were combined to address the scientific challenges of the most topical marine biodiversity questions and to provide new insights and answers at a scale of research never before attempted in this field in Europe. The core strategic research

programme consisted of three research themes: (1) examining patterns of species diversity, (2) identifying what structures the species diversity, and (3) the socio-economic consequences of biodiversity change.

Data and databases

MarBEF has established a baseline from which trends in marine biodiversity change can be detected at the relevant spatial and temporal scales. This involved the integration of 251 datasets, provided by more than 100 scientists from 94 institutions in 17 countries. This baseline data is bringing new insights into ecosystem processes and distribution patterns of life in the oceans. MarBEF has published 415 scientific articles, 82% of which are "open access" since MarBEF joined the Open Archives Initiative. MarBEF has captured 5.2 million distribution records of 17,000 species.

Discoveries

Over the last three years, a total of 137 species new to science have been added to the European Register of Marine Species (ERMS) by MarBEF. The project's scientists also found 333 nematode species never before recorded in Europe. Recent advances in molecular technologies allowed MarBEF scientists to identify the key microbes that participate in biogeochemical cycling in different areas in Europe, providing further crucial data for understanding the links between biodiversity (or at least the "identity" component of it) and ecosystem functioning. Cold-water marine caves were shown by MarBEF scientists to exhibit strong faunal and ecological parallels with the deep-sea and provide a refuge during episodes of warming. A study on deep-sea vents showed that the distribution of the assemblages on the surface of vents is related to the position of the fluid venting and the resulting temperature gradients. MarBEF scientists applied the most advanced genetic technologies to study marine biodiversity and phylogeographic structures. Their results will be used to help improve the way fisheries are managed. MarBEF scientists working in the field of chemical ecology discovered that bacteria communicate at the molecular level; that some diatom species produce chemicals that induce abortions and birth defects in the copepods that graze on them; and that dinoflagellates produce potent neurotoxins that can be transferred up the marine food chain. All of these discoveries give us a better understanding of the role of secondary metabolites in maintaining marine biodiversity and driving ecosystem functioning.

Climate change

MarBEF scientists have identified distinct, vulnerable marine populations that are now living on the edge of survival as a result of climate change. One of the remarkable scientific findings made by the network was that, contrary to expectations, a warming climate could be leading to higher biodiversity in the Arctic and simultaneous food shortages for the top predators there. Warming temperatures are contributing to an overall increase in fish species diversity in the North Sea and initiating changes in phytoplankton assemblages in Mediterranean waters. Shifts in different elements of the deep sea-bed communities at the Porcupine Abyssal Plain are attributed to the North Atlantic Oscillation, a climatic phenomenon. Today, the Brittany peninsula is a hotspot of accumulated diversity for any taxa, whereas northwest Iberia is quickly becoming a "trailing edge" as increased sea surface temperatures push the boundaries of species' ranges northward. This type of retrospective-prospective analysis aids in understanding changes in biodiversity that will be unavoidable as the natural world responds to climate change.

Impacts and disturbances

In this era of advanced globalisation, environmental degradation is a major international concern. Human impacts propagate across the terrestrial and aquatic environments of the biosphere and throughout the atmosphere. Research into evolutionary effects of fishing on fish biodiversity have indicated that fish populations may be becoming more vulnerable (and less resilient) to perturbations including fishing, climate change and invasive alien species. Also, increased river inputs, due to climate change, may be altering food webs and fisheries. Many species are being reduced in abundance or driven to local extinction by human activities. Although there are clearly consequences of changing biodiversity for the functioning of ecosystems, the relative importance of different kinds of changes are not clear. MarBEF scientists have shown that: Alterations of key species abundances affect ecosystem functioning more than changes in species diversity. Only some types of human disturbances have strong effects on the stability of rocky shore assemblages.

MarBEF has examined impacts of disturbance at a truly European scale – collating, generating and comparing evidence from a wide range of disturbance types, habitats, taxa, places and times. Its researchers have worked to improve methodologies for data collection, archiving and analysis and have completed a substantial body of original research

Valuation and marine planning

MarBEF scientists defined specific ecosystem goods and services provided by marine biodiversity and suggested that they have the capacity to play a fundamental role in the ecosystem approach to environmental management. Marine biological valuations in the form of maps developed by MarBEF could be used as baselines for future spatial planning in the marine environment. MarBEF further developed a demonstration prototype of a decision support system (MarDSS) for identifying and selecting alternative solutions for the protection of marine biodiversity.

Future issues

MarBEF has focused on and elucidated many critical marine biodiversity issues, which are now much clearer than before. It has also identified areas where further research is essential and will require concentrated effort, namely: the impacts of global climate change; synergy of anthropogenic impacts additional to global warming; coastal management; phase shifts and alternate stable states; habitat diversity; ecosystem function; biodiversity; the role of species; biodiversity at a genetic level; microorganism diversity; marine biotechnology. MarBEF will continue after EC funding has ceased because the MarBEF members are of the opinion that multidisciplinary marine biodiversity research requires long-term commitment and integration on a large scale and that the integrative bottom-up approach within MarBEF is the proper mechanism to accomplish this. MarBEF has reached the critical mass to promote, unite and represent marine biodiversity research at a global scale, with 95 institutes as members. Therefore, it is beneficial to all if the network is kept alive and active. In preparation for such a lasting infrastructure, MarBEF is cooperating with MARS (the European Network of Marine Research Institutes and Stations) and Marine Genomics Europe to extend the network of institutes involved in marine biodiversity research in Europe and beyond.

MarinERA - Coordination of national and regional marine research projects

Summary information

Funding source:	FP6 - ERA-NET
Total Cost:	€ 2.950.000
EC contribution:	€ 2.950.000
Start – end date:	1/11/2004 – 30/04/2009
Duration:	54 months
Coordinator:	Maurice Héral, French Research Institute for Exploitation of the Sea – France
Deputy Coordinator:	Niamh Connolly, Marine Board-ESF

Project Website:
http://marinera.seas-era.eu/

Project Partners

1	Marine Board – European Science Foundation
2	Institute of Oceanology, Polish Academy of Sciences - Poland
3	Ministry of Science and Higher Education - Poland
4	Flemish Government, Departement of Economy, Science and Innovation - Belgium
5	Foundation for Science and Technology - Portugal
6	Ministry of Education and Science - Spain
7	Research Council of Norway - Norway
8	Genaral Secretariat for Research and Technology, Ministry of Development - Greece
9	Malta Council for Science and Technology - Malta
10	Netherlands Organisation for Scientific Research - Netherlands
11	Academy of Finland - Finland
12	Marine Institute - Ireland
13	Natural Environment Research Council - United Kingdom
14	Forschungszentrum Juelich Gmbh - Germany
15	Belgian Science Policy Office - Belgium

Background information

Project Summary

Abstract
An ERA-NET Scheme has been established within the 6th Framework Programme to catalyse the mobilisation of the European Research and Development sector to the Lisbon challenge. The MarinERA proposal represents the positive response of the European marine science community to this challenge. MarinERA is a partnership of the leading Marine RTD Funding Organisations in 13 European Member and Accession States, supported by the European Science Foundation Marine Board (ESF-MB). Together, these Funding Agencies represent an investment of circa 100 million / annum in marine research. In addition, amongst a range of Observer Groups, six international networks of research organisation (BONUS, EFARO, EuroGOOS, European Polar Board, IACMST, ICES) and a further Member State funding agency have associated themselves with the project.

Objectives

The main MarinERA project objectives are:

- Map European marine RTD programmes and specialised infrastructures to contribute towards the development of the marine element of the European Research Area, facilitating the creation of an internal market and quantifying the existing European marine research capacity.
- Facilitate the networking of Marine RTD Funding Agencies in the European Union, leading to a more cost effective and efficient use of Member State resources including scientific personnel, specialist infrastructures and planned investments.
- Contribute to the development of a European Marine Research Policy, identifying future challenges and opportunities and the priority research programmes that need to be put in place to address / benefit from them.
- Provide a basis for the sharing of available resources to address priority issues which are beyond the capacities of individual Member States.
- Progress the reciprocal opening of Member State Marine RTD Programmes.

Project Outputs

The MarinERA project has been a highly successful pilot ERA-NET project and has succeeded in:

Fostering an operational European Research Area Network of leading Marine Research Funding Organisations from 13 European coastal states.

At the outset of the MarinERA project, the diversity of research funding structures (e.g. Research Councils, Government Ministries and Research Funding Agencies), the scope of eligible topic areas that could be addressed, and the range of implementation procedures applied by the various agencies seemed an almost insurmountable obstacle to cooperation. However, recognising the great benefits of cooperation in terms of adding value to existing national budgets, sharing the cost (and risk) of large scale projects, providing improved access to specialist expertise and research infrastructures, the MarinERA partners persisted towards the ultimate realisation of a joint call of mutual benefit.

Implementing a ca. € 5 M competitively funded Joint Call for Proposals involving five participating partner countries (with associated infrastructure support representing a total estimated at € 8 M).

As anticipated, diversity proved to be a challenge that could be successfully addressed and answered through partnership, good will, and an appreciation of the scientific and financial benefits of cooperation.

Laying the basis for a pan-European Marine Research Funding Organisation Network

The MarinERA project was also successful in establishing operational links with other marine related ERA-NETs, such as BONUS and ECORDNet, and developed an advisory role towards AMPERA and MariFish, while providing a focal point for regular interaction with the wider European marine science community. Indeed, MarinERA successfully addressed all of the concepts encapsulated in its first five original objectives, and has gone beyond them to achieve a level of cooperation that will endure beyond its lifetime.

Towards integrated European marine research strategy and programmes

The SEAS-ERA FP7 proposal, for an Over-Arching Basin Scale Marine ERANET, aims to bring together 22 major European Marine Research Funding Organisations from 20 countries in the basin regions of the Atlantic, the Mediterranean and the Black Sea. The success of the MarinERA partnership, coupled with the publication of *An Integrated Maritime Policy for the European Union* (October 2007) and the *European Strategy for Marine and Maritime Research* (September 2008) were critical catalysts in the preparation of the SEAS-ERA proposal, which in turn is poised to play a major role in the implementation of both these policies. This evolution to a partnership of 22 Research Funding Organisations from 20 countries within SEAS-ERA, from the original MarinERA consortium, confirms the realisation of the impact of the MarinERA project, and awareness of the benefits and opportunities for increased cooperation between national funding programmes.

MARIRON - Modelling the marine iron cycle: Past and future biogeochemical-climate feedbacks

Summary information

Funding source:	FP6 - Marie Curie Actions
EC contribution:	€ 174.965
Start – end date:	1/06/2005 – 31/05/2007
Duration:	24 months
Project Coordinator:	Fortunat Joos (joos@climate.unibe.ch)
Organisation:	Universität Bern Physics Institute, Climate and Environmental Physics - Switzerland

Background information

Project Summary

Abstract
The goal of this proposal is to attract a female researcher to come to Europe for training and reinforce the scientific excellence of the European Union and Associated States. This will foster a mutually beneficial collaboration between two centres of excellence in climate modelling research, the Massachusetts Institute of Technology (MIT), USA and the University of Bern, Switzerland. Knowledge will also be transferred to the University of Bern on the modelling of marine iron, an important micronutrient for marine ecosystems.

The scientific objective of this proposal is to study the role of dust-derived iron in increasing the biological productivity of the marine ecosystem as a potential mechanism to drawdown carbon dioxide. This relates to the effect of global change on ecosystems, one of the 7 priority thematic areas of the European Research Area outlined in the Sixth Framework Programme. We will use an interdisciplinary approach that cuts across the disciplines of fluid dynamics, oceanography and biogeochemistry. Specifically, an iron cycling model developed at MIT will be coupled to a three dimensional ocean circulation-biogeochemistry model developed at the University of Bern and forced by dust flux records derived from ice cores to quantify the importance of aeolian iron supply on past and future atmospheric carbon dioxide, ecosystem structure and climate.

Access to emerging data from the European Project for Ice Coring in Antarctica (EPICA), the first ice core record going back 900,000 years will allow us to validate model results and test new hypotheses. Since iron fertilisation has been proposed as a mitigation strategy to sequester anthropogenic carbon dioxide into the ocean from the atmosphere, we will perform numerical simulations to test its effectiveness.

MERSEA - Marine Environment and Security for the European Area

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 24.320.000
EC contribution:	€ 14.000.000
Start – end date:	1/04/2004 – 30/09/2008
Duration:	54 months
Project Coordinator:	Yves Desaubies (merseaip@ifremer.fr)
Organisation:	French Research Institute for Exploitation of the Sea – France
Regional focus :	Global ocean; European Seas
Project keywords :	Ocean monitoring; ocean forecasting

Project Website:
http://strand1.mersea.eu.org/index.html

Project Partners

1 Thales Alenia Space France - France
2 Spanish National Research Council - Spain
3 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
4 Danmarks Meteorologiske Institut - Denmark
5 University of Southampton - United Kingdom
6 Met Office - United Kingdom
7 Ocean Numerics Limited - United Kingdom
8 European Centre for Medium-Range Weather Forecasts - United Kingdom
9 Orta Dogu Teknik Universitesi - Turkey
10 Nansen Environmental And Remote Sensing Center - Norway
11 Marine Information Service Maris B.V. - Netherlands
12 National Institute of Oceanography and Experimental Geophysics- Italy
13 Hellenic Centre for Marine Research - Greece
14 Gip Mercator Ocean - France
15 Collecte Localisation Satellites S.A. - France
16 Joint Research Centre – European Commission
17 Universitaet Hamburg - Germany
18 Fisheries and Oceans Canada - Canada
19 Meteorologisk Institutt - Norway
20 National Council for Scientific Research - France
21 Helsingin Yliopisto - Finland
22 National Research Council - Italy
23 National Interuniversity Consortium for Marine Sciences – Italy
24 Centre National De Recherches Meteorologiques Meteo France - France
25 Instituto Canario De Ciencias Marinas - Spain
26 University of Reading - United Kingdom
27 University of Bremen - Germany
28 Alfred Wegener Institute for Polar and Marine Research - Germany
29 Spanish Institute of Oceanography - Spain

30 Natural Environment Research Council - United Kingdom
31 National Institute of Geophysics and Volcanology - Italy
32 Ente Per Le Nuove Tecnologie, L' Energia E L'ambiente - Italy
33 University of Utrecht - Netherlands
34 Cyprus Oceanography Centre - Cyprus
35 Plymouth Marine Laboratory - United Kingdom
36 Techworks Marine Limited - Ireland

Background information

Project Summary

MERSEA aims to develop a European system for operational monitoring and forecasting on global and regional scales of ocean physics, biogeochemistry and ecosystems.

The strategic objective are:

- 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.
- develop a system that will serve as a key component of the Ocean and Marine services element of GMES (Global Monitoring for Environment and Security).

Project Outputs

The development of ocean monitoring and forecasting systems on global and European regional scales calls for a broad range of research and development activities to ensure that they operate on firm scientific and technical grounds; that optimal use is made of all data available; that the systems are fully validated and robust from an operational standpoint; that they are well integrated into an efficient system of systems, with easy access and smooth exchange of data; and that the systems are fit for purpose with engagement of the stakeholders.

Broadly speaking, the main outputs and achievements can be grouped in several inter-related categories: those dealing with data (from earth observing satellites, *in situ* data, and forcing fields); system development, implementation and operation; research and development; and user products and applications. Moreover, we had several actions of outreach, training, communication, and publications.

Data
Ocean data come from three broad classes of sources: *in situ* platforms (buoys, ships, floats); satellites; and numerical weather prediction (NWP) from meteorological services. Those observations are valuable as unique global data sets, and are used as input for assimilation or forcing fields of predictive numerical ocean models.
For remote sensing data, the focus of the project has been on improving the retrieval algorithms required to determine with high accuracy the geophysical parameters (e.g. ice concentration and extent, ice drift, chlorophyll, suspended matter, sea surface temperature, sea surface height, mean dynamic topography). Whenever possible, data from different satellites and sensors are used to obtain uniform merged data products, mapped onto geographic grids. Specific algorithms have been derived to obtain data sets adapted to the regional seas.

The data are available in real time and in delayed mode, for which long time-series are reprocessed. The data centres are linked into an integrated network of thematic portals, enabling data access and exchange. Detailed documentation on the processing, format, and all other relevant meta-data is also available on the portals.

The forcing fields necessary for ocean forecasts are provided by numerical weather prediction (NWP) from the ECMWF or national meteorological services. However the predictions made for the atmosphere, do not necessarily give the best estimates of the fluxes (moisture, heat, wind stress) over the ocean. We have derived

improved formulae for the fluxes, with validation from buoy data, which can be incorporated into the NWP predictions. A new technique has been developed to improve wind estimates over the ocean by combining satellite data (from scatterometers) with NWP fields. Although this technique cannot provide predictions, it delivers high resolution wind fields in near-real time (24 hrs delays) and retrospective analysis.

The project could not support a large contribution to *in situ* observing networks, but a few operations were conducted, if only as a reminder that no ocean monitoring is conceivable without *in situ* data. A set of Argo floats were deployed, most significantly in high latitudes, where a specific ice-detection algorithm was developed to allow for the first time data collection under the ice. Updated climatology of the Atlantic and the Global oceans have been obtained by retrospective synthesis of the global Argo array data, revealing large scale patterns of variability.

As a European contribution to the Ocean Sites programme, three moored stations were maintained in representative locations in the North Atlantic, and two in the Mediterranean. The stations allow real time transmission of multi-parameters, including bio-geochemical ones. The point time series are unique for validation of numerical models. Several tests and operations at sea of gliders have been conducted, including several runs over 1.000 km long in the Atlantic and the Mediterranean, where multi-instrument operations were conducted. Those glider experiments confirmed the high quality and value of the data collected, but pointed out also the high demand on personnel to conduct them, at least at the early development stage of this promising new technology. Research vessels should play a key role in the routine collection of surface data and as support for XBT launch; although some data was collected in this mode as part of the project, there is still considerable difficulty in convincing ship operators to carry out those simple operations. Considering the cost of data collection at sea it is necessary to ensure that all global data are available easily to users with the shortest delays. In performing that task, the Coriolis *in situ* data centre has very significantly increased (by a factor of three) the amount of quality controlled data available in real time, a large part of that increase being related to the ramping up of the Argo array.

Somewhat paradoxically, *in situ* data are scarce in the regional seas. While *in situ* monitoring is conducted in the framework of the Conventions (OSPAR, HELCOM, Barcelona) and of EuroGOOS cooperation, the data are usually not available in real time, and sometimes not freely available. Thus there are few data available for assimilation into the models, which are mostly constrained by the meteorological forcing fields, and by the satellite data sets.

System design, development, implementation and operation

One of the main challenges of the project was to integrate into a coherent system of systems the various centres that were operating in different contexts and stages of development. The design has led to the final structure of a distributed system comprising Monitoring and Forecasting Centres (MFC) and Thematic Assembly Centres (TAC). The MFCs cover the global ocean and the main European seas (Arctic, North East Atlantic, Baltic, and Mediterranean); the TACs process the data from satellite remote sensing (sea-ice, ocean colour, altimetry, and sea surface temperature), and from global *in situ* networks. All the Centres fulfil common functions (production and delivery, system management, monitoring, service provision, user desk, quality assessment). Common data formats have been agreed upon, and consistent documentation is available on the systems specification, their catalogues and inventories. The services provided include search and discovery, viewing, and download, consistently with the Inspire Directive. The protocols for data exchange have been defined as the MERSEA Information Management system. Thus different classes of users can be served according to their needs. As the concept of Marine Core Serviced evolved with the GMES implementation panel, it was recognized that the primary function of the system would be to deliver common baseline products and data to intermediate users, who would in turn develop bespoke services to final users. All those design concepts form the basis for the further developments to be carried out in the MyOcean project.

The monitoring and forecasting centres have been upgraded in several respects: model resolution, assimilation of satellite and *in situ* data, more frequent analysis and forecasts, adoption of new modelling framework (Nemo). The improved performance has been achieved by the introduction of new parameterisation and algorithms resulting in higher efficiency and realism of the models (e.g. bottom and interior mixing, ice modelling, topographic effects, mixed layer dynamics, advection schemes, assimilation techniques).

Implementation into the operational suites at the centres has entailed major computer engineering, transfer to new machines or to associated agencies; for instance: the Arctic system (based on the TOPAZ code at the Nansen Remote Sensing Centre) has been transferred to the met.no operational centre; or the high resolution global system has been run on the Météo France super computer.

All systems include bio-geochemical modelling, some in a demonstration mode, since those models still require extensive validation. Nonetheless, the primary ecosystem forecasts have been introduced in the operational suite at the Met Office (Northwest shelves) and in a pre-operational mode at INGV (Mediterranean).
The systems evolution and performance has been regularly evaluated for quality and consistency, with the aid of metrics, a methodology which has been adopted by the Global Ocean Data Assimilation Experiment. The continuous improvement of the systems has been quantified, and in particular the positive impact of assimilation of *in situ* profiles from the Argo array (where they are available).

At the end of the project, some of the upgrades still need further validation and development before being fully integrated into the operational suites. Examples include the global high resolution model (1/12°, i.e. about 10 km) which requires large computing power; the ecosystem modelling already mentioned; or the nesting of models. The latter has been attempted (Mediterranean, North East Atlantic and Arctic into the global, and Baltic into the North Sea), but all scientific questions (proper implementation of boundary conditions) or technical problems (timeliness of the provision of boundary data) have not been fully resolved.
Nonetheless, all system components are presently operating continuously, delivering high quality data, analysis and forecasts over the global ocean and regional seas.

Research on ocean modelling and data assimilation
While research has been conducted regularly in all work packages, most notably to develop high quality data sets from remote sensing observations, specific activities have been carried out in the domains of ocean modelling, including bio-geochemical, data assimilation, and seasonal forecasting. Some of the results have been directly transferred to the operational suites, as indicated above, leading to more accurate representation of processes, and more efficient computing. However it is recognized that research operates on longer time scales than implementation and production; some of the developments will bear fruits in future versions of the systems. Promising results have been obtained in ecosystem modelling (class size approach), in advanced data assimilation schemes, in nesting and grid refinement, data assimilation in coastal models. The long list of publications is a record of the advances made by the scientists engaged in the project in many diverse topics.
The Special Focus Experiments were devoted to the development of the coupling between the model system and the basic and generic model products of MERSEA with marine biogeochemical models for ecosystem forecasting, at the level of primary producer biomass and for the short time scales; and global atmospheric models for seasonal forecasting.

Serving user needs
Two broad classes of users have been considered in the project: those in the public sector, responsible for environmental monitoring and reporting; and maritime operations.

A workshop held at the European Environment Agency on European Marine Monitoring and Assessment initiated a dialogue with EEA and the Conventions. The Marine Core Services (MCS) are in a unique position to provide some of the Core Sets of Indicators, and such production started at the end of the project, in cooperation with the European Topic Center / Water. It is clear however that the MCS cannot deliver all the indicators called for in the conventions, but at the same time, it may be opportune to look at extended indicators, climatic for instance. We have started in that direction. In the future, the MCS will contribute to the assessments to be conducted in the framework of the Marine Strategy Directive.

Several applications in the maritime sector have been explored: ship routing, offshore industry support, and oil spill drift prediction. In all cases the positive impact of high resolution ocean products has been demonstrated, but very stringent requirements are placed by users on accuracy, which cannot always be met by state of the art products. They also expect specific products tailored to their applications, and appropriate delivery

mechanisms. Further investment and reliance by the industry on the MCS hinges on the establishment of a reliable perennial service.

Throughout the project we have maintained a constructive interaction with the GMES bureau and its MCS implementation panel, which has had a positive impact on the design of the MERSEA prototype system and has fed into the definition of the requirements for the MCS. This work will now be carried forward in the MyOcean project, where the focus is shifting from the development of a system to the establishment of services, with an enlarged partnership.

It is a measure of the success of the MERSEA project that it has produced so many original scientific results, high quality data sets, and is delivering an integrated system recognized as one of the most mature of the GMES components.

The project has generated a large number of project reports (Deliverables) and publications in peer reviewed journals (see website). Its main legacy is that all the system components continue operating after the end of the project, and that they will be further established in the FP7 MyOcean project.

The project final report is available via the EC cordis webportal (http://cordis.europa.eu/).

MILLENNIUM - European Climate of the Last Millennium

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 15.100.000
EC contribution:	€ 12.600.000
Start – end date:	1/01/2006 – 31/12/2010
Duration:	60 months
Project Coordinator:	Danny McCarroll (D.McCarroll@swansea.ac.uk)
Organisation:	University of Wales Swansea - United Kingdom
Project keywords:	Climate variability; multi-proxy approach; earth sciences, environmental protection; stable isotopes

Project Website:
http://www.millenniumproject.net/

Project Partners

1 University of Wales Swansea - United Kingdom
2 University of Oulu - Finland
3 Masaryk University of Brno - Czech Republic
4 University Court, University of St Andrews - United Kingdom
5 Swiss Federal Research Institute WSL - Switzerland
6 Scottish Association for Marine Science – United Kingdom
7 University of Tromsø - Norway
8 University of Oxford - United Kingdom
9 University of Bern - Switzerland
10 Paul Scherrer Institut - Switzerland
11 Slovenian Forestry Institute - Slovenia
12 Dm Technology Limited - United Kingdom
13 Cox Analytical Systems Sweden Ab - Sweden
14 Anglia Polytechnic University - United Kingdom
15 Helsingin Yliopisto - Finland
16 Ufz - Umweltforschungszentrum Leipzig - Halle Gmbh - Germany
17 Univerisity of Stockholm - Sweden
18 University of Wales - United Kingdom
19 Utrecht University - Netherlands
20 Forschungszentrum Juelich Gmbh - Germany
21 Finnish Forest Research Institute - Finland
22 Norwegian Polar Institute - Norway
23 University of Aarhus - Denmark
24 Science Institute, University of Iceland - Iceland
25 Nerc Isotope Geosciences Laboratory, British Geological Survey - United Kingdom
26 Umeå University - Sweden
27 Hohenheim University - Germany
28 University of Barcelona - Spain
29 Adam Mickiewicz University - Poland

30 Institute of Geography, Russian Academy of Sciences - Russian Federation
31 University of Freiburg - Germany
32 University of Edinburgh - United Kingdom
33 University of Sunderland - United Kingdom
34 Koninklijk Nederlands Meteorologisch Instituut - Netherlands
35 Institute of Meteorology and Water Management - Poland
36 University of Szeged - Hungary
37 Centre for Ecology and Hydrology - United Kingdom
38 University of Exeter - United Kingdom
39 National Research Council - Italy

Background information

Project Summary

Abstract
Millennium will answer one of the most critical questions in climate research: does the magnitude and rate of 20th Century climate change exceed the natural variability of European climate over the last millennium? Existing climate reconstructions rely on inadequate data and underestimate variability. Improved GCM parameterization requires more accurate reconstructions and integrated modelling. We will supply high-resolution chronologies that capture the magnitude and rate of change and the magnitude and frequency of extreme events over the last 1.000 years. Our multi-disciplinary team will use innovative and developing technologies to extract quantitative palaeoclimate information from documentary and natural archives, including trees, lakes, mires and ice cores. A multi-proxy approach provides seasonal palaeoclimate signals with quantified precision. Advances in dating allow us, for the first time, to place terrestrial and marine proxy records on the same timescale, allowing lead and lag relationships in ocean-atmosphere forcing to be captured. Annually banded seashells will be cross-dated like tree rings, and tephra-rich sediments used to construct a marine chronology independent of P14PC dating. This can be used to reconstruct changes in ventilation linked directly to the strength of North Atlantic circulation. Millennial reconstructions of European climate, at a range of scales, will define whether recent climate change is unusual in the context of past variability. Millennium proxy-based reconstructions will be fused with a hierarchy of models, run over both millennium and century time scales using a purpose-built PC cluster and the huge resources of the Climateprediction.net distributed computing network. Integrated hind- and forecast modelling, (using HadCM3) will allow us to test whether current empirically reconstructed climate records based on regression methods underestimate climate sensitivity or if current GCM simulations give overestimates.

Objectives
Millennium has a single clear objective: to determine with quantifiable precision whether the magnitude and rate of 20P_{thP} Century climate change exceeds the natural variability of European climate over the last millennium. To do this the project will use the very best documentary, biological and sedimentary archives available across Europe and apply the most powerful techniques to extract palaeoclimate signals. By harnessing some of the best laboratory facilities available we will produce multi-proxy climate reconstructions of unparalleled accuracy and precision. Combined with existing instrumental and proxy palaeoclimate data, our results will allow us to model the past and future impacts of anthropogenic climate forcing using realistic patterns of natural climate variability across Europe.

The Millennium project will achieve six aims:

- It will produce a database of the best data on past climate;
- It will produce new millennial-length palaeoclimate data using the most powerful and innovative methods;
- It will combine the existing and new data to reconstruct the climate of Europe for the last one thousand years at a range of spatial scales;
- It will use the reconstructions to define the natural variability of European climate, over both space and time, and taking account of changes in seasonality;

- It will test the ability of the most commonly used climate model to reproduce the magnitude of natural climate variability in the past;
- It will predict the probability of European climate passing critical thresholds, taking full account of the natural variability as well as greenhouse forcing.

To place recent climate change in a longer term context, several studies have developed millennial length, annually resolved reconstructions of northern hemispheric temperatures. However, despite the high profile status of some of these data-sets, they are limited for a variety of reasons:

- Such time-series provide only a large-scale picture of the mean state of one climate parameter - i.e. mean temperature. The spatial complexity of climate change cannot be assessed from these data;
- The fidelity/robustness of these reconstructions quickly diminishes back in time as very few proxies were included in the early portions of these series;
- Methods used to develop these reconstructions can potentially underestimate the temperature amplitude change over the whole millennium. A more precise assessment of the absolute reconstructed temperature amplitude change is needed to help quantify the relative influences of forcing mechanisms in climate models;
- Due to the strong bias to tree ring-width data, the reconstructions are also likely biased to the summer season, despite the fact that greatest recent changes have been observed in the winter months.

There is therefore a need for complementary investigations at small and intermediate scales with the expressed aim of reconstructing other climatic parameters (e.g. precipitation) and not just temperature. The record breaking central European floods in 2002 and the widespread European drought in 2003, demonstrate the need for a better understanding of precipitation variability in this region. The Millennium project will focus its investigations on Europe where previous research has shown a more varied climate compared to the largescale northern hemisphere reconstructions. The project is built on the rationale that a multi-proxy research approach represents the most productive route towards understanding climate variability, and more specifically for placing the 20th and 21st century climates in the context of the last millennium.

Europe is unique in that there exist long high-quality instrumental records with which assessment of proxy series can be made. This project will not only utilise existing proxy records (e.g. tree-ring and documentary sources), but will emphasise the development of isotopic tree-ring records as well as incorporating a range of new exciting proxy sources (e.g. isotopic records from molluscs, high resolution sedimentary archives and Alpine ice cores). The resulting multi-proxy data-base will not only be rigorously calibrated and furnished with realistic error estimates, but separate calculations for specific parameters, regions, times and time-scales will also be developed. From these data the project will provide the best available information on characteristic modes and magnitudes of natural climate variability for comparison with the natural forcing histories and outputs from climate models. The important questions about the nature, and the significance, of recent climate change can be addressed in separate model-based, and observational domains and ultimately, the issue of attribution can be explored using the combined information from both approaches.

Millennium directly addresses the central objective of Sub-Priority 1.1.6.3 ‘Global Change and Ecosystems’ by strengthening the scientific basis for understanding the processes and factors controlling global change and hence contributes to the protection of ecosystems and the preservation of biodiversity. Ultimately, the project will focus clearly on the most critical unresolved question concerning climate change in Europe, specifically: does the magnitude and rate of 20th Century climate change exceed the natural variability of European climate over the last millennium?

Project Outputs

A list of publications by Millennium scientists is available from the project website.

PHENOMED - Climate change, phenology and reproduction: Mediterranean sponges as models

Summary information

Funding source:	FP6 - Marie Curie Actions
EC contribution:	€ 214.023
Start – end date:	1/06/2007 – 31/05/2009
Duration:	24 months
Project Coordinator:	Thierry Perez
Organisation:	National Council for Scientific Research, Laboratoire Diversite, Evolution et Ecologie – France
CLAMER regional focus :	Mediterranean Sea
Project keywords :	Biodiversity, ecosystem functioning, life/reproductive cycle, Porifera, gametogenesis, embryogenesis, temperature anomalies

Background information

Project Summary

Potential effects of global change act at different organization levels from physiological to community and can affect the biodiversity and ecosystem functioning. PHENOMED was implemented in NW Mediterranean coastal ecosystems, because they harbour a high biodiversity which suffered dramatic effects from global change.

This programme proposed an approach, which aimed at understanding the recent and forthcoming effects of the warming at the life/reproductive cycle level. Although the resilience of a population severely affected depends on its reproduction and dispersal abilities, almost nothing has been done for assessing the potential effects of thermal anomalies on the benthic organisms at reproductive level.

PHENOMED contributed to a better understanding of the impact of strong disturbances on the phenology in order to provide management and conservation advices. For this purpose, we comparatively investigated reproductive cycles and strategy of temperature sensitive and tolerant species living in different ecological conditions.

Our models: Porifera is one of the most abundant group of metazoans within hard substratum communities, which provide services to human societies and have been severely affected by high temperature events during the last decades.

The detailed objectives were:

- Characterizing the gametogenesis, embryogenesis, larval ultrastructure, metamorphosis, and recruitment of target sponge species.
- Acquiring baselines on their life cycle and reproductive effort.
- Studying the modification of the reproductive cycles and strategies in natural and experimental conditions.
- Assessing experimentally the warming effect at the cellular level.

Thus PHENOMED combined in vitro and *in situ* approaches that provided a first evaluation of the potential warming effects on the phenology of marine organisms and new baselines for assessing the resilience of sensitive populations within the global change context.

QUANTIFY - Quantifying the Climate Impact of Global and European Transport Systems

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 12.770.000
EC contribution:	€ 8.390.000
Start – end date:	1/03/2005 – 28/02/2010
Duration:	60 months
Project Coordinator:	Robert Sausen (robert.sausen@dlr.de)
Organisation:	Deutsches Zentrum für Luft und Raumfahrt E.V. - Germany
Project keywords:	Transport systems; greenhouse gases

Project Website:
http://www.pa.op.dlr.de/quantify/

Project Partners

1	Deutsches Zentrum für Luft und Raumfahrt E.V. - Germany
2	Airbus France - France
3	Commissariat à l'Energie Atomique - France
4	Cambridge Environmental Research Consultants Limited - United Kingdom
5	Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique - France
6	Cicero Senter for Klimaforskning - Norway
7	Météo France - France
8	National Council for Scientific Research - France
9	Univerzita Karlova V Praze - Czech Republic
10	Danmarks Meteorologiske Institut - Denmark
11	Det Norske Veritas AS - Norway
12	Eidgenoessische Technische Hochschule - Switzerland
13	Heavens-Above Gmbh - Germany
14	Administratia Nationala de Meteorologie - Romania
15	University of Bremen - Germany
16	Ivl Svenska Miljoeinstitutet Ab - Sweden
17	Koninklijk Nederlands Meteorologisch Instituut - Netherlands
18	Koezlekedestudomanyi Intezet Koezhasznu Tarsasag - Hungary
19	Manchester Metropolitan University - United Kingdom
20	Max Planck Gesellschaft zur Foerderung der Wissenschaften E.V. - Germany
21	National and Kapodistrian University of Athens - Greece
22	National Institute of Meteorology and Hydrology, Bulgarian Academy of Sciences - Bulgaria
23	Office National d'Etudes et de Recherches Aérospatiales - France
24	Paul Scherrer Institut - Switzerland
25	University of Szeged - Hungary
26	Transport & Mobility Leuven - Belgium
27	University of Cambridge - United Kingdom
28	The Regents of the University of California - United States
29	University of Oslo - Norway
30	Regents of the University of Michigan – United States

31 University of Hamburg - Germany
32 University of Oxford - United Kingdom
33 University of Reading - United Kingdom
34 University of Warsaw - Poland
35 University of York - United Kingdom

Background information

Project Summary

Abstract
The main goal of QUANTIFY is to quantify the climate impact of global and European transport systems for the present situation and for several scenarios of future development. The climate impact of various transport modes (land surface, shipping, aviation) will be assessed, including those of long-lived greenhouse gases like CO_2 and N_2O, and in particular the effects of emissions of ozone precursors and particles, as well as of contrails and ship tracks. The project goal includes provision of forecasts and other policy-relevant advice, which will be supplied to governments and to international assessments of climate change and ozone depletion, such as the IPCC reports (Kyoto Protocol) and WMO-UNEP ozone assessments (Montreal Protocol). Using significantly improved transport emission inventories, better evaluated and hence more reliable models, these new forecasts in QUANTIFY will represent a considerable improvement of current predictions. Long time scales are involved in the transport system and its effects on climate: some transportation modes have long development and in-service times; some emissions have long residence times and thermal inertia of the climate system protracts possible effects. Yet the impact of shortlived species depends on location and time of the emissions. So several transport scenarios and potential mitigation options need to be assessed on a sound common basis to identify the most effective combination of short and long-term measures and to inform policymakers and industry. We aim to provide such guidance by focused field measurements, exploitation of existing data, a range of numerical models, and new policy-relevant metrics of climate change. To achieve the goal, several advances in our fundamental understanding of atmospheric processes will be required such as the mechanisms by which pollutants are transported from exhaust into the free atmosphere, the impact of pollutants on clouds and the role of absorbing aerosols.

Objectives
Long time scales are involved in the transport system and its effects on climate: some transportation modes have long development and in-service times; some emissions have long residence times and the thermal inertia of the climate system protracts possible effects. Thus, it is clear that potential mitigation procedures need to be assessed soon to provide policymakers and industry with adequate guidance for decisions. It is our aim to provide such guidance through the QUANTIFY Integrated Project, based on new focused field measurements, further exploitation of existing observations, and a range of chemical, radiative and coupled climate models. The central project goal of QUANTIFY is to quantify the climate impact of the global and European transport systems for the present situation and for different scenarios of future development. Our project goal requires the production of projections and other policy relevant advice, which will be supplied to governments and to international assessments of climate change and ozone depletion prepared in support of policy such as the IPCC reports (Kyoto protocol) and the WMOUNEP ozone assessments (Montreal Protocol). The forecasts will be built on models, which will be refined and improved in this project by exploitation of existing data for model testing and validation and by the provision of new data on fundamental processes. Using significantly improved transport emission inventories and more reliable models, our new forecasts will represent a considerable improvement on current predictions. The central project goal of QUANTIFY will be achieved through the following main objectives:

- To establish consistent inventories of (direct) emissions (greenhouse gases, particles, precursors of greenhouse gases and aerosols) from present day and past transport, separately for the different modes of transport.
- To generate transport (direct) emission inventories for scenarios of future development, which are consistent with the IPCC SRES scenarios.

- To determine the fate of emissions from shipping during dilution to regions of the size of global scale models, i.e. to scales in the range from 100 to 500 km.
- To develop parameterisations for “effective emission indices” linking local emissions (at the exhaust) to scales appropriate for use in global models for all modes of transport (aviation, shipping, land surface transport).
- To consistently calculate the global chemical impact of the different modes of transport, for present day conditions and several future scenarios.
- To determine regional structures in transport-induced perturbations of the chemical composition of the atmosphere, e.g. North-South contrast, tropics versus non-tropics, with emphasis on the UTLS region, where changes in the atmospheric composition have a particularly large radiative impact.
- To provide quantitative estimates of the impact of the different modes of transport on aerosols and clouds, in particular on cirrus (contrails and contrail-cirrus) and low marine clouds (ship tracks) in terms of, e.g. cloud cover and cloud optical properties. To test the hypothesis that anthropogenic aerosol causes the formation of additional cirrus clouds.
- To consistently determine the radiative forcing from transport-induced changes in atmospheric (and surface) parameters, including the separation of the contributions from different modes of transport, for present day transport and for several future scenarios.
- To determine the spatial and temporal patterns of transport-induced climate change and to search for specific fingerprints.
- To develop and evaluate policy relevant metrics that comprise all important impacts on climate and that take the particular characteristics of transport into account. To estimate the impact of potential transport related mitigation options on atmospheric composition and climate.

Project Outputs

A consistent new set of transport emission inventories has been produced; the effect of these emissions on atmospheric composition and on clouds has been modelled, the results have been used to compute new estimates of the effect of all transport modes on climate; simplified climate models have been gauged with results from the more complete models and new metrics have been investigated.

The outcome of QUANTIFY informs the EU in developing its policy and its position in international climate conventions (as the Kyoto Protocol). Moreover, QUANTIFY informs the debate over potential emission reductions and mitigation strategies. Furthermore, results from QUANTIFY feed in to forthcoming IPCC Assessment Reports, and potentially further international assessment studies, thereby strengthening the European position. The results are also directly relevant to the European aviation, car and shipping industries as well as to a number of European and international agencies and programmes (e.g. ICAO, IMO, ACEA).

A list of project related publications is available at the project website.

QUANTIFY TTC - Quantifying the Climate Impact of Global and European Transport Systems - Extension

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 619.172
EC contribution:	€ 388.172
Start – end date:	1/12/2006 – 28/02/2010
Duration:	39 months
Project Coordinator:	Robert Sausen (robert.sausen@dlr.de)
Organisation:	Deutsches Zentrum für Luft und Raumfahrt E.V. - Germany
Project keywords:	Transport systems; greenhouse gases

Project Website:
http://www.pa.op.dlr.de/quantify/

Project Partners

1 Deutsches Zentrum für Luft und Raumfahrt E.V. - Germany
2 Central Aerological Observatory - Russian Federation
3 Skobeltsyn Institute of Nuclear Physics, Moscow State University - Russian Federation
4 Federal State Unitary Enterprise Central Aerohydrodynamic Institute - Russian Federation
5 Center for Sustainable Transportation, China Academy of Transportation Sciences - China
6 Department of Environmental Sciences and Engineering, Tsinghua University - China
7 Central Institute of Road Transport - India

Background information

Project Summary

Abstract
The main goal of the IP QUANTIFY is to quantify the climate impact of global and European transport systems for the present situation and for several scenarios of future development. The climate impacts of various transport modes (land, shipping, and aviation) are assessed in high resolution, including long-lived greenhouse gases like CO_2 and N_2O, and in particular the effects of emissions of ozone precursors and particles, as well as of contrails and ship tracks. The project goal includes provision of forecasts and other policy-relevant advice, which will be supplied to governments and to international assessments of climate change and ozone depletion, such as the IPCC reports and WMO-UNEP ozone assessments. Using significantly improved transport emission inventories, better evaluated and hence more reliable models, these new forecasts will represent a considerable improvement of current predictions.

Several transport scenarios and potential mitigation options need to be assessed to inform policymakers and industry. QUANTIFY provides such guidance by focused field measurements, exploitation of existing data, a range of numerical models, and new policy-relevant metrics of climate change. To achieve this goal, several advances in our fundamental understanding of atmospheric processes will be required such as the mechanisms

by which pollutants are transported from exhaust into the free atmosphere, the impact of pollutants on clouds and the role of absorbing aerosols.

The QUANTIFY-TTC extension aims to enhance QUANTIFY by integrating partners from Russian Federation, India, and China to provide transport emission and scenario information from this rapidly developing region of the world, to obtain empirical data to significantly reduce uncertainties and to strengthen the flight campaign and cloud-aerosol interaction research by providing presently unavailable experimental data. Consequences and intervention options for European policy and technology can thus be identified.

The basic concept behind the proposed QUANTIFY-TTC extension is to increase the knowledge base necessary to reach the main QUANTIFY goal in those areas where either modellers and cloud microphysicists can strongly benefit from presently unavailable experimental data, or where the present QUANTIFY emission inventory databases can be significantly augmented from the currently rapidly developing Russian Federation and Asian region.

RECLAIM - Resolving Climatic Impacts on fish stocks

Summary information

Funding source:	FP6 - Specific Targeted Research Project
Total Cost:	€ 2.990.000
EC contribution:	€ 1.700.000
Start – end date:	1/01/2007 – 31/12/2009
Duration:	36 months
Project Coordinator:	Adriaan Rijnsdorp (Adriaan.Rijnsdorp@wur.nl)
Organisation:	Stichting Dienst Landbouwkundig Onderzoek, IMARES, Wageningen - Netherlands
CLAMER thematic focus:	Biological impacts; socio-economic consequences
CLAMER regional focus:	North Atlantic; North Sea
Project Keywords:	Impacts of climate change on fish and shellfish populations, climate process, ecosystem structure and function

Project Website:
http://www.climateandfish.eu/

Project Partners

1 Scottish Ministers acting through Fisheries Research Services – United Kingdom
2 Secretary of State for Environment, Food and Rural Affairs Acting through the Centre for Environment, Fisheries and Aquaculture Science - United Kingdom
3 French Research Institute for Exploitation of the Sea - France
4 University of Hamburg - Germany
5 Technical University of Denmark - Denmark
6 Institute of Marine Research - Norway
7 Royal Netherlands Institute for Sea Research - Netherlands
8 University of Bergen - Norway

Background information

Project Summary

Abstract
Climate change will impact fisheries resources and challenge managers to develop sustainable exploitation strategies. Knowledge on the impacts of climate on fisheries resources is still fragmentary. RECLAIM will summarize current knowledge, test process understanding, improve predictive capacity and formulate future research hypotheses by examining trophic processes, geographical distributions and essential habitat requirements for marine and shellfish in the NE Atlantic. A conceptual framework will be developed to distinguish between processes acting on individual (physiology, behaviour), population (predation, competition) and ecosystem (physical habitat qualities, biological productivity, trophic coupling) levels. The framework structures a literature review to detects gaps in knowledge and, where possible, distinguishes between climate and anthropogenic influences. A comparative analysis follows quantifying climate variability

and changes in distribution and productivity of (i) individual species, (ii) selected fish and shellfish communities, and (iii) ecosystem structure and functioning. Target species represent different commercially important resources, ecosystem components (pelagics, demersals), and play key trophic roles (wasp-waist, apex predators) within NE-Atlantic ecosystems. Changes in ecosystem structure and functioning will be analysed from fisheries and scientific survey data including planktonic, benthic and fish production and consumption in relation to climate forcing and fishing. Relevant spatial and temporal scales of climate change and variability will be explored using time series analyses, spatial statistics and coupled 3-D hydrodynamic ecosystem models. Using a variety of approaches, RECLAIM will both hindcast as well as forecast the effects of climate change on the productivity and distribution of fish and shellfish stocks to formulate hypotheses and research needs to be addressed in future EU research.

Objectives
RECLAIM's approach emphasizes the underlying processes affected by climate change and will:

- provide a review of the knowledge regarding climate change and its impacts on the productivity and distribution of fish and shellfish populations
- develop (and test) working hypotheses on the patterns of species and ecosystem changes
- develop (and test) working hypotheses on the underlying processes of change by data analyses and modelling (hindcasting exercises)
- scenario test the effects of climate change on the distribution and productivity of fish populations (forecasting exercises)
- formulate a suite of hypotheses to be tested and related research needs in future research programs
- include stakeholder participation and a dissemination of the results

Project Outputs

An extensive list of project outputs (including project documents, brochures, deliverables and information on project related publications and presentations) are available from the project website.

Seadatanet - A Pan-European Infrastructure for Ocean and Marine Data Management

Summary information

Funding source:	FP6 - Integrated Infrastructure Initiative
Total Cost:	€ 1.0510.000
EC contribution:	€ 8.750.000
Start – end date:	1/04/2006 – 31/03/2011
Duration:	60 months
Project Coordinator:	Gilbert Maudire (Gilbert.Maudire@ifremer.fr)
Organisation:	French Research Institute for Exploitation of the Sea – France
Project Keywords:	Data management, access and data sharing, information, products and knowledge originating from oceanographic fleets, new automatic observation systems and space sensors

Project Website:
http://www.seadatanet.org

Project Partners

1	Marine Research Institute - Iceland
2	Natural Environment Research Council – United Kingdom
3	Latvian Institute of Aquatic Ecology - Latvia
4	Marine Institute - Ireland
5	Aarhus Universitet - Denmark
6	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente - italy
7	Marine Information Service - Netherlands
8	Institut National des Sciences et Technologies de la Mer - Tunisia
9	Institut des Sciences de la Mer et de l'Aménagement du Littoral - Algeria
10	Israel Oceanographic and Limnological Research Limited - Israel
11	Polytechnic University of Tirana - Albania
12	Institute of Oceanography and Fisheries - Croatia
13	Center of Marine Research - Lithuania
14	Spanish Institute of Oceanography - Spain
15	Hellenic Centre for Marine Research - Greece
16	National Research Council - Italy
17	National Council for Scientific Research, National Center for Marines Sciences - Lebanon
18	Oceanography Centre, University of Cyprus - Cyprus
19	University of Malta - Malta
20	National Institute of Biology - Slovenia
21	Institut National de Recherche Halieutique - Morocco
22	Iv Javakhishvili Tbilisi State University - Georgia
23	National Institute for Marine Research and Development "Grigore Antipa" - Romania
24	Institute of Oceanology, Bulgarian Academy of Sciences - Bulgaria
25	Marine Hydrophysical Institute, Ukrainian National Academy of Sciences - Ukraine
26	P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences - Russian Federation
27	Tallinn University of Technology - Estonia

28 Institute of Meteorology and Water Management - Poland
29 Finnish Institute of Marine Research - Finland
30 Flanders Marine Institute - Belgium
31 Royal Belgian Institute of Natural Sciences - Belgium
32 Rijksinstituut Voor Kust En Zee, Rijkswaterstaat - Netherlands
33 Instituto Hidrografico - Portugal
34 Joint Research Centre – European Commission
35 International Council for the Exploration of the Sea - Denmark
36 Institute of Marine Research - Norway
37 University of Liège - Belgium
38 Alfred Wegener Institute for Polar and Marine Research - Germany
39 Collecte Localisation Satellites SA - France
40 Middle East Technical University - Turkey
41 National Institute of Geophysics and Volcanology - Italy
42 UNESCO Intergovernmental Oceanographic Commission
43 All-Russian Research Institute of Hydrometeorological Information, World Data Centre - Russian Federation
44 National Institute of Oceanography and Experimental Geophysics - Italy
45 Swedish Meteorological and Hydrological Institute - Sweden
46 Bundesamt Fuer Seeschiffahrt Und Hydrographie - Germany

Background information

Project Summary

Abstract
Data availability is of vital importance for marine research but most of the European data are fragmented, not always validated and not easily accessible. In the 40 countries bordering the European seas, more than 600 scientific laboratories from governmental organizations and private industry collect data by using various sensors on board of research vessels, submarines, fixed and drifting platforms, airplanes and satellites to measure physical, geophysical, geological, biological and chemical parameters, species etc.

SEADATANET aims to develop an efficient distributed Pan-European Marine Data Management Infrastructure for managing these large and diverse data sets. The objective is to network the existing professional data centres of 35 countries, active in data collection, and provide integrated databases of standardized quality on-line. The on-line access to *in situ* and remote sensing data, meta-data and products will be provided through a unique portal interconnecting, in the first phase, 11 interoperable node platforms. The development and adoption of common communication standards and adapted technology will ensure the platforms interoperability. This activity will be developed to gradually connect all the other data centres to the interoperable system.

The quality, compatibility and coherence of the data issuing from so many sources, will be ensured by adopting standardized methodologies for data checking, by dedicating part of the activities to training and preparation of synthesised regional and global statistical gridded products from the most comprehensive *in situ* and remote sensing data sets made available by the participants. These products will be easier to interpret by non-specialist users, and will be used first to check the data and the system operability, and further to market SEADATANET and to serve a wider range of uses than raw data: e.g. model initialisation, industrial projects and teaching.

Project Outputs

SEADATANET has developed an efficient distributed Marine Data Management Infrastructure for the management of large and diverse sets of data deriving from *in situ* and remote observation of the seas and oceans.

Professional data centres, active in data collection are constituting a pan-European network providing on-line integrated databases of standardized quality.

The on-line access to *in situ* and remote sensing data, meta-data and products is provided through a unique portal interconnecting the interoperable node platforms constituted by the SeaDataNet data centres.

The development and adoption of common communication standards and adapted technology ensure the platforms interoperability. The quality, compatibility and coherence of the data issuing from so many sources, is assured by the adoption of standardized methodologies for data checking, by dedicating part of the activities to training and preparation of synthesised regional and global statistical products from the most comprehensive *in situ* and remote sensing data sets made available by the SeaDataNet partners.

Data, value added products and dictionaries serve wide uses: e.g. research, model initialisation, industrial projects, teaching, marine environmental assessment.

SEAMOCS - Applied stochastic models for ocean engineering, climate and safe transportation

Summary information

Funding source:	FP6 - Marie Curie Actions
EC contribution:	€ 2.000.000
Start – end date:	1/11/2005 – 31/10/2009
Duration:	48 months
Project Coordinator:	Georg Lindgren (georg@maths.lth.se)
Organisation:	Lunds Universitet - Sweden

Project Website:
http://www.maths.lth.se/seamocs/index.html

Project Partners

1 Det Norske Veritas As - Norway
2 Royal Netherlands Meteorological Institute - Netherlands
3 Institute of Cybernetics, Tallinn University of Technology - Estonia
4 Chalmers Tekniska Högskola Aktiebolag - Sweden
5 Université Paul Sabatier - France
6 Swedish Meteorological and Hydrological Institute - Sweden
7 Katholieke Universiteit Leuven - Belgium
8 University of Sheffield - United Kingdom

Background information

Project Summary

The network shall bring together probabilists/statisticians, researchers in the marine and meteorological fields, and maritime safety enterprises on wave climate, information and databases, and the safety of marine transports, and offshore and coastal installations.

Much of the research in the area has been highly fragmented. There are few statisticians working actively with the very intricate problems arising in maritime safety, and naval engineering does not influence statistics research in a way that, for example, control engineering of life science research has done.

The idea behind the network is to bring together the best possible knowledge and research potential in the different fields in order to:

- Improve information extraction from marine data,
- Validate non-linear wave models from spectral properties,
- Improve extreme value analysis for climate and sea data,
- Improve computational tools for wave analysis and route simulation,
- Get better understanding of near-shore waves and hazards for coastal installations,
- Improve technique to determine stricter safety limits in marine design, regulation and operation.

The project website provides links to information and positions within the network.

Search for DAMOCLES - Study of Environmental Arctic Change – Developing Arctic Modelling and Observing Capability for Long-term Environmental Studies

Summary information

Funding source:	FP6 - Specific Support Action
Total Cost:	€ 605.000
EC contribution:	€ 605.000
Start – end date:	1/10/2006 –31/05/2010
Duration:	44 months
Project Coordinator:	Jean-Claude Gascard (gascard@lodyc.jussieu.fr)
Organisation:	Université Pierre et Marie Curie – France
CLAMER thematic focus:	Ice melting; biological impacts; socio-economic consequences
CLAMER Regional focus:	Arctic

Project Website:
http://www.damocles-eu.org/

Project Partners

1 Université Pierre et Marie Curie - France
2 Colombia University - United States
3 Norwegian Meteorological Institute - Norway
4 University of Alaska Fairbanks - United States
5 Swedish Meteorological and Hydrological Institute - Sweden
6 Center for International and Environmental Research - Norway
7 Alfred Wegener Institute for Polar and Marine Research - Germany
8 University of Alaska – United States
9 National Snow and Ice Data Center, University of Colorado - United States

Background information

Project Summary

Abstract
SEARCH for DAMOCLES is proposing an SSA that is based on recent initiatives started in Europe and the USA in the field of Arctic marine ecosystems and global change, with specific emphasis on Arctic Ocean long-term observatories. The SSA will capitalize on opportunities and significant benefits arising from coordination of large scale research programmes such as the European Integrated Project DAMOCLES (Developing Arctic Modelling and Observing Capabilities for Long-term Environmental studies) and the US research program SEARCH (Study of Environmental Arctic Change). SEARCH for DAMOCLES, positioned in the domain of Arctic Science, will be particularly timely in the context of the International Polar Year and will significantly contribute to the coordinated implementation of the DAMOCLES and SEARCH work programmes in the field of Global

Change and Ecosystems. Close synchronization of these programmes will enhance the acquisition of pan-Arctic data sets, and their analysis, the dissemination and archiving of results, as well as heightening public awareness. International workshops and conferences including other partners such as Canada, Russian Federation, and Asian countries (Japan, China, and South Korea), will enable translation of the results into planning of integrated, future activities that will be based on the SSA SEARCH for DAMOCLES. The coordination and synchronization of Arctic programs such as DAMOCLES and SEARCH, through an SSA is a unique opportunity to ensure the necessary pan-Arctic coverage of observations and data evaluation for understanding Arctic system variability, avoiding major gaps and unnecessary overlaps. This EU-US SSA will also contribute to promotion and facilitation of future RTD activities via prospective studies, exploratory measures and pilot actions. The EU-US SSA SEARCH for DAMOCLES is proposed for 3 years covering the 3 last years of the 4-year DAMOCLES Integrated Project (2006-2009) and the 2 years of the IPY (2007-2008).

Objectives

Recently the two independent pan-Arctic, long-term research programmes SEARCH (Study of Environmental Arctic Change) and DAMOCLES (Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies) have been designed in the US and Europe, respectively, to increase our capability for predicting Arctic climate changes. Both programmes propose elements of an integrated observing and forecasting system on seasonal to climate time scales. These programmes have been funded independently: SEARCH by a US interagency consortium (NSF, NOAA, NASA etc.) and DAMOCLES by the European Union under the 6th Framework Programme. Both projects have set out ambitious goals that challenge the intellectual and infrastructural resources of the Arctic science community. In spite of these challenges, they certainly will constitute one of the highlights of the upcoming International Polar Year (IPY) in 2007 and 2008. DAMOCLES represents a major effort in Europe gathering 45 institutions (more than 100 principal investigators) in 12 European countries (including Russian Federation). SEARCH reaches similarly deep into the US Arctic science community. The main objective of the Specific Support Action “SEARCH for DAMOCLES” is to explore and realize opportunities and benefits to coordinate these two large research programmes that represent major efforts by EU and US scientists and have largely common goals and objectives. This EU-US SSA will be a key enabling mechanism for the two programmes SEARCH and DAMOCLES to successfully tackle one of the largest challenges Arctic scientists have faced. The SSA will also contribute to reinforcing the international cooperation to develop long-term environmental research programmes in the Arctic regions to answer the key questions underlying the observed rapid changes and their impact on physical, biological and human domains in a fragile and delicately balanced Arctic system.

The overall objectives of SEARCH for DAMOCLES are to:

- Coordinate across the Atlantic the scientific efforts to make systematic observations of atmospheric and oceanic variables in the Arctic and subarctic domain, including those of sea-ice, so as to improve forecasting of the Arctic marine and atmospheric environment, as well as projections of long-term trends.
- Consolidate long-term observations required for documentation and modelling of change and in particular prediction of extreme climate events.
- Establish common databases and contribute to international programmes (ISAC, IPY, CliC, CLIVAR, AOSB).
- The specific objectives of SEARCH and DAMOCLES are to coordinate the research conducted within the SEARCH and DAMOCLES programmes required for answering fundamental scientific questions with the goal to:
- Determine the processes responsible for present variability and changes in the Arctic climate system.
- Improve our capabilities to predict Arctic climate changes in particular extreme climate events.
- Design optimal components of a long-term integrated monitoring and forecasting system for the Arctic Ocean.
- Assess impacts of an extreme climate event such as the disappearance of the Arctic perennial sea-ice.

SESAME - Southern European Seas: Assessing and Modelling Ecosystem changes

Summary information

Funding source:	FP6 - Integrated Project
Total Cost:	€ 14.790.000
EC contribution:	€ 10.000.000
Start – end date:	1/11/2006 – 30/04/2011
Duration:	54 months
Project Coordinator:	Evangelos Papathanassiou (vpapath@ath.hcmr.gr)
Organisation:	Hellenic Centre for Marine Research, Institute of Oceanography – Greece
CLAMER thematic focus:	Abiotic and biotic impacts; socio-economic changes deep circulation changes; freshwater inflow;
CLAMER Regional focus:	Mediterranean Sea; Black Sea
Project Keywords:	Climate change assessment and prediction; biodiversity; ecosystem research; carbon sequestration; fisheries; tourism; ecosystem goods and services; mitigation of climate change; sequestration in water and sediments

Project Website:
http://www.sesame-ip.eu

Project Partners

1 Hellenic Centre for Marine Research - Greece
2 French National Centre for Scientific Research - France
3 P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences - Russian Federation
4 Middle East Technical University - Turkey
5 University of Liege, Mare Interfacultary Research Centre - Belgium
6 Spanish National Research Council - Spain
7 National Interuniversity Consortium for Marine Sciences - Italy
8 Panepistimion Aigaiou, Aegean - Greece
9 Institute of Oceanology, Bulgarian Academy of Sciences – Bulgaria
10 Israel Oceanographic and Limnological Research Limited - Israel
11 Athens University of Economics and Business, Research Center - Greece
12 Bogazici Universitesi, Econ-Boun - Turkey
13 National Council for Scientific Research - Lebanon
14 National Reserach Council - Italy
15 University of Sofia - Bulgaria
16 Italian National Agency for New Technologies, Energy and Sustainable Economic Developement - Italy
17 Fondazione Eni Enrico Mattei - Italy
18 National Institute of Marine Geology and Geo-Ecology - Romania
19 French Reserach Institute for Exploitation of the Sea - France
20 Institute of Biology of Southern Seas - Ukraine
21 Institute of Oceanography and Fisheries - Croatia
22 Istituto Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare - Italy
23 National Institute of Oceanography and Experimental Geophysics - Italy
24 Fondazione Imc-Centro Marino Internazional-Onlus - Italy
25 Joint Research Centre – European Commission

26 Institut National des Sciences et Techniques de la Mer - Tunisia
27 Marine Hydrophysical Institute, Ukrainian National Academy Of Science - Ukraine
28 National Institute for Marine Research and Development "Grigore Antipa" - Romania
29 National Institute of Biology - Slovenia
30 National Institute of Geophysics and Volcanology - Italy
31 National Institute of Oceanography and Fisheries - Egypt
32 University of Cyprus - Cyprus
33 South Scientific Centre of Russian Academy of Sciences - Russian Federation
34 Stazione Zoologica 'Anton Dohrn' Szn - Italy
35 Tbilisi State University Ivane Javakhishvili - Georgia
36 University of Barcelona - Spain
37 University of Huelva - Spain
38 University of Bremen - Germany
39 University of Crete - Greece
40 University Of Malta, Physical Oceanography Unit - Malta
41 Polytechnic University of Marche Universita Politecnica delle Marche - Italy
42 Université du Littoral Côte D'opale - France
43 University of Oldenburg, Institute for Chemistry and Biology of the Marine Environment - Germany
44 University of Plymouth - United Kingdom
45 Cyprus International Institute of Management - Cyprus
46 Clu S.r.l. - Italy
47 SOPAB Brest - France

Background information

Project Summary

The SESAME project was designed to study the past, present and future environmental changes in the Mediterranean and Black Sea ecosystems, and their abilities to provide goods and services with fundamental societal importance, such as tourism, fisheries, mitigation of climate through carbon sequestration and ecosystem stability through conservation of biodiversity.
With the help of historical data, in combination with newly collected data, SESAME aimed to identify the changes these two ecosystems have experienced over the last 50 years. The goal was, based on the past and current status, to predict possible changes within the next 50 years.

Project Outputs

The project assessed the changes in the Southern European Seas (SES) ecosystems over the last 50 years, determined the current status and predicted the changes that may happen in the Mediterranean and Black Sea ecosystems in the 21st century. In addition, SESAME assessed and predicted the abilities of these ecosystems to provide goods and services with fundamental societal importance. The project approached the two seas as a coupled climatic/ecosystem entity, with links and feedbacks to the world ocean, something not attempted before at such a large scale for these ecosystems. Overall the project, working in an integrated and multidisciplinary mode, managed to create a large network of scientists who worked together as a team, to increase the capacity building especially in less advanced SES regions, and to ensure that a structured dialogue between researchers and potential users is created and maintained. Strong focus was placed on disseminating this knowledge to all relevant stakeholders. This involved the integration of socio-economics and natural sciences, while at the same time creating a platform for education and further learning opportunities.

SESAME completed its research activities through multidisciplinary collaborations, both within as well as outside the EU. One of these examples was the simultaneous multi-national cruises carried out in the Mediterranean and the Black Seas, which not only strengthened collaborations among the scientific teams of different partner institutes, but provided the scientists with the opportunity to produce a “snap-shot” of the ecological state of the Southern European Seas in 2008, which could be used in the years to come as reference for potential changes. The assessment of ecosystem changes was based on the identification of the major

regime shifts that occurred during the last 50 years, which was successfully accomplished through the research cruises, the modelling efforts and the socio-economic focus of the project. Integrating the socio-economic evaluation of SES marine ecosystems with solid, state-of-the-art scientific modelling and field observations achieved a dual future projection. Firstly, it provided information in terms of numerical modelling efforts and, thus, the process through which we can now define the potential changes occurring in the SES ecosystem dynamics under unified consensus scenarios of climatic change and direct anthropogenic pressure. Secondly, it allows for the quantification of welfare effects for SES countries (GDP effects), which may be caused by changes in the ability of these ecosystems to provide goods and services (e.g. fisheries catch potential, ecosystem biodiversity, attractiveness etc.).

Moreover, SESAME's scientific efforts were effectively and efficiently managed, starting with the analysis of existing and newly collected data at basin and regional scale as well as through model simulations, to attain and create a comprehensive, integrated Database regarding the Mediterranean and the Black Sea, to be maintained beyond the project's life span.

The analysis of historical data together with models showed that several components of the SES ecosystems have changed during the last 50 years. Changes were not identical in both basins, nor attributed to the same drivers. Black Sea has been strongly affected by human activities (eutrophication, introduction of alien species, overfishing) both in coastal and offshore waters. Climate variability seems to have induced changes, mainly through the sea water temperature, affecting the dynamics of plankton. The observed changes in the Mediterranean Sea were attributed mainly to temperature through its impact on the water stratification and circulation. The occurrence of the Eastern Mediterranean Transient (EMT), connected with temperature, impacted also the system.

Useful project outcomes can be used when designing and re-defining policies that protect marine ecosystems. Results show the considerable improvements to be achieved by combining and coordinating socio-economic and scientific modelling towards the development of improved integrated research strategies and policies. Assessing the ecosystem status and societal cost for goods and services derived from the SES marine ecosystems is of key importance. In this respect, some of the project's results clearly indicate that the warming of the atmosphere, a process apparently in action in the last quarter of the 20th century, has been found to continue and, with respect to the SES, translates in a progressive warming of the SES waters. Additionally, the temporal and spatial pattern of this progressive warming might have important consequences and alter the biogeographical structure and biodiversity of the SES. Finally, the results of the Mediterranean Sea model indicate that the progressive warming evolves with a northward shift of the surface isotherm, potentially paving the way for meridionalization processes in the basin (ingression into the basin of warm water or alien species).

TENATSO - Tropical Eastern North Atlantic Time-Series Observatory

Summary information

Funding source:	FP6 - Specific Support Action
Total Cost:	€ 549.760
EC contribution:	€ 549.760
Start – end date:	1/10/2006 – 31/03/2009
Duration:	30 months
Project Coordinator:	Douglas Wallace (dwallace@ifm-geomar.de)
Organisation:	Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
CLAMER thematic focus:	Temperature changes; ocean current changes; oxygen depletion; biological impacts; socio-economic consequences
CLAMER Regional focus:	North Atlantic
Project Keywords:	Aerosols; greenhouse gases; GAW; GEOSS; natural resources

Project Website:
http://tenatso.ifm-geomar.de/?Home

Project Partners

1 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
2 Leibniz-Institut Fuer Troposphaerenforschung - Germany
3 Instituto Nacional De Desenvolvimento Das Pescas - Cape Verde
4 Instituto Nacional De Meterologia E Geofisica - Cape Verde
5 Max-Planck-Gesellschaft Zur Förderung Der Wissenschaften - Germany
6 University of York - United Kingdom

Background information

Project Summary

Abstract
Observation is fundamental to understanding global change. Atmospheric change impacts marine ecosystems, and the atmosphere is influenced by ocean physical and biogeochemical processes. Many impacts/feedbacks are focussed on the Tropics.

TENATSO will support pre-operational atmosphere and ocean observation capability in the tropical Eastern North Atlantic Ocean, specifically at Cape Verde (17°36'N, 24°16'W). The entire region is data poor but plays a key role in air-sea interaction. Cape Verde is ideally located for both atmosphere and ocean observation. Being downwind of the Mauritanian up welling, the Observatory will provide unique information linking biological productivity and atmospheric composition. The location is critical for climate and greenhouse gas studies and for investigating dust impacts on marine ecosystems.

The Observatory can contribute data for assessment of major marine biological resources. This Action proposes no research or monitoring: rather it supports transfer of European technology/expertise to a developing country with strong ties to Europe. The Action is leveraged on financial support by the Partners and the Observatory is of use to European programmes.
The atmospheric site will measure meteorological parameters, greenhouse and short-lived gases, and aerosols. Data links to the Global Atmospheric Watch of the WMO will be established. The ocean site will include a mooring for temperature, salinity, current and oxygen measurements and establish data links to international observing programmes. Cape Verde's vessel will be equipped to collect samples for marine parameters. The data will contribute to GEOSS.

The co-location of atmospheric and ocean Observatories is unique. The Observatory will support additional research measurements by international investigators and become a resource to European and international projects. The work plan is structured to establish the Atmospheric and Oceanic Observatories, train Cape Verde personnel, test systems and perform outreach to the potential user community and funders.

TENATSO work plan is divided into 3 work packages (WP):
WP1: Support and technical activities for the atmospheric site
WP2: Support and technical activities for the oceanographic site
WP3: Project management, including joint coordination of the atmospheric and oceanic components, assessment of progress, dissemination and outreach.

Project Outputs

The main results of this project will be the establishment of long-term observations from a data poor yet very important region. The data will contribute not only to better understanding the Tropics, but also indicate potential consequences for climate change at the global level. The observatory is used as a site for campaign-style measurements, including visits from international scientists. It also supports an increasing number of Cape Verdean scientists, technicians and students.

With respect to atmospheric observation, TENATSO capitalized on an atmospheric observation site initially developed by UK SOLAS (a NERC Thematic Programme), but enhanced the facilities significantly so that they are suitable for long-term measurements and science support. This included measurement of key meteorological and climate parameters relevant to the Global Earth Observation System of Systems including long-lived greenhouse gases and the size and chemical composition of the aerosol and dust. The atmospheric site is suitable for support of shorter-term research visits.

With respect to oceanographic observation, two sampling modes were established at a pelagic site representative of open ocean conditions that is located immediately “upwind/upstream‟ of the atmospheric observation site:

- Regular visits of the Cape Verde research vessel Islândia to the site, together with CTD profiling and water sampling for nutrients, dissolved gases and plankton;
- Establishment of a long-term mooring for the continuous measurement of physical and basic chemical parameters. In this case existing Cape Verdean infrastructure were enhanced and complemented with hardware and expertise provided by the European partners.

Specific project achievements can be found on the project website.

TICOPIC - Triple Isotopic Composition of Oxygen in Polar Ice Core to understand the links between climate change and water cycle

Summary information

Funding source:	FP6 - Marie Curie Actions
EC contribution:	€ 172.254
Start – end date:	1/11/2005 – 31/01/2007
Duration:	15 months
Project Coordinator:	Boaz Luz (Boaz.Luz@huji.ac.il)
Organisation:	Hebrew University of Jerusalem, Institute of Earth Sciences, Faculty of Science - Israël

Background information

Project Summary

Abstract
Strong modifications of the water cycle favoured the major climate changes. Over the late Quaternary, the measurements of three water isotopes (H216O, HDO, H218O) in deep Antarctic and Greenland ice cores suggested a strong relationship between climate and water cycle over the succession of glacial and interglacial period and over the rapid climatic variability of the last glacial period.

Such a result comes from the different mass-dependent fractionation processes (equilibrium and kinetic) in the water cycle. However, even if a huge measurements and isotopic modelling effort was produced, no quantitative reconstruction of past changes of water cycle could be proposed (especially changes in temperature and humidity of evaporative regions). It therefore prevents correct description of the water cycle in global models to describe climate change mechanisms.

The last water isotope, H217O, as additional ice core tracer, should provide the missing information because of different equilibrium and kinetic fractionation coefficients (as shown by preliminar measurements and simple modelling studies). Its difficult analytical measurement with sufficient precision for that purpose is now possible at the Institute of Earth Sciences in Jerusalem.

After a first calibration part with laboratory experiment and existing sampling over polar transects, we propose to measure H217O in deep ice cores in Antarctica and Greenland where H218O and HD16O are available to understand quantitatively the links between climate and water cycle variations. The use of simple and GCM models including water isotopes will favour the interpretation.

My knowledge of isotopes in ice cores and of the European ice cores community, the unique expertise of the Institute of Earth Sciences in H217O measurements and the collaboration with Laboratoire des Sciences du Climat et de l'Environnement for isotopic modelling are great advantages for the success of the project.


FP7

ArcRisk - Arctic Health Risks: Impacts on health in the Arctic and Europe owing to climate-induced changes in contaminant cycling

Summary information

Funding source:	FP7 - Collaborative Research Project Small or Mediumscale Focused Research
Total Cost:	€ 4.740.000
EC contribution:	€ 3.500.000
Start – end date:	1/06/2009 – 30/11/2013
Duration:	54 months
Project Coordinator:	Janet Pawlak (jpawlak@dahm.dk)
Organisation:	Arctic Monitoring and Assessment Programme Secretariat – Norway
CLAMER thematic focus:	Biological impacts; socio-economic consequences
CLAMER Regional focus:	Arctic
Project Keywords:	Human health, long-range transport contaminants, arctic, food webs,.

Project Website:
http://www.arcrisk.eu/

Project Partners

1 Arctic Monitoring and Assessment Programme Secretariat - Norway
2 Stockholm University - Sweden
3 Aarhus University - Denmark
4 Alfred Wegener Institute for Polar and Marine Research - Germany
5 Lancaster University – United Kingdom
6 University Centre in Svalbard - Norway
7 Spanish National Research Council - Spain
8 IVL Swedish Environmental Research Institute Limited - Sweden
9 University of Oulu - Finland
10 Norwegian Institute for Air Research - Norway
11 Jožef Stefan Institute - Slovenia
12 Ocean Atmosphere Systems GmbH - Germany
13 Max Planck Institute for Chemistry - Germany
14 Swiss Federal Insitute of Technology - Switzerland
15 Masaryk University - Czech Republic
16 Norwegian Institute of Public Health - Norway
17 University of Tromso - Norway
18 Northwest Public Health Research Center, Russian Ministry of Health - Russian Federation
19 Environment Canada, Aquatic Ecosystem Protection Research Division - Canada
20 Arctic Ecosystem Health Freshwater Institute, Department of Fisheries and Oceans - Canada
21 Health Canada, Safe Environments Programme Environmental Health - Canada

Background information

Project Summary

Studies in the Arctic have identified populations that have very high dietary exposure to environmental contaminants, largely as a result of their traditional subsistence diets. Several of these populations have been the subject of detailed health studies. The developments of policies to reduce levels of environmental contamination and protect human health, that also take into account our changing climate, require a sound scientific basis. The Arctic studies provide a rich source of information that can be used to make comparisons with situations in other parts of Europe, now and under future scenarios of climate change. Long-range transport of contaminants to the Arctic, the resulting exposures observed in Arctic human populations, and impacts of such exposures on human health have been the subject of considerable work in recent years, providing a baseline against which to compare future developments. Global climate change has the potential to remobilize environmental contaminants and alter contaminant transport pathways, fate, and routes of exposure in human populations. The Arctic is particularly sensitive to climate change and already exhibits clear impacts. Thus, research into contaminant exposure and its effects on human health in the Arctic, in comparison with other exposed populations in Europe, presents an opportunity to gain insight into changes that may later impact other areas. The influence of climate change on contaminant spreading and transfer and the resultant risk to human populations in the Arctic and other areas of Europe will be studied by:

- Research on the ways in which climate change will affect the long-range transport and fate of selected groups of contaminants, and possible implications for the re-distribution of contaminants. This will involve modelling, utilizing the information base that exists on the distribution of such contaminants in the Arctic and other areas of Europe.
- Research on the impacts that changing pathways and climatic conditions will have on contaminant uptake and transfer within food webs, leading to foods consumed by humans. This will involve experimental work, process studies and targeted analytical studies, the latter focussed on supporting the modelling work and process studies related to human exposure to contaminants.
- Research focussing on human health, aimed at determining how climate-mediated changes in the environmental fate of selected groups of contaminants will result in changes in exposure of human populations, in the Arctic and in selected areas of Europe.

Results of the research will be evaluated from a policy-development perspective and synthesised in products appropriate for policy-makers and other stakeholders.

Expected Achievements

- New information about the chemical characteristics and environmental behaviour of representative contaminants in Arctic conditions.
- Model results describing the transport of chemical contaminants from source regions to the Arctic, and their fate, including uptake in food webs, under selected climate scenarios.
- Compilations of data and information providing an overview of exposure of Arctic populations to contaminants at the present time, and how this may change in the future due to climate change.
- Compilations of data and results of past and current health studies of human populations in several areas of the Arctic, and their analysis with respect to the potential health impacts of contaminant exposure.
- Comparison of information from Arctic health studies with results of studies of contaminant effects on populations in other selected areas of Europe.
- Evaluation of policy measures that could be taken at the European level to reduce exposure to contaminants and associated health effects in the Arctic and in Europe under changing climatic conditions.
- Materials to communicate ArcRisk project results to key stakeholders.

ATP - Arctic Tipping Points

Summary information

Funding source:	FP7 - Collaborative Project
Total Cost:	€ 6.550.000
EC contribution:	€ 5.000.000
Start – end date:	1/02/2009 – 31/01/2012
Duration:	36 months
Project Coordinator:	Paul Wassmann (paul.wassmann@uit.no)
Organisation:	University of Tromsø – Norway
CLAMER thematic focus:	Ice melting; abiotic changes; biological impacts; socio-economic consequences
CLAMER Regional focus:	Arctic

Project Website:
http://www.eu-atp.org/

Project Partners

1 University of Tromsø - Norway
2 Spanish National Research Council - Spain
3 Akvaplan-niva AS - Norway
4 SINTEF - Norway
5 Aarhus Universitet - Denmark
6 Institute of Oceanology, Polish Academy of Sciences - Poland
7 University of Cambridge, Department of Applied Mathematics and Theoretical Physics – United Kingdom
8 Université Pierre et Marie Curie - France
9 Centre of Marine Sciences - Portugal
10 P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences - Russian Federation
11 Greenland Institute of Natural Resources - Greenland
12 Svenska Vitskapsakademin, Beijer Institute for Ecological Economics - Sweden
13 Max-Planck-Gesellshaft zur Forderung der Wissen- shaften, Institut fur Meteorologie - Germany

Background information

Project Summary

There is mounting evidence that ecosystem response to certain types or magnitudes of extrinsic pressures (climate, human impacts, etc.) is often abrupt and non-linear, leading to a significant reorganization of system properties and processes. These ecosystem changes are known as regime shifts (Scheffer *et al*. 2001). Such non-linear responses are often initiated by qualitative changes in the structure or function of the ecosystem, and are so fundamental that the impacted ecosystems respond to new pressures in completely different manners than the original ecosystem did (May 1977). Regime shifts arise, for instance, from the introduction of alien species or the loss of key species in ecosystems. These changes can result in alterations of the most basic ecosystem parameters, including food-web structure, the flow of organic matter and nutrients through the ecosystem, or the patterns of space occupation, leading to a cascade of changes in the ecosystem. Climate drives both community structure and key organismal functions, so it is hardly surprising that regime shifts identified from marine ecosystems are often linked to climate (Cushing 1982, Steele 2004).

The broad interdisciplinary consortia assembled in the Arctic Tipping Points (ATP) project will be managed (WP1) to identify the elements of the Arctic marine ecosystem likely to show abrupt changes in response to climate change, and establish the levels of the corresponding climate drivers inducing the regime shift for these tipping elements. ATP will evaluate the consequences of crossing those tipping points, and the associated risks and opportunities for economic activities dependent on the Arctic marine ecosystem. Historical records of Arctic climate change and projections of future changes in Arctic sea climate and ice systems are compiled (WP2), and time series of Arctic ecosystem components analysed using novel statistical tools to detect regime shifts and ecological thresholds and tipping points, and evaluate their sensitivity to climatic forcing (WP3). Experimental manipulations and comparative analyses across broad climatic ranges will be used to detect climatic thresholds and tipping points of Arctic organisms and ecosystems, using genome-wide analyses to develop genomic markers of climate-driven stress useful as early warning indicators of the proximity of tipping points (WP4). A biological-physical coupled 3 D model will be used to generate future trajectories of Arctic ecosystems under projected climate change scenarios and to identify their consequences for the Arctic ecosystem (WP5). The impacts of abrupt changes in the Arctic ecosystems for activities of strategic importance for the European Arctic and the associated impacts on employment and income will be elucidated, and policies and legislative frameworks to adapt and mitigate these impacts will be analysed (WP 6). The effectiveness of possible alternative, post-Kyoto policies and stabilization targets in avoiding climate-driven thresholds in the Arctic ecosystem will be examined, and the results and projections will be conveyed to policy makers, economic sectors and the public in general (WP7).

CLAMER - Climate Change and Marine Ecosystem Research Results

Summary information

Funding source:	FP7 – Coordiation Support Action
Project cost:	€ 1.16 million
EC contribution:	€ 991,357
Start – end date:	1/04/2010 – 30/09/2011
Duration:	18 months
Project Coordinator:	Carlo Heip (Carlo.Heip@nioz.nl)
Organisation:	Royal Netherlands Institute for Sea Research - Netherlands

Project Website:
www.clamer.eu

Project Partners

1 SOPAB Brest SA – France
2 Marine Board – European Science Foundation
3 Flanders Marine Institute – Belgium
4 Universtiy of Tromsø – Norway
5 Spanish National Research Council – Spain
6 Hellenic Centre for Marine Research - Greece
7 Royal Netherlands Institute for Sea Research - Netherlands
8 Danish Meteorological Institute - Denmark
9 Secretary of State for Environment, Food and Rural Affairs - United Kingdom
10 University of East Anglia - United Kingdom
11 Universita Politecnica delle Marche – Italy
12 Sir Alister Hardy Foundation for Ocean Science - United Kingdom
13 Université de Bretagne Occidentale - France
14 Plymouth Marine Laboratory - United Kingdom
15 National University of Ireland - Ireland
16 Natural Environment Research Council - United Kingdom

Background information

Project Summary

Although there is no certainty regarding the precise nature and rate of future climate change, even the most moderate scenarios predict a continuing change of the marine environment, with associated major environmental and social impacts. To prepare society for the necessary mitigation and adaptation measures, the awareness of citizens to research results, both certainties and uncertainties, in this specific area should be raised.

During the last years, much new information has been gathered in large EU-funded research, but to date this information has not been synthesized nor has it become an important part of public knowledge. The aim of this proposal is to make a synthesis of EU research results on the impacts of climate change on the marine

environment and to make this knowledge and its socio-economic consequences better known to European citizens and society at large.

Together with expert representatives of major Networks of Excellence, large EU projects and research networks, we will produce a state-of-the-art overview of European research results on the effects of climate change on marine environment.

An up-to-date overview of public knowledge and perception on the effects of climate change on marine environments and their socio-economic consequences will be produced by means of polls and questionnaires. The results will be used to identify the main issues to be addressed and the best practices to be used during the outreach activities.

Enhancement of public knowledge on climate change impacts on the marine environment, including the socio-economic consequences, will be achieved by means of challenging and innovative tools such as an interactive Pan-European conference at the end of 2010 and a high-quality internet-based portal within an e-learning platform. These outreach activities will build upon recent experience as has been gathered within EU-funded research to communicate with European citizens on impacts of climate change on marine ecosystems.

CORALFISH - Assessment of the interaction between corals, fish and fisheries in the deep waters of Europe and beyond

Summary information

Funding source:	FP7 - Collaborative Research Project - Large-scale Integrating Project
Total Cost:	€ 10.890.000
EC contribution:	€ 6.500.000
Start – end date:	1/06/2008 – 31/05/2012
Duration:	48 months
Project Coordinator:	Anthony Grehan (anthony.grehan@nuigalway.ie)
Organisation:	National University of Ireland – Ireland
CLAMER thematic focus:	Temerature changes; ocean cuirculation changes; ocean acidification; deep circulation changes; biological impacts; socio-economuic consequences
CLAMER Regional focus:	Arctic; North Atlantic; Mediterranean Sea
Project Keywords:	Habitat suitability modelling (HSM); predicted distribution of vulnerable marine ecosystems; cold-water corals; climate change scenarios; deep sea; coral habitat; fisheries; fish

Project Website:
www.eu-fp7-coralfish.net

Project Partners

17	National University of Ireland - Ireland
18	Institute of Marine Research - Norway
19	Marine Research Institute - Iceland
20	French Research Institute for Exploitation of the Sea - France
21	Instituto do Mar - Centro dos Acores - Portugal
22	Hellenic Centre for Marine Research - Greece
23	National Interuniversity Consortium for Marine Sciences – Italy
24	Nederlands Institute for Ecology - Nederlands
25	Zoological Society of London, Institute of Zoology – United Kingdom
26	University of Tromsø - Norway
27	University Court of The University of Aberdeen - United Kingdom
28	Royal Netherlands Institute for Sea Research - Netherlands
29	O'Malley Fisheries - Ireland
30	Friedrich-Alexander-Universität Erlangen-Nürnberg - Germany
31	National University of Ireland, Cork. University College Cork - Ireland
32	University of Bremen – Germany

Background information

Project Summary

In 2006, the UN General Assembly Resolution (AL61/L38) called upon fisheries management organisations worldwide to: i) assess the impact of bottom fishing on vulnerable marine ecosystems, ii) identify/map vulnerable ecosystems through improved scientific research/data collection, and iii) close such areas to bottom fishing unless conservation and management measures were established to prevent their degradation. In European deep waters, in addition, there is now a need to establish monitoring tools to evaluate the effectiveness of closed areas for the conservation of biodiversity and fish and their impact on fisheries. Currently the tools necessary to achieve these management goals are wholly lacking. CoralFISH aims to support the implementation of an ecosystem-based management approach in the deep-sea by studying the interaction between cold-water coral habitat, fish and fisheries. CoralFISH brings together a unique consortium of deep-sea fisheries biologists, ecosystem researchers/modellers, economists and a fishing industry SME, who will collaborate to collect data from key European marine eco-regions.

CoralFISH aims to:

- develop essential methodologies and indicators for baseline and subsequent monitoring of closed areas;
- integrate fish into coral ecosystem models to better understand coral fish-carrying capacity;
- evaluate the distribution of deepwater bottom fishing effort to identify areas of potential interaction and impact upon coral habitat;
- use genetic fingerprinting to assess the potential erosion of genetic fitness of corals due to long-term exposure to fishing impacts;
- construct bio-economic models to assess management effects on corals and fisheries to provide policy options;
- produce habitat suitability maps both regionally and for OSPAR Region V to identify areas likely to contain vulnerable habitat. The latter will provide the EU with the tools to address the issues raised by the UNGA resolution.

New data acquisition is an important goal of CoralFISH. This process can be divided into three parts in the project:

- improved mapping of coral habitat in each of six regional study areas;
- coordinated surveys in each of these regions to investigate the interaction of fish with coral habitat using the same methodologies, i.e. acoustic fisheries survey, commercial long-lining and finally detailed *in situ* observation with Remotely Operated Vehicles or submersibles or towed video apparatus;
- detailed temporal observations of both fish and coral and their response to changing environmental forcing using 'state of the art' instrumented lander systems provided by NIOZ and UNIABDN.

The lander work will be carried out in three known coral locations in Norway, off the west coast of Ireland and in the Ionian Sea, and will provide a wide variation in ambient environmental conditions and will feed into WP 5 - ecosystem modelling. Coral by-catch caught on long-lines will be preserved, identified and sent to partners carrying out genetic studies in WP4. Information generated in WP 5 will be used to constrain habitat suitability models to enable better prediction of the likely occurrence of vulnerable habitat (corals) in WP6 and WP7. All of this information together with evaluation of deep-water bottom fisheries (WP2) will inform the development of bio-economic models (WP8) that will be used to assess the impact of management measures to protect coral habitat from fisheries.

Eco2 - Sub-seabed CO2 Storage: Impact on Marine Ecosystems

Summary information

Funding source:	FP7
EC contribution:	10.500.000 €
Duration:	48 months

Project Partners

1	Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
2	Plymouth Marine Laboratory – United Kingdom
3	Norsk Institutt For Vannforskning - Norway
4	Natural Environment Research Council - United Kingdom
5	University of Bergen - Norway
6	Max Planck Gesellschaft zur Foerderung der Wissenschaften - Germany
7	Christian-Albrechts-Universitaet zu Kiel - Germany
8	University of Tromsø - Norway
9	Konsortium Deutsche Meeresforschung - Germany
10	Alfred-Wegener Institute for Polar and Marine Research - Germany
11	Institute for Baltic Sea Research Warnemünde - Germany
12	Universita degli Studi di Roma la Sapienza - Italy
13	National Institute of Oceanography and Experimental Geophysics - Italy
14	University of Stuttgart - Germany
15	Statoil Petroleum AS - Norway
16	Det Norske Veritas AS - Norway
17	University of Southampton - United Kingdom
18	Institut fur Weltwirtschaft – Germany
19	University of Edinburgh – United Kingdom
20	University of Gent - Belgium
21	Heriot-Watt University - United Kingdom
22	Göteborg University - Sweden
23	Nederlandse Organisatie voor toegepast natuurwetenschappelijk onderzoek - Netherlands
24	Stichting Energieonderzoek Centrum Nederland - Netherlands
25	French Research Institute for Exploitation of the Sea - France
26	University of Gdansk - Poland
27	Grupa Lotos - Poland

Background information

Project Summary

The ECO2 project sets out to assess the risks associated with the storage of CO_2 below the seabed. Carbon Capture and Storage (CCS) is regarded as a key technology for the reduction of CO_2 emissions from power plants and other sources at the European and international level. The EU will hence support a selected portfolio of demonstration projects to promote, at industrial scale, the implementation of CCS in Europe. Several of these projects aim to store CO_2 below the seabed. However, little is known about the short-term and long-term impacts of CO_2 storage on marine ecosystems even though CO_2 has been stored sub-seabed in the North Sea (Sleipner) for over 13 years and for one year in the Barents Sea (Snøhvit). Against this background,

the proposed ECO2 project will assess the likelihood of leakage and impact of leakage on marine ecosystems. In order to do so ECO2 will study a sub-seabed storage site in operation since 1996 (Sleipner, 90 m water depth), a recently opened site (Snøhvit, 2008, 330 m water depth), and a potential storage site located in the Polish sector of the Baltic Sea (B3 field site, 80 m water depth) covering the major geological settings to be used for the storage of CO_2. Novel monitoring techniques will be applied to detect and quantify the fluxes of formation fluids, natural gas, and CO_2 from storage sites and to develop appropriate and effective monitoring strategies. Field work at storage sites will be supported by modelling and laboratory experiments and complemented by process and monitoring studies at natural CO_2 seeps that serve as analogues for potential CO_2 leaks at storage sites. ECO2 will also investigate the perception of marine CCS in the public and develop effective means to disseminate the project results to stakeholders and policymakers. Finally, a best practice guide for the management of sub-seabed CO_2 storage sites will be developed applying the precautionary principle and valuing the costs for monitoring and remediation

EnviroGRIDS - Building Capacity for a Black Sea Catchment Observation and Assessment System supporting Sustainable Development

Summary information

Funding source:	FP7 - Collaborative Research Project-SICA
Total Cost:	€ 7.900.000
EC contribution:	€ 6.220.000
Start – end date:	1/04/2009 – 31/03/2013
Duration:	48 months
Project Coordinator:	Anthony Lehmann (anthony.lehmann@unige.ch)
Organisation:	University of Geneva – Switzerland
CLAMER regional focus:	Black Sea

Project Website:
http://www.envirogrids.net/

Project Partners

1 University of Geneva - Switzerland
2 arx iT Consulting - Switzerland
3 Melitopol State Pedagogical University and Azov-Black Sea Ornithological Station - Ukraine
4 International Commission for the Protection of the Danube River - Austria
5 Black Sea Regional Energy Centre - Bulgaria
6 Ceske Centrum pro Vedu a Spolecnost – Czech Republic
7 European Organization for Nuclear Research - Switzerland
8 Center for Advanced Studies, Research and Development in Sardinia - Italy
9 Institutul National de Cercetare – Dezvoltare Delta Dunarii Tulcea - Romania
10 Danube Hydrometeorological Observatory - Ukraine
11 Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz - Switzerland
12 GIS & RS Consulting Center GeoGraphic Limited - Georgia
13 Institute of Biology of the Southern Seas - Ukraine
14 Institute of Geography - Romanian Academy - Romania
15 UNESCO-IHE Institute for Water Education - Netherlands
16 Permanent Secretariat of the Commission on the Protection of the Black Sea against Pollution - Turkey
17 Istanbul Technical University - Turkey
18 National Institute of Hydrology and Water Management - Romania
19 Odessa National University - Ukraine
20 St. Petersburg State University – Russian Federation
21 V.I. Vernadsky Taurida National University - Ukraine
22 Universitat Autonoma de Barcelona - Spain
23 National Institute of Meteorology and Hydrology - Bulgaria
24 Ukrainian Scientific and Research Institute of Ecological Problems - Ukraine
25 Technical University of Cluj-Napoca - Romania
26 VITUKI, Enviromental Protection and Water Management Research Institute – Hungary
27 ANTEA Group – Belgium
28 Central European University - Hungary

29 Ministry of Environment and Forestry - Turkey
30 University of Malaga - Spain

Background information

Project Summary

The Black Sea Basin is internationally recognized for its ecologically unsustainable development and inadequate resource management leading to severe environmental, social and economical problems. EnviroGRIDS aims at developing a Black Sea Basin Observation System that will store, analyze, visualize and disseminate information on past, present and future states of the region to assess and predict its sustainability and vulnerability. A gap analysis will identify specific areas where most efforts are needed. As climatic and hydrological changes are of concern, their impacts on several societal benefits areas of the Group on Earth Observation will be evaluated, namely on environment and health, energy, water, ecosystems, agriculture, biodiversity and environmental risks. EnviroGRIDS will rely on ultra-modern technology using the largest gridded computing infrastructure in the world. It will serve as a benchmark for the development of the European directive on Infrastructure for Spatial Information and for the Global Earth Observation System of Systems. Spatially-explicit scenarios of drivers of changes such as climate, demography and land cover will be created. EnviroGRIDS will be validated through several thematic implementations within the Black Sea basin. Finally, a web-based observation system including attractive visualisation tools will warn target populations about environmental risks and help regional/governmental agencies to prepare the most adequate responses. Capacity building will be based on a networking platform supported by state-of-theart e-learning courses on the internet and on DVD. The aim is to raise public and decision makers' awareness on key environmental issues and observation system technologies by organizing live and virtual trainings. Through the combination of all these activities, EnviroGRIDS will improve data access and use in the Black Sea basin, and build regional capacity on Observation Systems to favour its sustainable development.

EPOCA - European Project on Ocean Acidification

Summary information

Funding source:	FP7 - Collaborative Research Project - Large-scale Integrating Project
Total Cost:	€ 9.750.000
EC contribution:	€ 6.550.000
Start – end date:	1/05/2008 – 30/04/2012
Duration:	48 months
Project Coordinator:	Jean-Pierre Gattuso (gattuso@obs-vlfr.fr)
Organisation:	National Council for Scientific Research – France
CLAMER thematic focus:	Ocean acidification; biological impacts; socio-economic consequences

Project Website:
http://epoca-project.eu

Project Partners

1	National Council for Scientific Research – France
1.1	Laboratoire d'Oceanographie de Villefranche - France
1.2	Centre Europeen de Recherche et d'Enseignement des Geosciences de l'Environnement CEREGE - France
1.3	Station Biologique de Roscoff - France
2	University of Bergen - Norway
3	Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
4	Natural Environment Research Council - United Kingdom
5	Alfred Wegener Institute for Polar and Marine Research - Germany
6	The Chancellor, Masters and Scholars of the University of Cambridge of the Old Schools UCAM - United Kingdom
7	Commissariat a l'Energie Atomique - France
8	Plymouth Marine Laboratory - United Kingdom
9	Scottish Association for Marine Science - United Kingdom
10	Max-Planck-Gesellschaft zur Forderung der Wissenschaften E.V - Germany
11	Marine Biological Association of the United Kingdom - United Kingdom
12	Göteborg University - Sweden
13	Royal Netherlands Institute for Sea Research - Netherlands
14	Universiteit Utrecht - The Netherlands
15	Netherlands Institute of Ecology, KNAW - The Netherlands
16	Sir Alister Hardy Foundation for Ocean Science - United Kingdom
17	Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH - Germany
18	University of Bern - Switzerland
19	Universite Libre de Bruxelles - Belgium
20	Philippe Saugier International Educational Projects - France
21	Vereniging voor Christelijk Hoger Onderwijs Wetenschappelijk Onderzoek en Patientenzorg - Netherlands
22	Eidgenoessische Technische Hochschule Zuerich - Switzerland
23	Hafrannsoknastofnunin, Marine Research Institute - Iceland
24	University of Southampton, SOTON-SOES - United Kingdom

25 University of Plymouth Higher Education Corporation - United Kingdom
26 UNESCO Intergovernmental Oceanographic Commission - France
27 University of Bristol, UNIVBRIS - United Kingdom

Background information

Project Summary

Since the beginning of the industrial revolution, about one third of the CO_2 released in the atmosphere by anthropogenic activities has been absorbed by the world's oceans, which play a key role in moderating climate change. As CO_2 reacts with seawater, it generates dramatic changes in carbonate chemistry, including decreases in pH and in the concentration of carbonate ions. The impacts of this phenomenon, known as "ocean acidification", on marine ecosystems are only poorly known. One of the most likely consequences is the slower growth of organisms forming calcareous skeletons or shells, such as corals and mollusks. More information on the effects of ocean acidification is a major environmental priority because of the threat it poses to certain processes, organisms and ecosystems.

The overall goal of EPOCA is to fill numerous gaps in the understanding of the consequences of ocean acidification.

EPOCA aims to document the changes in ocean chemistry and geographical distribution of marine organisms across space and time. Paleo-reconstruction methods will be used on several archives, including foraminifera and deep-sea corals, to determine the past variability in ocean chemistry (carbonate, nutrients and trace metals) and to tie these to present-day chemical and biological observations.

EPOCA devotes much effort to quantifying the impact of ocean acidification on marine organisms and ecosystems. Key climate-relevant biogeochemical processes such as calcification, primary production and nitrogen fixation are investigated using a large array of techniques, ranging from molecular tools to physiological and ecological approaches. Perturbation experiments are carried out both in the laboratory and in the field. Key organisms have been selected on the basis of their ecological, biogeochemical or socio-economic importance.

The modelling component of EPOCA integrates the chemical, biological and biogeochemical impacts of ocean acidification into biogeochemical, sediment and coupled ocean-climate models. Special attention will be paid to feedbacks of physiological changes on the carbon, nitrogen, sulfur and iron cycles and in turn how these changes will affect and be affected by future climate change.
EPOCA assesses uncertainties, risks and thresholds ("tipping points") related to ocean acidification at molecular, cellular, organismal, local and global scales. It also assesses pathways of CO_2 emissions required to avoid the identified thresholds and describes the state change if these emissions are exceeded and the subsequent risk to the marine environment and Earth system.

Expected results

- Improve the understanding of the past and present spatio-temporal changes of ocean acidification due to increasing CO_2 uptake.
- Determine the impacts of ocean acidification on marine biota, their physiology, ecosystems, the potential for acclimation and adaptation, impacts on elemental cycling and production of climate-relevant gases.
- Improve understanding of future changes in ocean chemistry and biogeochemical feedbacks in terms of hotspots, uncertainties, and thresholds. Improve the description of the carbon cycle in coupled ocean-climate models. The key element cycles investigated are carbon, nitrogen, sulfur and iron.

- Synthesize information on tipping points. This ambitious mission relies on combining the strong EPOCA consortium of 27 partners and more than 160 leading European scientists, and their field and laboratory resources. EPOCA coordinates with major national and international projects and programmes.

EURO-BASIN - European Union Basin-scale Analysis, Synthesis and Integration

Summary information

Funding source:	FP7 – Large-scale integrating project
Total Cost:	€9.65 million
EC contribution:	€7 million
Start – end date:	31/12/2010 – 31/12/2014
Duration:	48 months
Project coord. group:	Michael St. John (michael.st.john@uni-hamburg.de), Ivo Grigorov (euro-basin@aqua.dtu.dk) and Ole Henrik Haslund (ohh@aqua.dtu.dk)
Organisation:	Technical University of Denmark – Denmark
CLAMER thematic focus:	Ecosystem changes
CLAMER regional focus:	North Atlantic
Project keywards:	Climate and anthropogenic forcing; ecosystem; key species; biological carbon pump; ecosystem based management

Project Website:
http://www.euro-basin.eu/

Project Partners

1 Technical University of Denmark, National Institute of Aquatic Resources – Denmark
2 University of Bremen - Germany
3 University of Hamburg - Germany
4 Fundacion AZTI/AZTI Fundazioa - Spain
5 Natural Environment Research Council - United Kingdom
6 Marine Research Institute - Iceland
7 Morski Instytut Rybacki w Gdyni - Poland
8 Plymouth Marine Laboratory - United Kingdom
9 University of East Anglia - United Kingdom
10 Aarhus University - Denmark
11 Institute of Marine Research - Norway
12 French Research Institute for Exploitation of the Sea - France
13 Sir Alister Hardy Foundation for Ocean Science - United Kingdom
14 Institut de Recherche pour le Developpement - France
15 National Council for Scientific Research - France
16 University of Strathclyde – United Kingdom
17 The Secretary of State for Environment, Food and Rural Affairs - United Kingdom
18 Bodø University College - Norway
19 Uni Research AS - Norway
20 Spanish Institute of Oceanography - Spain
21 Collecte Localisation Satellites - France
22 Swansea University - United Kingdom
23 Middle East Technical University – Turkey
24 Université Pierre et Marie Curie - France

Background information

Project Summary

EURO-BASIN is designed to advance our understanding on the variability, potential impacts, and feedbacks of global change and anthropogenic forcing on the structure, function and dynamics of the North Atlantic and associated shelf sea ecosystems as well as the key species influencing carbon sequestering and ecosystem functioning. The ultimate goal of the program is to further our capacity to manage these systems in a sustainable manner following the ecosystem approach. Given the scope and the international significance, EURO-BASIN is part of a multidisciplinary international effort linked with similar activities in the US and Canada. EURO-BASIN focuses on a number of key groups characterizing food web types, e.g. diatoms versus microbial loop players; key species copepods of the genus Calanus; pelagic fish, herring (*Clupea harengus*), mackerel (*Scomber scombrus*), blue whiting (*Micromesistius poutassou*) which represent some of the largest fish stocks on the planet; piscivorous pelagic bluefin tuna (*Thunnus thynnus*) and albacore (*Thunnus alalunga*) all of which serve to structure the ecosystem and thereby influence the flux of carbon from the euphotic zone via the biological carbon pump. In order to establish relationships between these key players, the project identifies and accesses relevant international databases and develops methods to integrate long term observations. These data will be used to perform retrospective analyses on ecosystem and key species/group dynamics, which are augmented by new data from laboratory experiments, mesocosm studies and field programs. These activities serve to advance modelling and predictive capacities based on an ensemble approach where modelling approaches such as size spectrum; mass balance; coupled NPZD; fisheries; and “end to end” models and as well as ecosystem indicators are combined to develop understanding of the past, present and future dynamics of North Atlantic and shelf sea ecosystems and their living marine resources.

Project objectives
The overarching objectives of the EURO-BASIN initiative are to understand and predict the population structure and dynamics of key plankton and fish species of the North Atlantic and shelf seas, and assess the impacts of climate variability on North Atlantic marine ecosystems and their goods and services.

EuroSITES - Integration and enhancement of key existing European deep-ocean observatories

Summary information

Funding source:	FP7 - Collaborative Research Project - Small or Mediumscale Focused Research
Total Cost:	€ 4.750.000
EC contribution:	€ 3.480.000
Start – end date:	1/04/2008 – 31/03/2011
Duration:	36 months
Project Coordinator:	Richard Lampitt (rsl@noc.soton.ac.uk)
Organisation:	Natural Environment Research Council, Swindon Wilthshire - United Kingdom
CLAMER thematic focus:	Abiotic changes; biological impacts; temperature changes; ocean current changes; deep circulation changes
CLAMER Regional focus:	Arctic; North Atlantic; Mediterranean Sea
Project Keywords:	Open ocean observatories; biological, physical and chemical recordings

Project Website:
http://www.eurosites.info/

Project Partners

1 Natural Environment Research Council – United Kingdom
2 University of Bergen - Norway
3 Hellenic Centre for Marine Research - Greece
4 National Institute of Oceanography and Experimental Geophysics - Italy
5 National Research Council - Italy
6 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
7 University Court of The University of Aberdeen - United Kingdom
8 National Council for Scientific Research - France
9 French Research Institute for Exploitation of the Sea - France
10 SOPAB Brest - France
11 Instituto Canario de Ciencias Marinas - Spain
12 Instituto Nacional de Desenvolvimento das Pescas – Cabo Verde
13 Universidad de Las Palmas de Gran Canaria - Spain

Background information

Project Summary

Abstract
At present there are a number of fixed point observatories that autonomously measure biological, chemical and physical variables in the oceans around Europe. These operate at various levels of sophistication but in a largely uncoordinated and fragmented manner. There is no agreed set of basic variables and common data protocols are not followed.

EuroSITES has two main objectives:

- To enhance the existing deep ocean observatories thus forming a coherent European network. This will then provide a clear and relevant description of the time varying properties of the ocean system.
- To perform a small number of specific science missions that will, in the future, form the basis for greatly improved and novel monitoring capability.

The work we propose addresses directly and explicitly the vision of GEOSS. We will address this in the context of the time changing properties of the ocean interior, seafloor and sub seafloor around Europe.
EuroSITES will promote links with other international observation networks such as the network envisioned under the U.S. National Science Foundation's Ocean Observatories Initiative (OOI).

Long-term time-series data offer some of the most important insights into the ways our oceans are changing. Crucially important processes occur on time scales that can not be observed by ships and in the deep parts of the ocean that are outside the reach of satellites. Sustained *in situ* observations are therefore required to provide high quality data on climatically and ecologically relevant variables at a few key locations. EuroSITES is the means to achieve this.

HERMIONE - Hotspot ecosystem research and Man's impact on European seas

Summary information

Funding source:	FP7 - Collaborative Research Project - Large-scale Integrating Project
Total Cost:	€ 10.880.000
EC contribution:	€ 8.000.000
Start – end date:	1/04/2009 – 31/03/2012
Duration:	36 months
Project Coordinator:	Philip P.E. Weaver (ppew@noc.soton.ac.uk)
Organisation:	Natural Environment Research Council, Swindon Wilthshire - United Kingdom
CLAMER thematic focus:	Deep circulation changes; abiotic changes; biological impacts; socio-economic consequences
CLAMER Regional focus:	Arctic; North Atlantic; Mediterranean Sea
Project Keywords:	Deep marine ecosystems and their environment; biodiversity; human impact; climate change; ecosystem goods and services; fishing activities; seabed installations; pollution; cold-water corals; canyons; cold and hot seeps; seamounts; open slopes/basins

Project Website:
http://www.eu-hermione.net/

Project Partners

1 Natural Environment Research Council – United Kingdom
2 French Research Institute for Exploitation of the Sea - France
3 Royal Netherlands Institute for Sea Research - Netherlands
4 University of Barcelona - Spain
5 Hellenic Centre for Marine Research - Greece
6 Leibniz-Institut für Meereswissenschaften - Germany
7 National Research Council - Italy
8 Alfred Wegener Institute for Polar and Marine Research - Germany
9 University of Tromsø - Norway
10 National University of Ireland - Ireland
11 Friedrich-Alexander Universitaet Erlangen-Nuremberg - Germany
12 University of Gent - Belgium
13 Spanish National Research Council - Spain
14 National Interuniversity Consortium for Marine Sciences – Italy
15 Max-Planck-Gesellschaft zur Forderung der Wissenschaften E. V. - Germany
16 National Council for Scientific Research – France
17 Instituto Hidrografico - Portugal
18 Jacobs University Bremen GmbH - Germany
19 University of Bremen – Germany
20 Cardiff University – United Kingdom
21 Institute of Marine Research - Norway

22 Göteborg University – Sweden
23 University of Southampton - United Kingdom
24 Royal Netherlands Academy of Arts and Sciences - Netherlands
25 University Court of the University of Aberdeen - United Kingdom
26 University of Liverpool - United Kingdom
27 Scottish Association for Marine Science - United Kingdom
28 Universidade de Aveiro - Portugal
29 Université Pierre et Marie Curie – France
30 P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences – Russian Federation
31 United Nations Environment Programme - World Conservation Monitoring Centre – United Kingdom
32 Universidade dos Açores - Portugal
33 MEDIAN SCP - Spain
34 ArchimediX, Möckl & Munzel Gesellschaft bürgerlichen Rechts (GbR) - Germany
35 University of Thessaly - Greece
36 University College Cork - Ireland
37 National Marine Aquarium - United Kingdom
38 Costa Edutainment S.P.A. - Acquario di Genova - Italy

Background information

Project Summary

The HERMIONE project is designed to make a major advance in our knowledge of the functioning of deep-sea ecosystems and their contribution to the production of goods and services. This will be achieved through a highly interdisciplinary approach (including biologists, ecologists, microbiologists, biogeochemists, sedimentologists, physical oceanographers, modelers and socio-economists) that will integrate biodiversity, specific adaptions and biological capacity in the context of a wide range of highly vulnerable deep-sea habitats. Gaining this understanding is crucial, because these ecosystems are now being affected by climate change and impacted by man through fishing, resource extraction, seabed installations and pollution. To design and implement effective governance strategies and management plans we must understand the extent, natural dynamics and interconnection of ocean ecosystems and integrate socio-economic research with natural science. The study sites include the Arctic, North Atlantic and Mediterranean and cover a range of ecosystems including cold-water corals, canyons, cold and hot seeps, seamounts and open slopes and deep-basins. The project will make strong connections between deep-sea science and user needs. HERMIONE will enhance the education and public perception of the deep-ocean issues also through some of the major EU aquaria. These actions, together with GEOSS databases that will be made available, will create a platform for discussion between a range of stakeholders, and contribute to EU environmental policies.

HYPOX - In situ monitoring of oxygen depletion in hypoxic ecosystems of coastal and open seas, and land-locked water bodies

Summary information

Funding source:	FP7 - Collaborative Research Project – Small or Mediumscale Focused Research
Total Cost:	€ 4.670.000
EC contribution:	€ 3.500.000
Start – end date:	1/04/2009 – 31/03/2012
Duration:	36 months
Project Coordinator:	Antje Boetius (aboetius@mpi-bremen.de)
Organisation:	Max Planck Society for the Advancement of Science, Max Planck Institute for Marine Microbiology – Germany
CLAMER thematic focus:	Oxygen depletion; eutrophication; temperature changes; stratification; deep-water circulation changes; biological impacts; ecosystem functions and services; socio-economic consequences
CLAMER Regional focus:	Mediterranean Sea; North Atlantic; Baltic Sea; Arctic; Black Sea
Project Keywords:	Monitoring; observatory, oxygen depletion; hypoxia causes and consequences, aquatic ecosystems; open and coastal seas, land-locked water bodies, eutrophication; climate change; global warming; degassing of oxygen; stratification; deep-water circulation; changes in wind patterns; biodiversity; biogeochemistry, modeling and assimilation, ecosystem functions and services

Project Website:
http://www.hypox.net/

Project Partners

1 Max Planck Society for the Advancement of Science, Max Planck Institute for Marine Microbiology - Germany
2 Alfred Wegener Institute for Polar and Marine Research - Germany
3 Swiss Federal Institute of Aquatic Science and Technology - Switzerland
4 Institute of Biology of the Southern Seas - Ukraine
5 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
6 French Research Institute for Exploitation of the Sea - France
7 National Institute of Geophysics and Volcanology - Italy
8 Leibnitz Institute for Baltic Sea Research - Germany
9 Istanbul Technical University, Eastern Mediterranean Centre for Oceanography and Limnology - Turkey
10 University of Bremen, Center for Marine Environmental Sciences- Germany
11 Scottish Association for Marine Science – United Kingdom
12 Göteborg University - Sweden
13 University of Patras - Greece
14 Helmholtz Centre Geesthacht, Institute of Coastal Research - Germany
15 The National Institute of Marine Geology and Geo-ecology of Romania - Romania
16 Centre for Estuarine and Marine Ecology, KNAW - Netherlands

Associated partners

- Norwegian Institute for Water Research - Norway
- Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin - Germany
- Alternative Energies and Atomic Energy Commission, Climate and Environment Sciences Laboratory - France
- University of Liège, Mare Interfacultary Research Centre - Belgium

Background information

Project Summary

Hypoxic (low oxygen) conditions in aquatic ecosystems increase in number, duration and extent due to global warming and eutrophication. Global warming will lead to degassing of oxygen, increased stratification, reduced deep-water circulation and changes in wind patterns affecting transport and mixing. Projected increases in hypoxia (e.g. exponential growth of "dead zones") are accompanied by enhanced emission of greenhouse gases, losses in biodiversity, ecosystem functions and services such as fisheries, aquaculture and tourism.

A better understanding of global changes in oxygen depletion requires a global observation system continuously monitoring oxygen at high resolution, including assessment of the role of the seafloor in controlling the sensitivity of aquatic systems to and recovery from hypoxia. HYPOX aims to monitor oxygen depletion and associated processes in aquatic systems that differ in oxygen status or sensitivity towards change:

- open ocean, oxic with high sensitivity to global warming (Arctic),
- semi-enclosed with permanent anoxia (Black Sea, Baltic Sea) and
- seasonally or locally anoxic land-locked systems (fjords, lagoons, lakes) subject to eutrophication.

HYPOX improves the capacity to monitor oxygen depletion globally, by implementing reliable long-term sensors to different platforms for *in situ* monitoring; and locally by training and implementing competence around the Black Sea.

HYPOX contributes to GEOSS tasks in the water, climate, ecosystem and biodiversity work plans, and complies to GEOSS standards by sharing of observations and products with common standards and adaptation to user needs using a state of the art world data centre. HYPOX is connected to the GOOS Regional Alliances and the SCOR working group and disseminates knowledge to local, regional and global organisations concerned with water and ecosystem health and management.

Ice2sea - Estimating the future contribution of continental ice to sea-level rise

Summary information

Funding source:	FP7 - Collaborative Research Project - Large-scale Integrating Project
Total Cost:	€ 1.3630.000
EC contribution:	€ 9.990.000
Start – end date:	1/03/2009 – 31/05/2013
Duration:	51 months
Project Coordinator:	David Glyn Vaughan (d.vaughan@bas.ac.uk)
Organisation:	Natural Environment Research Council, Swindon Wilthshire - United Kingdom
CLAMER thematic focus:	Sea level rise
CLAMER regional focus:	Arctic

Project Website:
http://www.ice2sea.eu/

Project Partners

1 Natural Environment Research Council - United Kingdom
2 Alfred Wegener Institute for Polar and Marine Research - Germany
3 CSC - Tieteelinen Laskenta Oy - Finland
4 Danish Meteorological Institute - Denmark
5 DTU-Space, Technical University of Denmark - Denmark
6 Geological Survey of Denmark and Greenland - Denmark
7 Institute of Earth Sciences, University of Iceland - Iceland
8 Utrecht University - Netherlands
9 National Council for Scientific Research - France
10 Met Office - United Kingdom
11 University of Oslo - Norway
12 Université Libre de Bruxelles - Belgium
13 Universita' degli Studi di Urbino – Italy
14 University of Bristol - United Kingdom
15 University of Edinburgh - United Kingdom
16 Vrije Universiteit Brussel - Belgium
17 University of Copenhagen, Niels Bohr Institute - Denmark
18 University of Liège - Belgium
19 University of Zurich - Zwitzerland
20 University of Silesia - Poland
21 Centro de Estudios Científicos - Chile
22 Ente per le Nuove tecnologie, l'Energia e l'Ambiente - Italy
23 Norwegian Polar Institute - Norway

Background information

Project Summary

The melting of continental ice (glaciers, ice caps and ice sheets) is a substantial source of current sea-level rise, and one that is accelerating more rapidly than was predicted even a few years ago. Indeed, the most recent report from Intergovernmental Panel on Climate Change highlighted that the uncertainty in projections of future sea-level rise is dominated by uncertainty concerning continental ice, and that understanding of the key processes that will lead to loss of continental ice must be improved before reliable projections of sea-level rise can be produced. The ice2sea programme will draw together European and international partners, to reduce these uncertainties. We will undertake targeted studies of key processes in mountain glacier systems and ice caps (e.g. Svalbard), and in ice sheets in both polar regions (Greenland and Antarctica) to improve understanding of how these systems will respond to future climate change. We will improve satellite determinations of continental ice mass, and provide much-needed datasets for testing glacier-response models. Using newly developed ice-sheet/glacier models, we will generate detailed projections of the contribution of continental ice to sea-level rise over the next 200 years, and identify thresholds that commit the planet to long-term sea-level rise. We will deliver these results in forms accessible to scientists, policy-makers and the general public, which will include clear presentations of the sources of uncertainty. The ice2sea programme will directly inform the ongoing international debate on climate-change mitigation, and European debates surrounding coastal adaptation and sea-defence planning. It will leave a legacy of improved understanding of key cryospheric processes affecting development of the Earth System and the predictive tools for glacier-response modelling, and it will train a new generation of young European researchers who can use those tools for the future benefit of society.

KnowSeas - Knowledge-based Sustainable Management for Europe's Seas

Summary information

Funding source:	FP7 - Collaborative Research Project - Large-scale Integrating Project
Total Cost:	€ 7.410.000
EC contribution:	€ 5.760.000
Start – end date:	1/04/2009 – 31/03/2013
Duration:	48 months
Project Coordinator:	Tim O'Higgins (knowseas-coordination@sams.ac.uk)
Organisation:	The Scottish Association for Marine Science, Dunbeg Oban - United Kingdom
CLAMER thematic focus:	Abiotic changes; biological impacts; socio-economic consequences
CLAMER Regional focus:	Black Sea; Mediterranean Sea; Baltic Sea; North Atlantic
Project Keywords:	Ecology; economics; governance and policy; Ecosystem Approach; sustainable development of Europe's regional seas; spatial planning, ecosystem goods and services; policy instruments; causes and consequences of ecosystem change (including climate change); costs and benefits; institutional and social aspects

Project Website:
http://www.knowseas.com/

Project Partners

1 The Scottish Association for Marine Science- United Kingdom
2 Alfred Wegener Institute for Polar and Marine Research - Germany
3 Stockholm University - Sweden
4 Secretary of State for Environment, Food & Rural Affairs acting through the Centre for Environment, Fisheries & Aquaculture Science - United Kingdom
5 National Research Council - Italy
7 Spanish National Research Council - Spain
8 Deltares - Netherlands
9 Envision Management Limited - United Kingdom
10 EUCC - Coastal & Marine Union - Netherlands
11 Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH- Germany
12 Institute for European Environmental Policy - United Kingdom
13 Instituto do Mar - Portugal
14 Institute of Oceanology, Bulgarian Academy of Sciences - Bulgaria
15 Royal Netherlands Academy of Arts and Sciences - Netherlands
16 University of Padua - Italy
17 Megapesca Lda - Portugal
18 Middle East Technical University - Turkey
19 Norsk Institutt for Luftforskning - Norway
20 Sir Alister Hardy Foundation for Ocean Science - United Kingdom
21 University of Plymouth- United Kingdom
22 University of Southern Denmark - Denmark
23 Morski Instytut Rybacki w Gdyni, Sea Fisheries Institute - Poland
24 Finnish Environment Institute - Finland

25 Université de Bretagne Occidentale - France
26 National University of Ireland, University College Cork - Ireland
27 University of East Anglia - United Kingdom
28 University of Bergen - Norway
29 Università Ca' Foscari di Venezia - Italy
30 University of Bath - United Kingdom
31 Vereniging voor christelijk hoger onderwijs, wetenschappelijk onderzoek en patiëntenzorg - Netherlands
32 University of Seville - Spain

Background information

Project Summary

Europe's four regional seas (Baltic, Black, Mediterranean and NE Atlantic) have suffered severe environmental degradation due to human pressure. Existing measures to manage pressures have proven inadequate and the EC has responded by proposing a new policy (Maritime Strategy Blue Book) and environmental legislation (Marine Strategy Framework Directive), both currently close to adoption. These instruments rely on the Ecosystem Approach, a management paradigm that encompasses humans and the supporting ecosystem. But the science base for this approach needs strengthening and practical tools must be developed and tested for policy implementation. In particular, criteria for assessing costs and benefits of management actions are poorly developed, particularly in the complex marine environment where multiple uses and management conflicts are common.

The KnowSeas consortium will strengthen the science base for managing Europe's seas through the practical application of systems thinking. It will work at the two scales envisaged for emergent EU policy: the Regional Sea Scale and Member State Economic Exclusive Zones (EEZs). We have developed a new approach of Decision Space Analysis to investigate mismatches of scale. Knowledge created through the FP6 European Lifestyles and Marine Ecosystems project, augmented with necessary new studies of climate effects, fisheries and maritime industries - in EEZ case studies - will provide a basis for assessing changes to natural systems and their human causes. New research will examine and model economic and social impacts of changes to ecosystem goods and services and costs and benefits of various management options available through existing and proposed policy instruments. Institutional and social analysis will determine conflicts of interest and examine governance as well as stakeholder values and perceptions. Our research will develop and test an assessment toolbox through regional liaison groups and a multisectoral Project Advisory Board.

The overall objective of the project is to provide a comprehensive scientific knowledge base and practical guidance for the application of the Ecosystem Approach to the sustainable development of Europe's regional seas. This will increase the evidence base available for decision makers and facilitate the practical implementation of the Ecosystem Approach, currently seen by some stakeholders as confusing and nebulous. It will be delivered through a series of specific sub-objectives that lead to a scientifically based suite of tools to assist policy makers and regulators with the practical application of the Ecosystem Approach. It is also expected to deliver high quality scientific outputs that advance our understanding of coupled social and ecological systems.

MEECE - Marine Ecosystem Evolution in a Changing Environment

Summary information

Funding source:	FP7 - Collaborative Research Project-SICA
Total Cost:	€ 8.670.000
EC contribution:	€ 6.500.000
Start – end date:	1/09/2008 – 31/08/2012
Duration:	48 months
Project Coordinator:	Julian Icarus Allen (JIA@pml.ac.uk)
Organisation:	Plymouth Marine Laboratory - United Kingdom
CLAMER thematic focus:	Ocean acidification; eutrophication; temperature changes; other abiotic changes; biological impacts; socio-economic consequences
CLAMER Regional focus:	Arctic; North Atlantic
Project Keywords:	Climate change impact modelling; plankton and fish; climate drivers (acidification, light, circulation and temperature); anthropogenic drivers (fishing, pollution, invasive species and eutrophication)

Project Website:
http://meece.eu/

Project Partners

1	Plymouth Marine Laboratory – United Kingdom
2	UNIFOB AS - Norway
3	University of Hamburg - Germany
4	Fundación AZTI - AZTI Fundazioa - Spain
5	Alma Mater Studiorum Università di Bologna Centro interdipartimentale per la ricerca sulle scienze ambientali - Italy
6	Wageningen IMARES B.V. - Netherlands
7	Secretary of State for Food, Environment, and Rural Affairs acting through the Centre for Environment, Fisheries and Aquaculture Science - United Kingdom
8	Natural Environment Research Council - United Kingdom
9	Institut de Recherche pour le Développement - France
10	Technical University of Denmark, Danish Institute for Fisheries Research - Denmark
11	Institute of Marine Research - Norway
12	Institute of Marine Sciences, Middle East Technical University - Turkey
13	Hellenic Centre for Marine Research - Greece
14	National Council for Scientific Research - France
15	Sir Alister Hardy Foundation for Ocean Science – United Kingdom
16	Università del Piemonte Orientale, DiSAV - Italy
17	Klaipeda University - Lithuania
18	Bolding & Burchard Hydrodynamics - Denmark
19	Instituto Español de Oceanografía - Spain
20	Commissariat à l'Energie Atomique - France

Background information

Project Summary

MEECE is a scientific research project which aims to use a combination of data synthesis, numerical simulation and targeted experimentation to further our knowledge of how marine ecosystems will respond to combinations of multiple climate change and anthropogenic drivers, in a holistic manner, rather than driver by driver as has been done in the past. MEECE will explore the impacts of both climate drivers (acidification, light, circulation and temperature) and anthropogenic drivers (fishing, pollution, invasive species and eutrophication).

With an emphasis on the European Marine Strategy (EMS), MEECE will improve the decision support tools to provide a structured link between management questions and the knowledge base that can help to address those questions. A strong knowledge transfer element will provide an effective means of communication between end-users and scientists. MEECE will also go a step further and provide methodologies to evaluate these new decision-making and management tools.

MEECE obectives are to:

- Review the impacts of the drivers on the marine ecosystem.
- Scenario-test the impacts of drivers on the structure and functioning of marine ecosystems.
- Develop indicators of ecosystem status.
- Develop a coupled model system to predict ecosystem response from plankton to fish.
- Create a model library of ecosystem modules couplers and decision support tools for management concerning the EC Marine Strategy, EC Maritime Policy and the EC Common Fisheries.

MICORE - Morphological Impacts and Coastal Risks induced by Extreme storm events

Summary information

Funding source:	FP7 - Collaborative Research Project – Small or Mediumscale Focused Research
Total Cost:	€ 4.600.000
EC contribution:	€ 3.500.000
Start – end date:	1/06/2008 – 31/05/2011
Duration:	36 months
Project Coordinator:	Paolo Ciavola (cvp@unife.it)
Organisation:	Universita Degli Studi di Ferrara – Italy
CLAMER thematic focus:	Storm frequency and intensity; erosion; socio-economic consequences
CLAMER Regional focus:	North Atlantic; Baltic Sea; Mediterranean Sea; North Sea; Black Sea
Project Keywords:	Marine storms; disaster reduction; storm impact indicators

Project Website:
https://www.micore.eu/

Project Partners

1 Consorzio Ferrara Ricerche - Italy
2 Agenzia Regione Emilia Romagna Prevenzione e Ambiente - Italy
3 Regione Emilia Romagna - Servizio Geologico, Sismico e dei Suoli - Italy
4 University of Algarve - Portugal
5 Fundação da Faculdade de Ciências da Universidade de Lisboa - Portugal
6 Universidad de Cadiz - Spain
7 BRGM - France
8 International Marine and Dredging Consultance - Belgium
9 University of Plymouth - United Kingdom
10 Uniwersytet Szczecinski - Poland
11 Institute of Oceanology - Bulgarian Academy of Sciences - Bulgaria
12 Stichting Waterloopkundig Laboratorium - Netherlands
13 Delft University of Technology - Netherlands
14 Natural environment Research Council - Proudman Oceanographic Laboratory - United Kingdom

Background information

Project Summary

Both the EU and The United Nations are now taking seriously the predicted climate change scenarios of the IPCC. Of particular relevance to Integrated Coastal Zone Management is the predicted increase in the intensity and frequency of powerful storm events characterised by larger peak wind speeds and consequently larger waves. Therefore, the MICORE project will provide the knowledge necessary to assess the present day risks and to study the economic and social impact of future severe storm events. The project will also develop operational predictive tools in support of emergency response to storm events. Together, these elements will have an important strategic impact on the safety of the people living in coastal areas. The project will also

investigate with stakeholders and end-users the possibilities of producing EU-wide guidelines for a viable and reliable risk mitigation strategy. MICORE will produce an up-to-date database for each partner country that will include: an historical review of storms; an inventory of data related to the forcing signals; quantification of the morphological response of coastal systems to storms and to sequences of storms; an assessment of socio-economic impact; a description of existing civil protection schemes and interventions.

The specific objectives of the MICORE project are:

1. To undertake a review of historical marine storms that had a significant impact on a representative number of sensitive European regional coastlines. The diverse range of coastal regions of the European Union is selected according to wave exposure, tidal regime and socio-economical pressures. They include outmost regions of the European Union at the border with surrounding states (e.g. the area of the Gibraltar Strait, the Baltic and Black Sea), as well as coastlines bordering open ocean and semi-enclosed shelf seas.

2. To collate data related to occurrence of significant extreme events and socio-economic impacts in a database. Parameters will include:
    - characteristics of the storms: wind and wave measurements, wave hindcasts, tide measurements, surge computations;
    - morphological impacts including pre- and post-storm beach profiles, presence of dune overwashing/overtopping, damage to coastal structures;
    - socio-economic impact including cost of reconstruction, loss of lives and property, dune reconstruction and beach replenishment;
    - civil protection schemes, implementation of warning systems and preparation of hazard and vulnerability maps;
    - competent authorities and statutory bodies and voluntary organisations for warnings

3. To undertake monitoring of nine European case study sites for a period of 1 year with the following aims:
    - to collect new data sets of bathymetry and topography using state-of-the-art technology (Lidar, ARGUS, Radar, DGPS); to simultaneously measure the forcing agents (wind and waves, tides, surges) that trigger the events;
    - to map the impact of the storms on living and non-living resources using portable GIS methods.

4. To test and develop reliable methods for numerical modelling of storm-induced morphological changes for the following purposes:
    - to test the predictive capability of wave and surge hindcast models routinely used by end users in each region of interest;
    - to link morphological models with wave hindcast models;
    - to evaluate the accuracy of off-the-shelf morphological models for prediction of extreme erosion hot-spots;
    - to test and develop a new open-source morphological model for the prediction of storm impacts.

5. To set-up real-time warning systems and to implement their use within Civil Protection agencies with the aim of:
    - linking morphological models with wave hindcast models;
    - preparing early warning protocols;
    - developing an expert system in support of long-term disaster reduction including timely disaster relief operations.

6. To disseminate results to end users at national, European and International levels through:
    - a series of non-technical workshops;
    - production of a multilanguage report;
    - production of a storm impact video-clips;
    - implementation of an interactive website with Web-GIS technology.

Past4Future - Climate change – Learning from the past climate

Summary information

Funding source:	FP7 - Collaborative Research Project – Large-scale Integrating Project
Total Cost:	€ 9.230.000
EC contribution:	€ 6.650.000
Start – end date:	1/01/2010 – 31/12/2014
Duration:	60 months
Project Coordinator:	Ivan Kristoffersen (ivk@adm.ku.dk)
Organisation:	University of Copenhagen – Denmark
Project Keywords:	Paleoclimate records; modelling of climate change; future ice sheet; sea-level; circulation; biogeochemical changes

Project Website:
www.past4future.eu

Project Partners

1. University of Copenhagen - Denmark
2. UNIFOB AS - Norway
3. National Council for Scientific Research - France
4. Aarhus University - Denmark
5. Universitaet Bern - Switzerland
8 Spanish National Research Council - Spain
9 Universitat Autonoma De Barcelona - Spain
10 Natural Environment Research Council - United Kingdom
11 University of Bristol - United Kingdom
12 Universite Catholique de Louvain - Belgium
13 Universitaet Bremen - Germany
6. Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.v. - Germany
7. Vereniging Voor Christelijk Hoger Onderwijs Wetenschappelijk Onderzoek en Patientenzorg - Netherlands
14 Commissariat à l'Energie Atomique - France
15 University College London - United Kingdom
16 Consiglio Nazionale Delle Ricerche - Italy
17 Alfred Wegener Institute for Polar and Marine Research - Germany
18 University of Cambridge - United Kingdom
19 PAGES - Past Global Changes - Switzerland
20 GEOTOP - Canada
21 East China Normal University Ecnu - China
22 University of Ottawa - Canada

Background information

Project Summary

Paleoclimatic records contain a wealth of information on the stability and variability of climate and its ability to perform abrupt changes. The overarching motivation for us to work with the paleoarchive is the drive to understand the climate system and the importance of predicting future climate changes. By drawing together a strong multidisciplinary team of European and international researchers with tight connection to the high resolution data records from interglacial periods and state-of-the-art Earth system models we will advance the knowledge on abrupt changes in interglacial climate periods.

In Past4Future we propose to combine multidisciplinary palaeoclimate records from ice cores, marine cores, speleothems, pollen and other records with focus on a global distribution of the records to reconstruct climate change and variability during the present interglacial and the last interglacial. The records will be combined in integrated analyses aided by proxy modeling and assimilation, to gain understanding of the climate processes involved in the dynamics of the interglacial climates. Earth system models (ESM) including physical and biogeochemical processes will be applied to simulate the past and present interglacial climate, confront and intercompare the simulations with climate changes as observed from the palaeodata to both advance the models and our understanding of the dynamics and predictability of the climate system. Focus will be on the most recent two interglacial periods, as these provide the highest resolved most-comprehensive data records. Moreover the last interglacial represents a situation where the mean state was warmer than at present in large regions due to orbital forcing, thereby allowing testing climate system sensitivity to constrain projections of potential future ice sheet, sea-level, circulation and biogeochemical changes. The data and earth system model results will be used to reduce the current large uncertainties in our capabilities to project future global and regional warming especially in relation to sea level changes, sea ice changes and thermohaline circulation changes. The Past4Future program will draw together a world leading team of European and international partners in a concerted effort to advance our knowledge on the causes, processes and risks of abrupt changes in warm periods, such as the one expected in the next century. The program will inform the international debate on climate system stability and the dissemination of results will be targeted at both citizens and governmental and non-governmental stakeholders.

SALSEA-MERGE - Advancing understanding of Atlantic Salmon at Sea: Merging Genetics and Ecology to resolve stock-specific Migration and Distribution patterns

Summary information

Funding source:	FP7 - Collaborative Research Project - Small-Medium Scale Collaborative Project
Total Cost:	€ 5.607.000
EC contribution:	€ 3.499.000
Start – end date:	1/03/2008 – 28/02/2011
Duration:	36 months
Project Coordinator:	Merethe Flatseth (merethe.flatseth@imr.no)
Organisation:	Institute of Marine Research- Norway
CLAMER thematic focus:	Biological impacts; socio-economic consequences
CLAMER Regional focus:	North Atlantic
Project Keywords:	Salmon; growth; feeding; climate change; genetic identification; trawls; distribution; migration models; ecology; oceanography

Project Website:
www.salmonatsea.com

Project Partners

1 Institute of Marine Research - Norway
2 Marine Institute - Ireland
3 Scottish Ministers Acting through Fisheries Research Services - United Kingdom
4 Norwegian Institute for Nature Research - Norway
5 University of Exeter - United Kingdom
6 University College Cork - Ireland
7 Queen's University Belfast - United Kingdom
8 University of Wales Swansea - United Kingdom
9 Technical University of Denmark - Denmark
10 Institute of Freshwater Fisheries - Iceland
11 University of Turku - Finland
12 University of Oviedo - Spain
13 GENINDEXE - France
14 Finnish Game and Fisheries Research Institute - Finland

Background information

Project Summary

Abstract
Over the past two decades, an increasing proportion of North Atlantic salmon are dying at sea during their oceanic feeding migration. The specific reasons for the decline in this important species are as yet unknown, however, climate change is likely to be an important factor. In some rivers in the southern part of the salmon's range, wild salmon now face extinction. This is in spite of unprecedented management measures to halt this decline. Arguably the greatest challenge in salmon conservation is to gain insight into the spatial and ecological use of the marine environment by different regional and river stocks, which are known to show variation in marine growth, condition, and survival. Salmon populations may migrate to different marine zones, whose environmental conditions may vary. To date it has been impossible to sample and identify the origin of sufficient numbers of wild salmon at sea to enable this vital question to be addressed. SALSEA-Merge will provide the basis for advancing our understanding of oceanic-scale, ecological and ecosystem processes. Such knowledge is fundamental to the future sustainable management of this key marine species. Through a partnership of 9 European nations the programme will deliver innovation in the areas of: genetic stock identification techniques, new genetic marker development, fine scale estimates of growth on a weekly and monthly basis, the use of novel high seas pelagic trawling technology and individual stock linked estimates of food and feeding patterns. In addition, the use of the three-dimensional Regional Ocean Modelling System, merging hydrography, oceanographic, genetic and ecological data, will deliver novel stock specific migration and distribution models. This widely supported project, provides the basis for a comprehensive investigation into the problems facing salmon at sea. It will also act as an important model for understanding the factors affecting survival of many other important marine species.

Objectives
SALSEA-Merge will deliver innovation in the areas of: genetic stock identification techniques; new genetic marker development; fine scale estimates of growth on a weekly and monthly basis; the use of novel high seas pelagic trawling technology; individual stock-linked estimates of food and feeding patterns; and novel stock specific migration and distribution models.
By merging genetic and ecological investigations, to advance understanding of stock specific migration and distribution patterns and overall ecology of the marine life of Atlantic salmon and gain an insight into the factors resulting in recent increases in marine mortality.

The information gained will be essential for the identification of areas critical to the species life cycle and needed for the designation of marine protected areas, the regulation of large pelagic fisheries to avoid mortality from by-catches, the regulation of fisheries for key prey species such as sandeel, herring and blue whiting, the targeted regulation of inshore commercial salmon fisheries, and to maximise natural sustainable freshwater production.

Recent evidence shows strong regional and local structuring of Atlantic salmon stocks in Europe and North America which indicates that it will be possible to develop a stock identification methodology for Atlantic salmon, as has been done successfully for Pacific salmonids (Beacham *et al*., 2006). With recent developments in molecular marker identification and screening technology, it is now possible to develop accurate diagnostic and cost effective methods for identifying the origin or proportional contributions of individual stocks from congregations of salmon, sampled at sea.

THESEUS - Innovative technologies for safer European coasts in a changing climate

Summary information

Funding source:	FP7 - Collaborative Research Project – Large scale Integrated Collaborative Project
Total Cost:	€ 8.520.000
EC contribution:	€ 6.530.000
Start – end date:	1/12/2009 – 30/11/2013
Duration:	48 months
Project Coordinator:	Barbara Zanuttigh (barbara.zanuttigh@unibo.it)
Organisation:	Alma Mater Studiorum-Universita di Bologna – Italy
CLAMER thematic focus:	Sea level rise; coastal erosion; storm frequency and intensity; sediment changes
CLAMER Regional focus:	North Atlantic; Baltic Sea; North Sea; Mediterranean Sea; Black Sea
Project Keywords:	Erosion; flooding; risk assessment; risk mitigation; climate change

Project Website:
http://www.theseusproject.eu/

Project Partners

1 Alma Mater Studiorum-Universita di Bologna - Italy
2 Universidad De Cantabria - Spain
3 University of Plymouth Higher Education Corporation - United Kingdom
4 Aalborg Universitet - Denmark
5 Infram International Bv - Netherlands
6 Gkss - Forschungszentrum Geesthacht Gmbh - Germany
7 University of Southampton - United Kingdom
8 Universite de Versailles Saint-Quentin-En-Yvelines - France
9 Centre D'etudes Techniques Maritimes et Fluviales - France
10 Middlesex University Higher Education Corporation - United Kingdom
11 Institute Of Meteorology And Water Management - Poland
12 Institute of Oceanology, Bulgarian Academy of Sciences - Bulgaria
13 Athens University of Economics and Business - Research Center - Greece
14 Royal Netherlands Academy of Arts and Sciences - Netherlands
15 Corila-Consorzio per la Gestione del Centro di Coordinamento delle Attivita di Ricerca Inerenti Il Sistema Lagunare di Venezia - Italy
16 Instytut Budownictwa Wodnego, Polish Academy of Sciences - Poland
17 Bangor University - United Kingdom
18 Bureau de Recherches Geologiques et Minieres - France
19 Hamburg Port Authority - Germany
20 EID Méditerranée - France
21 Latvijas University - Latvia
22 Istituto Superiore per la Ricerca e la Protezione Ambientale - Italy
23 Flanders Marine Institute - Belgium
24 Aristotle University of Thessalomiki - Greece

25 Katholieke Universiteit Leuven - Belgium
26 Marine Hydrophysical Institute of National Academy of Sciences of Ukraine - Ukraine
27 P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences – Russian Federation
28 University of Delaware – United States
29 Universidad Nacional Autónoma de México - Mexico
30 State Key Laboratory of Estuarine and Coastal Research - China
31 Coastal Ocean Monitoring Center – Taiwan

Background information

Project Summary

Abstract
Coastal areas are vital economic hubs in terms of settlement, industry, agriculture, trade and tourism to mention some key sectors. There are already many coastal problems including erosion, flood risk and long-term habitat deterioration. As economies continue to develop, the asset base at risk will grow, while accelerating climate change will increase the likelihood of damaging extreme events, as well as accelerate habitat decline. Existing coastal management and defence approaches are not well tuned to these challenges as they assume a static situation.

THESEUS will develop a systematic approach to delivering both a low-risk coast for human use and healthy habitats for evolving coastal zones subject to multiple change factors.

The innovative combined mitigation and adaptation technologies to be considered will include ecologically-based mitigation measures (such as restoration and/or creation of habitats), hydro-morphodynamic techniques (such as sediment reservoirs, multi-purpose structures, or overtop resistant dikes), actions to reduce the impact on society and economy (such as promotion of risk awareness or spatial planning) and GIS-based software to support defence planning.

To integrate the best of these technical measures in a strategic policy context we will develop overarching THESEUS guidelines which will consider the environmental, social and economic issues raised in any coastal area. It is in this spirit that THESEUS will advance European and international experience in applying innovative technologies to reducing coastal risks.

THESEUS activities will be carried out within a multidisciplinary framework using 8 study sites across Europe, with specific attention to the most vulnerable coastal environments such as deltas, estuaries and wetlands, where many large cities and industrial areas are located.

THOR - Stability of Thermohaline circulation

Summary information

Funding source:	FP7 - Collaborative Research Project – Small-Medium Scale Collaborative Project
Total Cost:	€ 12.950.000
EC contribution:	€ 9.270.000
Start – end date:	1/12/2008 – 30/11/2012
Duration:	48 months
Project Coordinator:	Detlef Quadfasel (detlef.quadfasel@zmaw.de)
Organisation:	Institute of Oceanography, University of Hamburg – Germany
CLAMER thematic focus:	Ice melting; ocean current changes; deep circulation changes; freshwater inflow;
CLAMER Regional focus:	North Atlantic
Project Keywords:	THC; uncertainties in model and forecasts; decadal variability

Project Website:
http://www.eu-thor.eu/

Project Partners

1 University of Hamburg – Germany
2 Max-Planck-Gesellschaft / Max Planck Institute for Meteorology - Germany
3 Met Office – United Kingdom
4 Université Pierre et Marie Curie - France
5 University of Bergen - Norway
6 University of Reading - United Kingdom
7 European Centre for Medium-Range Weather Forecasts - United Kingdom
8 Leibniz Institute of Marine Sciences at the Christian-Albrechts Universität zu Kiel - Germany
9 Royal Netherlands Meteorological Institute - Netherlands
10 Danish Meteorological Institute - Denmark
11 Havstovan - Faroe Islands
12 Finnish Meterological Institute - Finland
13 Marine Research Institute - Iceland
14 Royal Netherlands Institute for Sea Research - Netherlands
15 Secretary of State for Environment, Food and Rural Affairs acting through the Centre for Environment, Fisheries and Aquaculture Science - United Kingdom
16 Scottish Association for Marein Science - United Kingdom
17 Natural Environment Research Council - United Kingdom
18 Stockholm University - Sweden
19 Nansen Environmental and Remote Sensing Center – Norway
20 National Council for Scientific Research - France
21 Commissariat a l'Energie Atomique - France

Background information

Project Summary

THOR will establish an operational system that will monitor and forecast the development of the North Atlantic THC on decadal time scales and access its stability and the risk of a breakdown in a changing climate. Together with pre-existing data sets, ongoing observations within the project will allow precise quantitative monitoring of the Atlantic THC and its sources. This will, for the first time, allow an assessment of the strength of the Atlantic THC and its sources in a consistent manner and will provide early identification of any systematic changes in the THC that might occur. Analysis of palaeo observations covering the last millennium and millennium time scale experiments with coupled climate models will be carried out to identify the relevant key processes and feedback mechanisms between ocean, atmosphere, and cryosphere. In THOR, the combined effect of various global warming scenarios and melting of the Greenland ice sheet will also be thoroughly assessed in a coupled climate model. Through these studies and through the assimilation of systematic oceanic observations at key locations into ocean circulation models, THOR will forecast the development of the Atlantic THC and its variability until 2025, using global coupled ocean-atmosphere models. THOR will also assess induced climate implications of changes in the THC and the probability of extreme climate events with special emphasis on the European/North Atlantic region. THOR builds upon techniques, methods and models developed during several projects funded within FP5 and FP6 as well as many nationally funded projects. The project will contribute to Global Monitoring for Environment and Security (GMES), to Global Observing Systems such as to the Global Ocean Observing system (GOOS), and to the International Polar Year (IPY).

INTERREG Projects

IMCORE - Innovative Management for Europe's Changing Coastal Resource

Summary information

Funding source:	INTERREG IVb – North West Europe
Total Cost:	€ 5.993.551
EC contribution:	€ 2.996.776
Start – end date:	1/05/08– 31/10/2011
Duration:	42 months
Project Coordinator:	Jeremy Gault (J.Gault@ucc.ie)
Organisation:	Coastal & Marine Research Centre, National University of Ireland Cork - Ireland

Project Website:
http://www.imcore.eu/

Project Partners

1 National University of Ireland Cork – Ireland
2 CoastNet - the coastal network – United Kingdom
3 University of Ulster at Coleraine - United Kingdom
4 Donegal County Council - Ireland
5 University of Aberdeen - United Kingdom
6 Cork County Council - Ireland
7 Cardiff University - United Kingdom
8 EUCC - The Coastal Union - Netherlands
9 Maritiem Instituut, University of Gent - Belgium
10 Envision Management Ltd - United Kingdom
11 Université de Bretagne Occidentale - France
12 Sefton Council - United Kingdom
13 Durham County Council - United Kingdom
14 Agentschap voor Maritieme Dienstverlening en Kust - afdeling Kust - Belgium
15 Syndicat Intercommunal d'Aménagement du Golfe du Morbihan - France
16 Aberdeen City Council - United Kingdom
17 National Maritime College of Ireland - Ireland

Background information

Project Summary

The project aims to identify the key issues resulting from the impact of climate change on key coastal sectors including fishing, port development, marine recreation and coastal defence. These issues will then be used as the basis for developing adaptive management strategies at nine sites across North West Europe. Innovative techniques of partnership working between local authorities and research centres, stakeholder engagement, future scenario development and visualisation will be tested at each of the sites as part of the development process. Capacity to adapt will be augmented by a Training of Trainers workshop ensuring sustained knowledge transfer to local authorities. All the outcomes, and details of the methods tested, from the project will then be

made available on-line and should prove invaluable for coastal practitioners (amongst others) charged with developing local adaptation strategies.

The project aims to promote a transnational, innovative and sustainable approach to reducing the Ecological Social and Economic impacts of climate change on the coastal resources of NWE.

Project objectives are:

- To demonstrate how the innovative expert couplet approach (i.e. collaboration between coastal managers and scientists using the principles of sustainability science), can help with the effective implementation of adaptive management strategies for coastal resources.
- To improve the regional viability of our coastal sectors by developing common decision support tools and techniques for future planning.
- To provide coastal managers with the capacity to implement adaptive management strategies by providing examples of strategies tested at nine pilots and technology such as visualisation tools, specialised software, best practice guidelines and a management process indicator set will be incorporated in a freely available Multimedia Distance Learning set of tools / skills developed, tested and fine-tuned as representative sites across NWE.

SUSFISH - Shellfish productivity in the Irish Sea: Working towards a sustainable future

Summary information

Funding source:	EU INTERREG-IVA Ireland/Wales Programme
Total Cost:	€ 2.932.445
EC contribution:	€ 2.199.334
Start – end date:	2009 – 2012
Duration:	36 months
Project Coordinator:	Shelagh Malham (S.Malham@bangor.ac.uk)
Organisation:	Bangor University Wales – United Kingdom

Project Website:
http://www.susfish.com/

Project Partners

1 Bangor University Wales - United Kingdom
2 University College Cork - Ireland
3 Swansea University - United Kingdom
4 Aberstwyth University - United Kingdom

Background information

Project Summary

Aims
SUSFISH will produce guidelines for future fisheries management, ensuring sustainable development of the shellfish industry in Ireland and Wales for the next 50-100 years. This will be achieved by assessing the effects of climate change (via oceanographic models) on shellfish productivity in the Irish Sea and determining adaptation or mitigation strategies for the industry in the cross border TC area, including recommendations for protection of certain areas under Marine Spatial Planning (MSP). Aspects to be included are how current commercial shellfish productivity in the Irish Sea will respond to changes in temperature, salinity, water quality (eutrophication via organic and inorganic nutrients, acidification), sea level rise and changes in ocean current regimes. A range of climate change scenarios will be assessed from the IPCC worst-case scenario to conditions in the present day. SUSFISH will have significant socio-economic benefit for both Wales and Ireland, and will also be of international importance, as the project addresses issues that are of global concern.

Objectives

1. Set up a management and advisory group, hold two workshops for the dissemination of information to key stakeholders, policy makers and SMEs, (1 in Ireland and 1 in Wales. This WP will also deal with all publicity, media contacts, web pages and a database.
2. Collate historical and recent data on environmental conditions and shellfish productivity in the Irish Sea
3. Use oceanographic modelling to predict environmental conditions in the Irish Sea over the next 10-50 years. This will also incorporate hindcast data collected under objective 2.
4. Assess the ecological status (including larvae), physiological status, disease status, parasitological status of commercially important shellfish (Cockles, Mussels, Razor clams, native oyster, Edible crabs) with respect to environmental parameters predicted to change over the next 60 years, identified by objective 3.
5. Assess the population genetic structure and mixing of the common cockle *Cerastoderma edule* and the edible crab *Cancer pagurus* across Ireland and Wales coastal waters.
6. Assess likely increases in eutrophication and harmful algal events using the results of objective 3 and the likely economic impact on commercial aquaculture in the Irish Sea.
7. Undertake predictive modelling using the results of objectives 2-4 to determine future productivity of the Irish Sea under the predicted climate change scenarios. Areas of modelling will concentrate on i) biogeographic distribution of commercially important species and ii) bioeconomic modelling and risk assessments.
8. Incorporate current aspects of MSP into the outputs from objectives 4 and 5 to produce guidelines for management and policy with regards to shellfish sustainability in the Irish Sea.

Climate change impacts on coastal communities and habitats (scoping study)

Summary information

Funding source:	EU INTERREG-IVB - Northern Periphery Programme
Total Cost:	€ 30.000
EC contribution:	€ 18.000
Start – end date:	2007 – 2008
Project Coordinator:	Western Isles Council Scotland – United Kingdom

Project Partners

1 Western Isles Council – United Kingdom
2 Coastal and Marine Resources Centre – University College Cork - Ireland
3 Scottish Natural Heritage - United Kingdom
4 Institute for Coastal Science & Management - University of Aberdeen - United Kingdom
5 UHI Millennium Institute, Environmental Research Institute - United Kingdom
6 VisitScotland - United Kingdom
7 Centre for Coastal and Marine Research (CCMR)- University of Ulster - United Kingdom
8 Northern Research Institute - Norway

Background information

Project Summary

This project is a Preparatory Action designed to prepare a more comprehensive project proposal that will examine and quantify the impact of projected climate change on vulnerable low-lying coastal communities and habitats. The aim of the Preparatory Action is to develop relationships between and determine the precise role and task of each partner; identify and establish links with local municipalities to form case studies across the partner regions (Expert Couplet Nodes); identify additional partners as appropriate; review existing knowledge and identify existing climate change initiatives already existing in the participating region.

The Preparatory Action successfully submitted a full proposal COASTADAPT: Sustainable Adaptation to Climate Change in Coastal Communities and Habitats on Europe's Northern Periphery, in March 2008.

COASTADAPT - Sustainable Adaptation to Climate Change in Coastal Communities and Habitats on Europe's Northern Periphery

Summary information

Funding source:	EU INTERREG-IVB - Northern Periphery Programme
Total Cost:	€ 1,445,226
EC contribution:	€ 780,387
Start – end date:	2009 - 2012
Project Coordinator:	Western Isles Council Scotland – United Kingdom

Project Website:
www.coastadapt.org/

Project Partners

1. Coastal & Marine Resource Centre - Ireland
2. Institute for Coastal Science and Management - University of Aberdeen – United Kingdom
3. UHI Millennium Institute-, Environmental Research Institute – United Kingdom
4. Scottish Natural Heritage - United Kingdom
5. Centre for Coastal and Marine Research- University of Ulster - United Kingdom
6. Hammerfest Kommune - Norway
7. Northern Research Institute - Norway
8. Árborg Municipality - Iceland
9. Municipality of Vik - Iceland
10. University of Iceland, Institute for Sustainable Development -Iceland

Background information

Project Summary

The climate of the North Atlantic coastal regions is changing and sea-level is rising. Of great concern is the increased risk that climate change will bring to the economies and social well-being of North Atlantic coastal communities. CoastAdapt is a transnational project that will develop and implement a range of adaptation strategies and tools to enable people living in coastal communities take action to reduce the negative impacts as well as take advantage of the benefits of a changing climate.

CoastAdapt will form an international partnership of local municipalities, environmental organisations and academic institutions to involve local people and local government in a 'bottom-up' approach in the development of adaptive response and preparedness for the impacts of climate change. The project will also consider and develop long-term recovery planning from climate induced natural hazards. CoastAdapt will produce data; information; tools such as handbooks, vulnerability assessment frameworks, regional scenarios, and adaptation implementation strategies; and climate change networks between pilot study areas and beyond. This project will also provide a sustainable single site, one-stop web-based service to enable these resources to be accessed by end-users not just in the pilot areas, but by coastal communities and local government staff throughout all North Atlantic regions and further afield.

ERA-NET and EUROCORES Project Initiatives

BIOFUN - Biodiversity and ecosystem functioning in contrasting southern European deep-sea environments

Summary information

Funding source:	ESF-EUROCORES – EuroDEEP
Start – end date:	1/03/2008 – 28/02/2011
Duration:	36 months
Project Coordinator:	Professor Francisco Sardà Amills (siscu@icm.csic.es)
Organisation:	Institut de Ciències del Mar, CSIC - Spain

Project Website:
www.eurodeep.net/biofun/

Project Partners

1 Institu de Ciències del Mar - Spain
2 Royal Netherlands Institute for Sea Research - Netherlands
3 Netherlands Institute of Ecology - Netherlands
4 Centre de Formation et de Recherche sur l'Environnement Marin - France
5 Institute of Marine Sciences - Italy
6 National University of Ireland - Ireland
7 Institut de Ciències del Mar - Spain
8 University of Ghent - Belgium
9 Polytechnic University of Marche - Italy
10 Hellenic Centre for Marine Research - Greece
11 Department of Marine Zoology - Germany

Background information

Project Summary

The deep-sea, the largest habitat on Earth, is likely the largest reservoir of biodiversity, but still the least explored. The important natural resources available in the deep oceans are being increasingly exploited by fisheries and oil, mineral and gas industries. We know little of the effects of anthropogenic and climate change in deep-sea ecosystems, of special concern because they affect an unknown habitat where many species display long lifespans and delayed maturity, resulting in long recovery times of the damaged populations. Because of technological and resource challenges, deep-sea investigations require major coordination of efforts only possible through multidisciplinary and international initiatives such as EUROCORES. In this framework, the overall aim of BIOFUN is to characterise, through an ecosystemic approach, two deep-sea habitats – the mid-slope and abyssal plain – to understand the linkages between biodiversity patterns and ecosystem functioning in relation to environmental conditions along a trophic gradient, from Eastern Atlantic to the Western, Central and Eastern Mediterranean, enabling the simulation of their potential response to

changing trophic conditions. This is the first proposal aimed at a complete investigation of the entire food web, from viruses and microbes to megafauna, including commercial species. In particular, BIOFUN is structured in 4 major work-packages: 1) physical and geochemical habitat conditions; 2) community structure: biodiversity and biogeography; 3) ecosystem functioning: food web processes and life-history patterns; and 4) linkages between ecosystem functioning and biodiversity: tools for disturbance evaluation. BIOFUN is a consortium of 10 European partners leading deep-sea research at the international level and with wide expertise in the use of large platforms and state-of-the art methods. Results gathered in this project will provide new and essential information for a correct management of the biodiversity and natural resources of the deep-sea and for understanding the importance of these biological components on global biogeochemical cycles.

Defineit - Developing fisheries management indicators and targets

Summary information

Funding source:	Marifish ERA-NET project
Funding contribution:	2.092.580
Start – end date:	1/10/2009 – 30/06/2012
Duration:	33 months
Project Coordinator:	Anna Rindorf (ar@aqua.dtu.dk)
Organisation:	DTU Aqua, Technical University of Denmark - Denmark

Project Website:
http://www.defineit.dk/

Project Partners

1. DTU Aqua, Technical University of Denmark - Denmark
2. Centre for Environment, Fisheries & Aquaculture Science - United Kingdom
3. Institute of Food and Resource Economics - Denmark
4. Marine Research Centre of Greece – Greece
5. Imperial College London - United Kingdom
6. IMARES Wageningen - Netherlands
7. Department of Environmental and Business Economics, University of Southern Denmark - Demark
8. Institute of Marine Research – Norway
9. Marine Research Institute - Iceland
10. University of St Andrews – Scotland - United Kingdom

Background information

Project Summary

The project aims to produce the tools necessary to determine the economically optimal level of exploitation of European ecosystems under changing climatic conditions while ensuring that the pressure exerted on both commercial stocks and susceptible fish species is biologically sustainable.

The project objective is to construct operational models of fish stock dynamics explicitly taking account of climatically induced ecosystem changes as well as exploitation, to combine these models with economical models and predict the effort required to reach the optimal yield. The project integrates knowledge from a range of scientific areas, each of which affects the sustainability of the exploitation of the ecosystem.

DEFINEIT will construct operational models of fish stock dynamics explicitly taking account of exploitation and climatic conditions and combine these models with economic models. The project brings together key competences in operational multispecies modelling, stock recruitment relationships, population dynamics of non-target fish species and economic modelling of fisheries from a wide geographic area ranging from the Barents Sea to the Mediterranean.

In sustainable ecosystem management, it is crucial to account for the fact that increasing the amount of predatory fish leads to increased predation. The project will use multispecies models to investigate changes in predation induced by differences in distribution and the amount of alternative food. Effects of technical interactions in the fishing process will be considered to avoid delivering management advice for different stocks which is mutually inconsistent. Multispecies models have historically mainly been applied to North Atlantic areas but within this project, we will increase the coverage to include the Aegean Sea and for the first time develop such a model for the eastern Mediterranean. Integrating the knowledge gained, the project will identify relevant multispecies indicators and suggest methods for estimating reference points.

To understand the causes of the year to year variation in recruitment, both large scale temporal patterns, variability in the production of eggs, sub-stock structure and survival of eggs and larvae must be considered. The project will identify the main causes of variation in recruitment patterns between stocks as well as the key processes from spawning to recruitment of selected stocks. The consequences of using proxies to describe stock reproductive potential will be determined and survival during early life stages investigated to identify the role of the physical and biological environment. The effects of stock sub-structure and composition on recruitment will be investigated by using genomic differences to define sub-stocks and estimating the relative contributions to survivors of population sub-components under differing climatic conditions. The improved understanding of recruitment variability will be used in both individual stock assessment and included in multispecies models to provide reliable predictions.

The effect of technical interactions in the fishing process on bycatch of non-target species will be assessed by identifying susceptible species and determining the information required to develop management plans. The maximum level of fishing effort consistent with sustainment of these species will be estimated and options for protecting non-target species will be evaluated using Management Strategy Evaluation in order to develop Robust Management. The project will develop resource indicators that combine economic, social and biological indicators and relate directly to the benefit for the society. The annual user value of the selected fisheries will be identified and the maximum resource rent calculated based on combined economic and multispecies models. Further, a stochastic approach to economic indicators will be investigated since variance and uncertainty are critical issues in relation to the economic performance of natural resource systems.

Future stock dynamics, limits to sustainable ecosystem exploitation and the fishing levels delivering maximum sustainable economic yield under selected climatic scenarios will be analysed in unison to ensure the delivery of mutually consistent management advice. General properties of the ecosystems will be used to suggest rules of thumb for management in areas where the amount of data available is insufficient to construct similar models. Finally, we will disseminate project results to both the scientific community, managers, stakeholders and the general public to ensure that results are used in practical management.

ECODRIVE - Ecosystem Change in the North Sea: Processes, Drivers and Future scenarios

Summary information

Funding source:	MarinERA ERA-NET project
Funding contribution:	1.417.500
Start – end date:	1/04/2009 – 31/03/2012
Duration:	36 months
Project Coordinator:	Jürgen Alheit (juergen.alheit@io-warnemuende.de)
Organisation:	Leibniz Institute for Baltic Sea Research Warnemünde - Germany

Project Website:
http://www.io-warnemuende.de/ecodrive.html

Project Partners

1 Leibniz Institute for Baltic Sea Research Warnemünde - Germany
2 Alfred Wegener Institute for Polar and Marine Research - Germany
3 Geophysical Institute, University of Bergen - Norway
4 Institute of Marine Research - Norway
5 Institute of Oceanography, Hamburg University - Germany
6 Sir Alister Hardy Foundation for Ocean Science – United Kingdom (no funds through MarinERA)
7 IMARES Wageningen - Netherlands (no funds through MarinERA)

Background information

Project Summary

ECODRIVE brings together climatologists, modellers, planktologists, fisheries experts and ecophysiologists with the aim to assess and model historical and projected future changes in the trophodynamic structure and function of the North Sea ecosystem. ECODRIVE advances our predictive understanding of the impacts of various drivers of ecosystem change including those acting via climate change and variability as well as those acting more regionally via anthropogenic forcing such as fisheries exploitation and eutrophication.

The approach entails a combination of:
• retrospective analysis of long-term (40 to 100 year) time series of key biotic and abiotic variables;
• field studies to obtain indispensable information on the trophodynamic role of new species; and
• a suite of climate, hydrodynamic and ecosystem models to allow the development of future scenarios.

The focus will be on the pelagic realm as groups of pelagic organisms (e.g. phyto-, zooplankton and small pelagic fishes) react rapidly and often dramatically to external drivers and play an important role as sentinels of ecosystem change. Whereas earlier studies usually focused on changes occurring only during the previous 30 years (1970-2000), ECODRIVE emphasizes a wider time window that includes two warm water periods (1930-1960 and the recent one) that exhibit many similarities such as the occurrence of warm water species in the North Sea. ECODRIVE employs regionally downscaled environmental forcing from global climate models to help project future scenarios of the ecosystem structure of the North Sea.

HOLOCLIP - Holocene climate variability at high-southern latitudes: an integrated perspective

Summary information

Funding source:	EUROPOLAR ERA-NET project funded under the PolarCLIMATE Programme
Funding contribution:	759.000
Start – end date:	1/01/2010 – 31/12/2012
Duration:	36 months
Project Coordinator:	Dr. Barbara Stenni (stenni@univ.trieste.it)
Organisation:	University of Trieste - Italy

Project Website:
http://www.holoclip.org/

Project Partners

1 University of Trieste, Dipartimento di Geoscienze - Italy
2 Université Bordeaux - France
3 Alfred-Wegener Institute for Polar and Marine Research - Germany
4 University of Granada - Spain
5 VU University Amsterdam - Holland
6 Université Catholique de Louvain - Belgium
7 Cardiff University - United Kingdom

Background information

Project Summary

Abstract

HOLOCLIP is a European Science Foundation / European Polar Board PolarCLIMATE initiative (http://www.esf.org/research-areas/polar-sciences/polarclimate.html). The PolarCLIMATE programme has contributed to the development of a strategic common vision for Polar Climate research and is the first step towards joint implementation of programmes and fully utilising research stations and climate observatories in the Arctic and Antarctic. The funding in the PolarCLIMATE Project is by national research funding agencies.
HOLOCLIP aims to bring together the ice core, the sediment core and the modelling scientific communities to understand the processes linking different components of the climate system and linking climatic response to external forcing over the Holocene. High-latitudes are particularly interesting places to document natural climate variability since: (1) every component of the climate system interacts in these regions in a still poorly-constrained and non-linear way; (2) changes are amplified compared to low latitude environments; (3) Antarctica and its surrounding are characterized by a strong regional variability. Existing geological records, glacial records and model experiments have highlighted differences in the evolution of the climate as a function of the area. The areas on which the European research efforts have been concentrated over the past decades are suited for integrating existing ice and marine records, in terms of amount and quality of collected materials.

Objectives

The objectives of the Project are multiple and can be grouped under the following:

- To calibrate our tools in order to better understand the proxies that we currently use for climatic reconstructions. We will work on modern processes to validate and calibrate our proxies and will analyse water column and modern sediment trap samples (seasonal variations), short marine sediment cores, sea-bed morphology, shallow firn cores, snow pits and precipitation samples covering the instrumental period of the last decades.
- To document changes of different components of the Holocene climate system in terms of amplitudes, frequencies and timing. Using a multi-proxy approach, we will reconstruct climate and environmental parameters in the selected areas.
- To document the regional heterogeneity of the different components over the Holocene period. We will investigate several marine cores from the Antarctic continental margin and ice cores from the ice sheet, integrating the results with climate models using data assimilation techniques. The large number of records studied and their diversity (both regional and type of records) will allow us to better constrain the regional heterogeneity of the different components/parameters.
- To document the relationships between the different components/parameters. All the components are connected but their relationships/feedbacks are highly non-linear. Sea bed morphology is also a crucial component for downslope flowing of High Salinity Shelf Water, formed in coastal polynyas, and finally to mixing with Antarctic circumpolar water. We propose a detailed comparison of marine and ice core records to better document the interactions among atmosphere/cryosphere-ocean. The interpretations will feed into/validate numerical models.
- To document the forcing factors of the different components/parameters and to test the sensitivity of the climate system to different forcing factors. We will provide numerical models incorporating marine and ice core data to better understand the relationship between forcing factors and climatic response.
- To document the feedbacks of the different components/parameters on Holocene climate. We will combine marine and ice core data with those deriving from numerical models to determine the role of atmospheric circulation, sea ice, and ocean in regulating the Holocene climate in the different sectors of the Southern Ocean and the impact of the Southern Ocean on thermohaline circulation.

IMCOAST - Impact of climate induced glacial melting on marine coastal systems in the Western Antarctic Peninsula region

Summary information

Funding source: EUROPOLAR ERA-NET project funded under the PolarCLIMATE Programme

Start – end date: 1/01/2010 – 30/06/2011
Duration: 18 months

Project Coordinator: Doris Abele (Doris.Abele@awi.de)
Organisation: Alfred Wegener Institute for Polar and Marine Research - Germany

Project Website:
http://www.imcoast.org/

Project Partners

1 Alfred-Wegener Institute for Polar and Marine Research – Germany
2 University of Bonn – Germany
3 Universidad de Salamanca – Spain
4 University of Oldenburg - Germany
5 University of Ghent - Belgium
6 University of Groningen – Netherlands
7 Polish Academy of Sciences – Poland
8 Federal University of Rio Grande - Brazil
9 Argentine Antarctic Institute – Argentine
10 University of Kiel – Germany
11 University of Cordoba – Spain
12 British Antarctic Survey – United Kingdom
13 University of Cologne – Germany
14 University of Bremen - Germany

Background information

Project Summary

The coastline and the islands of the Western Antarctic Peninsula represent key areas immediately and most visibly affected by glacial retreat and melting, due to global climate warming. Although it is clear that coastal fresh water and sediment transport have increased both in length and volume, it is not clear how the sub-glacial and land run-off dynamics will change over time.

IMCOAST combines different physico-hydrographical, sedimentological, geochemical and biological proxies to investigate past, ongoing and future climate related changes of land ice masses and sedimentary run-off and their effects on coastal benthic and pelagic ecosystems in the King George Island coastal area.

This international research programme features a multidisciplinary approach involving geo- and biological sciences, field investigations, remote sensing and modelling, as well as knowledge into the hydrographical and biological history of the marine coastal ecosystems of the Western Antarctic Peninsula region.

Objectives

- To quantify variability and changes in fresh water budgets in coastal ecosystems and to provide the physical boundary conditions for geochemical, sedimentological and biophysical research
- Understand the effect of glacial retreat on sub-glacial and land run-off dynamics in the past and present
- Analyze the effects of the current climate change on coastal pelagic ecosystems
- Analyze carbon recycling in the sediment surface of coastal systems with and without impact of sedimentation, and the bentho-pelagic coupling in KGI coastal food webs
- Evaluate impact and strength of late Holocene warm phases on the KGI coastal system.

Marine phylogeographic structuring during climate change: the signature of leading and rear edge of range shifting populations

Summary information

Funding source:	MarinERA ERA-NET project
Funding contribution:	915.987
Start – end date:	1/01/2009 – 31/12/2011
Duration:	36 months
Project Coordinator:	Vitor Almada (valmada@ispa.pt)
Organisation:	Institute for Applied Psychology - Portugal

Project Website:
http://biocongroup.eu/MarinEra/Welcome.html

Project Partners

1 Institute for Applied Psychology, Eco-Ethology Research Unit - Portugal
2 Biologische Anstalt Helgoland, Alfred-Wegener Institute for Polar and Marine Research - Germany
3 Center for Marine Sciences, University of Algarve - Portugal
4 Mediterranean Institute for Advanced Studies - Spain
5 Institute of Marine Research - Norway
6 University of Cadiz - Spain

Background information

Project Summary

The Marine phylogeographic structuring during climate change project aims to monitor, sample and genotype a number of target species, in predetermined rocky-shore stations in the Mediterranean and along West Europe, with special attention to species having distributional limits within this area.

The approach is to:

- use both mitochondrial and nuclear markers as well as standard phylogeographic, historical demographic and food web related tools to compare the patterns detected in retreating edges and leading edges of cold temperate and warm water organisms respectively;
- search for changes in distributional records that might suggest changes in abundance during the study period;
- investigate the trophic ecology of each target species in order to detect trophodynamic changes and adaptations along the latitudinal gradient.

Apart from the main objectives this study will help to define the geographical limits of populations that are distinct, thus assisting policy makers to develop conservation schemes and marine protected areas.

MedEcos - Decadal-scale Variability of the Mediterranean Ecosystem

Summary information

Funding source:	MarinERA ERA-NET project
Funding contribution:	512.901
Start – end date:	1/01/2009 – 31/12/2011
Duration:	36 months
Project Coordinator:	Vassilis Zervakis (zervakis@marine.aegean.gr)
Organisation:	University of the Aegean, Department of Marine Sciences - Greece

Project Partners

1 University of the Aegean, Department of Marine Sciences - Greece
2 Hellenic Centre for Marine Research, Institute of Oceanography - Greece
3 University of Athens, Faculty of Geology and Geo-environment - Greece
4 Spanish National Research Council - Spain
5 Institute of Environmental Science and Technology - Spain

Background information

Project Summary

The project aims to improve our understanding and predictive capacity of the evolution of the Mediterranean Marine Ecosystem at decadal time scales by hindcasting conditions at the vicinity of connecting straits; and developping worst-case scenarios.

To this end, the approach of MedEcos encompasses:

- collecting available information on remote and local forcing;
- filling-in existing oceanographic and biogeochemical information and assessing variability;
- concentrating on natural Holocene climate shifts using multi-technique proxy-records;
- analyzing decadal variability;
- developing site-specific circulation and ecosystem models.

The project focuses on the geographic areas in the vicinity of the Gibraltar and Dardanelles Straits. Temporally, MedEcos will focus on periods of decadal length extending back to the last deglaciation, as well as the near future.

MedEcos should result in reproductions of the circulation and ecosystem functioning at selected periods of the Pleiocene; calibrated worst-case scenario for the next 100 years.

The project results will inform research working decadal- and regional-scale hindcasting and forecasting and improved exchange of know-how between paleoceanographers, modellers and field researchers.

MedEX - Inter-basin exchange in the changing Mediterranean Sea: Impact on the ecosystems in the vicinity of the Straits connecting the Mediterranean Sea with adjacent Basins

Summary information

Funding source:	MarinERA ERA-NET project
Funding contribution:	811.356
Start – end date:	1/05/2009 – 1/05/2012
Duration:	36 months
Project Coordinator:	Alvaro Peliz (ajpeliz@fc.ul.pt)
Organisation:	Faculty of Sciences of the University of Lisbon - Portugal

Project Partners

1 Faculty of Sciences of the University of Lisbon - Portugal
2 Department of Marine Sciences, University of the Aegean - Greece
3 Hellenic Centre for Marine Research - Greece
4 Institute of Accelerating Systems and Applications - Greece
5 Institute of Marine Science of Andalucía - Spain
6 Mediterranean Institute for Advanced Studies - Spain
7 National Institute for Biological Resources - Portugal
8 University of Málaga - Spain

Background information

Project Summary

Precipitation reduction across southern Europe and Northern Africa together with global warming are having significant impacts on the hydrology and circulation, affecting the Mediterranean Sea ecosystem to an as yet unprecedented extent. It is certain that the interbasin exchange will respond, affecting not only the hydrology of the entire Mediterranean Sea, but also the ecosystems in the marginal and communicating seas, like the Gulf of Cadiz and Alboran Sea to the west, and the North Aegean Sea to the east. MedEx will geographically "zoom" over these areas and focus on the changing inter-basin exchange processes impacting the ecosystems and will complement existing knowledge on local ecosystem dynamics, especially concerning processes directly dependant on the exchange between the Mediterranean and adjacent seas (the North Atlantic and the Black Sea). In order to achieve this goal, MedEX brings together a team of scientists from a broad range of disciplines and from both ends of the Mediterranean Sea with the aim to:

- perform a synthetic description of the physical processes directly associated with the inter-basin exchange between the Mediterranean Sea and the adjacent basins that affect the pelagic ecosystem in the vicinity of the Straits (Gibraltar and Dardanelles);
- depict the main trends of inter-basin exchange in the last 20 years as a regional driver of the marine ecosystems changes;
- implement/adapt an Atmosphere-Ocean-Ecology regional modelling system to investigate and predict ecosystem changes in the vicinity of the Straits, in hindcast/ forecast mode, and in a process-oriented perspective, and to assess the predictive skills of existing modelling systems.

ReDEcO - Regional Drivers of Ecosystem Change and its Influence on Deep-Sea populations in the Mediterranean

Summary information

Funding source:	MarinERA ERA-NET project
Funding contribution:	924,753
Start – end date:	1/04/2009 – 1/04/2012
Duration:	36 months
Project Coordinator:	Nikolaos Lampadariou (nlamp@her.hcmr.gr)
Organisation:	Hellenic Centre for Marine Research - Greece

Project Partners

1 Hellenic Centre for Marine Research - Greece
2 Institute of Marine Research - Portugal
3 University of de Aveiro, Centre for Environmental and Marine Studies - Portugal
4 University of Barcelona / Faculty of Geology - Spain
5 University of Piraeus, Department of Maritime Studies - Greece
6 National Centre for Scientific Research, CEFREM - France (no funds through MarinERA)

Background information

Project Summary

ReDEco brings together a consortium of six partners from four European countries with the aim to study the effects of regionally-driven ecosystem changes in selected deep-sea habitats of the Mediterranean Sea. The project focuses on key drivers of climate change such as temperature changes, shifts in surface productivity and cold water cascading, and examines their impacts on deep-sea populations. The principal objectives of the research programme are to:

- understand the effects of climate change on deep-sea ecosystems in relation to climate driven regional key factors and events;
- examine the variation of total particle flux to the seabed and understand how this may affect the micro-, meio-, macro-, and megabenthic communities;
- study benthic community responses to varying food supply;
- examine the effects of climate induced changes on deep-sea communities over shorter and longer (more than a decade)timescales;
- investigate historical demography and biogeography of selected species with distinctive dispersal capability and reproductive strategy;
- integrate available historical data, time series measurements and newly acquired data in a conceptual model to predict the impact of climate change on various physicochemical and/or biological parameters.

ReDEco will improve our understanding and prediction of decadal-scale fluctuations and their impact on biological communities and ecosystem functioning, which is essential for identifying vulnerable systems and pursuing options to enhance resilience and human well-being.

International and Regional Research Initiatives

BALTEX - The Baltic Sea experiment

Summary information

Funding source:	Project in the framework of the Regional Hydroclimate Project (RHP) of the Coordinated Energy and Water Cycle Observations Project (CEOP) within the Global Energy and Water Cycle Experiment (GEWEX) of the World Climate Research Programme (WCRP). Since January 2002, GKSS (now Helmholtz-Zentrum Geesthacht, HZG) has been the only sponsor of the International BALTEX Secretariat (IBS), covering salaries for the IBS staff members, infrastructure and travel support.
Start – end date:	Phase 1: 1993 – 2002 Phase 2: 2003 - 2012
Project Coordinator:	Helmholtz-Zentrum Geesthacht – Germany

Project Website:
http://www.baltex-research.eu/

Background information

Project Summary

Abstract
BALTEX (the Baltic Sea Experiment) is a Regional Hydroclimate Project (RHP) of the Coordinated Energy and Water Cycle Observations Project (CEOP) within the Global Energy and Water Cycle Experiment (GEWEX) of the World Climate Research Programme (WCRP).

The research focus of BALTEX Phase I (1993-2002) was primarily on the hydrological cycle and the exchange of energy between the atmosphere and the surface of the Earth, as they control and regulate the climate in a fundamental manner. BALTEX Phase II (2003-2012) has extended the scope of research to regional climate change, water management and biogeochemical cycles and transport processes in the regional Earth system. The study region of BALTEX is the Baltic Sea and its hydrological drainage basin, which constitutes a unique European water basin, creating specific demands on models and scientific concepts

The numerous scientific achievements of BALTEX Phase I have called for application in other areas where knowledge on and modelling capabilities of the water and energy cycles in the climate system are fundamental. A Science Plan for BALTEX Phase II has therefore been published in early 2004, which defines 6 major objectives including several specific goals with the overall strategy to enlarge the scientific scope of the programme and also to contribute to generating environmental policy- and stakeholder relevant information.

An important aspect of BALTEX Phase II will be a more holistic approach towards observing, understanding and modelling major environmental and socio-economic aspects relevant for the entire Baltic Sea basin. Parts of the BALTEX Phase II research activities will thus contribute to the build-up of a high resolution integrated modelling capability for Northern Europe, embedded in an Earth System Model.

Objectives

BALTEX Phase I Objectives, formulated in 1995:

- To explore and model the various mechanisms determining the space and time variability of energy and water budgets of the BALTEX region and this region's interactions with surrounding regions
- To relate these mechanisms to the large-scale circulation systems in the atmosphere and oceans over the globe
- To develop transportable methodologies in order to contribute to basic needs of climate, climate impact, and environmental research

BALTEX comprises both meteorological and hydrological research. Additionally, it has a strong oceanographic research component, at present a unique feature among the GEWEX regional-scale projects. BALTEX is designed as a cage experiment to assess the total heat and water flux divergence of the BALTEX area. The basic BALTEX programme elements include numerical modelling, data assimilation, experimental and numerical process studies, re-analysis of existing data sets, and application of remote sensing.

BALTEX Phase II (2003-2012) exceeds the scope of BALTEX to more applied and environmental research areas such as:

- Climate change and extreme events
- Improving tools for water management
- Air and water quality
- Involvement of stakeholders and decision makers
- Education and outreach

Basic research in the field of water and energy cycles remains the backbone of the programme. The vision is to create a common platform for scientists from all environmental disciplines, striving towards an integrative description of the Baltic Sea basin, including a retrospective modelling of the past and the simulation of the Baltic Sea basin environment in the future. An important aspect of BALTEX Phase II is the holistic approach towards observing, understanding and modelling major environmental and socio-economic aspects relevant for the entire Baltic Sea basin. BALTEX Phase II research thus contributes to the build-up of a high resolution integrated modelling capability for Northern Europe, embedded in an Earth System Model.

Project Outputs

Achievements of BALTEX Phase I

BALTEX Phase I has generated active research covering the whole field of advanced modelling and data studies in meteorology, hydrology and oceanography. Major research elements of BALTEX include the collection of in situ and remote sensing data, re-analysis of existing data sets, data assimilation, numerical experiments and coupled modelling and process studies including field experiments. It has brought major results both in scientific knowledge and research infrastructure at the European level.
In the following, a short overview over major achievements of BALTEX Phase I is given for the major compartments of the water and energy cycle of the Baltic Sea basin:

Phase I Achievements: Atmosphere

- Improved understanding of sea-atmosphere and land-atmosphere interaction in the BALTEX region through observational studies and offline model evaluation and through numerical studies with coupled models.
- Improved knowledge on precipitation and evaporation over the BALTEX region through new instruments, radar estimates and satellite sensors.
- Development of improved remote sensing techniques to determine e.g. precipitation rates by weather radar, precipitable water by GPS and cloud climatologies by AVHRR.
- Improvement of understanding and modelling of cloud physics, cloud-radiation interaction and precipitation initiation.

- Development of retrieval methods for cloud liquid water path from passive imagers and optimized estimates of the spatial distribution of liquid cloud water.
- Assessment of model liquid water path, cloud vertical structure and cloud overlap with microwave, lidar and cloud radar observations and the impact on radiation.
- Development of fully coupled atmosphere-land-ocean models of the Baltic Sea basin for present day and climate change applications.

Examples include the first coupled regional models for the entire Baltic Sea basin and improved water budget estimates through newly assimilated data sets. Also special observing periods, such as the Pilot Study for Intensive Data Collection and Analysis of Precipitation (PIDCAP) in 1995, and BRIDGE, the major enhanced observational period within BALTEX during 1999 to 2002 with dedicated additional observations, were conducted in the frame of BALTEX. BALTEX projects are still ongoing in different countries funded mainly by institutional and national sources.

Phase I Achievements: Hydrology and Runoff

- A database of monthly river flow has been compiled and made available through the BALTEX Hydrological Data Centre.
- Large-scale hydrological models of river flow to the Baltic Sea exist.
- Improved communication between meteorologists and hydrologists resulting in a better understanding of the water cycle and the modelling of it.
- Lateral water transport through runoff routing has been applied in climate models.
- Efforts to improve flood forecasting schemes with the help of regional atmospheric models for specific river basins have been made.
- Climate change scenarios of impacts to the water cycle in the Baltic Sea basin have been performed.

BALTEX Phase I has marked a significant advance in research on regional meteorology, hydrology of the Baltic Sea basin as well as oceanography of the Baltic Sea including sea ice. Results of BALTEX are documented in more than 250 peer-reviewed journal articles and numerous reports. Special journal volumes dedicated to the four BALTEX Study Conferences held in 1995, 1998, 2001 and 2004 provide comprehensive insight to BALTEX results. These include issues of Tellus (1996, Volume 48 A, No 5), Meteorologische Zeitschrift (2000, Volume 9, No 1 and 2), Meteorological and Atmospheric Physics (2001, Volume 77, No 1-4), Boreal Environmental Research (2002, Volume 7, No 3 and 4), and Nordic Hydrology (2005, Volume 36, Issues 4-5). Achievements of BALTEX Phase I have been compiled in a detailed state-of-the-art report (BALTEX, 2005). For a comprehensive overview over BALTEX publications, click here.

Phase I Achievements: Baltic Sea including sea-ice

- Meteorological, hydrological, ocean and ice data are now available for the research community through BALTEX data centres.
- Progress in understanding of the strong impact of large-scale atmospheric circulation on Baltic Sea circulation, water mass exchange, sea ice evolution, and changes in the ocean conditions of the Baltic Sea.
- Progress in understanding of the importance of strait flows in the exchange of water into and within the Baltic Sea.
- Progress in understanding of intra-basin processes.
- Ocean models are introduced to Baltic Sea water and energy studies.
- Development of turbulence models and 3D ocean circulation models for Baltic Sea.
- Advances of thermodynamic and dynamic coupling between the atmosphere, sea ice, and the sea; field experiments and modelling studies have yielded new results on local and regional surface fluxes and the interaction of the atmospheric boundary layer, sea ice, and open water.
- Progress in understanding the interaction between sea ice dynamics and thermodynamics.
- Advanced understanding of effects of river discharge and ice melt on the oceanic boundary layer below sea ice.
- Advanced understanding of the role of the large-scale atmospheric circulation for the ice conditions in the Baltic Sea.

CLIVAR - Climate variability and predictability

Summary information

Funding source:	International - World Climate Research Programme (WCRP)
Start – end date:	1998 – 2013
Duration:	15 years
Project Coordination:	International CLIVAR Project Office (icpo@noc.soton.ac.uk) National Oceanography Centre, Southampton – United Kingdom

Project Website:
http://www.clivar.org/

Background information

Project Summary

CLIVAR is the World Climate Research Programme (WCRP) project that addresses Climate Variability and Predictability, with a particular focus on the role of ocean-atmosphere interactions in climate. It works closely with its companion WCRP projects on issues such as the role of the land surface, snow and ice and the role of stratospheric processes in climate.

The challenges for CLIVAR are to develop our understanding of climate variability, to apply this to provide useful prediction of climate variability and change through the use of improved climate models, and to monitor and detect changes in our climate system.

As CLIVAR science advances, it becomes increasingly important and possible to address all aspects of the climate system, including the role of biogeochemical cycles, and to build the application of CLIVAR science to societal applications and impacts. To enable the necessary scientific interactions, CLIVAR looks to partnership with other international programmes, especially the International Biosphere-Geosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the International Programme of Biodiversity Science (DIVERSITAS).

The specific objectives of CLIVAR are:

- To describe and understand the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial time-scales, through the collection and analysis of observations and the development and application of models of the coupled climate system, in cooperation with other relevant climate-research and observing programmes.
- To extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled paleoclimatic and instrumental data sets.
- To extend the range and accuracy of seasonal to interannual climate prediction through the development of global coupled predictive models.
- To understand and predict the response of the climate system to increases of radiatively active gases and aerosols and to compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal.

A complete overview about CLIVAR can be found in the CLIVAR Handbook (see project website).

GLOBEC - Global Ocean Ecosystem Dynamics

Summary information

Funding source:	Project of The International Geosphere-Biosphere Programme (IGBP), an interdisciplinary scientific activity established and sponsored by the International Council for Science (ICSU). Project co-sponsored by IGBP, SCOR and UNESCO/IOC
Start – end date:	1999-2009
Duration:	10 years
Project Coordinator:	Manuel Barange (GLOBEC Director) (m.barange@pml.ac.uk)

Project Website:
http://www.globec.org/

Background information

Project Summary

About GLOBEC
The GLOBEC programme officially ran from 1999-2009. The aim was to advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change. GLOBEC considered global change in the broad sense, encompassing the gradual processes of climate change and its impacts on marine systems, as well as those shorter-term changes resulting from anthropogenic pressures, such as population growth in coastal areas, increased pollution, overfishing, changing fishing practices and changing human use of the seas.

GLOBEC had four primary objectives:

- To better understand how multiscale physical environmental processes force large-scale changes in marine ecosystems
- To determine the relationships between structure and dynamics in a variety of oceanic systems which typify significant components of the global ocean ecosystem, with emphasis on trophodynamic pathways, their variability and the role of nutrition quality in the food web.
- To determine the impacts of global change on stock dynamics using coupled physical, biological and chemical models linked to appropriate observation systems and to develop the capability to predict future impacts.
- To determine how changing marine ecosystems will affect the global earth system by identifying and quantifying feedback mechanisms.

GLOBEC consisted of 4 cross cutting research foci, 7 regional programmes and National programme activities.

Project outputs

This 10 year project produced a wealth of useful results, data and information products. The project website provides an overview of the available data and information products including downloadable project highlights and access to project databases.

IMBER - Integrated Marine Biogeochemistry and Ecosystem Research

Summary information

Funding source:	IMBER is an IGBP-SCOR project
Start – end date:	2004 – present
Project Coordinator:	Lisa Madidison (Executive Officer) (Lisa.Maddison@univ-brest.fr)

Project Website:
http://www.imber.info/

Background information

Project Summary

IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) is an IGBP-SCOR project focussing on ocean biogeochemical cycles and ecosystems. IMBER builds on the success of the now-completed JGOFS and GLOBEC projects. The IMBER vision is to provide a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth System and human society. The IMBER Science Plan and Implementation Strategy (SPIS) was recently updated to facilitate the inclusion of the ongoing regional programmes from GLOBEC and the new relevant research directions. The Supplement to the IMBER SPIS can be downloaded from http://www.imber.info/SPIS.html. Alternatively, copies can be requested from imber@univ-brest.fr Here, an overview of the scope of the IMBER science agenda is provided.

Human activities are rapidly altering Earth System processes that directly and indirectly influence society. Informed decisions require an understanding of which parts of the Earth System are most sensitive to change, and the nature and extent of anticipated impacts. This requirement underlies the IMBER goal: *to investigate the sensitivity of marine biogeochemical cycles and ecosystems to global change, on time scales ranging from years to decades.*

To achieve this IMBER will identify key interactions between marine biogeochemical cycles and ecosystems, and assess how these interactions respond to complex natural and anthropogenic forcings. Important forcings include large-scale climate variations, changing physical and biological dynamics, changing carbon cycle chemistry and nutrient fluxes, and widespread marine harvesting. The major drivers of change considered are physical dynamics, seawater CO_2 (controlling ocean pH), nutrients (with changing inputs to the euphotic zone from the subsurface waters, sediments and land), and intensive fish harvesting. This research will fill the critical gap between short-term climate events (seasonal scale) and anthropogenic global change (century scale). To address its goal IMBER research is structured around four themes as follows:

Theme 1: Interactions Between Biogeochemical Cycles and Marine Food Webs

Key issues: (i) the transformation of organic matter in food webs, (ii) transfers of matter across ocean interfaces, and (iii) material flows in end-to-end food webs. Interactions between biogeochemical cycles and food webs are expected to differ between environments such as continental margins associated with coastal upwelling, high latitude and Polar Regions, and tropical and subtropical oligotrophic gyres. Comparison of different systems will provide new insights for identifying and understanding fundamental interactions between marine biogeochemical cycles and ecosystems.

Theme 2: Sensitivity to Global Change

This theme will advance understanding of how marine biogeochemical cycles and ecosystems respond to the complex suite of forcings associated with global change. Identifying components that respond directly to global change is a primary concern. In this theme, responses are partitioned into four major issues: (i) effects of climate-induced changes in the physical dynamics of the ocean, (ii) effects of increasing CO_2 levels and decreasing pH, (iii) effects of changes in macro- and micronutrient inputs to the ocean, and (iv) impacts of marine harvesting. The issues are considered from different interdisciplinary perspectives.

Theme 3: Feedbacks to the Earth System

This theme will focus on the present and future capacity of the ocean to affect the climate system via ocean effects on atmospheric composition and heat storage. The key issues here are: (i) the varying capacity of the ocean to store anthropogenic CO_2, (ii) ecosystem feedbacks on ocean physics and climate and (iii) how changes in low-oxygen zones affect the nitrogen cycle, particularly transformations involving N_2O. Understanding of local and regional manifestations of global change in the ocean is required to model the potential feedbacks from marine biogeochemical cycles and ecosystems to the Earth System.

Theme 4: Responses of Society

This theme will focus on interactions between human and ocean systems. Its motivation stems from recognition that humans not only influence ocean systems, but also depend on ocean systems for goods and services. The theme goal is to promote an understanding of the multiple feedbacks between human and ocean systems, and to clarify what human institutions can do, either to mitigate anthropogenic perturbations of the ocean system, or to adapt to such changes. A major challenge of this theme will be to bring together scientists from a wide range of disciplines, to identify areas of joint concern and interest, and to create an ongoing natural-social science marine research community.

Implementation

IMBER will take advantage of new and innovative approaches to marine research ranging from new molecular techniques to sustained *in situ* and remotely sensed observations. The development of new sustained observation sites will be an important part of the implementation strategy complemented by targeted field-based process studies, *in situ* mesocosm studies, and field and laboratory experiments. A suite of hierarchical models will be developed to test hypotheses, analyse data and extrapolate in space and time, and identify crucial knowledge gaps that require new observations. Extrapolation to the global scale will require integration and assimilation of data from basin-wide surveys. To support modelling and synthesis, interconnected biological, geochemical and physical databases will be built, extended, and updated in near real-time.

Answering the broad interdisciplinary questions will require an effort much larger than any single nation can mobilise. Multiple investigators spanning disciplines, and intercomparisons of data across a range of systems will be needed. Interfacing the natural and social science communities to study the key impacts and feedbacks between marine and human systems will be a major challenge. IMBER will encourage collaborative activities that will draw on the expertise of other international research projects and programmes, including the Global Ocean Observing System, to avoid duplication and to ensure a truly interdisciplinary approach.

Project Outputs

Newsletters, reports and publications are available from the project website which also includes an IMBER data portal (http://www.imber.info/DM_home.html).

ODBMS Black Sea - Black Sea Ecosystem Processes And Forecasting / Operational Database Management System

Summary information

Funding source:	NATO Science for Peace Sub-Programme
Start – end date:	1/01/1998 - 1/03/2003
Duration:	60 months

Project Website:
http://sfp1.ims.metu.edu.tr/

Project Partners

1 Institute of Marine Sciences METU - Turkey
2 Marine Hydrophysical Institute - Ukraine
3 P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences - Russian Federation
4 Southern Branch of P.P.Shirshov Institute of Oceanology - Russian Federation
5 Institute of Biology of Southern Seas - Ukraine
6 Romanian Marine Research Institute - Romania
7 Institute of Oceanology of Bulgarian Academy of Sciences - Bulgaria
8 Tbilisi State University - Georgia

Background information

Project Summary

Project Description
In relation to its marine ecosystems, the Black Sea deserves increased vigilance and effective environmental management. This is primarily due to the fact that of all the basins of the world ocean, the environmental degradation in the Black Sea is the most severe. Environmental problems of the Black Sea are intimately related to the unique characteristics of the marine environment. The Black Sea is nearly landlocked and the ventilation of the deep waters by lateral influxes is poor. In addition, a strong density stratification effectively inhibits vertical mixing. As a result, permanent anoxia exists within 87% of the Black Seas volume, making the Black Sea the largest anoxic basin of the global ocean. Its surface area is five times smaller than its catchment basin, covering parts of the neighboring European and Asian continents where human activities impose environmental burdens on this basin. About 162 million people live in the catchment area of the Black Sea (Mee, 1992; Unluata *et al*., 1993). The health and wellbeing of these people are affected by the environmental degradation in the Black Sea.

Adequate prediction of the environmental variability in the Black Sea is needed to identify, analyze and determine the costs of solutions for better management of the marine environment aimed for sustainable development of the Black Sea resources. Furthermore, the environmental management of the Black Sea and the related scientific and technological developments require an interdisciplinary and easily accessible Data Base Management System (DBMS) with user friendly interfaces for data reception, assembly, quality control, storage, continuous dissemination, and exchange.

Objectives of the Project:

- To explore, quantify and predict the ecosystem variability of the Black Sea through process studies and development of coupled interdisciplinary models with data assimilation schemes that will allow: prediction of the future states of the sea (FORECASTING); descriptions of the present (NOWCASTING) and the past states of the sea and displaying trends and changes (HINDCASTING).
- To develop further the NATO Black Sea Data Base and Management System for management oriented operational marine forecasting and research, requiring transmission to a wide variety of users quality controlled data received from moored buoys, ships, drifting sensor arrays, fixed platforms and satellites, with stringent requirements in DBMS-to-USER transmission in delayed and / or near-real-time modes.

The specific objectives include:

- To describe the physical and biochemical processes, explain and understand the mechanisms involved, and determine the extent of the predictability of the system on time scales of weeks to months, and space scales from several kilometers to several hundreds of kilometers (i.e., the mesoscale);
- To accumulate quantitative understanding of the interactions between small-, meso- and large-scale physical and ecosystem processes;
- To develop data assimilative general circulation and nested regional/coastal/shelf nowcast/forecast models capable of predicting the current, temperature, and salinity fields on time scales of a few weeks to several months;
- To further develop coupled biochemical-physical interdisciplinary models to predict the variability of the lower trophic levels of the deep water and the coastal ecosystems as they are affected by anthropogenic forcing, synoptic variability, and climate fluctuations;
- To upgrade software and hardware capabilities of the existing NATO Black Sea Data Base and Management System in regard to large volumes of data from observation systems;
- To advance the data exchange capabilities among the Riparian States by developing new capabilities for handling satellite and meteorological data;
- To rescue the existing interdisciplinary historical data sets, particularly to enable trend-monitoring for the purpose of environmental management;
- Integrate the project activities with the creation of a regional Global Ocean Observations Systems (GOOS) program for the Black Sea under the sponsorship of national governments (to be implemented by the national agencies) by linking the predictive models with interdisciplinary data assimilation schemes to the observational network to be developed and making sure that the linkage also involves a module for designing optimum sensor- sampling configurations and specifications through theory and observations.

Firstly, intensive field observations on specific processes (process studies) will be carried out for testing of the various crucial hypotheses. General analysis schemes will be developed for the identification and interpretation of coupled physical-biogeochemical ecosystem dynamical processes. The specific tasks of these activities will be to document the pathways, the regulation of rates and feedbacks, the population dynamics, and the roles of physical, climatic and anthropogenic forcing in driving the ecosystem variability of the Black Sea. Furthermore, these efforts will be critical in the determination of various rate parameters including respiration, grazing, and fecal pellet production that are needed in the models.

Secondly, coupled physical-biological-chemical ecosystem dynamical models with interdisciplinary data assimilation schemes will be developed, validated and applied. The models will involve:

- A basinwide ocean general circulation model (OGCM) for the physical component of the ecosystem, capable of simulating and predicting the three-dimensional structure of the flow field, temperature, and salinity distributions and their time evolutions with mesoscale resolution, with particular emphasis on the coastal-shelf regions; and
- A biogeochemical model coupled to the physical model for simulating and predicting the seasonal and longer term variability and spatial distribution of contaminants, nutrients, and other living and non-living components of the ecosystem (BGCM).

Other environmental issues that the coupled biogeochemical-physical model will address include exchanges of nutrients and other biogenic materials between the shelf and the interior, pathways of nutrient transport, translocation and change in the spawning / overwintering characteristics of fish, egg and larvae stocks and their correlation with the primary productivity on the regional scale.

Thirdly, a database management system based on the existing NATO Black Sea Data Base and Management System will be developed. This is needed to develop innovative, efficient and practical ways of processing, archiving, and disseminating the large volume of data needed by the modellers. A fundamental issue here is the provision of services with fast turnover time without adversely affecting the accuracy of the resulting product, using sophisticated signal processing algorithms. When complemented with historical data, the existing database and management system will also serve to monitor the environmental trends which are crucial from the management perspective.

And, finally, dissemination of the results of the Project to the end users, and other environmental management agencies and authorities will be fulfilled.

Project Outputs

Extensive information on the project outputs is available on the project website, including a project database.

Annex 1. List of other indireclty relevant projects which are of interest

FP5

- **BIOCOMBE** - The impact of BIOdiversity changes in COastal Marine Benthic Ecosystems
  http://www.nioo.knaw.nl/projects/biocombe/index%20pages/index.htm
- **MAMA** - Mediterranean network to Assess and upgrade the Monitoring and forecasting Activity in the region
  http://cordis.europa.eu/fetch?CALLER=PROJ_ICT&ACTION=D&CAT=PROJ&RCN=60767

FP6

- **ADAM –** Adaptation and Mitigation Strategies: Supporting European climate policy
  http://www.adamproject.eu
- **AMMA** - African Monsoon Multidisciplinary Analysis
  http://amma.mediasfrance.org/
- **ASCABOS** - A Supporting Programme for Capacity Building in the Black Sea Region towards Operational Status of Oceanographic Services
  http://www.ascabos.io-bas.bg/
- **BLACK SEA SCENE** - Upgrade Black Sea Scientific Network
  http://www.blackseascene.net/
- **BONUS ERA-NET** - BONUS for the Baltic Sea Science – Network of Funding Agencies
  http://www.bonusportal.org/about_bonus/bonus_era-net/
- **CIRCLE** - Climate Impact Research Co-ordination for a Larger Europe
  http://cordis.europa.eu/fetch?CALLER=FP6_PROJ&ACTION=D&RCN=72858&DOC=1&CAT=PROJ&QUERY=2
- **ENCORA** - European Network for Coastal Research
  http://www.coastalwiki.org/coastalwiki/Main_Page
- **ENHANCE** - Enhancing the European Participation in Living with Climate Variability and Change: Understanding the Uncertainties and Managing the Risks
  http://www.ist-world.org/ProjectDetails.aspx?ProjectId=83d07126ea08427f9d8293d4ac54a201
- **EUCAARI** - European Integrated Project on Aerosol Cloud Climate Air Quality Interactions
  http://www.atm.helsinki.fi/eucaari/
- **IN EX FISH –** Inconrporating Extrinsic Drivers into Fisheries Management
  http://www.liv.ac.uk/inexfish/index.html
- **NET-BIOME** - NETworking tropical and subtropical Blodiversity research in OuterMost regions and territories of Europe in support of sustainable development
  http://www.netbiome.org/
- **NOAHS ARK** - Global Climate Change Impact on Built Heritage and Cultural Landscapes
  http://noahsark.isac.cnr.it/
- **OOMPH** - Organics over the Ocean Modifying Particles in both Hemispheres
  http://cordis.europa.eu/fetch?CALLER=FP6_PROJ&ACTION=D&DOC=1&CAT=PROJ&RCN=74906
- **SPICOSA** - Science and policy integration for coastal System Assessment
  http://www.spicosa.eu/
- **WIT** - What poor information can tell: Analysis of climate policies under large uncertainty about climate change

FP7

- **CAREX** - Coordination Action for Research Activities on life in Extreme Environments
  http://www.carex-eu.org/

- **BONUS +** - Multilateral call for research projects within the Joint Baltic Sea Research Programme BONUS+
  http://www.bonusportal.org/about_bonus/bonus_call
- **CIRCLE 2 ERA-NET** - Climate Impact Research Co-ordination for a Larger Europe
  http://www.circle-era.eu/np4/home.html
- **ECO2** - Sub-seabed CO2 Storage: Impact on Marine Ecosystems
  http://www.eco2-project.eu
- **EUROMARINE** - Integration of European Marine Research Networks of Excellence
  http://www.euromarineconsortium.eu/vision
- **ODEMM** - Options for Delivering Ecosystem-Based Marine Management
  http://www.liv.ac.uk/odemm/
- **PEGASO** - People for Ecosystem Based Governance in Assessing Sustainable Development of Ocean and Coast
  http://www.pegasoproject.eu/
- **MyOcean** - Development of the GMES Marine core services
  http://www.myocean.eu.org/
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Other European, international and regional projects and initiatives

- **BADMINTON** - Bycatch and discards: management indicators, trends and location
  http://83.212.243.10/badminton.html
- **CLIMAFISH** - CLIMAte and small pelagic FISH
  http://climafish.wikispaces.com/
- **CPR** - Continuous Plankton Recorder Survey
  http://www.sahfos.ac.uk/about-us/cpr-survey/the-cpr-survey.aspx
- **Ecosystem Modeling as a Management Tool for the Black Sea**
  http://sfp1.ims.metu.edu.tr/TU-BlackSea/default.htm
- **ESA CCI –** ESA Climate Change Intitiative
  http://earth.eo.esa.int/workshops/esa_cci/
- **ESEAS** - European Sea-Level Service
  http://www.eseas.org/
- **EURO-ARGO** - European component of a world wide *in situ* global ocean observing system, based on autonomous profiling floats
  http://www.euro-argo.eu/About-Euro-Argo
- **GEOTRACES** - An International Study of the Marine Biogeochemical Cycles of Trace Elements and Their Isotopes
  http://www.geotraces.org/
- **GOOS** - Global Ocean Observing System
  http://www.ioc-goos.org/
- **IGBP** - The International Geosphere-Biosphere Programme
  http://www.igbp.kva.se/
- **IHDP** - International Human Dimensions Programme on Global Environmental Change
  http://www.ihdp.unu.edu/
- **IPBES** - Intergovernmental platform on biodiversity and ecosystem services
  http://ipbes.net/
- **IPCC** - Intergovernmental Panel on Climate Change
  http://www.ipcc.ch/
- **LOICZ –** Land Ocean Interactions in the Coastal Zone
  http://www.loicz.org/
- **MOON** - Mediterranean Operational Oceanography Network
  http://www.moon-oceanforecasting.eu/
- **NEMO** - Nucleus for European Modelling of the Ocean Consortium
  http://www.nemo-ocean.eu/

- **OceanSITES** - Worldwide system of long-term, deepwater reference stations
  http://www.whoi.edu/virtual/oceansites/
- **OSPAR QSR 2010** – The 2010 Quality Status Report of the North-East Atlantic and its sub-regions
  http://qsr2010.ospar.org/en/index.html
- **REPRODUCE** - Understanding recruitment processes using coupled biophysical models of the pelagic ecosystem
  http://www.pelagic-ecosystems.net/REPROdUCE/
- **SOLAS** - Surface Ocean Lower Atmosphere Study
  http://solas-int.org/
- **VACCIA** - Vulnerability assessment of ecosystem services for climate change impacts and adaptation
  http://thule.oulu.fi/vaccia/index.html
- **WCRP** - World Climate research programme
  http://www.wcrp-climate.org/
- **WOCE** - The World Ocean Circulation Experiment
  http://woce.nodc.noaa.gov/wdiu/