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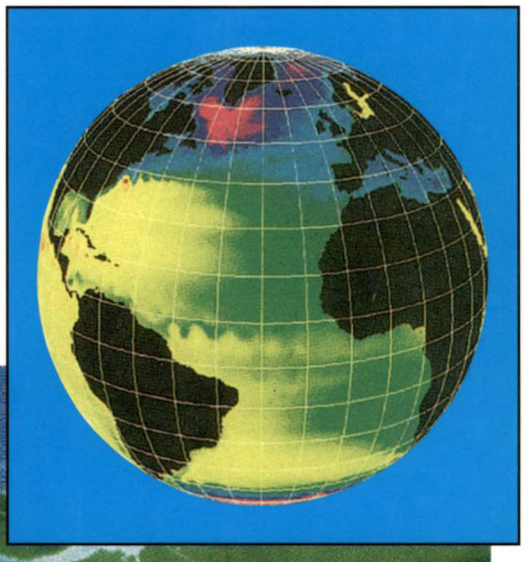
14

European Global Ocean Observing System

The EuroGOOS Plan



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Cover picture

Large image: "A water perspective of Europe", courtesy of Swedish Meteorological and Hydrological Institute. The white lines show the watershed boundaries between the different catchment areas flowing into the regional seas of Europe.

Inset image: Height of the sea surface in the north Atlantic and Arctic simulated by the OCCAM global ocean model, courtesy of David Webb, James Rennell Division, Southampton Oceanography Centre.

Preface

The European Association for the Global Ocean Observing System (EuroGOOS) exists to maximise the benefits to Europe from operational oceanography within the framework of the Global Ocean Observing System (GOOS). EuroGOOS Member Agencies are already deeply committed to conducting marine research, to conducting operational oceanography, and delivering products to customers (See Annexe 1). Extensive customer research has been carried out, and EuroGOOS has identified both the customer community, and the products which they need. The scale of the business generated in operational oceanography will be of the order of 5000 jobs, with a turnover of the order of 500 million Ecu per year.

The provision of a service, created collaboratively by European and national agencies, which provide statistics and forecasts of the state of the coasts, seas and ocean will support hundreds of commercial and governmental activities. The estimated benefit to European industry and maritime services is of the order of 2 to 5 bn Ecu per year. The same service will contribute to predicting climate change and sea level rise.

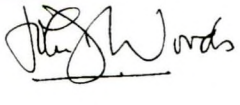
Exploiting the trend to globalisation, Europe can export its hardware and services in this sector of operational oceanography, and establish competitive advantages alongside USA and Japan. If we fail in this, European industries will buy their ocean forecast services from Japan, USA and a few other technically developed countries.

European citizens expect new industries to improve their quality of life, work, and the environment, and to support sustainable development. They expect that nations will collaborate in a system of intelligent management of the environment, preventing or minimising the adverse impacts of climate change, and maintaining biodiversity. These objectives will be advanced by national and European agencies collaborating in monitoring and predicting the seas and oceans through a cost-effective system of operational oceanographic services. EuroGOOS provides the framework for achieving that co-operation.

The EuroGOOS Plan builds on the "Strategy for EuroGOOS", which was approved by the EuroGOOS Conference in The Hague in October 1996 after an extensive review process. The Plan is presented here in outline; it introduces six regional projects and two underpinning programmes. These projects are being designed to demonstrate the potential of collaboration between agencies in creating operational services in European home waters and in the oceanic hinterland. More details of each project will be presented in an expanded version of the EuroGOOS Plan to be published in June 1997.

These EuroGOOS projects will be funded in three ways: (1) from the resources of the member Agencies which will bid for additional national funds in the usual way, (2) from the resources of participating European Agencies, and (3) from funds administered by the European Commission. The coherent, collaborative and cost effective approach being developed in these projects will provide a model for the future permanent structure. The projects serve not only to resolve technical challenges posed by the transition from the research-based discipline of oceanography to operational services, but also the socio-political challenge of establishing new infrastructure that will serve the whole community by improving economic competitiveness and the quality of life.

The map on the cover reminds us that Europe is a continent of peninsulas and islands. It enjoys a maritime climate and its population interacts closely with the surrounding seas and the rivers that flow into them. The bulk of our trade is carried by ships. The marine environment matters more to Europe than to any other continent. It is therefore appropriate that now we have the technology we in Europe should take the lead in monitoring and predicting our home waters and their oceanic hinterland. The new political order in Europe makes it possible to do so in a cost effective manner through an ambitious and unprecedented programme of collaboration. That is the EuroGOOS Plan.



Introduction

United Nations Agencies (IOC, WMO, UNEP) and the International Council of Scientific Unions (ICSU) have established the Global Ocean Observing System (GOOS). EuroGOOS is the Association of European national agencies established to provide forecasts of the ocean, coastal seas, and climate by means of monitoring and modelling the state of the sea, within the framework of GOOS. The business of measuring, monitoring, modelling, and forecasting is called operational oceanography.

Investment of research in operational oceanography during Framework 5, combined with operational development in the Directorates responsible for Transport, Fisheries, Energy, and the Environment, will create a new European resource which benefits industry, the environment, and future scientific research.

GOOS is supported by the Agenda 21 report published by the United Nations Conference on the Environment and Development (UNCED) in 1992. The subsequent Conventions on the Climate, Biodiversity, and Sustainable Development all require a full understanding and management of the ocean if they are to be implemented successfully. GOOS and EuroGOOS provide the means by which the nations of the world can measure, model, and predict the state of the world ocean.

Recent developments in satellite observations of the ocean, super-computers, remote-controlled robotic instrument platforms, data transmission, ocean modelling software, and micro-miniaturisation of instruments, permit the design of an economically justified observing system. The economics of GOOS was studied at an OECD Workshop held in Tokyo in 1993.

The purpose of the EuroGOOS Plan is to:

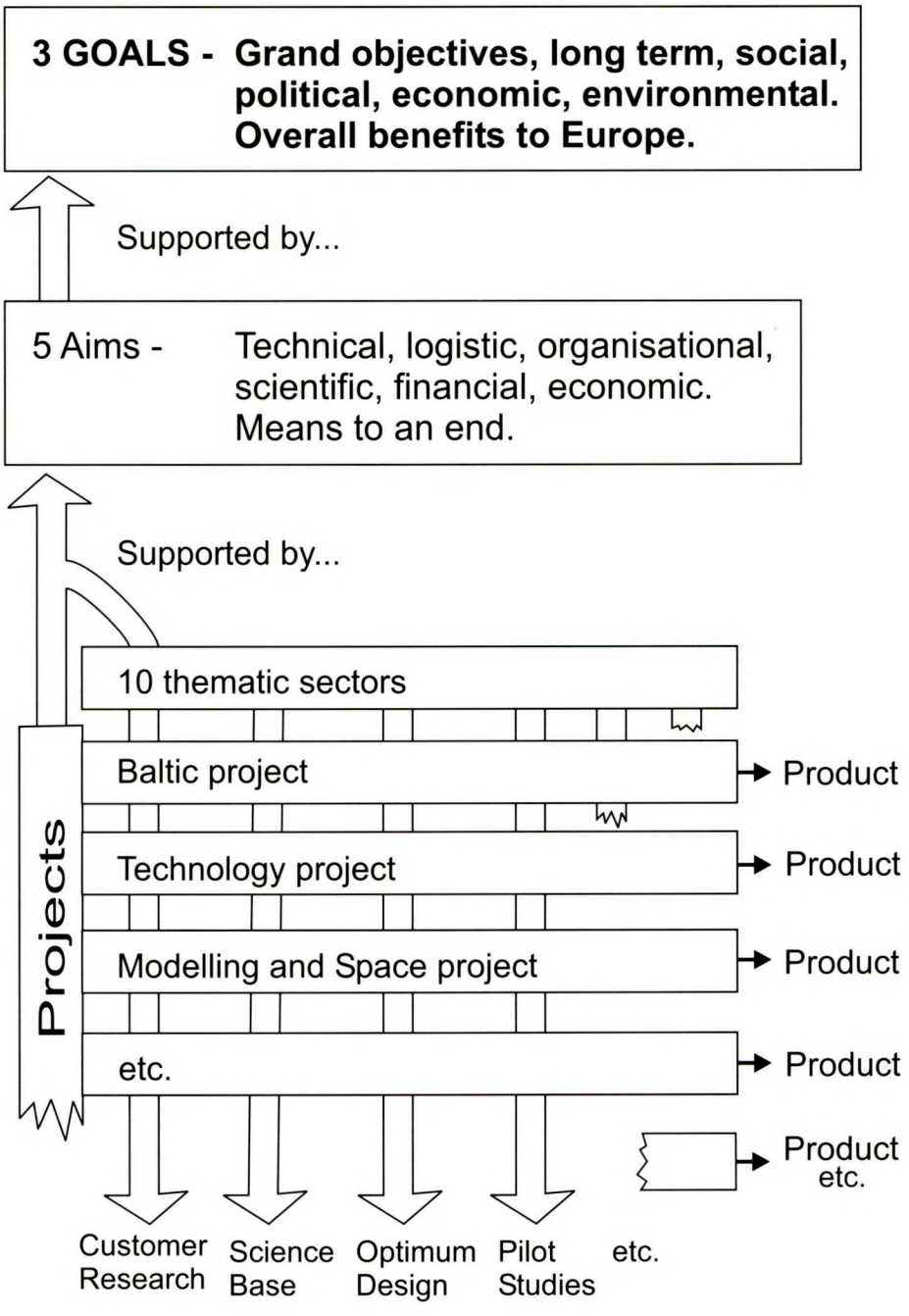
- Focus implementation of the EuroGOOS Strategy onto six regional projects and two underpinning programmes.
- Define the steps needed to produce economic and social benefits for Europe from EuroGOOS
- Inform EU Institutions, the EC, Council of Ministers, and European Parliament.
- Outline the costs and benefits of EuroGOOS, and suggest methods of funding
- Promote the development of national and European co-ordination in order to implement the Plan

High technology marine industries depend upon increasingly sophisticated data and environmental services for design of structures and operations. The deepest exploitation of offshore oil is now in a depth of 1650 m of sea water. Pipelines for oil and gas are routinely laid for hundreds of km on the European continental shelf. Exploration for and production of offshore oil and gas are now carried out in the North Atlantic west of the Shetlands, off Norway, and in the Arctic ocean off the coast of Russia, as well as in the North Sea and Mediterranean. Fibre optic communications cables are laid across every ocean. Fisheries require ever more data for efficient management and conservation of stocks. Faster ships require increasingly sophisticated information on wind, waves, currents and ice so as to enhance safety, speed, and efficiency. Marine tourism is one of the fastest growing sectors, and is the dominant source of marine revenue in several countries. The investment in so many marine industries and services leads to a greater mass of capital equipment and installations at risk. Operational oceanography provides an essential service, with forecasts of the maritime conditions, and management information for control of pollution and coastal protection. The challenge for EuroGOOS is to design an integrated system that can economically satisfy the needs of that wide range of customers.

Marine conditions have a controlling influence on the weather, both over the ocean and over the land. Improved availability of ocean forecasting models and shelf seas models will generate benefits in weather forecasts in the medium term, and improve seasonal forecasts of the atmosphere. Ultimately, coupled ocean atmosphere models will provide the only hope of predicting climate variability and climate change on timescales of several years to decades.

Industrial and commercial organisations expect that governments will provide the infrastructure for ocean modelling and prediction on the global and European scales. They regard it as feasible and necessary. The general public expects ocean monitoring to be conducted in such a way that the health of the oceans is protected, and biodiversity is preserved. The means to achieve these ends are becoming available, and the political climate is right. The EuroGOOS Plan shows how we can most effectively achieve the transition from the curiosity-led discipline of oceanography to operational services describing and predicting the marine environment.

EuroGOOS Implementation



Goals of EuroGOOS

The structure of EuroGOOS is shown in the diagram opposite. The Goals of EuroGOOS are the long term over-riding reasons for developing operational oceanography in order to provide benefits to Europe. These goals are supported by a group of Aims, which are more technical and organisational. These in turn are achieved by implementing operational projects, supported by thematic research and development.

The Goals of EuroGOOS are:

Goal 1. Building on Scientific Success. Now is the time to gain the full benefits from the last 50 years of investment in marine science and technology in Europe. Integration of present skills into global and regional modelling, with forecasting, will provide a new range of services.

Goal 2. Creating new Operational Marine Services. Operational oceanography will create new businesses in Europe, and new jobs. Operational oceanography provides predictions and forecasts which will improve the efficiency of industries and services presently contributing 200 bn Ecu per year to the European GNP.

Goal 3. Developing a Global System. The public expects a collaborative scientific approach to planetary environmental management. To succeed, we must learn to predict the ocean and coastal seas. European collaboration will permit Europe to wield influence on a global scale.

The Aims of EuroGOOS are to:

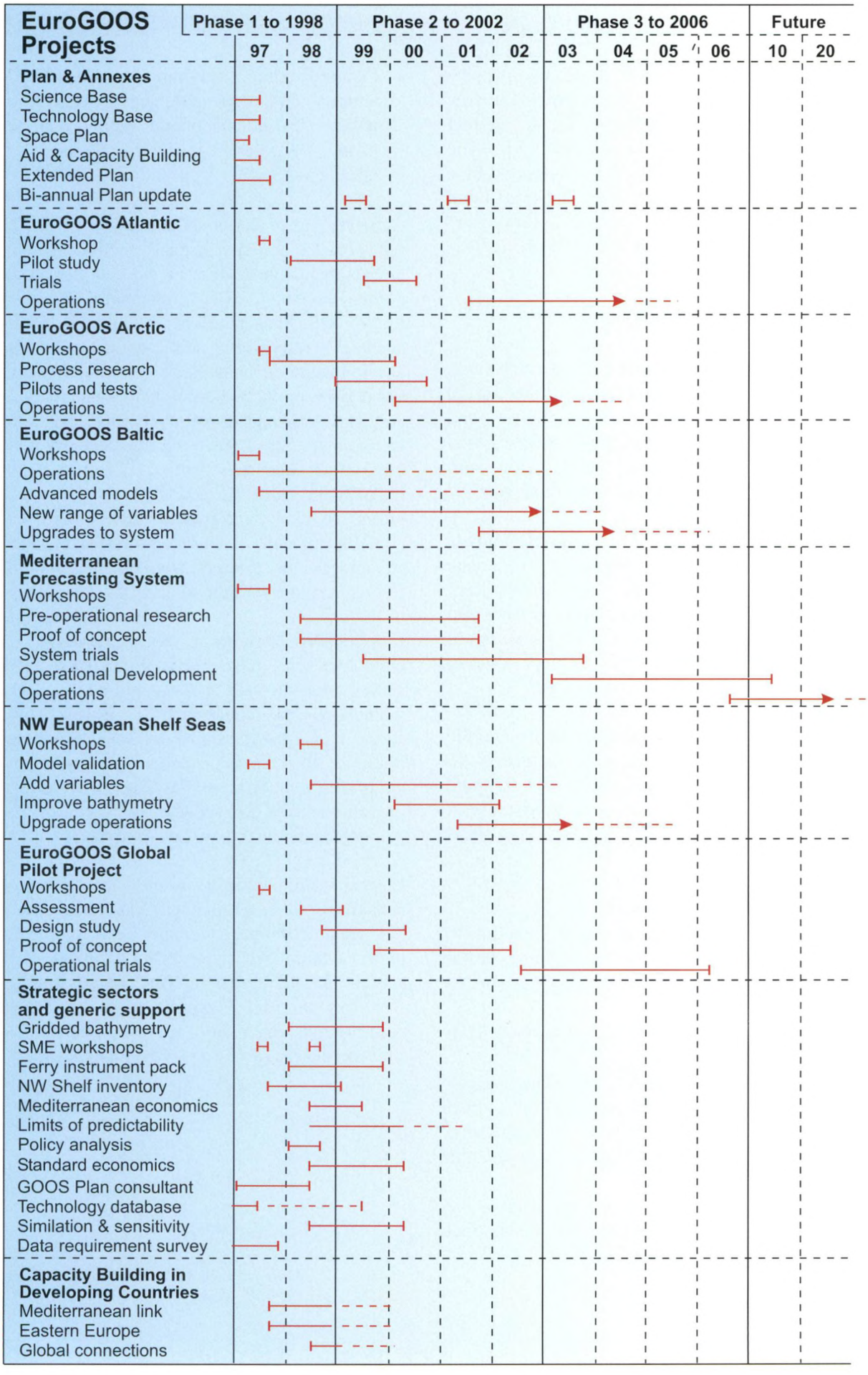
- Assess the economic and social benefits to Europe from forecasting marine and coastal conditions and the marine contribution to climate forecasting.
- Prioritise the benefits to Europe from operational oceanography
- Promote the development of technological, computer, and science-based industries which will advance European operational oceanography for predicting the state of the ocean.
- Establish a concerted European approach to the planning and implementation of the Global Ocean Observing System (GOOS)
- Ensure routine collaboration between European national and multi-national agencies so as to obtain maximum economic and social benefit from the new business of operational oceanography.

Achievement of the goals and aims of EuroGOOS will produce benefits in many sectors of industry, environmental management, and services such as public health. The implementation of the EuroGOOS Plan requires collaboration between agencies responsible for maritime transport, environmental management, coastal defences and flood prevention, fisheries, harbours, offshore oil and gas, tourism, maritime research, and marine technology. Since the formation of EuroGOOS in 1994 most countries with Member agencies in EuroGOOS have formed national co-ordination groups to plan their participation in both GOOS and EuroGOOS. These groups can sum the advantages which result from improved maritime forecasts, and assess the total national benefit.

EuroGOOS Members, both nationally and collaboratively, have conducted market research surveys, liaison with industry and SMEs, and held workshops and conferences to ensure that the services planned through EuroGOOS are designed directly to meet economic, social, and environmental needs. By developing these services in collaboration we achieve goals which are not attainable any other way, and save money.

Europe is in a strong position to lead in the ocean revolution. The EuroGOOS Plan shows the way. No single European country can monitor and predict all the sea areas which influence its own economic, environmental and social conditions. Nor can a single country make a significant contribution to the global structure and implementation of GOOS. Together we can.

EuroGOOS Plan Timetable



Projects & implementation

The Strategy for EuroGOOS sets out phases for the development of EuroGOOS.

Phase 1- from 1996 to 1998
Phase 2- from 1998 to 2002
Phase 3- from 2002 to 2006, and beyond.

The various regional seas projects, and the Atlantic and Global Pilot Project will proceed at different rates because of radically different starting conditions in each area, differing requirements, and the different obstacles to installing observing systems. For example, it is much more difficult to obtain measurements from the bottom of the central Atlantic than from the Baltic or North Sea. Some regions have to start developments with applied process research and pre-operational development, while in other regions some work can start on improving and up-grading existing services through the application of new technology and new scientific knowledge.

Types of Projects to be implemented include:

- Regional seas operational implementation, long term objectives.
- Regional seas pilot projects.
- Demonstration projects
  - Paper studies
  - Trials
  - Test Cases
  - Pilot projects on procedures and systems
- Organise collaboration between EuroGOOS and the objectives and programmes of European Agencies.
- Improved Communications
  - Conferences, proceedings
  - Workshops
  - Web page
  - Newsletter
  - Task Teams
  - Publications, books, manuals
- Communications with SMEs
  - Joint projects
  - Workshops on commercial participation
- International aid and capacity building programmes

The projects implemented by EuroGOOS are themselves supported by ten thematic (generic) strategic sectors, devoted to market research, product development, technology, numerical modelling, etc.

EuroGOOS Agencies already have substantial experience of the research needed to develop operational ocean services, and the procedures for running such services. The EuroGOOS Annual report for 1996 lists 30 projects already under way at the national level, or conducted by groups of agencies between a few countries. There is thus a secure base of experience upon which to develop the more ambitious integration of data, modelling, and products at the scale of regional seas, and the whole of Europe and the North Atlantic.

This Plan will describe in outline the main regional seas Projects, which fall into the following classes in terms of their starting position:

- **Development of existing systems, integration, extension of variables and products:**
  Baltic, North West European Shelf.

- **Pre-operational pilot projects:**
  Atlantic, Arctic, and Mediterranean.

- **EuroGOOS contribution to the global system of GOOS:**
  Atlantic global pilot project

and:

- **Capacity building**

The following pages describe the implementation of the EuroGOOS Plan in these regions. The final sections of this Plan describe the cross-cutting thematic and strategic sectors of work needed to support the projects listed above.

The Autosub-1 is an autonomous underwater vehicle which can travel hundreds of km making measurements of the state of ocean water. The demonstrator vehicle undergoing sea trials in this picture was part funded through a MAST project. Development work was carried out by NERC and IFREMER. Source: SOC

EuroGOOS Atlantic

Understanding the Atlantic and predicting its state are vital to Europe. More than 90% of Europe's external trade is carried by sea, much of it across the Atlantic, and most of Europe's fisheries are on the Atlantic margin and marginal seas. Oil and gas exploration now extends west of the Shetland Islands, west of Ireland, and in deep water off the coast of Norway. Prospecting is being conducted in ever deeper water, where production platforms are exposed to the full force of Atlantic storms and currents. Forces from the open ocean propagate across the margin of the continental shelf by very complex processes, and influence events in the shallow shelf seas.

Our weather and climate are dependent upon the northward transport of heat in the Atlantic surface currents. This depends upon the rate of formation of cold bottom water which sinks at the interface between the Arctic and Atlantic Oceans. Improvements in computer modelling and advances resulting from major science research programmes, provide the basis for operational modelling of the North Atlantic, including the prediction of major currents, decadal oscillations, processes and fluctuations on the Greenland-Iceland-UK sill, and the occurrence of ventilation, convection and deep water formation. Recent reports show that there has been less ice formed off the coast of Greenland for 3 successive years.

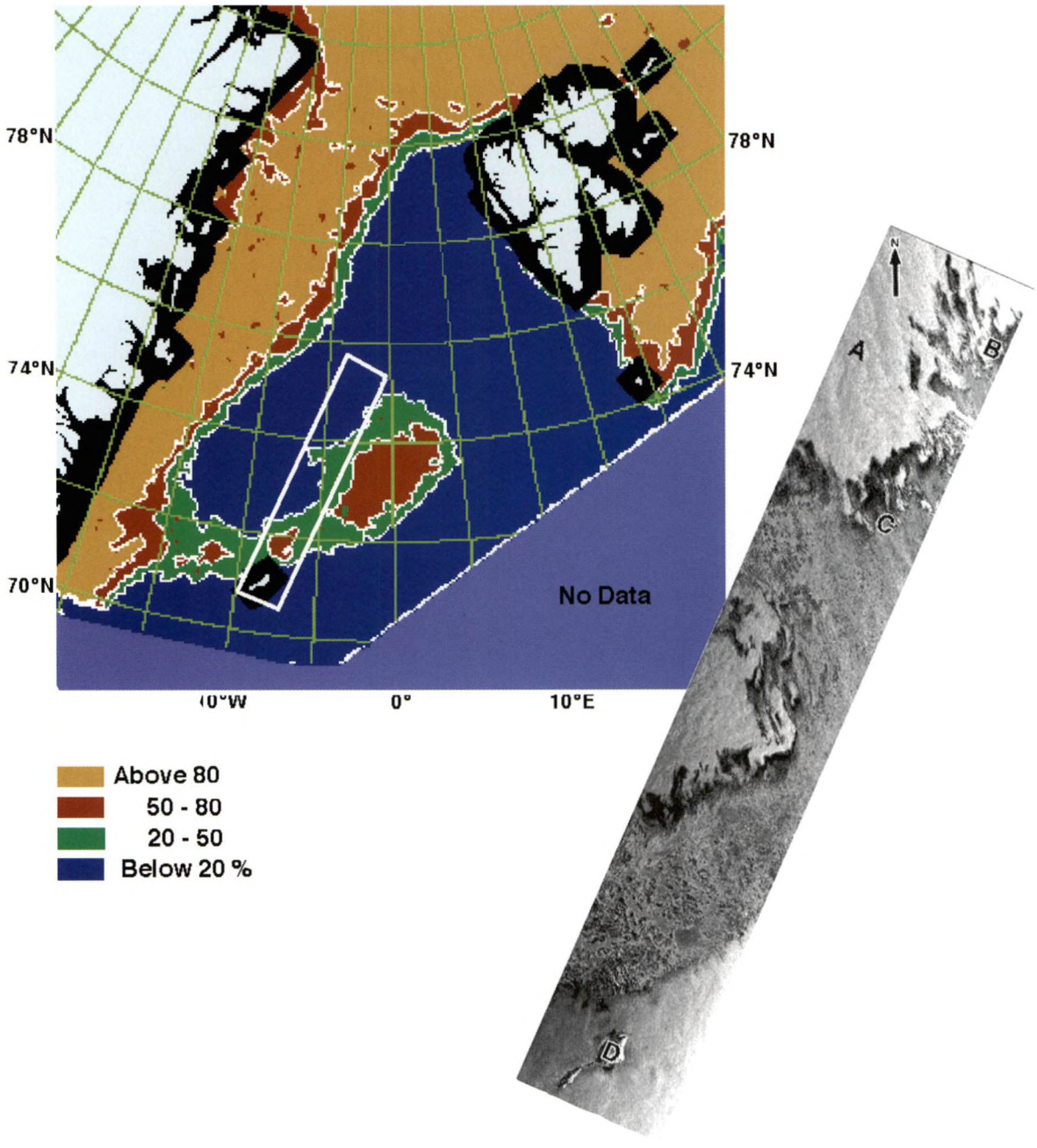
Research models of the Atlantic are already run by several institutions in EuroGOOS, and a prototype operational model of the whole Atlantic is run by the UK Met Office. Models are also being run by the European Centre for Medium Range Weather Forecasting (ECMWF). Operational models designed to predict processes in the North West Shelf region often extend out to about 20 degrees West, illustrating the importance of observing and monitoring the ocean-shelf interface. Such models are already in operation and run by RIKZ, BSH, UK Met Office, and Norway.

The EuroGOOS Atlantic Task Team will prioritise the variables which are of maximum importance to Europe in terms of economic, social, and environmental requirements on the timescales of days to a few years. The decadal climate requirements are discussed in the Global Pilot Project section, below. The variables on the priority list are: sea surface temperature, wind stress, wave spectrum, sea surface currents, ocean circulation, sea ice, heat transport, primary productivity, oxygen, nutrients, and some contaminants. Events to be detected, modelled, or predicted include the characteristics of the major currents, gyre and eddy fields, fronts, and deep water formation.

Observing systems already available include the satellites ERS2 and Topex-Poseidon, the mid-ocean drifting meteorological buoys managed by the European Group for Ocean Stations (EGOS), the chain of meteorological buoys run by the UK Met Office and IFREMER, and real time observations reported from ships of opportunity selected by WMO countries. Spanish and Portuguese agencies, because of their strong interest in Atlantic fisheries, conduct extensive observing programmes. Eumetsat has analysed the requirements for a sea ice information product derived from satellite remote sensing over the Atlantic.

New technology will be needed to gather observations from the Atlantic efficiently. Discussions are under way to extend the range of variables measured from the EGOS buoys and the IFREMER/Met Office moored buoys so as to include oceanographic measurements. Design of an Atlantic ocean observing and modelling scheme will include participation from agencies in America, especially USA and Canada. Ocean models on this scale have to be interfaced with a global meteorological model, and it is not clear where the southern boundary of this strictly Euro-centric analysis and prediction project would be. It will include the Azores and the Canary Islands, and would thus extend to the Tropic of Cancer. The high resolution, product-specific model, for the northern part of the Atlantic will interface with more generalised models of the whole Atlantic and the global ocean.

A workshop will be held during 1997, and the eventual products of this project are designed to meet the requirements for inter-seasonal climate forecasts, and present day operational services in support of shipping, fisheries, offshore hydrocarbons, and storm surge forecasting.



The SAR stripe is from 16 February 1993 and cuts across the Odden ice tongue which consists of small first-year and multi-year floes advected north-east with the Jan Mayen Current and locally formed grease and pancake ice. The ice tongue usually develops in December and lasts until April, but not every year. *Source: NERSC*

Legend:
- *A* *Open water*
- *B* *Location of photographs*
- *C* *Grease ice and pancake ice*
- *D* *Jan Mayen Island*

EuroGOOS Arctic

The Arctic region has enormous resources of offshore oil and gas, and fisheries. Marine transportation in the region is already used for the entire Siberian coast and rivers as well as having a future potential for transit between Europe and the Far East through the Northern Sea Route. Activities in the Arctic require particular care and attention in order to be able to operate efficiently and safely, and to protect the arid and vulnerable Arctic environment.

The Arctic Ocean is a system of high climatic sensitivity. Predictions of the global climate in the next century using General Circulation Models of atmosphere and ocean indicate an enhanced greenhouse warming in the Arctic relative to the lower latitudes by a factor of 2-4, which eventually may cause the ice-pack to drastically decrease or disappear. Therefore the northern seas offer the best opportunity for early detection of the 'fingerprint' of global warming.

The EuroGOOS Arctic Task Team (ATT) includes 15 agencies from 6 countries, and focuses its demonstration activities on the central European Arctic waters. Emphasis is on the Greenland, Iceland and Norwegian (GIN) Seas, the Barents Sea and the Russian Arctic. The latter is due to the fact that the relatively shallow ocean region is a primary source for marine food resources as well as an area of oil exploration.

Objective of EuroGOOS Arctic Task Team

- To develop an operational monitoring and forecasting system for the Arctic Marine Region using state-of-art remote sensing, in situ data, numerical modelling and data assimilation techniques.

Sub-objectives

- To detect trends in the large- and meso-scale sea ice parameters to help the prediction of climate change.
- To monitor sea ice parameters and ice dynamics as aid to shipping, fishing, and offshore industries working in the ice-covered areas.
- To monitor spread of marine algae blooms and pollution such as oil and radionuclides.

Existing Collaborative efforts

- Arctic Monitoring and Assessment Programme (AMAP)
- International Arctic Buoy Programme (IABP)
- Arctic Climate System Study (ACSYS)

Demonstration Projects

Based on the expertise of the ATT Members under each of the 5 GOOS modules the ATT will present relevant demonstration projects which are from data or activities based on ongoing operational or research activities at the various participating institutions. Source activities are hence on-going, although implementation is needed for the dedicated EuroGOOS objectives. In 1997 these activities are planned for implementation through time limited demonstration projects by each of the ATT member agencies.

Module 1: Climate Monitoring, Assessment and Prediction: (a) Ice cover and Climate Changes; (b) GIN Sea Deep Water Formation; (c) Arctic Wave Climate; (d) Arctic Extreme Weather Conditions.

Module 2: Monitoring and assessment of marine living resources: (a) Arctic Plankton Productivity; (b) Fish Stocks in the Barents Sea.

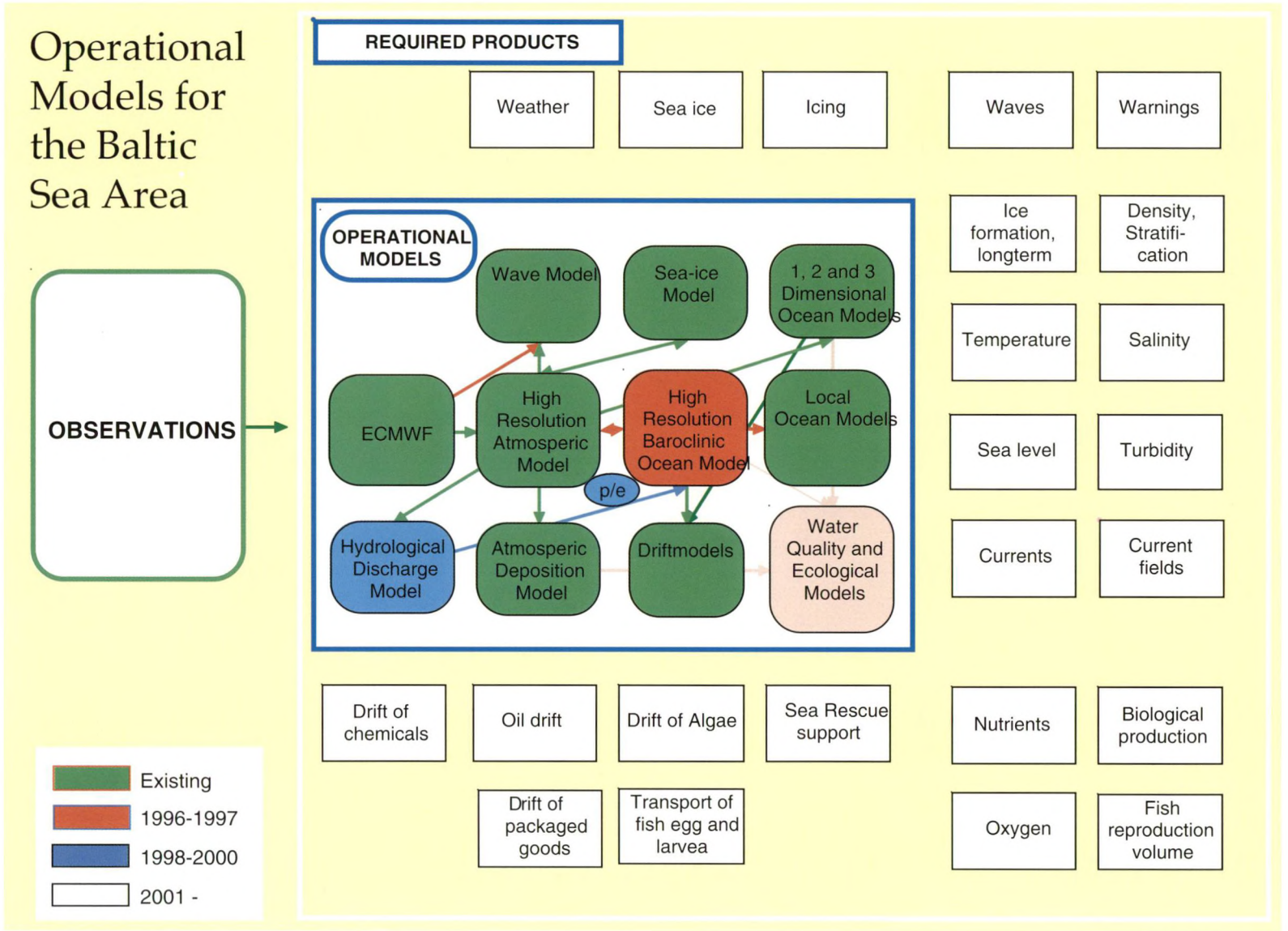
Module 3: Monitoring of the coastal zone environment: (No proposed demonstration projects yet).

Module 4: Assessment and prediction of the health of the ocean: (a) AMAP- Information on pollution: The Arctic Monitoring and Assessment Program.

Module 5: Marine meteorological and oceanographic operational services: (a) Operational Sea Ice Monitoring; (b) Sea Surface Temperature; (c) Modelling of Surface Currents.

Further Perspectives

To assure the continuity and coherence of the present activities it is necessary to place them in an international network of committed efforts by the participating institutions. The ATT will encourage and promote an implementation plan to achieve this through co-operation in EuroGOOS.



Operational models of the Baltic Sea area, and the expected rate of implementation of new model components and forecasts
Source: SMHI

EuroGOOS Baltic

The EuroGOOS Baltic Project consists of developing the existing collaborative marine services and modelling provided by the agencies of the coastal states, combined with a strong programme of up-grading and improvements. There are at present active members of EuroGOOS in five of the Baltic countries: Denmark, Finland, Germany, Poland, and Sweden. Discussions are under way with agencies in Russia. There are strong regional organisations for marine collaboration, including the International Council for the Exploration of the Seas (ICES) and the Helsinki Commission (HELCOM).

The Baltic Sea is almost totally enclosed, and is bordered by nine sovereign countries. Much of the northern shore is subject to continuous geological uplift, and the sea is liable to be covered by ice in winter. The Baltic is almost tideless, with a massive freshwater inflow from many rivers. There is an extensive fishery, much internal shipping traffic, and a serious threat of pollution from large cities, industry, and agriculture. The sensitive marine environment requires continuous assessment of the best available information, regular analysis, and daily forecasts. In one form or another, operational oceanography has existed in the Baltic for decades.

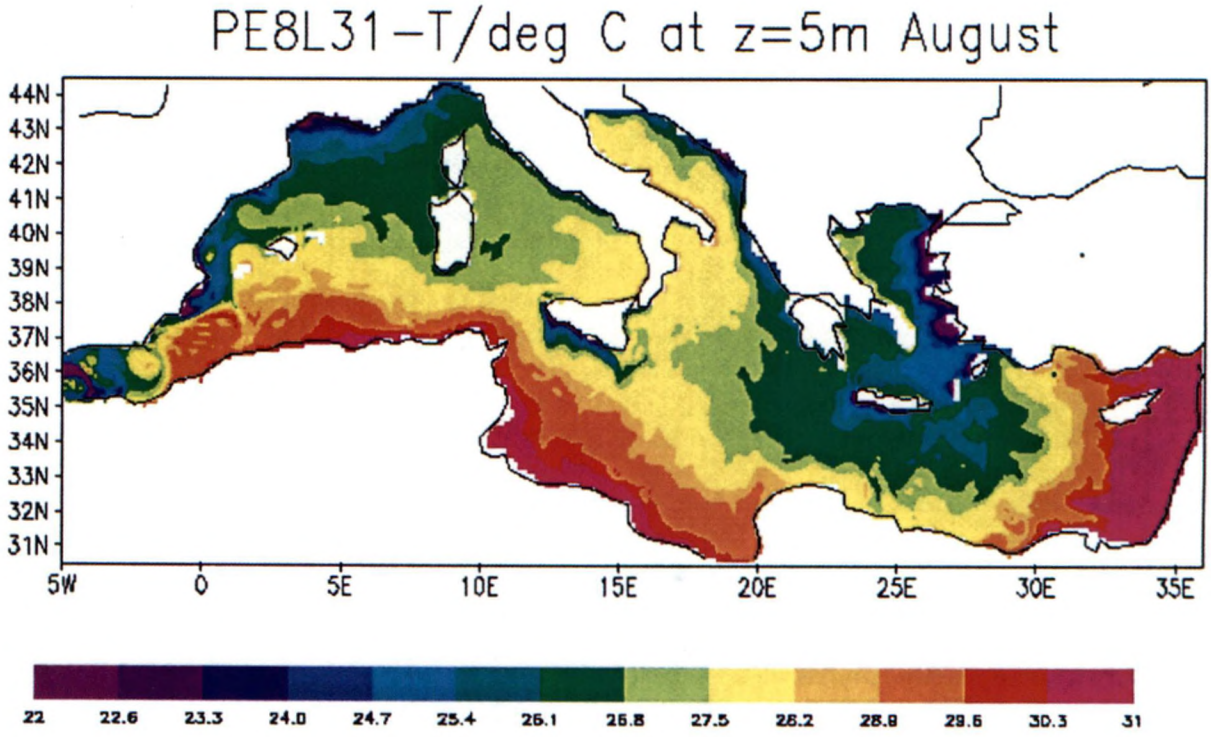
Co-operation in sharing information and increase the marine data availability between countries bordering the Baltic has been effective throughout the whole of this century, in spite of different political systems. Using the "Logic of GOOS", Baltic national maritime agencies are now working within the framework of EuroGOOS to produce increased co-operation, data exchange, and new data products and forecasts.

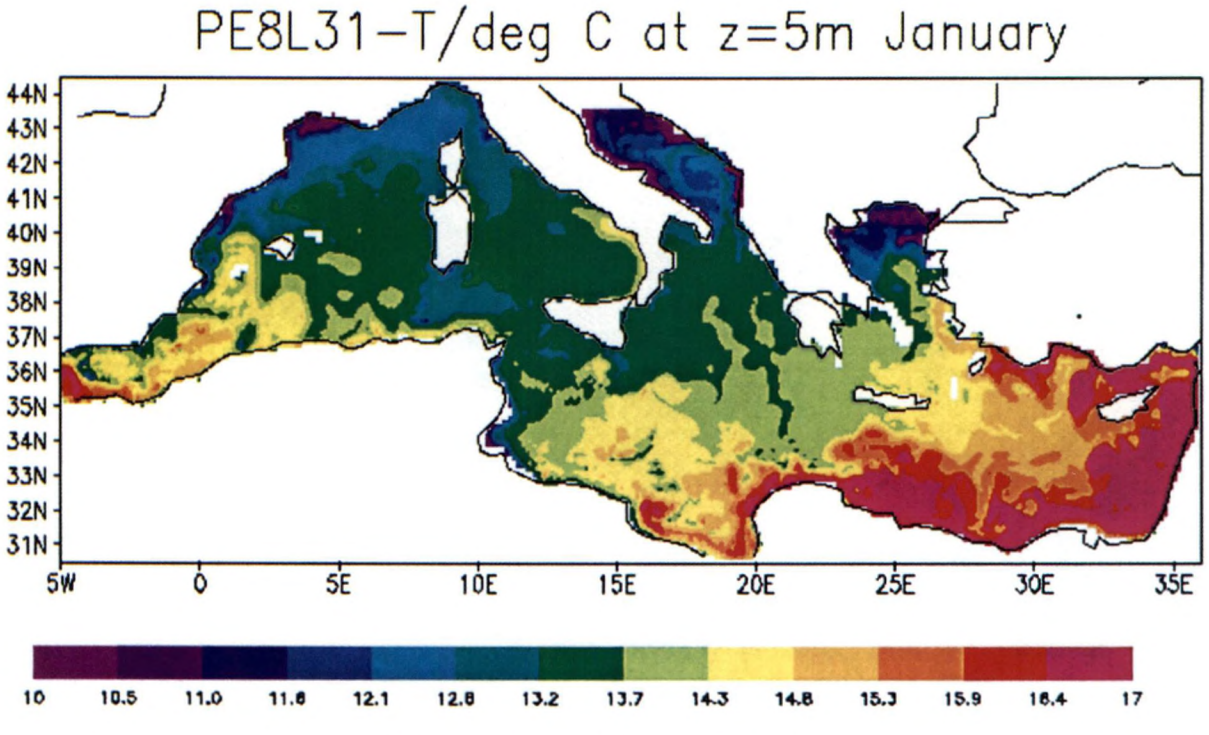
The aim is to establish a regional infrastructure for operational oceanography as a demonstration project within EuroGOOS, and as such, a future system for the Baltic.

An important task in the EuroGOOS Baltic Test Case and Baltic GOOS (or BOOS) system, is to use the present national resources in a co-operative and effective way to establish a joint system of real-time observation and data transmission stations. An inventory has been made of national observational systems from which data could be exchanged between Members as the basis for planning. The EuroGOOS Task Team for the Baltic has constructed a matrix of user requirements and available sources of data and technology.

Several of the required products are derived from operational models. An outline system of existing and planned computer models has been designed for several years into the future. The co-ordinated development of operational models has been carried out for several years. A High Resolution Operational Model of the Baltic Sea (HIROMB) will be operational in 1997. It includes daily validation with real time data supplied by the partners, and daily transmission of forecasted fields to all partners around the Baltic.

The development of computer code, new model components, and the infrastructure for the operational system will continue as part of the HIROMB partnership and the Baltic Test Case. A workshop is planned for April 1997 to continue the development of BOOS. The meeting will include the EuroGOOS Members, plus other Baltic agencies with national responsibilities for marine meteorology, environmental protection, and oceanography.





The figure represents model simulations for a depth of 5 meters, average temperature fields in August (top panel) and January (lower panel).

The model is run at one eighth degrees horizontal resolution (approximate grid size of 12 x 12 km) and has 31 levels in the vertical. It is a modified version of the Modular Ocean Model of GFDL, Princeton, US. The model is set to run on the Cray C90 supercomputer and can assimilate temperature data as well as run with daily atmospheric forcing parameters. The work has been done at IMGA-CNR by N Pinardi, G Korres and M G Angelucci and it has been supported by the Mediterranean Targeted Project-Mermaids-II

Mediterranean Forecasting System

The EuroGOOS Mediterranean project is a 3- year pre-operational development, structured as the first Phase of a 10 year project through operational trials and implementation to a full Mediterranean Forecasting System (MFS). The MFS proposal has been the subject of a major proposal to MAST 3.

The Mediterranean is an unusual sea area in having a very narrow continental shelf, often completely absent, and near oceanic depths of 4000m. The result is that the processes of the deep ocean basin impact almost directly on the shallow water and coast itself. The MFS is designed to meet these peculiar conditions, and provide forecasts that will be useful for fisheries management, ship-routeing, flood prevention, and control of pollution. On longer timescales, models of the Mediterranean circulation will improve weather forecasting and climate forecasting in the region, including North Africa.

The Mediterranean Forecasting System, first 3-year phase, consists of 4 core projects:

1) Data acquisition in Real Time for the Mediterranean Forecasting System (DART-MFS).
2) Mediterranean Multisensor Moored Array: M^3A.
3) Impact of Data strategy and Accuracy on MSF (MedImpact).
4) Nowcast/Forecast System for the coastal environment in the Mediterranean (MEDFOR).

The EuroGOOS Mediterranean Task Team consists of representatives of 60 agencies and laboratories all around the Mediterranean basin. Collaboration so far shows that there is a community capable of starting pilot forecasting experiments in the Mediterranean Sea as a proof-of -concept for a future operational system. The overall goal of Phase 1 is to explore, model, and quantify the potential predictability of the ecosystem fluctuations of the Mediterranean from the overall basin scale to the coastal/shelf scale for timescales of weeks to months, through the development of a nowcasting-forecasting modelling system. The pre-operational goal is to show the feasibility of a Mediterranean basin operational system for predictions of currents and biochemical parameters, and to develop interfaces to user communities for dissemination of forecast results.

The Target Operational Period (TOP) during Phase 1 will consist of 6 months with real time operational forecasts of the Mediterranean basin with 5-10 day forecasts.

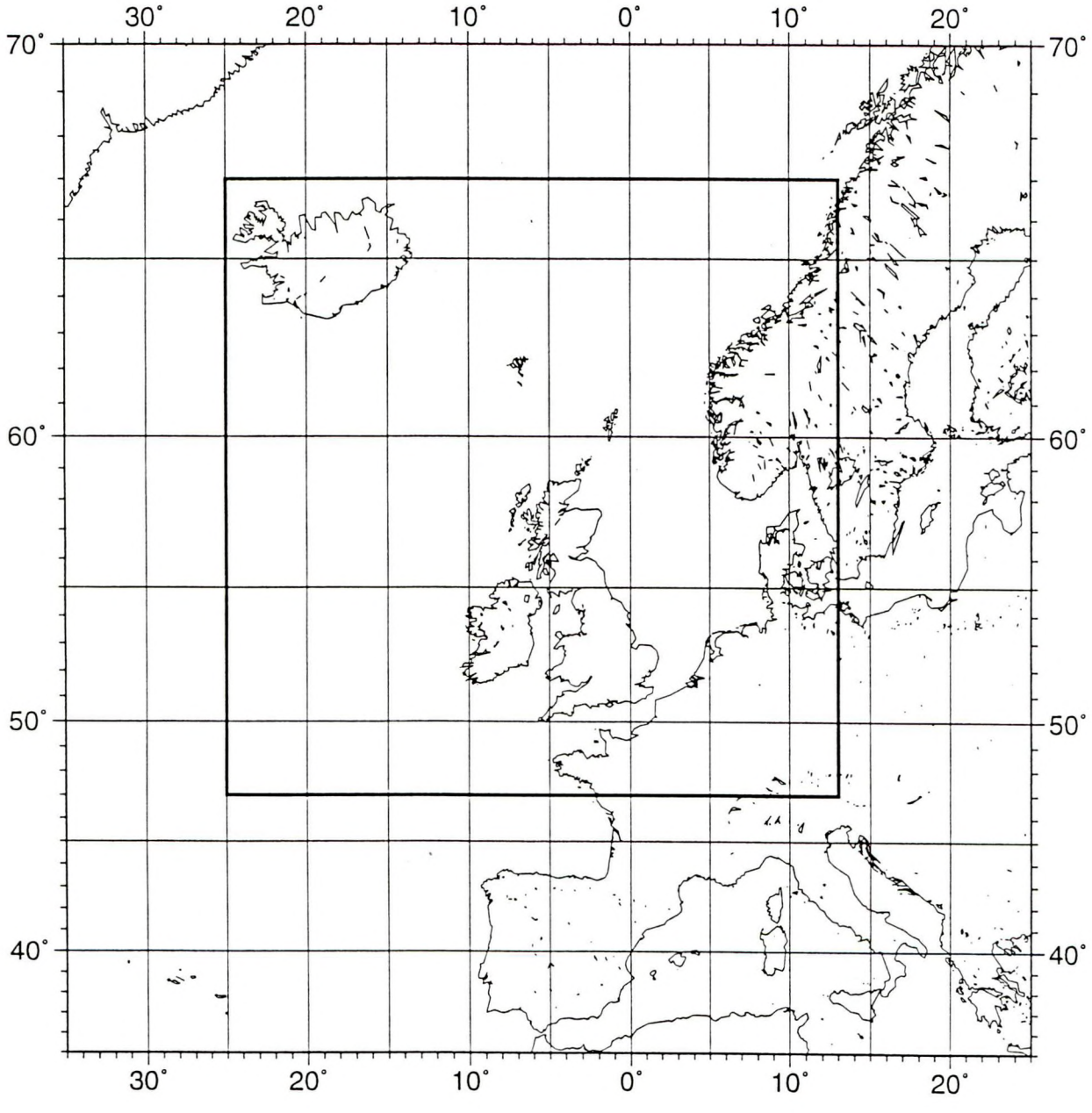
The observing system for the MFS will consist of:

1) Temperature and salinity profile measurements from ships of opportunity on repeat sections.
2) Pelagic monitoring system measuring nutrient profiles, optics, primary production, phytoplankton, and zooplankton, using undulating sensor packages from ships of opportunity.
3) Mediterranean Moored Multisensor Array (M^3A) of moored stations measuring air-sea interaction, upper thermocline current and temperature salinity profiles, and biochemical parameters.
4) Remotely sensed sea surface temperature, colour, and sea surface elevation, with operational analysis.
5) Surface drifters and floats to measure currents and water properties.
6) Acoustic tomography, impact assessment of acoustic data.
7) Numerical models and data assimilation, development of ocean-atmosphere coupling, nested regional/coastal/shelf models, ecological models for the coastal zone, predictive data products.
8) Data management, data flow and storage, data quality, dissemination of results.

During the TOP the Phase 1 project will generate real time forecasts under realistic working conditions, after which there will be a detailed period of analysis to assess the performance of the system, and before designing Phase 2.

EuroGOOS Marine Operational Stations

North West Shelf Modelling Boundaries



North West European Shelf Seas

This project consists of developing existing operational services, extending the range of variables measured, extending the coverage within the region, and increasing accuracy and period of forecast wherever possible. At present the most detailed forecasting is related to storm surge prediction in the southern North Sea, and services related to major ports and the offshore hydrocarbons industry.

The European North West Shelf regional seas include all the shallow seas from Norway, round the Shetland Islands, Scotland, Ireland, the south west UK, and to southern Brittany. In order to operate effective numerical models of the shelf seas it is necessary to include also the oceanic conditions at the edge of the continental shelf, the so-called open boundary. In practice these conditions can only be specified sufficiently accurately by observing and modelling the adjacent North Atlantic. The area of importance for this project is thus a fairly broadly defined box, as shown in the Figure opposite. The boundary should not be regarded as a hard and fast definition, but a limiting zone, within which data are highly relevant to the functioning of numerical models on the continental shelf.

The EuroGOOS NW Shelf Task Team has identified the priority variables and forecasts which are required by most organisations working in the region, which are also technically feasible in terms of operational prediction within a few years.

Existing operational models operated by EuroGOOS Agencies provide information in the following categories: Wind and wave characteristics; Currents; Sea water temperature and salinity; Sea level, tides, and storm surges; and aspects of water quality, water constituents, and sediment transport.

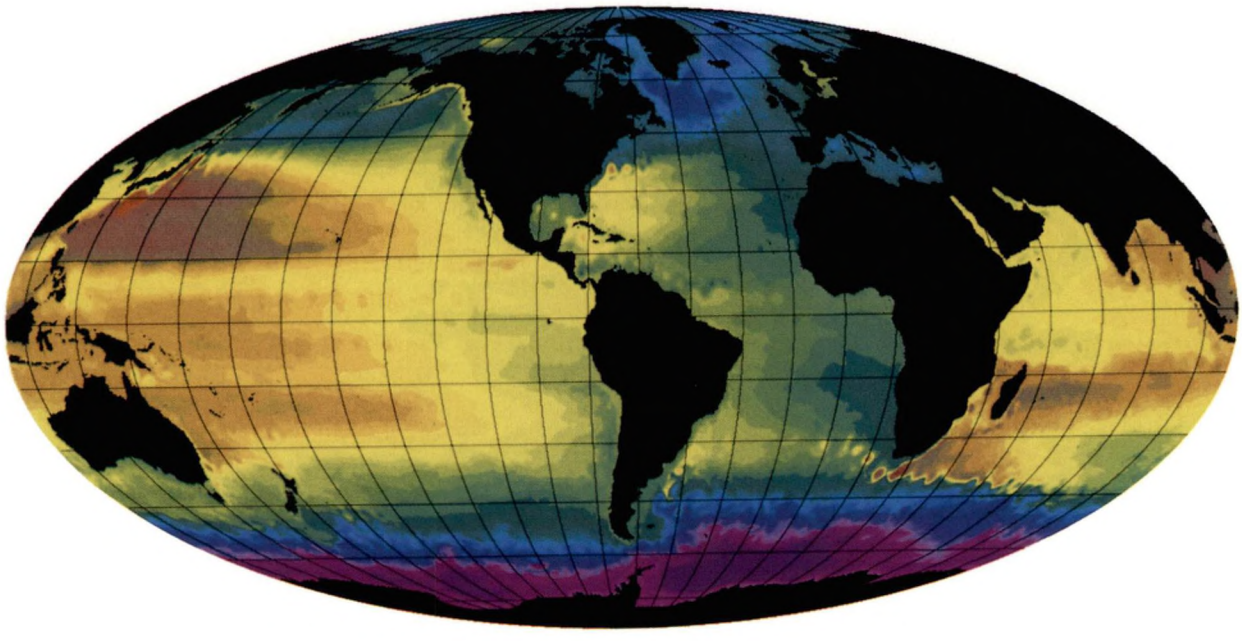
The Task Team has identified a practical need for forecasts of the following parameters: Temperature (surface and sub-surface), salinity (surface and sub-surface), wind field, barometric pressure, rainfall, evapotranspiration, wave field and spectra, heat flux, currents (tidal, wind driven, residual, shelf edge), sea level, storm surge, shelf edge fluctuations, nutrients (nitrate, nitrite, phosphate, silicate, oxygen), suspended sediments, sediment transport, properties of coastal wetlands, sound velocity in sea water, light transmissivity, chlorophyll, fluorescence, and variation in seabed bathymetry and bedforms. Hydrodynamic models in the North Sea region now have a resolution of the order of 600m, and there is an urgent need to improve modelling capability to include predictions of biogeochemical processes and sediment transport.

The NW Shelf Task Team is evaluating existing models, and undertaking a model validation scheme. In order to design and specify a new range of observing instrumentation it is necessary to document the entire range of existing instrument stations which deliver data reports in real time. The SeaNet Group has started such an inventory for the fixed stations on the North Sea coast. EuroGOOS is collaborating with SeaNet to increase the inventory of all routine observations in all the NW Shelf seas.

An assessment of the technology appropriate for a monitoring service in this area includes Compact Airborne Spectral Interferometry (CASI), satellite remote sensing, moored buoys, coastal instruments and tide gauges, ship-borne sections, HF radar, and observations from offshore oil rigs. There is an urgent need for improved chemical sensors, and a number of new devices are being reviewed. The installation of standard instrument packages on board commercial Ferries is likely to be an effective method for obtaining water quality and physical oceanographic data from the NW Shelf seas.

The High Precision Gridded Bathymetry Project (See Annexe 2) will provide improved bathymetric definition of the shelf seas, and hence increase accuracy of models.

The NW Shelf region includes some of the largest cities in Europe, the largest estuaries, and the most intensively exploited sea areas. Optimum management of these seas depends absolutely on an adequate flow of data from monitoring and predictive models in real time. The NW Shelf Project will progressively meet these requirements.



OCCAM global model plot of instantaneous sea level relative to the geoid

The colour scale range is from +2m (yellow/brown) to -2 (blue/purple). Source: SOC

EuroGOOS Global Pilot Project

European oceanographic and space organisations should take responsibility for a component of the global observing system of GOOS. Through ESA, CNES, ECMWF, and Eumetsat, there are already activities in global remote sensing of the ocean, and the operation of global models. The UK Met Office is already running global ocean models in prototype. In parallel with the launch of EuroGOOS, an association of agencies in the Pacific (from Japan, Russia, China, and Korea) has formed the North East Asian Region of GOOS (NEAR-GOOS). EuroGOOS is in routine correspondence with NEAR-GOOS, and NEAR-GOOS representatives attended the EuroGOOS Conference. The European initiative in GOOS will thus complement the initiatives in other regions on the global scale.

The best mechanism for European contribution to GOOS as a whole is still under review. EuroGOOS Members have decided that it is logical for Europe to concentrate resources on the Atlantic as a component of the global ocean. This is distinct from the regional concentration on the North Atlantic discussed in Section 4. All the Modules of GOOS, Health of the Ocean, Ocean Services, Living Marine Resources, and Coastal Management, depend upon routine modelling and forecasting of the conditions of the open ocean on a global scale, thus providing the boundary conditions for local and specialised models. This is in addition to the long term objective of measuring the ocean to make climate predictions.

Paleoclimatological records show decadal changes in the North Atlantic, but there is no evidence of simultaneous changes occurring in Antarctica. The changes, and the regional differences in change, are certainly linked to ocean circulation, and are almost certainly controlled by it. If we can learn the causes of decadal change, spot its precursors, and forecast it, there will be substantial economic benefits to humanity.

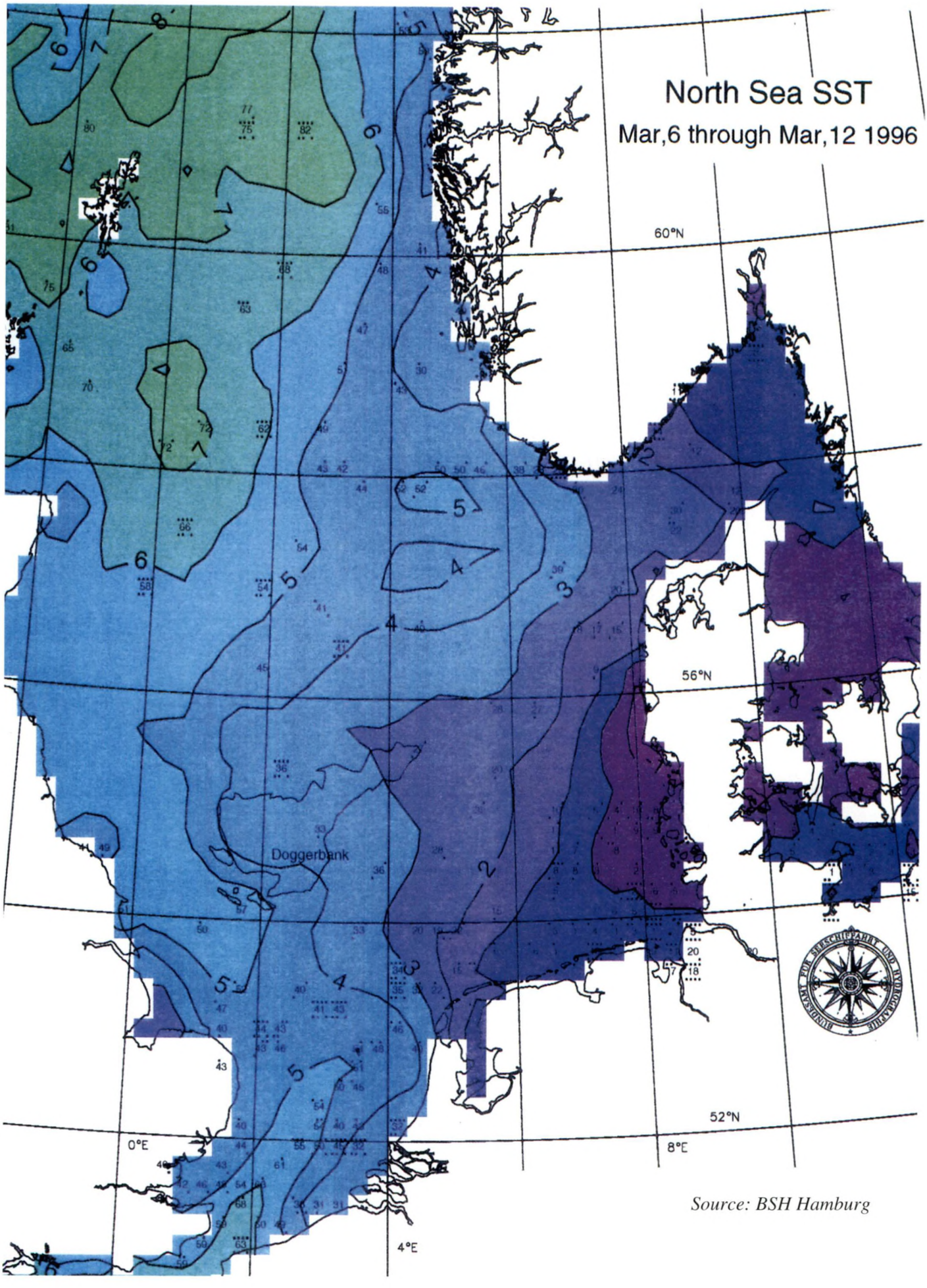
Whether or not we can forecast decadal changes a century ahead, given the chaotic nature of fluid flows, we can surely forecast decades ahead once we know enough about the patterns of decadal change in the ocean and have sufficient observations. This is an exciting and tractable challenge. Where WOCE will survey the oceans once over seven years, decadal change forecasting will require ocean-wide data more frequently, perhaps monthly or seasonally and certainly annually, on an ongoing basis. The signatures of decadal change cannot be observed from satellites. These changes are small compared to the seasonal variations that occur in the surface layers of the ocean and require precise measurements deep in the ocean's interior.

The European contribution to monitoring and modelling the Atlantic should thus support both the short term modelling and boundary conditions needed for local operational services, and the long term requirement for climate monitoring and forecasting on decadal scales.

The global monitoring and modelling of the open ocean on this scale will not resolve the phases of individual features or events such as oceanic eddies and jet meanders. It would monitor and predict large scale average fluxes. A preliminary design would be based on the results of WOCE and CLIVAR. EuroGOOS agencies have experience of working in all areas of the Atlantic from the Arctic Ocean to the Antarctic continent. Many countries with Agencies in EuroGOOS operate Antarctic bases, supported by supply ships. EuroGOOS will seek to involve American agencies in the planning and development of an Atlantic Pilot Project for GOOS.

Global ocean-atmosphere models in future will be based on higher resolution, and will require greater computing power. European agencies, or EuroGOOS collectively, will seek to ensure that major facilities in support of the GOOS system are located in Europe.

EuroGOOS plans a Workshop progress this proposal for late 1997. The rate of progress on this topic will be determined by the outcome of consultations during 1997, and discussions with J-GOOS and I-GOOS.



Source: BSH Hamburg

Strategic sectors & generic support

The regional seas, Atlantic, and Global Projects planned by EuroGOOS depend upon a generic, cross-cutting, background studies and analysis. Some of these sectors have formal Working Groups or Task Teams to carry out the work, others are flagged as permanent matters of concern to EuroGOOS, with tasks allocated to individual Members, or to the Secretariat, on an ad hoc basis. The projects and sub-projects listed in Annexe 2 are designed to fulfil the objectives identified during 1995-96, looking up to 6-10 years ahead.

The main regional seas Projects appear under item 5 on the list below. The other activities and sub-projects support the Regional Task Teams, or are components of other strategic sectors. Often a single project or sub-project supports several strategic sectors.

In the following list each strategic sector is shown with the status of the group working on it, and the project numbers shown in Annexe 2 which are related to it.

Strategic sectors of EuroGOOS and relation to Projects listed in Annexe 2

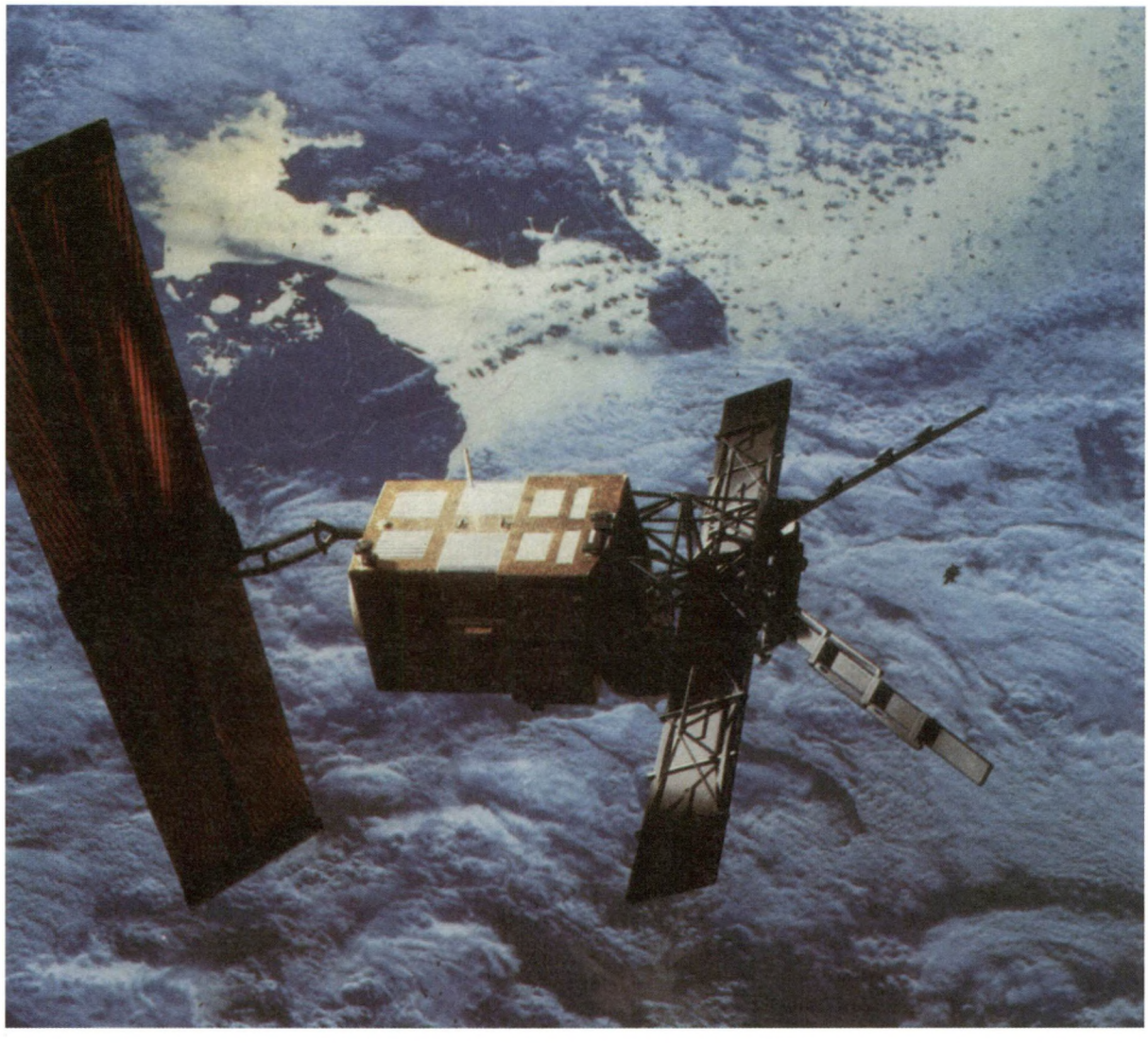
1. Identification of users, customers, and beneficiaries. (Projects 1, 3, 9, 21)
2. Economic studies (Projects 6, 9).
3. The science basis for EuroGOOS, (Working Group) (Projects 2, 7, 18)
4. The technology basis for EuroGOOS. (Working Group), (Projects 4, 16)
5. Case studies, trials, and pilot projects. (Regional Seas Task Teams) (Projects 5, 11, 13, 14, 19).
6. Operational design of observing systems. (Projects 5, 7, 17, 18)
7. Numerical modelling, data assimilation. (7, 17, 18).
8. Product development for customers. (Projects 16, 21).
9. Global dimension, GOOS, aid and capacity building. (Study Group, consultant) (Projects 10, 15).
10. Links to other European agencies. (Responsibility of Officers and Secretariat).

The two main subsidiary bodies of EuroGOOS are the Technology Plan Working Group (TPWG) and the Science Advisory Working Group (SAWG).

The TPWG has the responsibility to review all technological systems available for implementing operational ocean observing, to analyse the devices which are under development, and identify those sectors where further technological research is needed to meet the requirements. Surveys and workshops have been conducted, and reports are in preparation. Recommendations include development of a multi-sensor package for installation on ships of opportunity, research on chemical sensors of longer duration with low maintenance (6-12 months maintenance-free), solid state sensors, integration of in situ, airborne, and satellite observing systems, novel robotic instrument platforms, standardised communications technology, land-based radar systems, and under-ice observing instruments. A space technology plan for EuroGOOS will be produced. Commercial companies and SMEs will be involved in trials and pilot projects.

The SAWG has the responsibility to specify the scientific basis for EuroGOOS. The SAWG has identified as priority the need to explore the absolute limits of predictability of ocean and shelf seas processes. Deterministic and climatic predictions must be extended to the practical limits to meet operational objectives, but the reasons for limits must be understood. This project will permit calculation of trade-offs in decisions regarding investment in more observations, or higher accuracy, or more parameters, or bigger computers, or better modelling software, or better data assimilation programmes.

EuroGOOS has identified training of skilled personnel as an objective. The development of operational oceanography both commercially and as a public service creates a demand for marine professionals who work in a high tech scientific environment, but who are not research scientists. It is a new career. EuroGOOS will co-operate with training institutions to promote appropriate courses, both within Europe, and as part of aid programmes and capacity building.



ERS-1 and ERS-2 European satellites use a range of radar and radiometer instruments to measure properties of the ocean on a global scale. The data can be used in global models to provide a service to all countries

Capacity building in developing countries

The Global Ocean Observing System (GOOS) requires that observations be obtained equally from all parts of the world ocean, and that all states benefit equally from the services and products generated by GOOS.

It is important that all coastal states are involved in the design and implementation of GOOS. Coastal states have certain jurisdictional rights and obligations over the Exclusive Economic Zones (EEZs). Many developing countries lack, however, a marine capability to fulfil these rights and obligations. Therefore, capacity building activities form an intrinsic part of UNCLOS and UNCED. European states individually have historic links with many developing countries, and collectively the EU pursues a policy of support for aid to developing countries.

EuroGOOS has established a Study Group for Aid and Capacity Building. Two sessions of the EuroGOOS Conference were dedicated to Aid and Capacity Building, and links were established with delegates from Indonesia, Kenya, Colombia, Morocco, Brazil, Nigeria and China.

The EuroGOOS objectives of capacity building in the context of operational oceanography and GOOS are:

- Co-operation and capacity building in relation to North African and especially Mediterranean developing states in order to advance a basin-wide system in the Mediterranean.

- Aid and capacity building in support of regions with which European countries have historical links, such as southern Africa, Latin America, Caribbean, and regions in the Indian Ocean and Pacific, and South East Asia.

- Collaboration with Eastern Europe and Russia, especially in the Baltic, Arctic, and possibly in the Black Sea.

Assistance in marine technology development, design of local observing systems, data processing, and the distribution of data products, is best achieved through a long-term association or partnership between the countries or agencies involved. Capacity building requires a range of initiatives in establishing a marine science capacity, new technology, infrastructure development, connections with global data systems, personnel training, student exchanges, and other professional contacts.

The main international funding mechanism for implementation of the decisions of UNCED and Agenda 21 is the Global Environment Facility a joint program of the World Bank, UNEP and UNDP. This provides assistance to developing countries. In 1994 the GEF decided to concentrate its actions in 4 main areas, of which international waters is one. EuroGOOS is maintaining contacts with the appropriate committees and advisory groups in GEF, so as provide assistance in the design of projects, and to collaborate with developing countries. EuroGOOS will also establish contacts with national donors and the European Union in order to facilitate and initiate capacity building activities, especially in Africa.

Funding

EuroGOOS Member agencies have in many cases the responsibility to provide operational services at the national or regional level. They have existing programmes of funding at that level, and forward budget plans. There are also multi-lateral agreements linking operational agencies at ministerial level to meet European requirements on issues such as safety. Those EuroGOOS Members which concentrate on research, similarly have science plans and objectives. The work so far carried out directly by EuroGOOS has been funded from existing Agency budgets, with the exception of support for the EuroGOOS Conference from EC, ESA, and EUROMAR.

Additionally, Members are conducting a wide range of projects, research programmes, and providing operational maritime services, listed in Annexe 1. Some of these projects have been the recipients of EC support, but many of them are funded at national level, or by collaboration of national agencies.

EuroGOOS Projects listed in Annexe 2 are in different stages of development. Some have already been submitted to MAST3. Others are being developed as part of a series of Concerted Actions, or composite Concerted Actions. Some will be more appropriate for consideration as Supporting Initiatives. In separate documents EuroGOOS is submitting to the EC estimates of costs and timescales for each project or group of projects, together with full scientific, technical and administrative descriptions in the appropriate proposal formats.

The present proposals listed in Annexe 2 are those which have been developed principally for the short term period up to the year 2000, although many of the projects will lead onto more activities on longer timescales. At present all activities planned and requiring European funding are either paper studies, workshops, technology development, or applied pre-operational research. Within one or two years joint operational projects are likely to be developed, which cannot be funded through science budgets. EuroGOOS will have to consider other European mechanisms based on infrastructure, regional support, or the requirements of European Agencies to meet operational objectives.

EuroGOOS will seek collaboration with European Organisations such as ESF, ESA, Eumetsat, CEOS, EEA, and ECMWF.

On the global scale the participation of EuroGOOS Members in GOOS, or GOOS Pilot Projects, may be eligible for non-European funds. Projects involving developing countries, such as in the South Atlantic, may be suitable for World Bank or GEF support.

EuroGOOS will seek to obtain funding support for the projects listed in Annexe 2, and engage consultants to organise the collaboration needed for each project. If projects are grouped into composite Concerted Actions, this will permit a consistent and coherent effort to be allocated, working within short timescales.

Annexe 1

Projects at present organised by EuroGOOS Members

The following projects have been notified to EuroGOOS by Members who wish these activities to be recognised as associated with EuroGOOS, and contributing to the objectives of EuroGOOS. This list includes multi-national projects which have been supported by EC funding, and national level operational observing projects.

1. Mediterranean Forecasting System, submitted to MAST-3 by the EuroGOOS Mediterranean Task Team, co-ordinated by CNR, Italy.
2. POSEICOM. Pollutant sea surveillance system by high precision electrical conductivity measurements. Submitted to MAST-3, co-ordinated by CNR, Italy.
3. DIADEM. Advanced Data Assimilation Systems for Monitoring, Forecasting and Management of the European Coastal Zone. Submitted to MAST-3, co-ordinated by Nansen Environmental and Remote Sensing Centre, Norway.
4. AOSGE. Arctic Ocean System in the Global Environment, co-ordinated by Nansen Environmental and Remote Sensing Centre, Norway.
5. POSEIDON. Marine environmental monitoring, forecasting and information system for Greek waters. National Centre for Marine Research and Hellenic Information System, Greece.
6. CAMS. Integrated, Interactive Monitoring System for the Coastal Marine Environment. EOS, JRC, FAO, ISMARE, NCMR, Irish Marine Data Centre.
7. RIMD. Reo Integrada de Mareografos. (Integration and zero level all Spanish tide gauge network), Instituto Espanol Oceanografia, Instituto Geografico Nacional, Puertos del Estado, Instituto Hidrografico de la Marina.
8. RAYO. Reo de Alerta y Observacion. (Meteorological and wave monitoring buoy network), Puertos del Estado, Spain.
9. ENVALDAT. Customer Valuation of Environmental Data. Irish Marine Data Centre, with JRC, SOC, PML, GKSS, NIOZ.
10. COLORS. Coastal Ocean Colour Remote Sensing. Irish Marine Data Centre, with JRC, SOC, PML, GKSS, NIOZ.
11. Survey of Capacity in Ireland for Operational Oceanographic Observations. Irish Marine Data Centre, Marine Institute, Coastal Resources Centre, Ireland.
12. Oceanographic Monitoring of Danish Waters. Royal Danish Administration of Navigation and Hydrography, Denmark.
13. Ship of Opportunity Programme (lines AX-3 and AX-11), BSH, Germany.
14. North Sea and Baltic Network of automatic oceanographic stations (5 North Sea and 6 Baltic), BSH, Germany.
15. Contribution to Monitoring Programmes of OSPAR and HELCOM. BSH, Germany, UK, Netherlands.
16. Joint Federal/States Monitoring Programme in German Coastal Waters. BSH and Agencies of the German States.
17. Hydrographic Section across North Atlantic at about 48°N. BSH, Germany.
18. Weekly SST Charts in North Sea and Baltic, daily ice charts; from NOAA Satellite data reception. BSH, Germany.
19. Deutsches Ozeanographisches Datenzentrum (German Oceanographic Data Centre). BSH, Germany.
20. Water level, Storm Surge, and Ice forecasts for German coast. BSH, Germany.
21. Operational modelling (waves, water level, storm surge, currents, transport and spreading of conservative substances). BSH, Germany.
22. Co-ordination of German contribution to GOOS. BSH, Germany.
23. Estudio Series Historicas de Datos Oceanograficos: Proyecto Radiales. 6 Sections across the Spanish continental shelf, monthly surveys. Instituto Espanol Oceanografia.
24. ESTOC. Estacio Europea de Series Temporales Oceanicas de Canarias. Instituto Español Oceanografia, Instituto Canario de Ciencias Marina, Institut für Meereskunde, Universität Kiel.
25. Baseline coastal survey. Environment Agency, UK.
26. PROMISE, comparative modelling study, co-ordinated by POL, NERC. UK.
27. Note: See list of operational oceanographic repeat observations published by IACMST, UK.

28. Ice service. Finnish Institute of Marine Research.
29. Water level and wave service. Finnish Institute of Marine Research.
30. Algae blooms. Finnish Institute of Marine Research and FEC.
31. OSIMS (Operational Ice Monitoring in Europe). Finnish Institute of Marine Research, DNMI, NERSC.
32. IMSI. Finnish Institute of Marine Research, HUT, DNMI, NERSC, TUD, IFREMER.
33. Ice model. Finnish Institute of Marine Research.
34. EMAC. Finnish Institute of Marine Research, HUT.
35. Wave studies. Finnish Institute of Marine Research.
36. Water level studies. Finnish Institute of Marine Research.
37. Hydrodynamical-Ecological Models. Finnish Institute of Marine Research.
38. SEANET. All countries around the North West Shelf (leading: The Netherlands)
39. SUSD. Storm Surge Warning System (including data assimilation and remote sensing). RIKZ and KNMI.
40. REMSSBOT. Pilot for open systems communication. Telematics in the Environment Programme. The Netherlands (Rijkswaterstaat), Belgium, Greece, Italy.
41. OPTIMOM. Optimalisation of Monitoring. MAST proposal. RIKZ and other participants.
42. SILTMAN. Siltation management. Prediction of siltation near river outflow. RIKZ, North Sea Directorate, Delft Hydraulics.
43. MET-programmes (EU and COST projects). Physical sca-air interaction for the benefit of climate and operational maritime forecasts.
44. EGOS. European Group on Ocean Stations. EU countries.
45. Satellite data programmes. Together with Eumestat. SAFs (Science and Application Facilities) (for example Ocean and Ice SAF).

Annexe 2

Projects planned for the immediate future

The following projects are those planned by EuroGOOS during 1996-97, and either submitted for funding, or in the stage of proposal drafting for future implementation.

1. EuroGOOS Publications series.
2. Standard high precision gridded bathymetry of the European continental shelf and Mediterranean.
3. Industrial liaison programme with SMEs.
4. Automatic real time instrument suite for installation on ferries to measure water properties.
5. North West Shelf observing station inventory.
6. Economic impact of a Mediterranean Forecasting System.
7. Analysis of the limits of predictability from ocean numerical models.
8. Long term policy analysis for European operational oceanography.
9. Standardised economic methodology for quantifying maritime industries and services in Europe.
10. Support for one third of the cost of a contractor to prepare the Plan for GOOS.
11. Mediterranean Forecasting System.
13. EuroGOOS Arctic Pilot Project.
14. EuroGOOS Baltic Pilot Project.
15. Aid and capacity building for developing countries.
16. Oceanographic Technology Working Group information data base.
17. North West Shelf validation of numerical forecasting models.
18. Scientific Advisory Working Group, simulation and sensitivity experiment.
19. EuroGOOS Atlantic project.
20. EuroGOOS Global Pilot Project: the Atlantic component of GOOS.
21. EuroGOOS data requirements survey, data processing and analysis.

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Acronyms

ACSYS	Arctic Climate System Study
AMAP	Arctic Monitoring and Assessment Programme
AOSGE	Arctic Ocean System in the Global Environment (Norway)
BSH	Bundesamt für Seeschiffahrt und Hydrographie
CEOS	Committee on Earth Observation Satellies
CICYT	Comision Interministerial de Ciencia y Technologie
CLIVAR	Climate Variability and Predictability (of WCRP)
CNES	Conseil National d'Etudes Spatiales (Fr)
CNR	Consiglio Nazionale Delle Ricerche, Italy
DART-MFS	Data acquisition in Real Time for the Mediterranean Forecasting System
DNMI	Norwegian Meteorological Institute
EC	European Commission
ECMWF	European Centre for Medium Term Weather Forecasting
EEA	European Environmental Agency
EEZ	Exclusive Economic Zone
EGOS	European Group for Ocean Stations
ENEA	Ente per le Nuove tecnologie, l'Energia e l'Ambiente, Rome, Italy
ESA	European Space Agency
ESF	European Science Foundation
EU	European Union
Eumetsat	European Meteorological Satellite organisation
EUROMAR	European Marine Research Programme within EUREKA
FAO	Food and Agriculture Organization (UN)
GEF	Global Environment Facility
GOOS	Global Ocean Observing System
HELCOM	Helsinki Commission
HIROMB	High Resolution Operational Model of the Baltic Sea
IABP	International Arctic Buoy Programme
ICES	International Council for the Exploration of the Seas
ICSU	International Council of Scientific Unions
IOC	Intergovernmental Oceanographic Commission (Unesco)
JRC	Joint Research Centre
M^3A	Mediterranean Moored Multisensor Array
MAST	Marine Science and Technology (DG-XII EC)
MEDFOR	Nowcast/Forecast System for the coastal environment in the Mediterranean
MFS	Mediterranean Forecasting System
MUMM	Department of Environment, Belgium
NCMR	National Centre for Marine Research (Greece)
NEAR-GOOS	North-East Asian Region GOOS
NERC	Natural Environment Research Council
NERSC	Nansen Environmental and Remote Sensing Centre
NOAA	National Oceanographic and Atmospheric Administration (USA)
OECD	Organisation for Economic Co-operation and Development
OSPARCOM	Oslo and Paris Commission
PML	Plymouth Marine Laboratory (UK)
POL	Proudman Oceanographic Laboratory (UK)
POSEICOM	Pollutant sea surveillance system by high precision conductivity measurements
POSEIDON	Marine environmental monitoring, forecasting system for Greek waters
RIKZ	Directoraat-Generaal Rijkswaterstaat, The Netherlands
SAWG	Science Advisory Working Group
SME	Small and medium-sized enterprises
SMHI	Swedish Meteorological and Hydrological Institute
SOC	Southampton Oceanography Centre
SST	Sea Surface Temperature
TPWG	Technology Plan Working Group
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WMO	World Meteorological Organisation
WOCE	World Ocean Circulation Experiment

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