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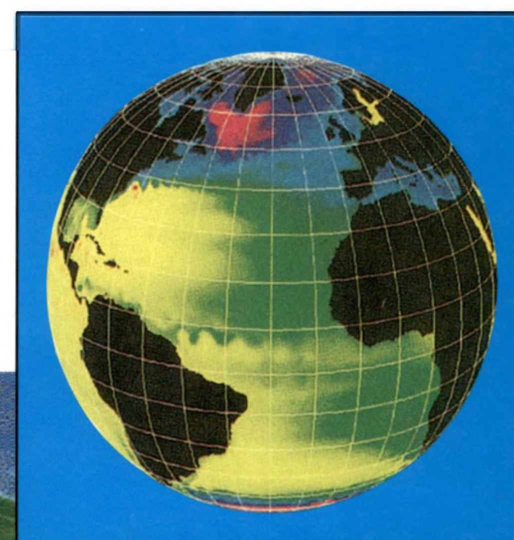
European Global Ocean Observing System

The Strategy for EuroGOOS



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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.

The Strategy for EuroGOOS

Edited by J D Woods, H Dahlin, L Droppert,
M Glass, S Vallerga and N C Flemming

EuroGOOS, the European Association for the Global Ocean Observing System (GOOS), was founded in December 1994. The Strategy for EuroGOOS was written during 1995-96 to state the most important advances which we need in order to create an efficient system of operational ocean monitoring and forecasting for Europe. We have tried to identify the key facts about the range of potential customers, the benefits which can be generated from improved marine forecasts, the technology which is needed, the science base for modelling coastal seas and ocean basins, and the range of products which must be delivered. We have also identified, so far as possible, the strengths of the European agencies and organisations with the necessary skills and experience. We conclude that Europe is in a strong position to proceed with GOOS.

We have examined many aspects of operational oceanography and its potential. A wide range of assumptions have been checked and examined to ensure that we are justified in our policy and strategy. These background data in engineering, economics, computer modelling, information processing, and other specialities are summarised in the Strategy Document. If this were not done even the most professional reader would be faced with hundreds of references which had to be checked and read before the arguments in support of EuroGOOS could be accepted. Inevitably the Strategy Document is therefore long. The Officers of EuroGOOS decided to publish a document which can stand on its own, and provide a complete outline of the many factors in operational oceanography.

This Strategy Document does not include elements of an Implementation Plan, or a Business Plan. It describes the work done so far by EuroGOOS and its component groups, and identifies the next steps for action. It identifies a number of objectives and methods which suffice to cover the whole field of developing operational oceanography, and which can be maintained steadily and consistently for at least 5-10 years. This gives EuroGOOS a sense of purpose and direction. It tells other organisations the direction in which we hope to go, and suggests areas of collaboration.

A more detailed EuroGOOS Plan will be produced in 1997. The Plan will take as a starting position the conclusions reached in this Strategy, and the comments we receive on it. The Plan will establish the technical and business steps needed for implementation.

EuroGOOS and its Members are making practical decisions, changes in activities, adapting their marine data gathering and modelling procedures, and generating new products, on a continuous basis. The Members do not stand still while EuroGOOS analyses the future requirements. Practical developments by the Members working together during the last year have included steady increase of operational collaboration by agencies in the Baltic, initiation of the first plans for operational forecasting experiments in the Mediterranean, the start of engineering studies to install automatic instrument packages on a large number of European ferries, and the start of a dialogue with commercial companies interested in operational oceanography on the European and global scales.

This report provides information on EuroGOOS itself, and background information on operational oceanography and its benefits for Europe. It is not yet possible to make any promises about precise technology or instruments which will be needed, the exact size of the market, or the exact specification of instruments. Nevertheless, starting from the points made in this Strategy, combining them with the results of the EuroGOOS Survey of Marine Technology to be published during 1996, and adding in 1997 the EuroGOOS Plan, it will be possible for commercial companies to obtain a clear assessment of the types of product which are needed.

In this document we are also setting out our objectives and raison d'être as information to European Agencies and Organisations. We are conscious of the wide range of existing multi-national organisations at both the European level, and regional level. EuroGOOS must take its place amongst them without wasteful duplication or overlap, and provide a valuable service which other organisations can respect and use.

The Global Ocean Observing System is a truly global enterprise, and we seek to advance the cause of European success by contributing strongly to GOOS.

Professor J D Woods (Chairman EuroGOOS)

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Summary

DEFINITIONS

The Global Ocean Observing System (GOOS) is an international programme preparing the permanent global framework of observations, modelling and analysis of ocean variables needed to support operational ocean services wherever they are undertaken around the world. GOOS is promoted by the following UN Agencies: The Intergovernmental Oceanographic Commission, the World Meteorological Organization and the United Nations Environment Programme. The Joint Scientific and Technical Committee responsible for designing GOOS is sponsored by those UN Agencies and the International Council of Scientific Unions (ICSU). GOOS was launched at the Second World Climate Conference in 1990. It will provide the ocean component of the Global Climate Observing System.

EuroGOOS is the European component of GOOS, and consists of an Association of national Agencies working together to foster European participation in GOOS, and the development of operational oceanography for the benefit of Europe. EuroGOOS at present has 22 Members in 14 European countries.

THE BENEFIT TO EUROPE

Operational oceanography presents Europe with the opportunity to profit from previous investment in marine science, and to develop a new business which will directly employ some 5000 people, with a turnover of the order of 500 Million ECU per year. This business will support and improve the performance of existing maritime industries and services which have an annual GNP value in the EU of 110-190bn ECU/yr. The additional economic benefit created by improvements in efficiency, better decision-making, and better management of the environment is expected to be in the range 2 to 5bn ECU per year.

Forecasts of the state of coastal seas and oceans for days to decades into the future will add several percent to the revenue of all maritime industries. They will produce benefits of the same order of magnitude in improved seasonal and inter-annual climate forecasts which will create a statistical basis for improved management of agriculture, water supplies, and power generation.

Europe should be able to capture at least one third of the global business in operational marine observation and forecasting outside Europe. Operational oceanography generates a demand for new technology, field survey skills, and computing services, which can be exported globally

THE PENALTY FROM TAKING NO ACTION

Failure to exploit the previous investment, and failure to invest further by developing the skills of government agencies and commercial companies throughout Europe will lead to less efficient maritime industries, increased losses from poor environmental management and marine pollution, increased public health risk, and penetration of European markets by non-European organisations offering services to Europe. On the global scale, European service companies would fail to gain their share of a global market measured in billions of dollars.

Inadequate marine environmental prediction systems will result in lack of investment in projects which appear environmentally sensitive, but which could be acceptable and beneficial.

European politicians negotiating on issues such as global warming, climate change, and pollution, would have to rely increasingly on non-European coupled global ocean and atmosphere models and predictions provided by non-European agencies.

THE EUROPEAN ADVANTAGE

Europe has particularly strong assets in its advanced numerical modelling, strong space agencies, advanced maritime industries, strong environmental management policies, and accumulated skills from decades of investment in basic and strategic marine science. Europe has a strong network of marine laboratories, a fleet of research and survey vessels, strong meteorological services, and a range of companies with world-wide skills in coastal and offshore services.

Efficient operational oceanography demands an economically designed array of observing systems, buoys, satellites, ships, gathering data from each sea area according to a scientifically designed sampling scheme. Experience of European collaboration in space and weather forecasting shows that we can work together at all geographical scales. This collaboration requires planned installation of observing systems, rapid exchange and transmission of data, preferably within a few hours, computation of the best description of the state of the sea or ocean, and rapid dissemination of data and forecasts to users.

The European Principles of Competitiveness, Cohesion, Subsidiarity, Human Capital, and European Identity provide an excellent political framework for collaboration within EuroGOOS to achieve the goals of successful operational ocean services.

EuroGOOS AND ITS CUSTOMERS

We have identified numerous sectors of the growing business of operational oceanography, and Members have compiled lists of hundreds of potential customers in each country. Many of the data and forecasts obtained by European and Government agencies will be processed further by commercial companies in the value-added industry, and transmitted through a chain of intermediaries to customer groups requiring very different products. The final benefits accrue within individual industries and activities such as:

Offshore oil and gas
Fisheries
Mineral extraction
Defence
Pollution management
Climate prediction
Port operations
Coastal protection
Ship-routeing
Aquaculture
Tourism
Public health

GUIDING PRINCIPLES

We identify guiding principles for the development of operational oceanography. The services derived from operational oceanography must be targeted towards identified user groups. There must be a continuing dialogue with potential users of operational marine data and forecasts. All operations, data gathering, modelling, and forecasting, should be done with optimum planning of installations and services so that coastal states and agencies share responsibilities without duplication. New technology of sensors, satellites, and computer modelling can be implemented so as to produce a new range of cost-efficient services. The full benefits of operational oceanography are only obtained when observations and modelling are integrated at scales from global, to regional, to local. It is possible to develop and improve existing systems in parallel with the consistent introduction of new technology and new science so that we converge towards an optimal system in 5-10 years time. Europe should systematically transfer technology and capacity building to developing countries, especially in the southern hemisphere, in order to ensure that all Member States of the UN System are able to participate in GOOS and benefit from it. New training systems are needed in Europe to provide expert staff in operational oceanography.

Europe has global interests in the development of GOOS, and should collaborate technically with the major participants including America, Australia, India, China, Japan and Russia. The European sea areas of especial interest are the marginal and semi-enclosed seas, Baltic, North West European shelf seas, the Mediterranean, and the adjacent Arctic Ocean. Europe has a special requirement to understand and predict the Atlantic both for reasons of short term economics, and for long term prediction of climate variability and climate change.

COMPONENTS OF THE STRATEGY

We have identified ten linked strategic sectors of action, and have started work in all ten.
The sectors are:

1. **Identification of customers, users, and beneficiary groups**
2. **Economics of EuroGOOS and the estimation of the costs and benefits of operational oceanography.**
3. **The Scientific Basis of EuroGOOS.**
4. **The Technology needed for EuroGOOS.**
5. **Development, Trials, and Case Studies**
6. **Design and optimisation of the civil operational marine observing system**
7. **Numerical modelling, data assimilation and forecasting.**
8. **Products, services, value added, and services to the end user.**
9. **The global dimension and interface with the global organisation of GOOS.**
10. **Links to other European scale organisations and programmes.**

These strategic sectors provide areas of activity where the pursuit of consistent objectives can be maintained with steadfast purpose. It is unlikely that any of these components of the strategy will ever be dropped.

In this report, each sector of activity is analysed in terms of actions required and the objectives defined on three timescales: (1) 1996-98, (2) 1998-2002, and (3) 2002 to 2006 and beyond.

RESOURCES AND ASSETS

Europe possesses a world-class range of facilities for the development of operational oceanography. These include numerical modelling groups, satellite design and launch capabilities, research ships, experience of working globally in both operational services and global marine science experiments, existing regional and local marine operational forecasting services, engineering of marine robotic instruments and autonomous underwater vehicles, a well-informed and technically experienced user community ready to benefit from improved environmental data and forecasts, a strong marine science programme with integration across Europe between many laboratories, a strong high technology manufacturing base and a wide range of marine service companies. Europe benefits from a number of European trans-national agencies and programmes which have an interest in maritime development and marine science and technology. These include:

- EU/EC
- ESA
- Council of Europe
- Eumetsat
- ESF/EMaPS
- Eureka/EUROMAR
- EEA
- OSPARCOM
- MIF

Leading international organisations with a majority of European members and interests in marine technology include:

- G7
- OECD
- NATO
- ICES

METHODS AND ACTIVITIES

EuroGOOS has started a programme of activities which includes design studies and surveys of customers and data requirements, trials of technology and systems, test case studies of the design for operational services in a variety of sea areas, workshops, publications and communications with industry, demonstration projects, collaboration with other European Agencies and Programmes, organisation of a major Conference, communications with GOOS programmes in the USA, Australia, and North East Asia, scientific analysis of the possible improvements to marine numerical models, estimation of the limits to predictability in shelf seas, optimal design of an observational sampling strategy, and identifying gaps in technology.

NEXT STEPS

We will hold a major international conference in the Hague in October 1996. During 1996 the various working groups and studies carried out by EuroGOOS will be drawn together to create the inputs for the EuroGOOS Plan, which will contain elements of more detailed analysis of costs and future sources of funding. Operational oceanography will need to be funded by a combination of commercial sales of products and services, the provision of services and forecasts to government agencies with statutory responsibilities, national support in the public good, and European or international funding to provide European and global services.

In the immediate future, while preparing the EuroGOOS Plan, effort will be devoted to:

- Foster partnerships, projects, and joint ventures between Members of EuroGOOS.
- Develop relations with existing and potential users and partners
- Foster European industries providing the tools needed for operational oceanographic services.
- Develop relations with European Institutions.
- Develop relations between EuroGOOS and International GOOS, other regional bodies in GOOS, and other international organisations:
- Organise European summer schools and seminars.
- Strengthen the EuroGOOS Association.
- Identify sources of funding for EuroGOOS.

EuroGOOS will make a special effort to identify technical, instrument, and system requirements which could be provided by European companies. Manufacturers and service companies will be provided with information on the technology requirements, and encouraged to participate in trials and prototype tests of systems.

At the global level EuroGOOS has strong working relations with both the Intergovernmental Committee for GOOS (I-GOOS) and the Joint Scientific and Technical Committee for GOOS (J-GOOS).

CONCLUSION

Operational oceanography provides an opportunity for investment and development which promises to produce a significant economic return to Europe, and provide extensive benefits in management of the environment, protection of public health and safety, and assist in prediction of climate change. The scale of the new business of operational marine forecasting is of the order of 500 million ECU/yr, and 5000 new jobs. Europe is in an excellent position to establish a global role in operational oceanography, and has a sound foundation in existing scientific and technological assets. If we do not decide to invest in operational oceanography, European organisations will suffer diseconomies, and will have to buy the services and forecasts from outside Europe. All aspects of European marine environment policy will become more effective with EuroGOOS. These are powerful reasons for Europe to play a major role in GOOS.

Chapter 1

Introduction

What is EuroGOOS?

EuroGOOS activities

Why does Europe need EuroGOOS?

Benefits to Europe

Existing strengths in Europe

Need for collaboration

Contribution to furthering European principles

BOX 1 DEFINITION OF OPERATIONAL OCEANOGRAPHY

Operational oceanography is the activity of routinely making, disseminating, and interpreting measurements of the seas and oceans and atmosphere so as to:

- **provide continuous forecasts of the future condition of the sea for as far ahead as possible**
- **provide the most usefully accurate description of the present state of the sea including living resources**
- **assemble climatic long term data set which will provide data for description of past states, and time series showing trends and changes.**

Operational oceanography proceeds usually, but not always, by the rapid transmission of observational data to computerised data assembly centres, where the data are processed through numerical forecasting models. The outputs from the models are used to generate secondary data products which have special applications, often at local or regional level. The final data products and forecasts must be distributed rapidly to industrial users, government agencies, and regulatory authorities.

Operational oceanography already exists at local levels, and for a limited number of factors. Forecasts regularly provided at present include: wind velocity and direction over the sea; wave height, direction and spectrum; surface currents, tides, storms surges, floating sea ice, and sea surface temperature. There are great advantages in making operational oceanography global so that all parts of the system can be analysed and forecast simultaneously with greater accuracy and further into the future.

There are many more products of value to industry and government agencies which can be made available soon, or for which the forecast periods and accuracies can be increased. These include indicators of marine pollution and contamination, movement of oil slicks, prediction of water quality, concentrations of nutrients, primary productivity, sub-surface currents, temperature and salinity profiles, sediment transport, and erosion.

Scientific and technological research which has already been funded in Europe leads logically to greatly improved forecasts through operational oceanography, and substantial benefits to a vast range of industries, services, and regulatory authorities.

Ultimately, new systems based on new technology and new understanding of the sea will permit long range forecasts which will be of great benefit in managing the seas and oceans, and in predicting changes and variability of climate.

Chapter 1

Introduction

WHAT IS EuroGOOS?

EuroGOOS is an informal association, founded in 1994, whose member agencies seek to foster European co-operation and participation in the Global Ocean Observing System (GOOS). EuroGOOS is established with full recognition of the importance of existing systems in research and operational oceanography in Europe at national and European scales. Operational Oceanography is defined in Box 1.

The Members of EuroGOOS are listed in Box 2, and the full addresses of Member Agencies and key personnel are shown in Annexe 1; the internal organisation of EuroGOOS, and the Terms of Reference of its subsidiary components are listed in Annexe 2. The Memorandum of Understanding which established EuroGOOS is attached as Annexe 4.

Members of EuroGOOS co-operate to establish a concerted European approach to the following:

- Identifying European priorities for operational oceanography, promoting the development of the scientific, technology and computer systems for operational oceanography, and its implementation, assessing the economic and social benefits from operational oceanography
- Contributing to international planning and implementation of GOOS and promoting it at national, European and global level

EuroGOOS ACTIVITIES

The goals of EuroGOOS are:

1. **To advance European Operational Oceanography.**
2. **To foster European contributions to GOOS.**
3. **To promote development of technology needed for GOOS.**
4. **To promote operational oceanography in developing countries.**

EuroGOOS activities are designed to collaborate with and maximise the benefits from existing activities in operational oceanography, promoting the integration of these activities within the framework of GOOS. Members of EuroGOOS collaborate and support the following groups of activities:

ADVANCING EUROPEAN OPERATIONAL OCEANOGRAPHY IN GOOS

i) Promoting development of regional European and local operational oceanography, taking into account the Modules of GOOS for the Coastal Zone, Health of the Ocean, Living Marine Resources, Climate, and Ocean Services.

ii) Promoting development of common European operational data procedures and services, including data quality control and data management for operational oceanography.

iii) Promoting research and pre-operational research which will solve problems relating to operational oceanography.

iv) Promoting development of common infrastructure and to promote major systems or capital installations required to support European operational oceanography.

v) Promoting pilot studies in GOOS operations, local, regional, or global.

vi) Promoting development of common European operational oceanographic services and products of maximum value to European Governments and Agencies, furtherance of European industries and service companies, and the protection of the environment and health in the European coastal and shelf seas.

BOX 2 MEMBERS AND ASSOCIATE MEMBERS OF EuroGOOS

Bundesamt für Seeschiffahrt und Hydrographie (BSH), Germany

Comision Interministerial de Ciencia y Technologie (CICYT), Spain

Consiglio Nazionale Delle Ricerche (CNR), Italy

Ente per le Nuove tecnologie, l'Energia e l'Ambiente (ENEA), Italy

Environment Agency (EA) (formerly National Rivers Authority), UK

Finnish Institute of Marine Research, Finland

GeoHydrodynamics and Environment Research (GHER), Belgium

IFREMER, France

Institute of Marine Research, Bergen, Norway

Institute of Oceanology, Polish Academy of Sciences, Poland

Institution of Marine Biology of Crete, Greece

Marine Institute, Ireland

Meteorological Office, UK

MUMM, Department of Environment, Belgium

Nansen Environmental and Remote Sensing Center, Norway

National Centre for Marine Research of Greece

National Institute for Coastal and Marine Management (RIKZ), Rijkswaterstaat, Netherlands

Natural Environment Research Council (NERC), UK

Netherlands Geosciences Foundation (GOA), Netherlands

Puertos del Estado, Clima Maritimo, Spain

Royal Danish Administration of Navigation and Hydrography, Denmark

Swedish Meteorological and Hydrological Institute (SMHI), Sweden

POLICY IN PROMOTING GOOS

vii) To develop policies for the furtherance of GOOS and co-ordinating the best European participation in GOOS, identifying where greatest value is added by collaboration.

viii) To promote collaboration between existing European multi-national agencies, programmes, organisations, and initiatives having expertise in oceanography, operational systems, and remote sensing of the ocean.

ix) To provide, as appropriate, expertise, WGs, consultants, etc., to J-GOOS and I-GOOS.

x) To promote studies and evaluation of the economic and social benefits produced by operational oceanography.

xi) To co-operate as appropriate with organisations concerned with climate change, global environmental research, and the impacts of climate variability and climate change.

xii) To publish findings of meetings, workshops, studies, and other documents commissioned by the EuroGOOS members, joint representation at and submission of documents to international meetings related to GOOS, and collective representation of GOOS to European and national Agencies, when requested by members.

xiii) To co-ordinate GOOS data acquisition with existing European and national data gathering under Agreements and Conventions relating to pollution monitoring, marine meteorology, navigation and safety at sea.

PROMOTION OF INSTRUMENTATION AND TECHNOLOGY

xiv) To promote the development of low cost efficient operational instrumentation, observing systems, and data acquisition systems.

xv) To support operational oceanography and services in collaboration with public and private sector organisations and programmes in Europe concerned with ocean technology.

xvi) To promote collaboration with space agencies and remote sensing scientists and engineers so as to ensure optimum integration of both in situ and remote sensed data in operational oceanography.

AID AND CAPACITY BUILDING

xvii) To promote aid, technology transfer, and collaboration with developing countries within the framework of GOOS.

xviii) To promote collaboration between European institutes and agencies in providing aid and assistance to developing countries for operational oceanography, and the necessary capacity building.

WHY DOES EUROPE NEED EuroGOOS?

Between 3 and 5% of input to the European (EU) GNP is generated directly by marine based industries and services. The value added directly by these activities is in the range 110-190bn ECU/yr ($140-230bn/yr). The industries and services are subject to uncertainty, loss of efficiency, and direct costs and damage caused by the unpredictable forces of the marine environment such as storms, sea level surges, waves, erosion, transport and resuspension of pollutants, shifts in fish stock migration, and toxic algal blooms. The temperature and salinity of the north Atlantic determine the weather and climate of Europe, Russia, and the Mediterranean. Europe has a great need to understand, monitor and predict the state of its coastal seas, the Mediterranean, and the adjacent oceans, Atlantic and Arctic.

Europe possess the wealth, institutions, and expertise to benefit strongly from operational oceanography on a European, Mediterranean, and North Atlantic and Arctic scale. (See Chapter 5 for a fuller discussion of the institutional advantages). The same institutions permit Europe to participate in and benefit from the Global Ocean Observing System (GOOS). It is important to Europe to make sure that the global infrastructure of GOOS is designed so as to guarantee the data products needed to benefit Europe.

TABLE 1.1
INDUSTRIES AND ACTIVITIES CONSIDERED BY CCMST

TRANSPORT (excluding military)
Shipping operations
Hovercraft operations
Hydrofoil operations
Submersible/submarine operations/ROVs
Tunnel subsea operations
Barrage roads
Causeway
Bridges, sea channels
Navigational safety, lights, etc.
Safety services, rescue, life preserving, fire
Port operations

ENERGY PRODUCTION
Oil & gas production (oil & gas companies only)
Oil & gas exploration, fabrication, and drilling services
OTEC
Wave energy
Tidal energy
Wind, offshore installation

ENVIRONMENTAL PROTECTION/ PRESERVATION
Clean beaches
Oil pollution control
Non-oil pollution
Estuarine pollution
Health hazards
Marine reserves
Species protection
Forecasts
Flood prevention
Safe waste disposal
Amenity evaluation
Environmental quality control
Environmental data services

MINERAL EXTRACTION
Aggregate, sand, gravel
Deep ocean, Mn, hydrothermal muds, crusts
Placer minerals, diamonds, tin, etc.
Salt extraction, magnesia, bromine
Desalination
Phosphate
Coal, subsea

FOOD FROM THE SEA
Fisheries, catching
Fish farming
Shellfisheries
Shellfish, crustacea, farming
Fishing gear

DEFENCE
Military vessels, surface & submarine
ASW, oceanographic applications
Underwater weapons
Navigation, position fixing, etc.
Defence sales, equipment, components
Operations & efficiency, logistics, controls, computing

BUILDING, CONSTRUCTION & ENGINEERING
Coastal defences
Port construction
Dredging
Land reclamation
Barrage construction
Tunnel construction
Outfalls, intakes
Consulting engineering
Components, hydraulics, motors, pumps, batteries, etc.
Cables, manufacture & operations, laying
Corrosion prevention, paint, antifouling, etc.
Heavy lifting, cranes, winches
Marine propulsion, efficient ship, automatic ships, DP, props
Offshore construction, platforms, etc.
Pipelaying, trenching, burial
Ship building, non-defence, all kinds

SERVICES
Insurance
Certification
Inspection, maintenance, repaid
Diving, including suppliers
Salvage, towing
Metocean survey, mapping, hydrographic surveys
Remote sensing
Project management, non-defence, consultancy

EQUIPMENT SALES
Marine electronics, instruments, radar, opto-electronics, etc.
Sonar
Buoys

TOURISM & RECREATION

Source: CCMST, 1990

Europe is dependent upon and influenced by marine conditions more than any other developed continental region. The weather and climate of Europe are dominated by the oceanographic circulation of the Atlantic, whilst a greater concentration of people and industry is closer to the coast than in any other part of the world. Changes in mean sea level, changes in storm conditions and coastal erosion, have a greater impact on shelf-seas and oceanic fisheries, tourism, land use, shipping and ports, and offshore oil than in other continents. The Mediterranean is an almost closed basin with unique circulation which will require a relatively high resolution observation and modelling scheme. This modelling is important both for the Mediterranean coastal states, and to provide accurate assessment of the Mediterranean outflow of dense water into the Atlantic.

European climate and weather are dependent upon the northward transport of heat in the Atlantic surface currents. The heat transport depends upon the rate of formation of cold bottom water which sinks at the interface between the Arctic and Atlantic Oceans. Records from ice cores and ocean sediments show that this circulation has varied dramatically in the past, and that significant changes could occur which would result in the climate of Europe becoming similar to present day Labrador. More normal fluctuations show that there are decadal variations in mean temperature of the upper Atlantic Ocean which cause variations in currents, fisheries migrations, and continental weather. These decadal fluctuations have a profound effect on the global climate, and dominate global fluctuations on a timescale longer than the ENSO period of 2-5 years. By monitoring and predicting the northward heat transport in the North Atlantic Europe would be making a vital contribution to global climate prediction, and acting in its own interests.

The ability to monitor and predict North Atlantic changes on the multi-year timescale would provide the boundary conditions for models of the shelf seas, and hence permit prediction of conditions in the coastal areas. European nations have a strong interest in predicting the state of the North Atlantic and adjacent Arctic Ocean. It is vitally important to understand the variability of Arctic sea ice, and the variability of the ocean waters under the ice. European countries could benefit greatly from a programme of remote sensing of the Atlantic and Arctic Oceans, combined with in situ instrumentation. The ocean scale models should be run so as to provide seasonal, inter-annual and multi-year predictions, assisting in the forecast of climate variability.

At the global scale, Europe alone has the potential to take an equal share with Asia and North America in organising, planning, and implementing GOOS. GOOS will be developed in phases, and it is in Europe's interest to ensure that aspects most relevant to the global parameters which influence the conditions and climate in Europe are developed early in the programme. For example, if too much emphasis is placed on predicting ENSO, low priority will be given to monitoring the polar regions, ice edge, and cold deep water formation, all of which are essential to Europe. It follows that Europe should assess the scale of appropriate commitment to funding operational oceanographic satellites, ground stations, and data processing and modelling centres as part of global framework of GOOS. European research centres and operational agencies should consider taking responsibility for in situ measurements and technology development to monitor ocean conditions in a significant proportion of the Arctic Ocean, the whole Atlantic, parts of the Southern Ocean, and probably small parts of the Pacific.

European institutions and modelling groups have a world class position already, and lead in many aspects of global modelling. It follows that these achievements should be exploited as an advantage in the design and management of GOOS, and the prioritisation of more advanced global operational models.

The effective development of operational oceanography in Europe will therefore protect and improve the efficiency of existing maritime industries and services, develop a new class of business - that is, the business of operational oceanography - and provide essential data and forecasts for the management of resources and protection of the environment.

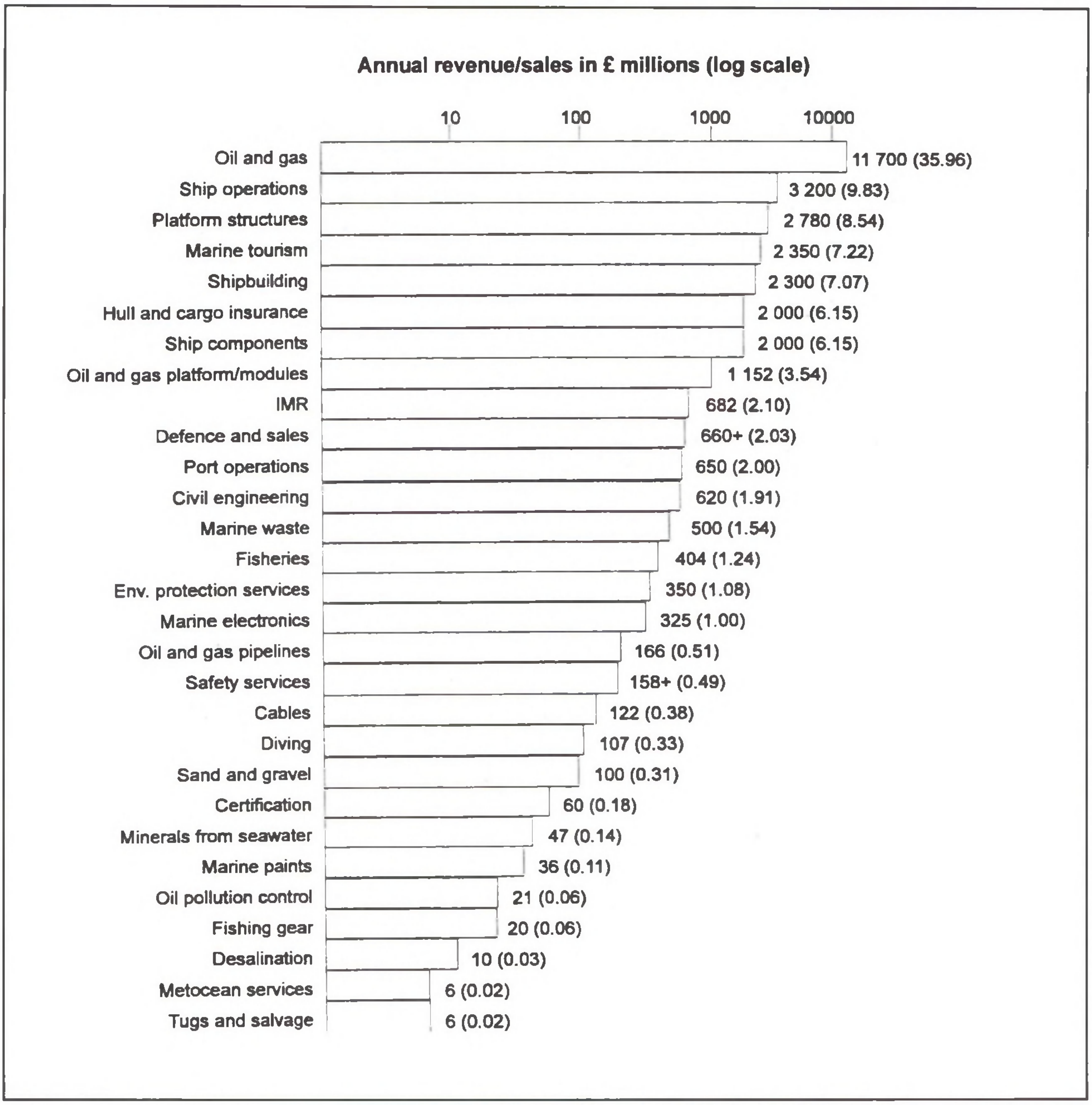

Figure 1.1 Scale of industries and activities by sales and revenue

The sales of British commercial marine industries or services and the costs of non-commercial activities and services, are ranked on a logarithmic scale, in £ millions. Data are mostly for 1986. Sales/costs are listed for UK based activities so as to give an estimate of the scale of the operation conducted from the UK, and should not be interpreted as an estimate of global market. Numbers in brackets show % of total. Source: CCMST, 1990

BENEFITS TO EUROPE

New business

Operational oceanography is a new activity which is at the beginning of a rapid growth phase. If Europe moves fast now, we will establish a lead, possibly globally, with a secure business turnover, and growing new business and foreign sales of services, expertise, and equipment. The generic business of operational oceanography will be a partially collaborative activity involving European Agencies, Government agencies, space agencies, universities, industry, and value-added information and consultancy services, operating either in concerted fashion, or in competition as appropriate.

Maritime industries operate throughout the world with strong international competition. Technological progress is vital for the success of the industry, which is of major importance to Europe, and accurate forecasts of marine conditions ensure the most effective design of systems, and the most efficient operation. Three of the main sectors of the industry (shipbuilding, transport and marine resources) together provide more than 800,000 jobs in the Union. The EC Task Force on Maritime Systems of the Future is engaged in regular consultation with the maritime industry promoted in the framework of the Maritime Industries Forum, which has identified a number of areas for action at the European level. To these broad categories of industries which are natural customers for the products of EuroGOOS we should add a wide range of civil engineering activities in the coastal zone, cable and pipelaying, tourism, environmental management of the coasts and estuaries, and many other activities which will be discussed in more detail below. The total number of jobs in the full range of marine industries and services is therefore of the order of 1.0-1.5 million in the EU.

Several countries have conducted analysis of the contribution to GNP of their maritime and coastal industries: USA (Pontecorvo, 1980; 1989; Broadus et al. 1988, National Research Council, 1989), Australia (Franklin, 1989), and UK (CCMST, 1990). More recently France, USA, Japan, Australia and UK have published reviews and reports describing how they identify the approximate value of GOOS products to their industries and services, and how they could deploy national research and operational resources to further the aims of GOOS, (References respectively: France (GOOS-France 1994); USA (National Research Council 1994); Japan (Hirose, 1993); Australia (AODC, 1993); UK (IACMST, Workshop Reports 1994a, 1994b, 1995). Such plans are in an early stage because national agencies and governments need to make iterative estimates both of the potential benefits of GOOS, and how they might actually be obtained. Since it costs more to make a more accurate study, each successive more detailed analysis is only embarked upon if a previous study is positive.

Fig. 1.1 and Table 1.1 illustrate the summary of the industries analysed in UK (CCMST 1990). Table 1.2 summarises the scale of maritime industries in Australia, and Table 1.3 illustrates a very approximate summation for global industries based on the reports of international global trade and commodity organisations. The OECD Megascience Report (1994, Annexe 2, p.139-144) concludes that the total contribution to global GNP of the maritime and coastal industries and services is of the order of $800-1000bn per year. This excludes on-land benefits from short- to medium-term prediction of climate variability.

For the EU, using figures from EC reports (SEC (95) 1824), and referring only to the three sectors mentioned above (Shipbuilding, transport, and marine resources), the following facts apply:

- More than 90% of the Union's external trade is carried by sea. As far as intra-Union trade is concerned, it is estimated that approximately 35% of it is undertaken by short sea transport or inland water ways.
- The European Union shipbuilding industry accounts for one fifth of the world market and employs 84,000 people. Maritime industry is a global sector and therefore open to international competition. The shipbuilding industry is currently facing severe difficulties and therefore needs renewal. In the context of ever-increasing international trade, solutions need to be found to remedy the decline of the European fleet and to increase the attraction of maritime transport, relative to other modes of transport.
- The marine environment and its resources are a potential source of large amounts of energy and raw materials.
- The Union is the world's largest market for fish products and the third major fishing power behind Japan and China. 300,000 people in the European Union are fishermen.
- Maritime transport services are in the process of being liberalised overall, while the EU is developing a maritime transport policy. Marine resources have a huge potential which is still to be fully explored.

- The development of Short Sea Shipping and the application of new technologies to traffic management offer alternative solutions to traffic congestion.
- The marine resources industry will be confronted with increasing competition and environmental requirements.
- The fishing sector suffers world-wide from an over-exploitation of most important fish stocks and over capacities of the fishing fleet.
- Regular consultation with maritime industry representatives and users has been promoted within the framework of the Maritime Industries Forum (MIF) since 1992.
- A Research and Development co-ordination group has been created by the industry, in the framework of the MIF, as a single interface for R & D programmes.
- In February 1995 the G7 members, in the context of their initiative for the Global Information Society, have launched the MARIS project, which is a concrete industrial application of information technology and telematics in the maritime sector.
- MARIS (Marine Information Service) meetings have already taken place with the industry in March, April and July 1995 preceded by interservice meetings.

TABLE 1.2 VALUE OF AUSTRALIAN MARINE INDUSTRIES IN 1986-87

Industry	Year	Total value A$ m	Export value A$ m[a]
Fisheries	87-88	828[b]	724
Recreation fishing	83-83	1 100[c]	Low
Oil and gas[d]	86-87	5 173[e]	1 018
Marine tourism	86-87	4 700[f]	400[g]
Shipping			
ship-based	86-87	1 250[h]	350[i]
shore-based	86-87	2 300[j]	2 000[k]
Civil shipbuilding	87-88	132[l]	51[m]
Naval shipbuilding[n]	87-88	434	13
Coastal engineering	87-88	>188[o]	Low
Offshore engineering	87-88	569[p]	Low
Marine scientific equipment	85-86	<30	<15
Total[q]		**16 700**	**4 570**

a) All export values are gross, that is, they include the value of imported inputs to the production process.
b) Value to fishermen.
c) Expenditure on fishing and related equipment.
d) Includes both onshore and offshore production. Over 90 per cent is offshore production.
e) 1986; total crude oil import replacement and exports, and LPG exports.
f) Direct expenditure by domestic travellers and international visitors in Australia.
g) Direct expenditure by international visitors to Australia.
h) Coastal shipping A$ 690 million. International shipping A$ 560 million.
i) Export freight earnings.
j) Production value of port-related services (Bureau of Transport and Communications Economics estimate).
k) Overestimate; includes onshore transport costs of non-bulk goods.
l) Ships exceeding 150 gross construction tonnes; value of vessels completed.
m) Ships exceeding 150 gross construction tonnes; export value of vessels completed.
n) Expenditure during the year. Total projected value to 1999; more than A$ 8 billion.
o) Value of work done to harbours; A$ 188 million.
p) Engineering construction work done in relation to oil and gas (almost all of it offshore).
q) Not complete; does not include all relevant industries.

Source: Franklin, 1989 and OECD, 1994

TABLE 1.3 VALUE OF GLOBAL MARITIME INDUSTRIES FROM INTERNATIONAL GLOBAL SOURCES (INCOMPLETE)

Industry or service	$bn/yr	
Offshore oil and gas	135	Meyer, 1990
Construction of rigs and platforms	45	CCMST, 0.33 x oil revenue
Global fisheries	126	FAO, 1990
Marine electronics	10	Broadus *et al.*, 1988
Maritime transport revenue	173	1991, UNCTAD, 1992
Value of maritime seaborne trade goods	3 314	Economist, 1992 not included in total
Expenditure on civil shipbuilding	10	UNCTAD 1992
Income from port operations	?	
Total loss of all ships/year	?	
Global marine tourism	100	IOC/INF-915, 1993, p.A7
Sand and gravel	?	
Civil engineering	?	
Recreational boat sales	20-30	Broadus *et al*, 1988, US only (x4 = global)
Global cable laying and telecommunications		CCMST
Salvage	?	
Coastguards, rescue, lights, navigational safety	?	
Waste disposal	?	
Coastal defence construction and maintenance	?	
Insurance		
Military ship building		
Marine forecasting		
TOTAL	**$629 billion per year +**	

These facts and figures, though far from complete, substantiate the argument that the maritime industries and services are an essential and growing component of European wealth and prosperity. The new business of marine operational forecasting, which will enable the maritime industries and services to be run at a greater profit, with greater safety, and greater protection of the environment, is therefore itself vital to the future of Europe.

A prediction system which gave information about the future state of the ocean in terms of sea state, winds, storms, upper ocean thermal structure, currents, stratification, fronts, gyres, eddies, internal waves, sea ice, primary photosynthetic productivity, nutrient concentrations, contaminants, and the prediction of extreme events in coastal seas and on the shore could improve the performance of these industries and services and regulatory management decisions by a few percent of annual value. It would be particularly rewarding to extend deterministic predictions into the time range of 10-30 days.

Improvement of the short- to medium-term prediction services for maritime conditions would improve the value of maritime industries and services by a few percent. If we accept 1% as a most conservative estimate, the value added to the maritime GNP of the EU by a prediction system is of the order of 1.1-1.9bn ECU/yr. This is a minimum which should be exceeded by a factor of 2-3. In addition there are the longer term benefits of climate prediction, and its impact on agriculture, energy generation, water supply management, land use and other social activities, which would be of the same order.

To establish whether such benefits are achievable EuroGOOS works directly with the practitioners of each industry. What information do they really need? What horizon of forecasts is most useful, and how accurate or reliable does it have to be? What are the risks in each industry of using inaccurate information and making a mistake which causes loss or damage? Do the customers want raw data, processed data which they can interpret themselves, or predictions based on the output of numerical models run by a central service facility? Studies of this kind have been conducted in an exploratory manner in the USA and UK, and possibly other countries. (National Research Council 1989, Woods Hole Oceanographic Institution 1993; IACMST Workshops 1994a, 1994b). These studies reveal a very literate and numerate user community, already geared up to exploit the data presently available, and aware that an improved operational ocean observing system could produce significant financial gains. They can make cautious and reasonable estimates of the improvement which might be possible in 5-10 years time. It is too early to try and sum the accumulated value of the individual industrial studies completed so far, but narrow sector studies of industries such as soft engineering coastal defences, marine water quality management, or trans-oceanic ship routeing and towing, produce benefits in 5-10 years time of the order of a few tens of millions of dollars per year per sector for the UK. These figures could be up-rated pro-rata to arrive at European sums. Provided that several tens of industrial sectors of this kind are evaluated in several different countries, it is not necessary to analyse every sector and every country. If the results are consistent, then it is possible to gross up the total in proportion to the scale of industrial and commercial sectors and services in other countries in Europe.

The net benefit from the product of European operational oceanography, by applying information and forecasts to European marine industries will be of the order of 1.1-1.9 bn ECU/yr. The nominal price that customers are willing to pay for this benefit in order to ensure a good return on their investment in the information, and reduce risk if the information does not pay off, will be an order of magnitude less, that is to say, of the order of 110-192 Million ECU/yr. Since many of the activities and services will be funded in the public domain, the justifiable expenditure will be higher than the minimum. This factor increases the estimate of the scale of the new business, and the number of people employed in it.

The EU countries collectively produce 30% of the world GNP. It is debatable how much marine technology and marine forecasting services Europe could market either to developed OECD countries outside Europe (representing 49% of world GNP), or to developing countries and other non-OECD countries, representing 21% of world GNP. It would be conservative to assume that some services and commercial contracting within Europe would be conducted by non-European companies from other developed countries, especially the USA. Nevertheless, Europe will, in this new business, be competing effectively only with the USA and Japan for the world market, and is in a good position to compete. A number of European companies have already demonstrated that they can market ocean services and instruments globally. The business servicing the contracts of European industrial companies operating outside Europe, and the business of servicing non-European activities anywhere in the world will add substantially to the scale of the new business within Europe, perhaps adding a further quarter to the estimate based on business within Europe.

Allowing for the combined benefits to maritime and terrestrial industries, the best estimate of the total scale of the business of operational oceanography run by European enterprises and government agencies is of the order of 500 Million ECU/yr, in 5-10 years time. This represents of the order of 5000 new jobs.

These figures are necessarily approximate, but are based on the best evidence available.

The great majority of new jobs will be at a high technical and professional level, requiring technical, scientific, engineering, computing, and managerial skills.

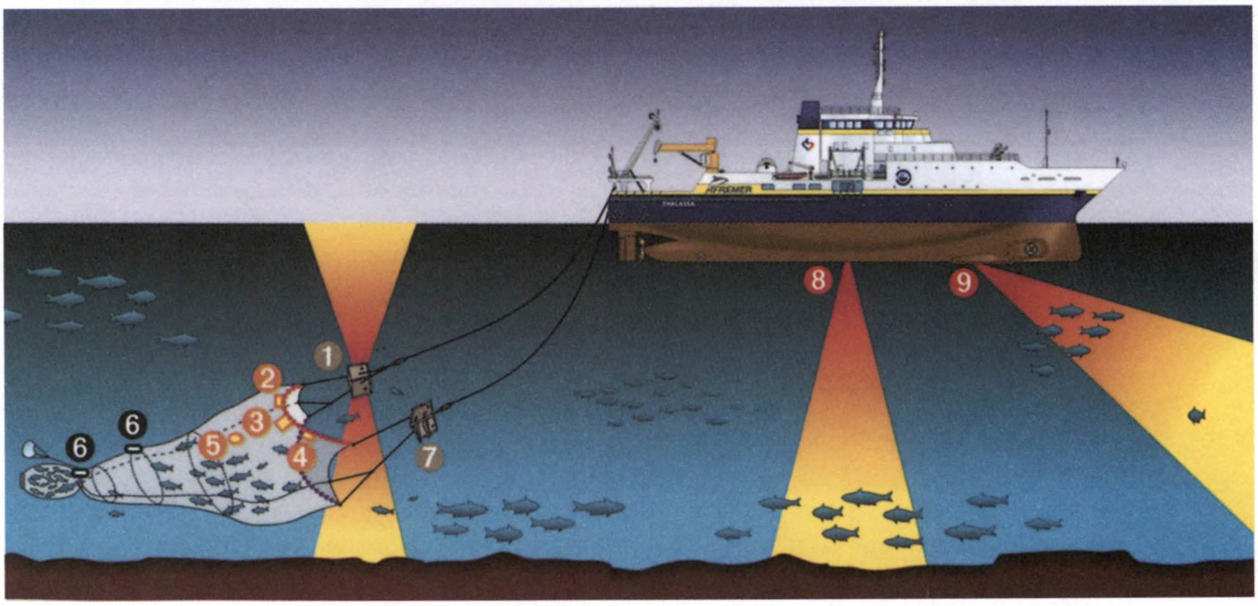

Figure 1.2 French research ship 'Thalassa'

1) Minitransponder; 2) Sensor for vertical opening of the net; 3) Trawl net sounder; 4) Speed sensor; 5) Depth and temperature sensor; 6) Remote controlled net closure; 7) Sensor for horizontal opening; 8) Vertical echo-sounder; 9) Sonar. Source: IFREMER

NEW BENEFITS

The benefits arising from the application of operational oceanography on a systematic basis are new. Advances in computing power, modelling theory, and scientific understanding of oceanography and meteorology during the last decade permit now the operational production of marine forecasts with a spatial resolution less than 1km, and prediction of many parameters describing the sea, the biological productivity, and sediment transports. Predictions with deterministic accuracy will be possible for many days, and statistical descriptions or averages for months or even years. This has not been possible before.

Europe includes within its borders and on its margins five semi-enclosed or almost totally enclosed seas. These are amongst the most intensively used seas in the world. In western Europe a population of 360 million with a high level of industrialisation and agricultural waste disposal relies upon these sea areas for fisheries, transport, oil and gas, recreation, and many other activities. These seas are amongst the most heavily stressed environmentally in the world. On the western and northern boundaries Europe utilises and depends upon the open ocean of the Atlantic and the Arctic. These oceans determine the climate of Europe, and are valuable sources of fish, transport, and to a growing extent oil and gas extracted from water depths of 500m and more.

If the seas of Europe are managed effectively we can maximise the economic benefits, as indicated above, and preserve the environment. If operational diagnostic descriptions of the sea and ocean, and forecasts of their future state are not provided. industries will be less efficient, and there will be expensive mistakes and avoidable accidents, including severe damage to the environment and loss of life.

The estimation of short- to medium-term economic benefits from GOOS falls into two categories:

- i) Economic benefits accruing to industries and services conducted at sea, beneath the surface of the sea, and on the coast.
- ii) Economic benefits accruing on land through the prediction of climate variability.

GOOS is economically justified by the fact that a multinational global investment to set up and implement operational planetary oceanography will produce benefits which, discounted for the delay in benefits, will amply repay that investment.

The benefits will take many forms and must be estimated in different ways. They include:

- i) Improved efficiency and reduction of costs in wealth-creating industries and activities;
- ii) Improved ability, because of improved information, to decide to undertake operations which would otherwise have been neglected;
- iii) Improved management of environmental resources, amenities, and protection of wildlife and biodiversity;
- iv) Avoidance or reduction of risk, or warnings of public health hazards and natural disasters, and reduction of hazards impacting on capital installations such as harbours and offshore oil and gas platforms;
- v) Multi-year prediction of natural climate fluctuations such as El Niño Southern Oscillation (ENSO), interannual climate variations, and decadal variations in maritime conditions;
- vi) Provision of oceanographic forecast data for long-term prediction of climate on a time scale of decades; long-term advance warning of the probability of events that are extremely damaging but have very low probability; insurance policy and reduction of uncertainty.

Provisional analyses by OECD show that industries, services, and amenities based on the ocean and coastal waters contribute a total of the order of $800 billion per year to world GNP. This offers a starting point for considering the activities and benefits of categories i), ii) and iii) above, where forecasts on time scales of ten days to a year or more are most applicable. Assuming that the non-space components of GOOS will cost some $1 billion a year, (OECD, 1994; Woods, 1994) it becomes reasonable to analyse the detailed economics of investing in its creation and implementation if it can be shown that information provided by GOOS can be used to improve the performance of these activities by approximately one per cent, for a benefit/cost ratio of about 8:1. These figures are approximate, but the general case for regarding GOOS as potentially very valuable would not change if world maritime industries were to contribute, say, $500 billion per year or $700 billion a year to world GNP, as the benefit/cost ratios would then be 5:1 and 7:1 respectively. In any case, it appears worth embarking upon much more detailed and technically robust evaluations of the true benefits to each industry, through cost-benefit studies and calculation of net present value and opportunity costs.

Category iv) concerns adverse effects on the ocean and coastal seas which occur from either natural or anthropogenic causes and for which the costing exercise involves defining the benefit obtained from avoiding or reducing disaster or damage. These include hurricanes, tsunamis, sea-level rise, sea-level surges, toxic algal blooms, extreme coastal erosion events, hazards from icebergs, dispersal of pollutants and contaminants, radionuclide hazards, and advance warning of damage to ecosystems such as coral reefs or mangrove forests.

Category v) deals with the impacts of natural climate variability on marine and terrestrial production on a multi-year time scale, assuming coarse resolution predictions without precise prediction of timing and location. Here, the benefits accrue over years to decades and concern industries and activities such as agriculture, energy generation, the construction industry, forestry, land use management, and long-term planning. The derivation of benefits would require making use of GOOS data to improve global coupled ocean-atmosphere models and hence including expenditures on the complete World Weather Watch (WWW) and GCOS observing systems (JSTC-GCOS, 1993).

Category vi) considers the contribution of GOOS data to the prediction of extremely damaging or hazardous events of very low probability in terms both of costing and estimating benefits, this presents a different situation from one concerned with predicting changes that are statistically likely to occur.

There is a range of additional benefits which are more difficult to quantify, but which all add value to the benefits from GOOS and EuroGOOS. Firstly there are the long term benefits from improved climate prediction which are quantifiable, though reduced in value by discounting. These are being examined by GCOS, and there is no doubt that this will show increased benefits attributable to GOOS (GCOS, 1994; Florida State University, 1993; Adams et al. et al, 1995, NOAA calculation of benefits to agriculture). Additionally there are a host of rather intangible benefits which may be measurable in economic terms, but which at first sight are intractable to measurement in money. Econometric techniques have been developed in this field, but they have not yet been applied to marine and coastal activities. These benefits include the aspects of conserving biodiversity, protecting wildlife, preserving the aesthetic appearance of the coastal zone and wetlands, preserving ecological balance even when it is not shown to jeopardise fisheries or other living resources, and minimising the public sense of disturbance or insecurity which may be caused by climate change or rise in sea level. In the UK an assessment of the effects of managed retreat of the coastline has been carried out. It makes economic sense not to try and defend every metre of a fragile coast from erosion or flooding if very few people live there, or the agricultural land is of modest value. Nevertheless, the people who are displaced by this policy inevitably feel aggrieved, and substantial compensation may be needed unless they moved into the location deliberately and against advice from the authorities. On a larger scale, if the sea level does rise, or if storm patterns become more damaging combined with a high sea level, the public sense that the government is responsible will be very strong. The small proportion of the population which is directly affected will make a disproportionately forceful lobby to register their complaint, and would probably receive much sympathy and support from the media. People never like being forced to change their way of life, or move house under duress.

For low lying countries such as the Netherlands, and low lying areas such a the Po Delta, the Venice Lagoon, and the Nile delta, the social and political implications are more stark. On this scale the potential damage is not quantifiable only in dollars, but becomes additionally social, cultural, and political (Jeftic, Sestini and Milliman 1993; Jeftic et al., 1996).

It is beyond the scope of this report to suggest methods of evaluating these benefits of GOOS and EuroGOOS, other than to say that EuroGOOS clearly can contribute positively in these areas, and that the purely economic assessment of the value of EuroGOOS is therefore a conservative minimum.

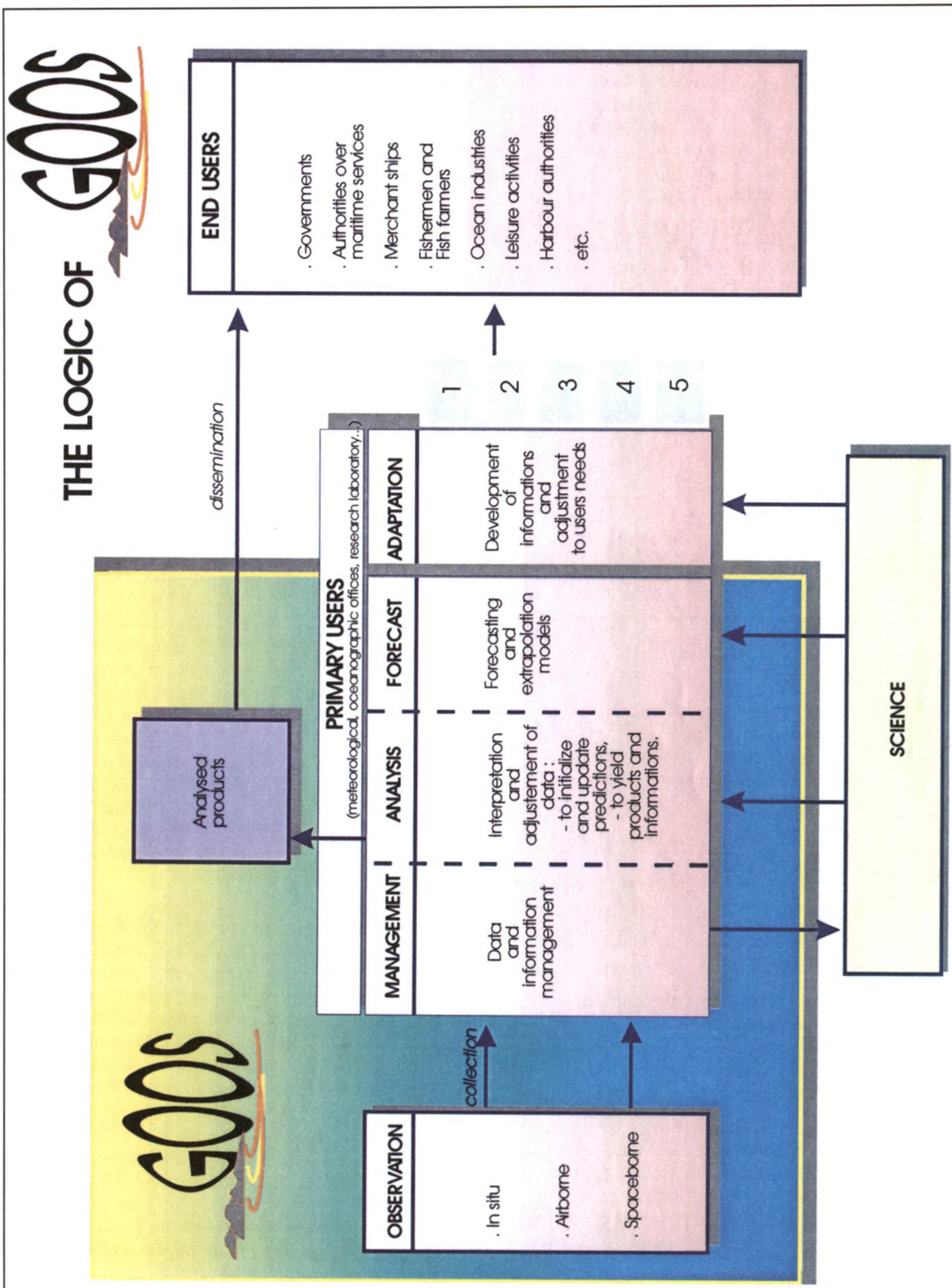

Figure 1.3 The logic of GOOS
Source: IFREMER

EXISTING STRENGTHS IN EUROPE

European countries singly or collectively have the competence and resources to define and operate the necessary operational oceanographic services in coastal waters and European shelf seas and marginal seas. Europe should also commit itself to ensure that the future Atlantic and Arctic basin scale operational oceanography is conducted with the maximum benefit to Europe, and that the planetary infrastructure of GOOS is designed with European objectives and policies in mind. (The resources and institutions needed to do this are analysed more fully in Chapter 5). In order to participate in GOOS as a major player, controlling a substantial part of the global materiel and hence influencing the design of GOOS, a country or group of countries must be able to deploy the following:

- **i)** Routine capability to launch reliable operational satellites for ocean monitoring.
- **ii)** A network of ground stations and ground sector components for data collection and transmission from remote sensing satellites.
- **iii)** A global fleet of oceanographic research and survey ships.
- **iv)** The ability to deploy an oceanic fleet of operational observing vessels, or technical support vessels maintaining unmanned surface and sub-surface instruments.
- **v)** A wide-ranging and proven industry for operational oceanographic instrument manufacture and marketing, with an emphasis on high data rates, long duration, and low maintenance.
- **vi)** Experience of research and operations in polar seas, on and under sea ice.
- **vii)** A strong base of scientific and technical personnel familiar with sea-going oceanography, and an educational system which will continue to train marine scientists and engineers.
- **viii)** A network of large and competent marine research establishments covering every aspect of marine science and technology from biotechnology to deep ocean sediments, and from air-sea interactions to biogeochemistry.
- **ix)** World class competence in oceanographic numerical modelling at all scales from estuarine to global.
- **x)** World class competence and experience of real-time numerical modelling and forecasting with 4-dimensional data assimilation.
- **xi)** A numerate technically professional customer community who could use advanced predictions and forecasts intelligently to improve wealth creating and environmental management.
- **xii)** Experience of regional or limited parameter operational services for marine forecasting of waves, surges, sea temperature, fronts, currents, etc.

In accordance with its dependence upon the ocean and shelf seas Europe has developed a network of over 300 marine research institutes and university departments within the EU, and a strong fleet of ocean going research vessels. Within the EU there are 9 civilian research vessels in the size range 80-120m length; 16 in the range 60-79m length; and 11 in the range 40-59m. During the last 5 years a range of EC programmes (MAST, Environment, Climate, EPOCH, etc.) have generated added value on the European scale above the excellent work carried out at the national level. European laboratories and scientists have also participated strongly in the global ocean programmes such as World Ocean Circulation Experiment (WOCE), Tropical Ocean Global Atmosphere (TOGA) Experiment, and Joint Global Ocean Fluxes Study (JGOFS). The launch and operation of the satellites ERS-1, ERS-2, and Topex-Poseidon have made major contributions to oceanographic science. Envisat will follow in the next few years, and ESA is examining the implications of missions dedicated to coastal or oceanographic operational observations.

Europe exploits a vast range of marine and coastal resources. European states have substantial offshore oil and gas reserves and producing fields off the coast of Norway, in the Barents Sea, the North Sea, west of the Shetlands in the Atlantic, the Irish Sea, the Channel (La Manche) and the Mediterranean. Large quantities of gas are piped under the Mediterranean from Tunisia and Algeria, and a pipeline has recently been constructed across the Straits of Gibraltar. European fisheries require intensive monitoring and precise management to prevent over-fishing and destruction of stocks. Millions of tonnes of sand and gravel are dredged from European waters each year for concrete and ballast, while extensive dredging operations are also carried out for navigational channels and pipeline entrenching and protection. European coastal seas and estuaries are amongst the busiest navigational routes in the

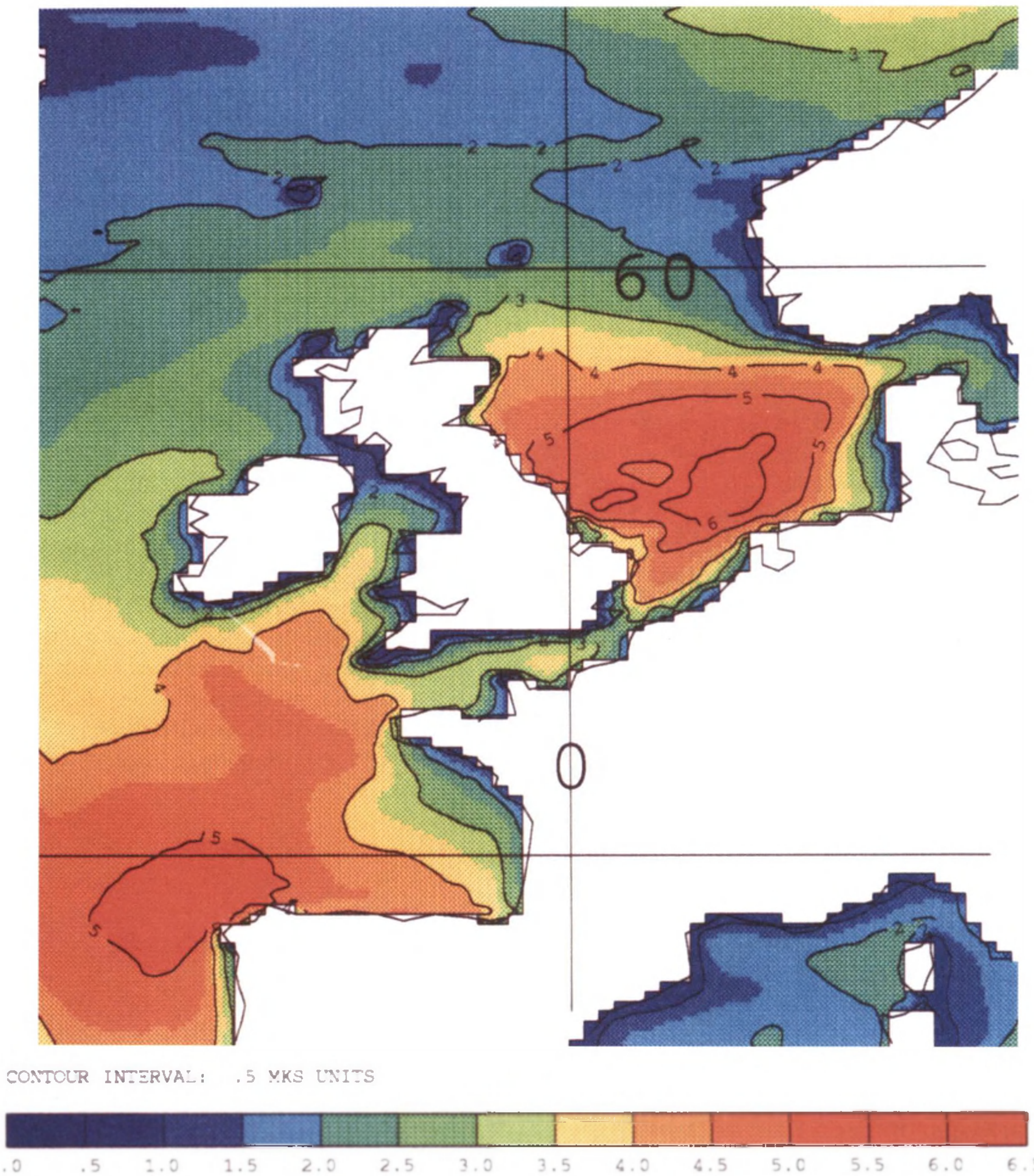

Figure 1.4 European model of wave height in metres for the North Sea Area for 20 February 1996
Source: UK Met. Office

world, while the pressure on estuarine resources in terms of waste disposal, fisheries, shell-fisheries, aquaculture, recreation, and navigation requires extremely careful control and management. Inland and semi-enclosed seas such as the Baltic, North Sea, Mediterranean, Adriatic and Black Sea are used intensively, and require continuous environmental monitoring and management. In all these activities there is a great benefit to be obtained from better monitoring and prediction of the marine environment.

European coastal states have developed operational oceanographic data gathering and forecasting at the shelf seas level and local levels. Operational projects in Norway, the Baltic, Germany, Netherlands, UK, France, Spain and Portugal provide monitoring and short term forecasts of conditions such as storm surges of sea level, wave conditions, currents, icing, floating sea ice, plankton or algal blooms, sea surface temperature, dissolved oxygen, coastal and estuarine pollutants, radionuclides and movement of oil slicks. These systems have limited spatial extent and give only short-term forecasts, but they provide essential experience in testing instrumentation, communications, data analysis, and data product delivery to customers. On the scale of the European shelf and regional seas there are major advantages in pooling resources to join the forecasting systems together, and to use the best practices available as standards. This would permit the rapid generation of marine data products and forecasts from Norway, to Ireland and the Mediterranean. The MAST data and modelling programmes are already starting to analyse this objective. The technical issue of in situ data gathering are addressed by EUROMAR, and the North Sea Fixed Platform Monitoring Network (now SeaNet).

The USA and Japan each has the capability singly to make a global impact in almost every sector of operational oceanography. Russia could in principle participate as a full global contributor/participant, but is unlikely to do so for a few years. The Russian satellite launch capacity and fleet of research vessels are both potentially useful to GOOS. China will also be a player of growing importance, but is not able to deploy full world-class oceanographic capability yet, and will probably not be able to do so for another 10 years. Several other countries have the ability now to make useful technical contributions to GOOS. India is launching ocean observing satellites. No single European country has either the resources, manpower, or full range of technology to match the USA or Japan in the design and implementation of a regional component of GOOS. Japanese agencies have started collaboration with agencies in Korea, China, and Russia in a regional GOOS component known as North East Asian Region of GOOS (NEAR-GOOS).

From a European perspective, these developments lead to excessive emphasis on the Pacific. Europe has the option now to participate in GOOS as the third major participant, and no other single country or grouping of countries has the ability to do this. If Europe acts now, the global system will always be structured to produce appropriate benefits in the Mediterranean, North Atlantic and in the European coastal and shelf seas.

Europe has a further advantage in that its States and national agencies are members of a range of multi-national institutions which can greatly strengthen the overall participation in operational oceanography, and facilitate the distribution of information, forecasts, and economic and social benefits. (This is discussed more fully in Chapter 5). Relevant multi-national bodies include those which might have input regarding GOOS and EuroGOOS, those which could be active partners in a major technical part of EuroGOOS development and operations, and those which could provide valuable services or advice, or assist in the distribution of benefits. The following bodies involving the richer countries of the world, and having a strong or majority European membership, will be considered:

- Council of Europe
- ECMWF
- ECOPS
- EEA
- EMaPS
- ESA
- ESF
- EU/EC (DGs VII, XI, XIV, XVII)
- Eumetsat
- Eureka
- G7
- ICES
- MIF
- NATO/NATA
- OECD
- OSPARCOM, HELCOM
- WEU

See Chapter 5 for discussion of the role of each of these organisations.

NEED FOR COLLABORATION

Collaboration between EU governments and between national agencies has already produced striking benefits in other sectors. Examples are CERN for nuclear physics, ESA for space, ECMWF for weather forecasting, and EUMETSAT for operational meteorological satellites. Collaboration for the development of ocean sciences has been successful through the MAST programme of DG-XII. European marine technology has been promoted both through MAST and Eureka-EUROMAR. The growth in collaboration is further demonstrated by the recent agreement to pool the resources of the ocean science research vessels of France, Germany and the UK. The effectiveness of European participation in GOOS, and the benefits to Europe of the implementation of GOOS, will be maximised if there is collaboration and sharing of effort in those aspects of GOOS which cannot be carried out effectively by one country, or where multiple projects would be wasteful.

European assets and experience can only be deployed and utilised effectively both for the benefit of Europe directly, and for maximising participation in GOOS, if there is complete cross-border collaboration, except in those cases where the principle of subsidiarity dictates otherwise.

European regional seas

Europe is a continent of peninsulae and archipelagos. It could legitimately be called the water continent. The only comparable areas of the globe so dominated by coastal seas, enclosed seas, islands, straits, and large areas of continental shelf, are northern Canada and South East Asia. Northern Canada, in spite of boasting the longest national coastline in the world, has an extremely low population density, and small economic significance apart from some prospects of offshore oil. South East Asia is an area of important economic growth and high population, but no country in that region is yet a major player in marine science or marine technology.

Fig. 1.5 (Map of European seas and watershed drainage areas) emphasises that each sea area can only be measured, observed, modelled, predicted, and managed by collaboration of groups of adjacent coastal states.

It is scientifically and technically impossible to describe and forecast the state of these semi-enclosed seas without rapid observation of all the relevant parameters using standard techniques, and rapid exchange of data between adjacent countries. Collaborative programmes and projects have

Figure 1.5 Water perspective of Europe
Map of European seas and watershed drainage areas. Source: SMHI

already grown up over many years to meet the requirement to exchange data and assemble archives before the era of operational oceanography (e.g. HELCOM, ICES, UNEP-MAP, OSPARCOM). The need for collaboration was apparent even when data were exchanged months or years after the field observations. Now that the Member Agencies of EuroGOOS require to synthesise data from a multiplicity of sensors, satellites, and buoys, deployed by different countries and agencies, and assemble and process the data to be distributed to users within hours, the necessity for collaboration in the design and operation of the system is over-riding.

Data transmitted to data assembly centres and modelling centres must have standard quality and be encoded in a format which is instantly readable and verifiable by the computers. This means that the design of instrumentation, sensor quality, and data transmission systems and data formats must be agreed by the operators. Experience in solving these problems exists in Meteorological Offices, and in regional marine data managing projects. For example, EUROMAR has published the FIESTA standard, EC-IOC have published a Manual of Oceanographic Data Validation, and RIKZ have published a Manual of Standards for Hydrological and Meteorological Data (October 1995, RIKZ). These examples illustrate the point that an integrated approach is needed from the start in the installation of instruments supplying data to operational modelling, and this mandates collaboration of agencies and countries in the design of the system. In practice there are already some installations, tide gauges, wave measuring buoys, etc., which are in operation, and the process of standardisation will be carried out in such a way that existing installations or data formats are up-graded to converge on the agreed standards. An example of this process is the North Sea Fixed Monitoring Network (SeaNet).

The need for collaboration and agreement on technical standards extends further, into the area of product distribution and its use by customers. The data products generated and distributed by EuroGOOS Member Agencies will be used by civil engineers designing breakwaters, ship operators, and insurance companies, amongst others. There must be a high level of confidence in the technical validity and reliability of the forecast, regardless of the Agency supplying it, or the sea area to which it applies.

A critical factor in the design of an operational observing system is to define scientifically the minimum number of observations, (and hence minimum cost), which are needed to provide the accuracy required from computer model outputs. This optimum design and best benefit:cost ratio cannot be achieved by every country or agency deploying instruments according to separate programmes or strategies. Design, or managed evolution, of the observing system must be conducted in accordance with plans and objectives agreed by all the coastal states.

The procedures developed through collaboration to maximise the efficiency of observing and forecasting systems also have the effect of eliminating wasteful duplication of effort.

Baltic:	**Norway, Sweden, Finland, Russia, Latvia, Lithuania, Estonia, Poland, Germany, and Denmark**
European Arctic:	**Finland, Norway, Sweden, UK (with other interested states)**
NW Shelf Seas:	**Ireland, UK, Denmark, Germany, Netherlands, Belgium, France, Spain**
Mediterranean:	**Spain, France, Italy, Croatia, Slovenia, Bosnia-Herzogivina, Albania, Greece, Turkey, and the non-European states of the eastern and southern Mediterranean**

Europe as a whole

The case for collaboration in the development of European operational oceanography is increased by consideration of the needs for standardised data and uniform high quality advice and predictions on the whole European scale.

If we view Europe as including the adjacent shallowly submerged shelves, the continental shelf and slope adds 63% to the land area of Europe, and the next highest ratio is North America with an added area of 57% for its associated Arctic continental shelf and slope. On a standard classification of "Continentality" Europe rates lowest of continents with the greatest length of coast in relation to its land area, 62% of its regions close to the sea, and a mean distance of land from the ocean of only 340km. We have already shown the importance of understanding and predicting the state of the Atlantic and Arctic Oceans in European interests.

Thus, in addition to the need for consistent and standardised operational data sets describing the regional and semi-enclosed seas, there is a need for consistency and standardisation for some, but not all marine variables, for the whole Atlantic-Arctic-European-Mediterranean area. It is one of the tasks of EuroGOOS and GOOS to define those variables which must be consistently managed on this scale, and those for which different regional procedures can be used. Wind fields, atmospheric processes, large scale ocean currents, oceanic heat transport, changes of sea level, the biology of species which extend over thousands of km, or migrate thousands of km, and interactions between the open ocean and the shelf seas, all need to be measured and analysed at the full European scale.

The arguments used in the previous section to demonstrate the need for adjacent state collaboration on the regional sea scale, apply with the same force to the whole European scale from the Arctic to the Azores. However, it is probable that the procedures which need to be standardised on this scale will apply to a smaller number of variables than those needed locally, and that the operations will be conducted on a coarser grid resolution. Where EU Directorates are responsible for Directives concerning management of the marine environment and safety of marine industries, there is a need for consistent data sets and forecasts describing the whole European sea area.

Remote sensed observations from satellites are necessarily consistent across the whole of Europe and the adjacent sea and ocean areas, and the number of ground stations and data processing centres is limited. Thus the incorporation of remote sensed space data into European models is essentially an operation to be conducted at the full European scale. Similarly, EuroGOOS agencies can negotiate collectively with the space agencies (ESA, CNES) to promote optimal design of satellite instrument packages, orbits, and ground data management sectors. Analysis and optimisation of observations and data management at the European scale is also logically necessary when interfacing the data from the European region with global GOOS data, and vice versa.

We cannot comment on the political status of individual countries or agencies in regard to relations with the EU, the Council of Europe, or ESF, etc., but the present consideration of technical and geographical factors leads to the conclusion that the objectives of EuroGOOS would be best achieved by including consideration of the oceanographic characteristics of the White Sea adjacent to northern Russia, the entire Black Sea, and the southern and eastern parts of the Mediterranean, and the tropical Atlantic.

The global dimension

We have close and effective links to GOOS itself, and communications with the major global ocean science research programmes. The Chairman of the IOC-UNEP-WMO Committee for GOOS (I-GOOS) is a Vice-Chairman of EuroGOOS. I-GOOS and EuroGOOS have formal reciprocal Observer status. Four EuroGOOS Officers are Members of the Joint Scientific and Technical Committee for GOOS (J-GOOS), and the Scientific Advisory Committee for EuroGOOS (SAWG) formally transmits its records of meetings to J-GOOS. The Director EuroGOOS communicates regularly with the International Planning Office of the World Ocean Circulation Experiment (IPO-WOCE), and corresponds with the Director of the Climate Variability Experiment (CLIVAR).

CONTRIBUTION TO FURTHERING EUROPEAN PRINCIPLES

Competitiveness

The European Principle of Competitiveness is furthered by EuroGOOS as follows:

EuroGOOS promotes a new business activity which includes instrument manufacture, operational field activities, data processing, computer numerical modelling, and product distribution. The scale of the business is of the order of 500 million ECU/yr, with a possible 5000 jobs.
Building on the existing high scientific and engineering standards in Europe, EuroGOOS will bring together these skills in such a way as to maximise the competitiveness of European companies and organisations competing anywhere in the world.
EuroGOOS will strengthen European capability in operational oceanography, and hence minimise penetration of the European market by non-European competitors.
EuroGOOS will strengthen the capability of European companies in operational oceanography; large European maritime companies working anywhere in the world will thus tend to employ European sub-contractors in operational oceanography so as to prepare competitive turnkey packages when bidding for non-European contracts.

Cohesion

Multiple and regional cross-border collaboration is needed in operational oceanography, and this leads naturally and inevitably to integration and cohesion

Regional products which are accepted by several countries as the best available by all concerned foster cohesion and the natural adoption of common standards.

As already demonstrated, EuroGOOS cannot succeed without detailed and complex cross-border collaboration on all scales from regional to global. At the finer scales, extent a few hundred km, resolution less than 1km, regional and local agreements, standards, and products are required. At the full European-plus-oceanic scale a smaller number of parameters and variables must be measured and processed in a standard way with strict quality control over an extent of several thousand km. At both extremes of scale, and all scales in between, the technical need to use agreed standards, transmit data rapidly, and share beneficial products and forecasts will naturally motivate agencies and individuals to work together, and promote European cohesion.

Regional information products and forecasts which are respected and accepted by all parties in the region as the best available will foster cohesion further. Since there may be several different specialist products generated by different processing centres, the overall effect will be to produce a cross-linking of collaborative expertise, mutual respect, and cohesion. All parties will have a vested interest in making the system work.

Subsidiarity

The importance of relating the observing systems and forecast products to the scale of application has been referred to several times above. This structural constraint arises from the technical and geographical nature of forecasting sea areas and oceans. The pursuit of this objective for technical reasons of efficiency leads automatically to a reinforcement of the European Principle of Subsidiarity.

Single states or agencies will make very high resolution observations in their own coastal waters and estuaries, using local knowledge, measuring sometimes unique local variables, and satisfying local special needs. These local forecast products will be produced by combining the local data with the output from models nested within larger spatial scales at the regional, European, Atlantic, and global levels.

Regional collaboration around particular European seas will also produce results which are targeted at regional scale needs, but benefiting from the European infrastructure and super-models.

The cost of operational oceanography at the global and full European scale will become too high for individual nations to afford, in relation to the return which a single state could expect to obtain from its investment in an exclusive single-nation programme. Single European nations would also find it expensive to invest separately and divergently in components of the global GOOS in relation to the returns they obtain. Collaboration at the highest level is therefore justified by the added value both to Europe, and to individual states, which arises from that collaboration.

The natural hierarchy of spatial scales in EuroGOOS correlates well with the Principle of Subsidiarity.

Human capital

The development of a new type of business will mean new jobs, to the order of 5000, new careers and new professions. As shown by the ECOPS Conference on the Grand Challenges of Oceanography, (Hempel, 1995; Woods, 1995). Ocean Forecasting requires the employment of specialists in a range of scientific and technical disciplines, combined in ways which have not been needed before. New career paths will open up, and new training courses and qualifications or certification will gradually be developed. EuroGOOS Members are already laying the foundations for these courses.

The future business of operational oceanography will provide a demanding customer for the output from basic and strategic oceanographic research programmes, and hence raise the status and importance of the underpinning science and technology.

These impacts of EuroGOOS will support the European Principle of enhancing Human Capital.

Strengthening European identity

EuroGOOS works because all the Members have an interest in collaborating with their partners to produce products which are a benefit within Europe, and a further interest in collaborating to participate in ocean forecasting at the global scale within GOOS. There will also be advantages in gaining experience of operating together at the global level, and having the capability to offer services on a global scale to business and governments outside Europe. These characteristics of EuroGOOS support the European Principle of Strengthening European Identity.

Chapter 2

Objectives of EuroGOOS

To create in Europe the new business of operational services and forecasting of the ocean and coastal seas

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Exploit the advances in scientific understanding and technical capability resulting from the R&D investment in oceanography during the last 30 years

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Focus international development of operational ocean services and GOOS on the specific needs of European users

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Chapter 2

Objectives of EuroGOOS

To create in Europe the new business of operational services and forecasting of the ocean and coastal seas

Scale of the Business

The term "Business" is used here to describe a generic range of beneficial and largely profit-making activities, not a single commercial enterprise. The term is used to stress the fact that European enterprises, both commercial and governmental, need to develop operational oceanography for economic and commercial reasons, and that the skills developed are marketable globally.

Our strategic objective is to promote the business of operational oceanography in and for Europe within the context of GOOS and Framework 5. The European GNP value of all marine industries and services is of the order of ECU200 bn/yr. A substantial new business activity can therefore be developed to provide a wide range of European agencies and commercial companies with the marine environmental data and forecasts which maximise the efficiency and reliability of their operations. This new business has a financial scale of the order of 500 million ECU/yr, and a potential employment level of approximately 5000 jobs in 5-10 years (excluding the space sector, other than operational data processing) (see Chapter 1). Forecasts based on operational oceanographic observations could significantly increase the efficiency and benefits of commercial companies, and improve management of the marine and coastal environment. Further benefits would be obtained from improved prediction of climate variability, and its impact on agriculture and power requirements (OECD, 1994).

We have analysed the steps needed to improve operational oceanographic forecasts and services (see Chapter 4), and have identified 10 activities for consistent and continuous implementation:

- Economics and assessment of costs and benefits
- Identification of customers
- Products and services
- The Scientific Basis of EuroGOOS
- Technology
- The importance of numerical modelling
- Optimal design of the observing system
- Trials and case studies
- The interface of EuroGOOS with the global dimensions, including relations with I-GOOS and J-GOOS
- Links to other European organisations and programmes

These are analysed in detail in Chapter 4.

The business of operational oceanography ranges from global measurements of fluxes in the open ocean through to highly detailed and site-specific local measurements in estuaries and coastal waters. These are sometimes dubbed the "Blue Water" and "Brown Water" ends of the spectrum of oceanographic activities. The type of measurement and service provided in the Blue Water environment and the Brown Water environment also tend to range in type from public domain public good economics in open water to short term economic and commercial cash sales in coastal waters. The relationship is not exact, but it provides a useful guide.

As shown in Chapter 1, the geographical scales of GOOS and EuroGOOS are interdependent. Thus the full value of local Brown Water observations and forecasts is only achieved by providing boundary conditions and long term forecasts from the coarse grid global models. The public domain/ public good part of GOOS/EuroGOOS therefore tends to provide the truly global framework, and the large scale regional framework, while products at the local scale are more likely to be saleable for cash to commercial companies, or local government authorities and agencies. There are some global sea surface and upper ocean products which have immediate commercial value for ship routeing and fisheries operations. The more complex and expensive sub-surface observations to full ocean depth, and in all oceans of the world, only produce benefits through their contribution to the long term global models for predicting the environment, protecting biodiversity, and forecasting climate variability and climate change. The prediction of the ENSO cycle is an example of the economic and social benefits to millions of people obtained by investment in a forecasting system which is designed to make forecasts of the order of 1-3 years ahead of climate variability. (Adams et al.et al, 1995). The ENSO cycle effects agriculture (Sassone, 1996) and the oil and gas industry. (Offshore, Jan 1996, p.26). The contribution of GOOS and EuroGOOS to the Global Climate Observing System will pay off in 20-50 years. One of the principal long term benefits of EuroGOOS will be to reduce uncertainty about the circulation of the Atlantic on timescales of the order of a decade, and hence give warnings of the statistical probability of climate variability.The full economic analysis of the costs and benefits of GOOS and EuroGOOS, and the balance between public good components and commercial components, is a complex matter (OECD, 1994, OECD, 1995). EuroGOOS is actively supporting further studies and workshops (see Chapter 4).

The general nature and scale of the business of operational oceanography can be outlined at this stage, but more work is needed to break the business down into its public good and commercial components. We are working towards this objective. Analysis of the business of operational oceanography is a component of the First EuroGOOS Conference in October 1996 (Annexe 5).

Figure 2.1 Installing a current meter in the Denmark Strait, near Greenland
Source: Royal Danish Administration of Navigation and Hydrography

Sectors of the business

The business of operational oceanography includes numerous subsidiary sectors. The following list illustrates the range of activities and commercial opportunities within the general area of the business:

- Enterprises conducting seagoing observations, deployment of instruments, recording and transmitting data, and delivering data ashore.
- Manufacturers of seagoing equipment, buoys, platforms, ROVs, AUVs, moorings, sensors, and on-board data processing and data reduction packages.
- Remote sensing operations, launch of operational oceanographic satellites, design of oceanographic sensor packages, software and real time data analysis systems.
- Public domain data and information obtained by routine and operational observing systems, provided by government agencies.
- Oceanographic instrument manufacturers.
- Development and marketing of software, oceanographic models, and programmes which can use operational data and forecasts to provide detailed and accurate or site specific predictions for use in industry, management, or regulation of the environment.
- Development of numerical ocean and ocean + atmosphere models designed to assimilate real time data and make operational predictions. Calibration and test facilities for oceanographic instruments and systems.
- Environmental and bathymetric, surveying, EEZ survey and management contracts. Value added companies, data processors, etc., environmental consultants,
- Risk analysis, converting environmental data into advice on insurance risks and hazard prevention.
- Safety at sea, risk management using operational data, information and forecasts for safety services, navigational services, search and rescue, emergency services.
- Marine environmental monitoring, long term time series measurements, detection of trends, climate variability,
- Deployment, maintenance, recovery, and replacement of in situ operational marine measuring systems.
- Pollution monitoring, forecasting of contaminants and pollution, water quality management.
- Design services, provision of climatic marine environmental data for engineering design, and assessment of insurance risks over the lifetime of structures.
- Electronic charting, chart services, and combinations of environmental, bathymetric, and other real time data electronically.
- Fisheries monitoring in real time, fish stock modelling and predictions, monitoring the position and velocity of fishing vessels in real time.
- Marine data telemetry, instrument to satellite communications, global data transmission, satellite to ground data transmission. Oceanographic data banking, data retrieval and data distribution services.

This list is not exhaustive, at least in part because the business is at the early stage of a rapid learning curve, and many job types or specialities have not yet been defined. Many of the sectors listed above could split into two or three sub-specialities, each with their own economic and technical business niche.

The estimate of the size of the operational oceanographic business, and the list of sectors above, is strictly limited to the business of obtaining oceanographic data in real time, or near real time, and providing information products. It excludes conventional hydrographic surveying and paper chart publication, geophysical surveying for oil and gas prospecting, all aspects of scientific oceanographic research, fisheries stock monitoring by analysing fish landings, and all aspects of the design and construction of rockets and satellites other than the operation of sensors for monitoring the sea.

Create new jobs

Many of the sectors described above are already growing rapidly, as witnessed by the exhibition and advertising of their services at national and international trade exhibitions in Europe. The financial scale of each sector of business, or the numbers of people employed now, are difficult to ascertain, since these industries and services are not described or listed in a disaggregated form in national statistics, which tend to be based on old-fashioned categories.

These types of business are capital intensive, computer intensive, and skill intensive. They employ people who have high technical and scientific qualifications. Equivalent industry profiles might be obtained by comparison with the computing industry as a whole, consulting engineering, or satellite remote sensing, or the design and manufacture of modern medical equipment.

Present recruitment into the embryo and growing sectors is principally of graduates and highly skilled technicians. Some of the most successful companies are subsidiaries or components of larger organisations with expertise in biomedical engineering, aerospace, offshore geophysical surveying, etc. In these examples the skills and technologies from other sectors can be adapted and applied to operational oceanography. Also, given the fluctuating and sometimes unpredictable flow of business contracts, the diversity helps small companies survive business downturns.

A fully developed operational oceanographic industry, in all its sectors, with a turnover of the order of 500 M ECU/yr would create about 5000 new jobs.

New opportunities for the supply industry, and service and value added companies

Business opportunities exist in all the sectors listed above, and these can be broadly grouped as:

- Instrument manufacture, sensors, and instrument carrying platforms
- Data telemetry, processing, analysis, modelling, and product delivery
- Field operational services, special ships, instrument deployment, maintenance.

The business of operational oceanography will create new markets for instrument manufacture and the platforms which carry them. Oceanographic instruments at present are manufactured in small numbers for the research market, with the exception of Expendable Bathythermographs, XBTs, which are used operationally in large numbers (tens of thousands per year). Research instruments suffer from high overheads and high manufacturing costs. Operational oceanography and forecasting creates the demand for reliable, cheaper mass-produced or batch-produced devices, and production runs of hundreds or thousands of units would enable prices to be reduced. The concept of GOOS requires the development of instruments which can be deployed rapidly and cheaply, either drifting in buoys, air-dropped, or carousel-type systems releasing capsules or sensors at pre-determined intervals.

There is also an opportunity for new instrument types which measure wider areas of "swath" or "bin" observations, extending over an area or volume observed from a fixed point. Drifting, powered, and towed undulating vehicles also gather large volumes of data at a rate which may be more economical than conventional instrumentation platforms (Griffiths, 1994, Bosman et al., 1996).

Raw data acquired directly from instruments at sea or from remote observing satellites or aircraft is of minimal value until they are analysed in time and space, preferably through computer numerical modelling. The data products that result from the original observations thus create a long cascade of further derived products and services. Some agencies or organisations need to obtain large volumes of raw data, or partially processed data, either at global, regional, or local scales, and then process the data for their own objectives, or to sell the products on to further customers. Other organisations will wish to add further variables or observations of a highly specialised nature, and develop products to target at specialised markets, or, again, to sell on to intermediaries with yet more specialised markets. The data processing and value-added industry generates a diversified range of products which vary in geographical scale, accuracy, speed of delivery, range of variables, spatial resolution, sophistication of the targeted customer, and forecast horizon. There is a further range of off-line products based on archival data, re-worked data to improve accuracy and calibration, removal of errors from the fast data stream, and analysis of past climatic variability, trends, statistics, and extremes.

Data types to be processed include the physical variables describing the state of the sea and the sub-sea environment, which can usually be handled automatically in real time, and the chemical and biological variables which may have to be checked manually, or analysed off-line in specialised laboratories. Even in the latter case, our objective is to generate results and predictions within a short enough elapsed time to take corrective or managerial decisions.

The activity of obtaining the data efficiently in the field creates the opportunity for cost-effective deployment operations, servicing, replacement of instruments, re-calibration, replacing power packs, repairing moorings etc., which must be carried out very efficiently, and at minimum cost. These services are highly skilled, requiring specialised vessels, or specialised packages fitted on vessels of opportunity, and European companies could offer such services world-wide.

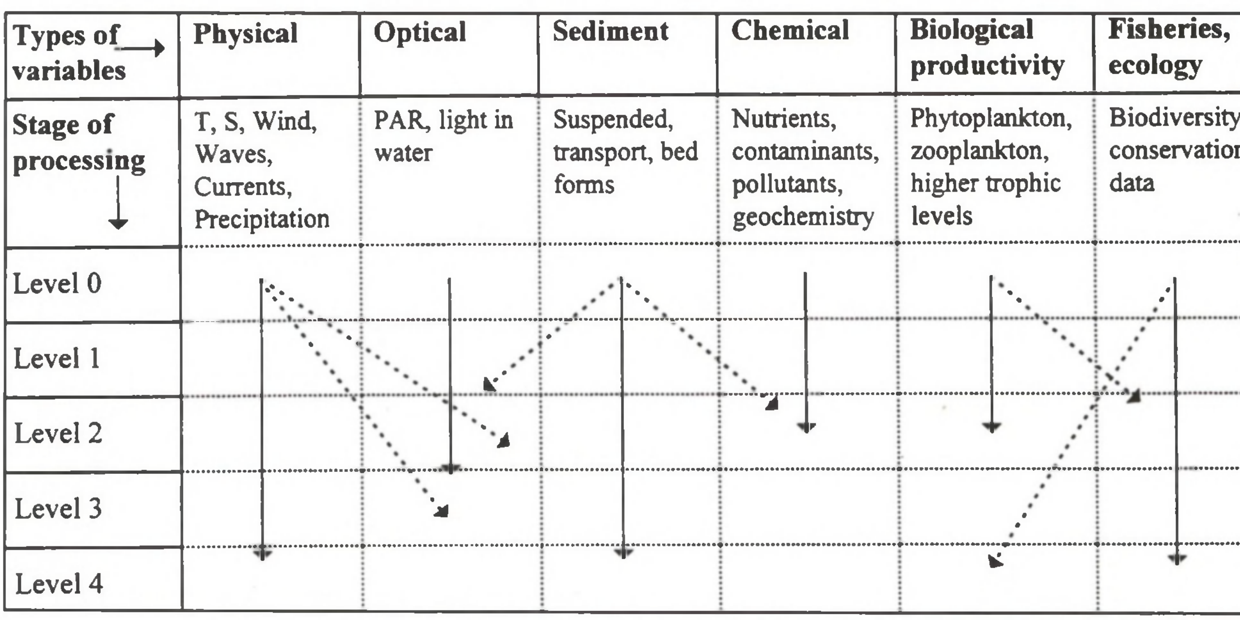

Figure 2.2 Interaction of observed variables, data processing, and products
This diagram indicates in an impressionistic way the fact that each data type is processed through a series of Levels, and that products are often made by combining variables for a particular application. Level 0 = raw observations in sequence as measured; Level 1 = corrected and checked data converted into geophysical or biological units; Level 2 = data sorted into geographical co-ordinate locations (geo-sorted); Level 3 = processed, mapped, and gridded data; Level 4 = output of models and customised products.

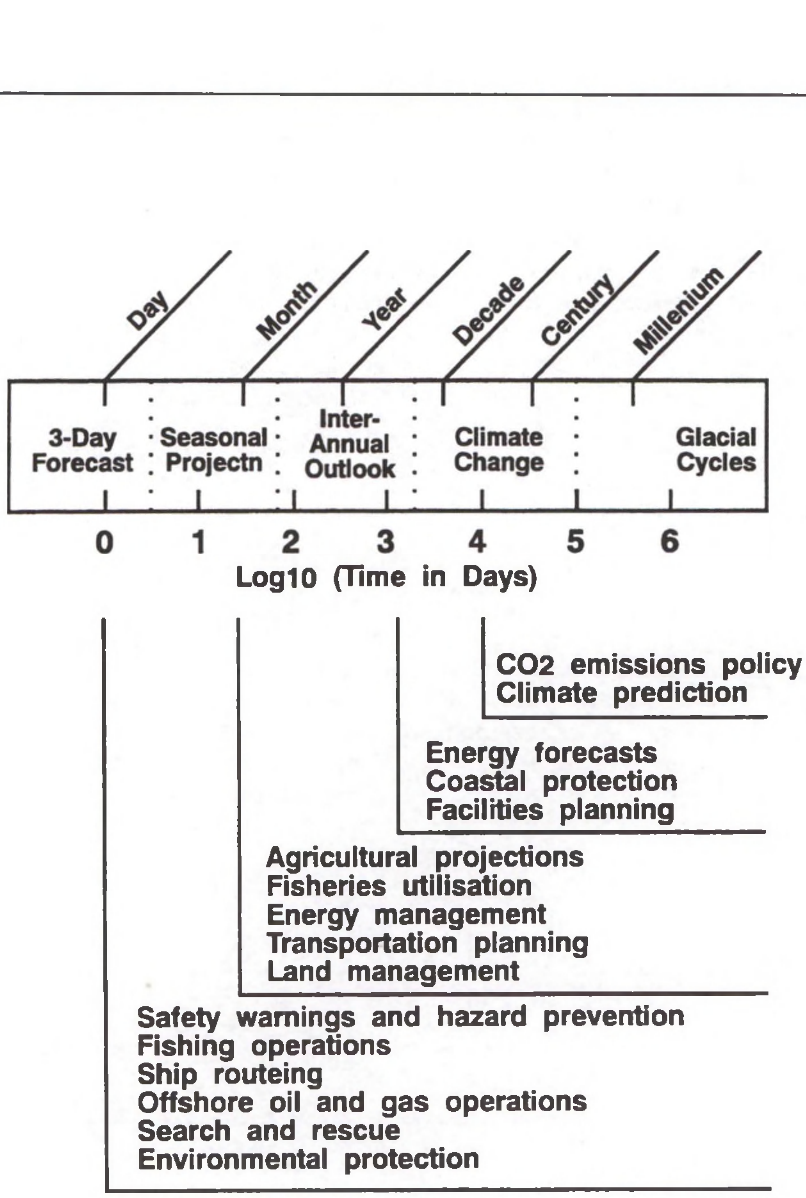

Figure 2.3 Benefits of improved ocean atmosphere predictability
The benefits of GOOS are effective over different timescales. Some information products will benefit fisheries, coastal defences, or agriculture with predictions applying to periods of a few weeks to months in advance. These products will be generated early in the GOOS Pilot Experiment. Other products and predictions will influence planning on a decadal timescale, and will take longer to develop. Source: Dana Kester

Benefits for users

The benefit to users is the advantage of having a specifically targeted description and forecast of the marine environment in which the customer works, designed to meet exactly the requirements of the customer at the site where the work is carried out, combined with forecasts of conditions for the maximum forward look which is achievable by deterministic modelling, and statistical forecasts of expected conditions for longer periods. Highly specific and customised products can be prepared rapidly by value-added companies because the original data stream and models provide an effectively complete data set, if required, at every grid node of a very fine resolution model, or they can be extracted from the model by the customer.

The short- and medium-term economic and social benefits from operational prediction of the ocean accrue mainly on the continental shelves and slopes, at or near the coast, both in coastal waters and in the adjacent hinterland. (CCMST (1990); IACMST Economic Workshop Reports, (1994a, 1994b, and 1995), ESA (Coastal Zone Earth Watch Workshops, 3 vols, 1995), USA-NRC Opportunities to improve marine forecasting (1989), OECD Megascience Forum (1994), Australia EEZ project, (1995). These benefits are mostly in the time range 2 days to 1 year and therefore pay off relatively quickly. Benefits on the timescale of months to 1 or 2 years arise from medium time climate forecasts which are relevant to agricultural planning and management, and to prediction for the demand of oil and gas. Longer term forecasts produce benefits in energy management, water resources, construction, and mitigation of the effects of climate change (Figure 2.3) (see Annexe 6).

The most thorough study of the benefits of ocean prediction through modelling is that conducted by NOAA in the USA for the impact of ENSO forecasts of 1 month to 1 year on the management of agriculture (Adams et al. 1995; Sassone, 1996). This showed annual benefits of the order of $200 million for agriculture, and an internal rate of return of 20%. The analysis used advanced economic and structural models of the USA agricultural business to obtain its results. This particular type of easily identifiable benefit to agriculture is not so applicable in Europe, since there is no medium-term climate fluctuation as extreme as the ENSO cycle in the North Atlantic. Much smaller studies have been conducted in UK on the potential benefits of improved operational oceanographic forecasts on three sectors: (i) Coastal soft engineering; (ii) Ocean towing and ship routeing; and (iii) Water Quality management in the North Sea. The results of these three studies are quoted below as illustrations of the new types of benefits. EuroGOOS will examine many more cases in the same manner, choosing industries in other countries, or on the European scale.

Benefit example (i): Coastal soft engineering

Soft engineering is the technique of using beach replenishment and modification of the offshore seabed profile to divert or control the natural transport of sediments so that the coast is dynamically stable year on year, without the construction of massive defences. The UK soft engineering coastal defence industry would use operational marine data very efficiently, with high uptake and utilisation. The potential benefit to the UK of an improved observation system in 5-10 years time is of the order of tens of £million per year in this sector, of which approximately £8m/yr is directly attributable to the use of new operational data (IACMST, 1994a). The techniques of sand replenishment and soft engineering are quite widely used in Europe and equivalent benefits could be obtained on all eroding coastlines of Europe.

The IACMST study identified the following factors which may be part of a soft engineering programme, and require reliable data in design and continuous management:-

i) Predicting extremes of sea level, flood and surge warnings, emergency action. (Climatic design criteria and operational predictions).

ii) Predicting storm overtopping events, emergency warnings and actions. (Wind+wave+tide+surge) (Climatic design and operational predictions).

iii) Monitoring and predicting conditions for coastal construction work (Waves offshore; sea level and overtopping on coast).

iv) Decisions on when to start and stop construction operations at the beginning and end of each summer season.

v) 3-dimensional directional wave field, spectrum, and orbital velocities. (Climatic and predicted, in order to calculate sediment transport).

vi) 3-dimensional current field and vertical profiles. (Climatic and predicted, to calculate sediment transport).

Figure 2.4 Location of tide gauges on the coast of Denmark
Source: Royal Danish Administration for Navigation and Hydrography

vii) Monitoring and predicting temporal and spatial changes in coastal and near-shore bathymetry. (Effects on waves, currents, erosion, and sediment transport, moving bars, sand waves).

viii) Improved bathymetry of European shelf seas to improve accuracy of numerical models.

ix) Use of sediment transport monitoring or models to explain and predict observed changes in bathymetry and coastal erosion/accretion. (Operational prediction of slumps and cliff falls, beach replenishment).

x) Monitoring and prediction of onshore-offshore sediment transport. (Beach replenishment, pumped replenishment, sediment by-passing).

xi) Dredging interacts with soft engineering, whether it is a source of replenishment material, or question of monitoring extracted ballast. Precise bathymetric checks are needed to 20cm.

xii) Response to relative sea level rise, salt marsh contraction, increased current and wave action due to sea level rise.

xiii) Beach and dune stabilisation by vegetation.

xiv) Dredge spoil may be dumped at a location from which it returns to the point of dredging. To identify safe dump locations the bottom profile must be monitored to an accuracy of ± 10cm.

Benefit example (ii)
Ship routeing and oceanic towing

Ship routeing services already exist, but are based on limited meteorological forecasts, and with very little information on currents. The IACMST report (1994b) examines how forecasts achievable by GOOS or EuroGOOS in 5 years time would increase efficiency and profits to customers. The value of routeing forecasts derived from improved operational oceanography which accrue to the towing industry and long distance shipping are of the order of £40m/yr in 5-10 years time. The most important forecasts for routeing and towing are in the time range 3 days to 3 months. There is a need to increase accuracy, resolution, geographical coverage, variables predicted, and forecast period over present performance. All the requirements are achievable within the existing planned systems envisaged for GOOS. The key variables to be measured, modelled, and forecast are: winds, wave spectra, currents, sea ice, sea level, and fog. The calculation of value of forecasts could be increased approximately pro rata for other countries in relation to the scale of their shipping industries.

UNCTAD (1992) shows that the global revenue from marine transport was $173bn in 1991, and that this was achieved in transporting $3314bn of seaborne imported trade goods. Shipping in the UK produced a revenue of £3.2bn in 1986, and hull and cargo insurance produced a revenue of £2bn.

Broad analysis of global statistics on shipping revenue implies that there is an upper bound on the potential benefit from forecasts and ship routeing of about $2.25bn/yr, and an upper limit on the potential benefit to UK operators of the order of £40m/yr. If these figures can be substantiated by examining the practice of the routeing industry, the up-take of data, and the way in which improved services can be utilised, this would justify a UK investment in GOOS of the order of £1-4m/yr.

Value to UK includes actual profit to UK owned shipping and towing services, plus:-

- Reduced losses to insurers
- Saved lives
- Profit to UK services organisations, sale of products, Met Office etc.
- Business for operators of the observing system
- Sales of technical systems to organisations in other countries
- Profit to manufacturers of goods transported with reduced transit times
- Reduced accidents, pollution, and reduced demand on emergency services
- Improved management of ports and port approach channels

Typical General Cargo or Container ship costs £3-4000/day plus fuel, making a total of about £5000/day or £100,000 per voyage. An efficient routeing system can save 5-10% of transit time at best, and occasionally prevent serious damage or disasters.

A routeing service would estimate on average to save 5 hours on a (10-day) trans-Atlantic voyage, or about 2-2.5% of transit time.

Savings are made through:

- Less fuel consumed
- Less time for stevedores waiting
- Cruise time shorter, ready for next trip
- Less damage to vessel

Scale of risk: a large container ship carrying 3000 cars is under pressure to sail on at all costs. Under these conditions the Master is prone to take risks, and suffer ship damage. There is enormous capital tied up in transit. This factor will tend to increase as more capital high-tech consumer goods are manufactured in one country and sold in another. The value of imports transported by sea annually is $3314bn (UNCTAD for 1991). Given the duration of ocean voyages, a significant proportion of this value is in transit at any one time.

Benefit example (iii)
Water quality modelling & management

A water quality modelling and prediction system for European coastal and shelf seas adjacent to the UK could be built up progressively over 5-10 years, with UK benefits of the order of several tens of £m per year, but the benefit is unlikely to be as high as £100m per year (IACMST 1995). Other coastal states would benefit to the same extent pro rata. The costs are of the order of a small multiple of £10m per year, on top of other costs already disbursed to support physical modelling of the shelf seas to produce other identified benefits. The ratio of benefits to cost on the basis of UK running the system alone is therefore of the order of 5:1, but this would be improved by a further factor of the order of 3-5 by the involvement of the other European riparian states. There are many aspects of policy and European Directives which benefit from a WQ model, but which are difficult to quantify.

The examples given above have been presented at some length since it is sometimes difficult to envisage how the data and forecasts generated by EuroGOOS would really be used. It is important to show that professional and potentially sceptical user groups are already mentally prepared to make the best use of data from EuroGOOS Member agencies. The three examples described, and the other studies by NOAA on climate forecasting for agriculture, and the ESA study of applications of coastal data (ESA 1995) are just 5 examples of analysis of benefits out of hundreds which might have been carried out. Other examples include sea ice forecasting in the Baltic, and storm surge predictions to prevent flooding in the Netherlands (Fig. 2.5). In every case the benefits derived from the data and forecasts are significant. At a provisional estimate, the sum of such benefits amounts to many times the cost of the observations.

This section has shown by case examples how the products of EuroGOOS will provide new benefits to users.

Economies of scale achieved through European collaboration

We have already shown that the technical and geographical constraints of operational oceanography require intensive collaboration. There is also a strong motive to devolve local observations and modelling to local communities, thus maximising subsidiarity. At the upper end of the size scale it would be uneconomic for numerous different agencies in different countries to run duplicated large scale models, or to repeat observations which only need to be made once. Thus a sound design of operational oceanographic infrastructure through EuroGOOS automatically provides the benefits of economies of scale.

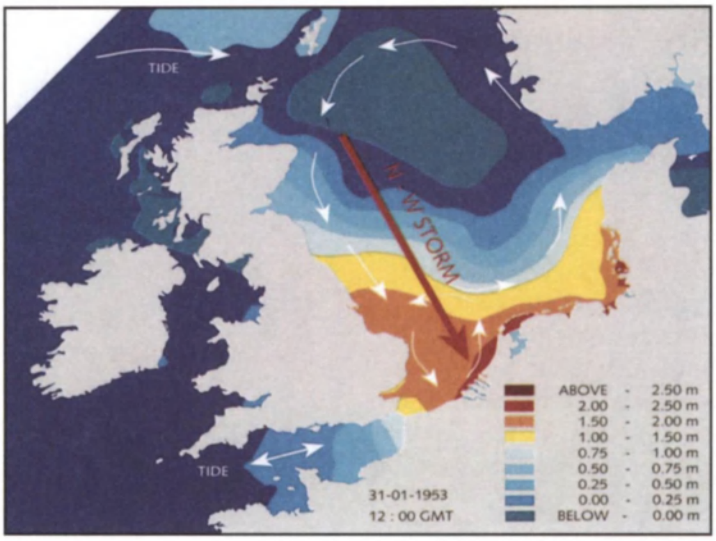

Figure 2.5 Diagram of the great storm surge of January 1953
The main tide enters the North Sea off the Scottish coast and circulates in the direction shown here by the white arrows. During north-westerly storms, the water is driven up against the Dutch coast. High water levels occur in particular when the height of the storm coincides with a high (spring) tide. Source: RIKZ

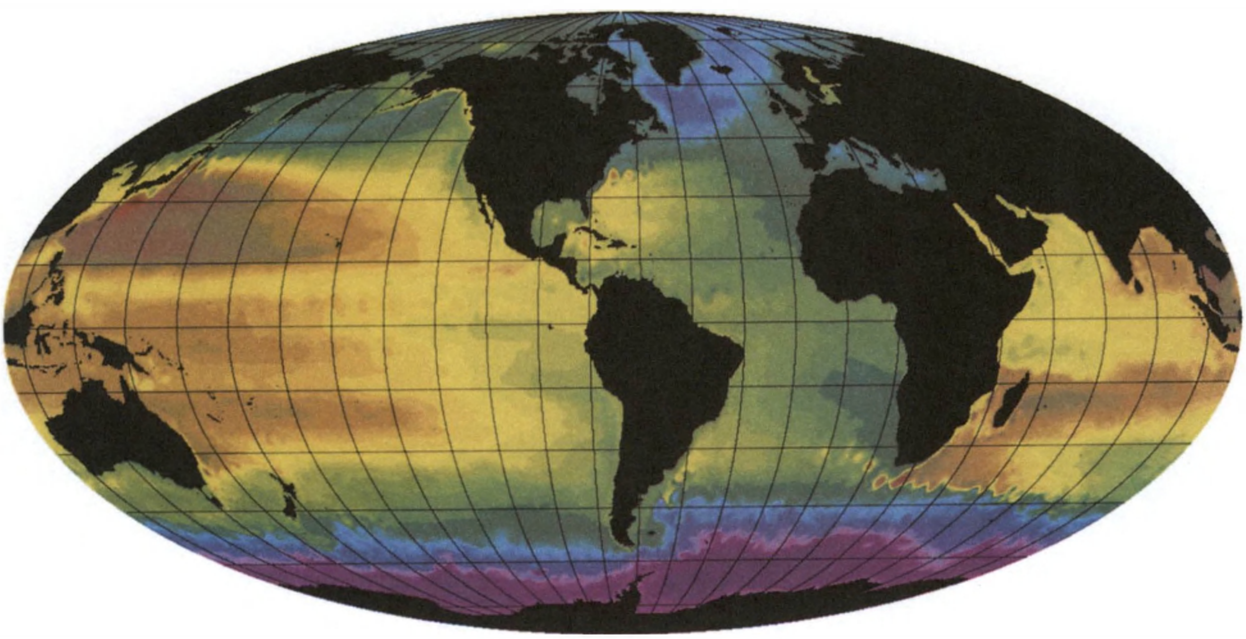

Figure 2.6 OCCAM global model plot of instantaneous sea level relative to the geoid
The colour scale range is from +2m (yellow/brown) to -2m (blue/purple). Source: SOC

Exploit the advances in scientific understanding and technical capability resulting from the R&D investment in oceanography during the last 30 years

Chapter 5 outlines the range of existing European institutions and collaborative arrangements which enhance the development of EuroGOOS. European oceanographic institutions have participated in all the major regional and global ocean science programmes since the Indian Ocean Expedition of 1958. During the last 20 years there has been massive investment in the collaborative research programmes as follows:

- Tropical Ocean Global Atmosphere Experiment (TOGA)
- World Ocean Circulation Experiment (WOCE)
- Joint Global Ocean Fluxes System experiment (JGOFS)
- Global Ecosystem Experiment (GLOBEC)
- Climate Variability experiment (CLIVAR).

Again, European laboratories have been fully involved. Hundreds of smaller regional research programmes have also been carried out by European groups in every ocean of the world, and in the European regional seas.

The greatest change in the social and financial pattern of European research in oceanography has been produced by the DG-XII Marine Science and Technology (MAST) programme, which was initiated in 1988, and the series of European Conferences launched by ESF and ECOPS, culminating in the Conference on Grand Challenges in Oceanography in Bremen in 1994. At the ECOPS Conference Ocean Forecasting was judged by the participants at the Conference to be the most important of the Grand Challenges (Woods, 1995). Recent analysis by EuroGOOS of the 114 projects completed in MAST-II up to 1995 showed that 51% of them were rated either (a) essential research which had to be carried out to support the development of EuroGOOS, or (b) research which would indirectly strongly support the development of EuroGOOS. It follows that there is a strong case for capitalising on the past research, and developing a system which will use the knowledge gained to produce wealth, save lives, and protect the environment.

The past investment in satellite remote sensing will also produce a pay-off through the application of operational marine data to forecasting. Annexe 7 shows the international schedule of satellite missions designed to observe the ocean and sea ice.

Focus international development of operational ocean services and GOOS on the specific needs of European users

The three major foci of investment in and benefits from GOOS are Europe, North America, and E + SE Asia, including Australia. Other regions will tend to depend heavily on aid and technology transfer programmes. The USA has already chosen to emphasise collaboration with the Pacific rim, and work with Japan, Australia, and to a certain extent China and India, to crack the ENSO problem. This will help many of the smaller countries in the Pacific and Indian Oceans, while providing maximum return on investment by giving prediction of the ENSO climate variability on land, and providing benefits for all the central American states. Europe benefits relatively little from this scenario. The USA will also allocate some effort to the east coast Atlantic waters, but not as much as to the Pacific.

Europe has a primary short and medium term interest in predicting the state of its shelf seas and semi-enclosed seas. Beyond this the economic operations of Europe extend into the Atlantic and Arctic waters, through shipping, fishing, and offshore oil and gas. The European import of oil and gas from the Middle East and West Africa also depends upon long distance tanker shipping in the Atlantic. The climate of Europe is determined by the northward heat transport in surface currents, especially by the Gulf Stream and the North Atlantic Current carrying heat up to Norway. Conversely, cold weather and colder climate in Europe are influenced by extension of the Arctic floating sea ice, or possible blocking of the northward currents by buoyant stratification of the North Atlantic. The latter event is a possible paradoxical consequence of global warming, since the increased meltwater would make the surface waters of the Atlantic lighter, and prevent downward convection of cold water from the Arctic, thus preventing the warm surface currents from penetrating far north. In the extreme case, climate in Europe would become similar to that at present experienced in Labrador.

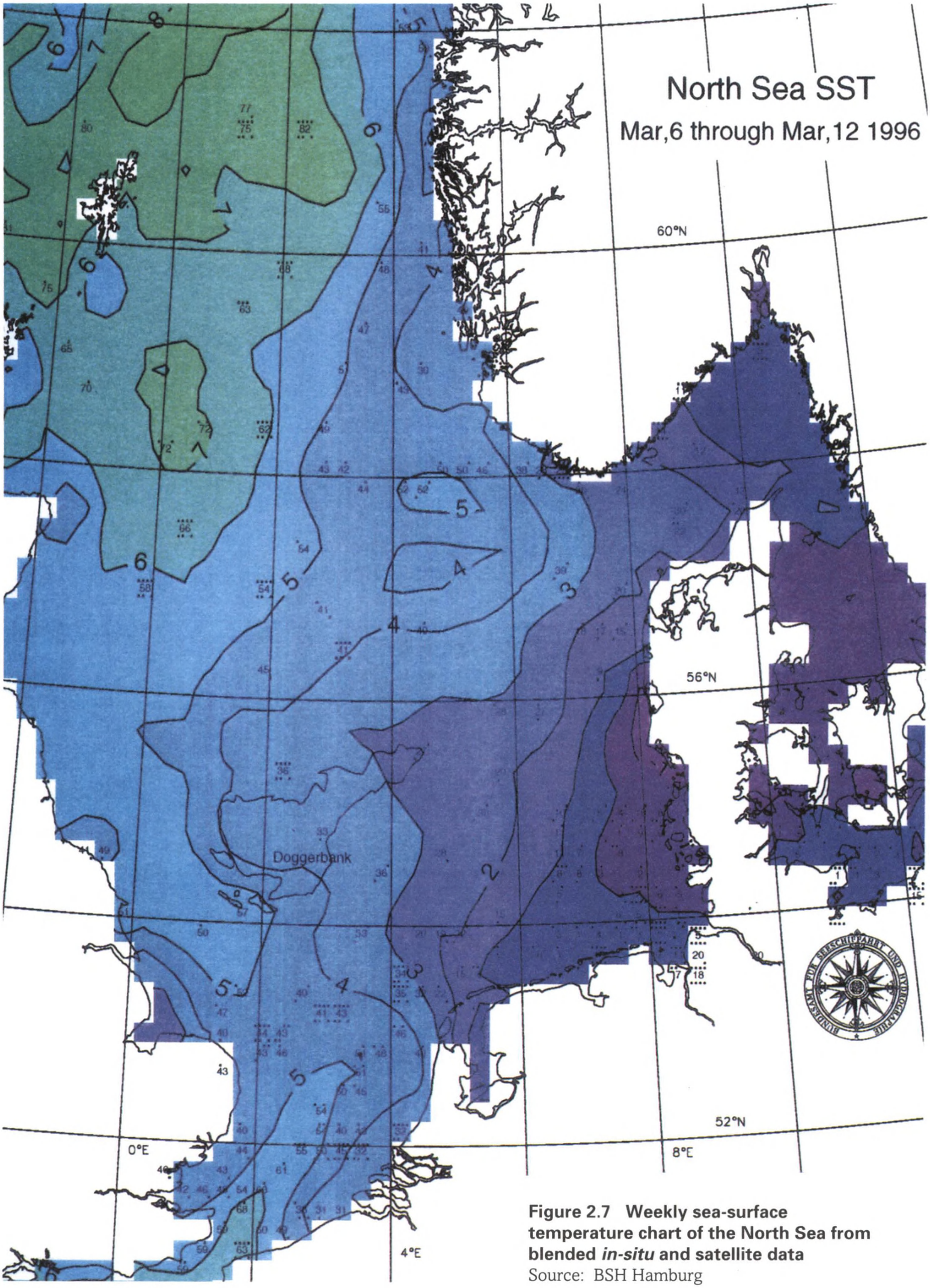

Figure 2.7 Weekly sea-surface temperature chart of the North Sea from blended *in-situ* and satellite data
Source: BSH Hamburg

Europe therefore has a strong interest at the global scale in understanding and predicting the whole Atlantic, from the Southern Ocean to the Arctic, including processes in the Arctic Ocean which influence climate and fisheries. If we take a broad view of the European area of scientific interest, this includes the Arctic waters as far east as Nova Zemlya, and the Mediterranean and Black Seas. The state of the Mediterranean surface waters appear to be correlated with the climate in north Africa and the Sahel, and prediction of these events will be of great economic and social importance.

Ocean basin modelling which includes floating sea ice and ice sheets inevitably requires global coupled modelling of the atmosphere, and, in practice, global ocean modelling. Several European national agencies, and the ECMWF, already have experience of global ocean coupled modelling, albeit global ocean models are still at a coarse resolution. The regional and ocean scale models which are of maximum benefit to Europe depend completely on adequate global data and global modelling, and thus Europe must play a major part in the development and operation of global models.

Europe needs to influence the planning and priorities of international GOOS for the following reasons:

- To ensure appropriate satellite instruments, polar extent, sensors, and orbits to cover the areas of European interest.
- To perform adequate modelling and deep ocean measurements in the Atlantic.
- To provide boundary conditions for the European shelf seas
- To ensure adequate aid and benefits to developing countries with whom we trade and have cultural relations.
- To ensure adequate global modelling to support the nested ocean basin models.
- To ensure that Europe is always in the vanguard of techniques and data sets required for operational global modelling and forecasting.

Chapter 3

Guiding Principles

Introduction

Develop services that are targeted towards identified user groups

New technology, and particularly the combination of high resolution modelling and data assimilation will increase the potential benefits, and produce a new range of cost-efficient services

Some general principles constraining the Strategy for EuroGOOS

Geographical Scope

Chapter 3

Guiding Principles

INTRODUCTION

The first two Chapters have presented the background and objectives of EuroGOOS, from which a number of guiding general principles are derived. These lead to the presentation of the Strategy itself in Chapter 4. The Guiding Principles are presented in this Chapter.

Develop services that are targeted towards identified user groups

New opportunities arising from new science and technology investment will create new potential user groups for EuroGOOS products

Chapter 2 has shown that the investment in marine science and technology research during recent decades has opened up the opportunity to develop operational oceanography as a new business. This enables us to produce a new range of cost-efficient services. In Chapter 4, where we set out the detailed Strategy for EuroGOOS, we will use the following conventions with regard to time phases:

Short term, 1996-1998: Implementation of components of EuroGOOS during this timescale will be based only on marine science and technology results which have already been completed. Improvements in performance of operational oceanography will be achieved by utilisation of existing knowledge, improvements of logistics, and improving standards of data management, formats, etc.

Medium term, 1998-2002: Implementation of components of EuroGOOS during this timescale will be based on science and technology which has already been funded, and is underway now.

Long term, 2002-2006, and later: Implementation of components of EuroGOOS during this timescale will be based on science and technology which has not yet been funded or started.

On each timescale we can anticipate that there are either customers who already appreciate their need for operational oceanographic products, customers who realise that products could be generated to meet their requirements if existing scientific and technological research were applied and implemented, and customers who consider at present that their requirements cannot be met. We will attempt to identify customers in these categories, and develop an understanding of their requirements, taking into account the differentiation of different types of product and service described in Chapter 1. During each phase there will be close links to the research community so that new science feeds through quickly to exploitation.

Develop dialogue with potential users

The potential users of modern oceanographic data products are not a uniform group of easily classified organisations or people. The users are spread across many tens of industrial and service sectors (see Chapter 1, Figure 1.1 and Table 1.1.); they exist in all European coastal states and world-wide, and they include European companies and organisations functioning outside Europe. The data and products which they require encompass a wide range of variables, degrees of processing, and product types.

We have already started to identify the categories of variable and product which users need, defined by variable, parameter, and industrial or service sector. As address lists and contacts are augmented, a dialogue will be developed, using feed back and "Technology Foresight" techniques to anticipate those developments and new information products which have the highest priority.

Trans-national collaboration within Europe

It is axiomatic for technical and geographical reasons (Chapter 1) and for reasons of economic benefits of scale (Chapter 2) that all EuroGOOS activities will involve collaboration between Member Agencies in different countries at a level appropriate and consistent with the Principle of Subsidiarity.

New technology, and particularly the combination of high resolution modelling and data assimilation will increase the potential benefits, and produce a new range of cost-efficient services

Chapter 2 has shown that new instrumentation, new methods of instrument deployment, reduction of costs and maintenance requirements, automation, and de-manning, combined with computer modelling and data assimilation will result in new data products and forecasts which would have been impossible a few years ago.

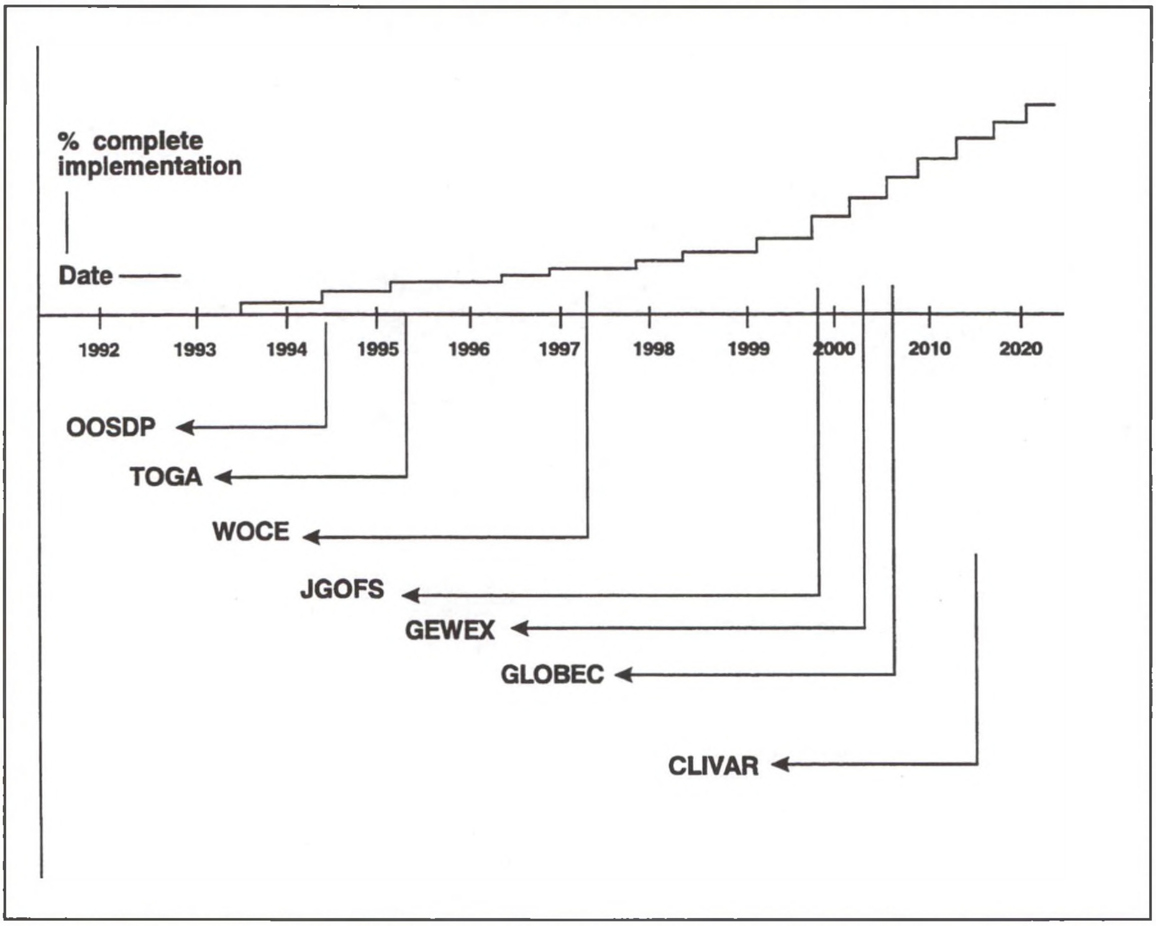

Figure 3.1 GOOS stepwise implementation

Several major global scientific experiments in marine science are already under way, or are planned for later this decade. The Ocean Observing System Development Panel (OOSDP) reported in 1995 on the design of an ocean data gathering system for climate research and prediction. The design and implementation of the GOOS will be carried out incrementally as the information becomes available. Some decisions can be made now; others depend on scientific experiments not yet completed.

SOME GENERAL PRINCIPLES CONSTRAINING THE STRATEGY FOR EUROGOOS

- Avoidance of duplication.
- Continuous interaction with the research community, and EU-supported research programmes.
- Balance between "Blue Water" and "Brown Water", between public good economics and commercial enterprise, short term and long term.
- Progressive introduction of more sophisticated computer models, higher spatial resolution, more variables, more complex multi-variate forecasts, and longer forecast horizons.
- Progressive introduction of improvements of technology.
- Technology transfer to developing countries, and an active aid and assistance programme.
- Promotion of training and educational courses within Europe so as to create skilled personnel for the new career of operational oceanography in Europe and elsewhere.

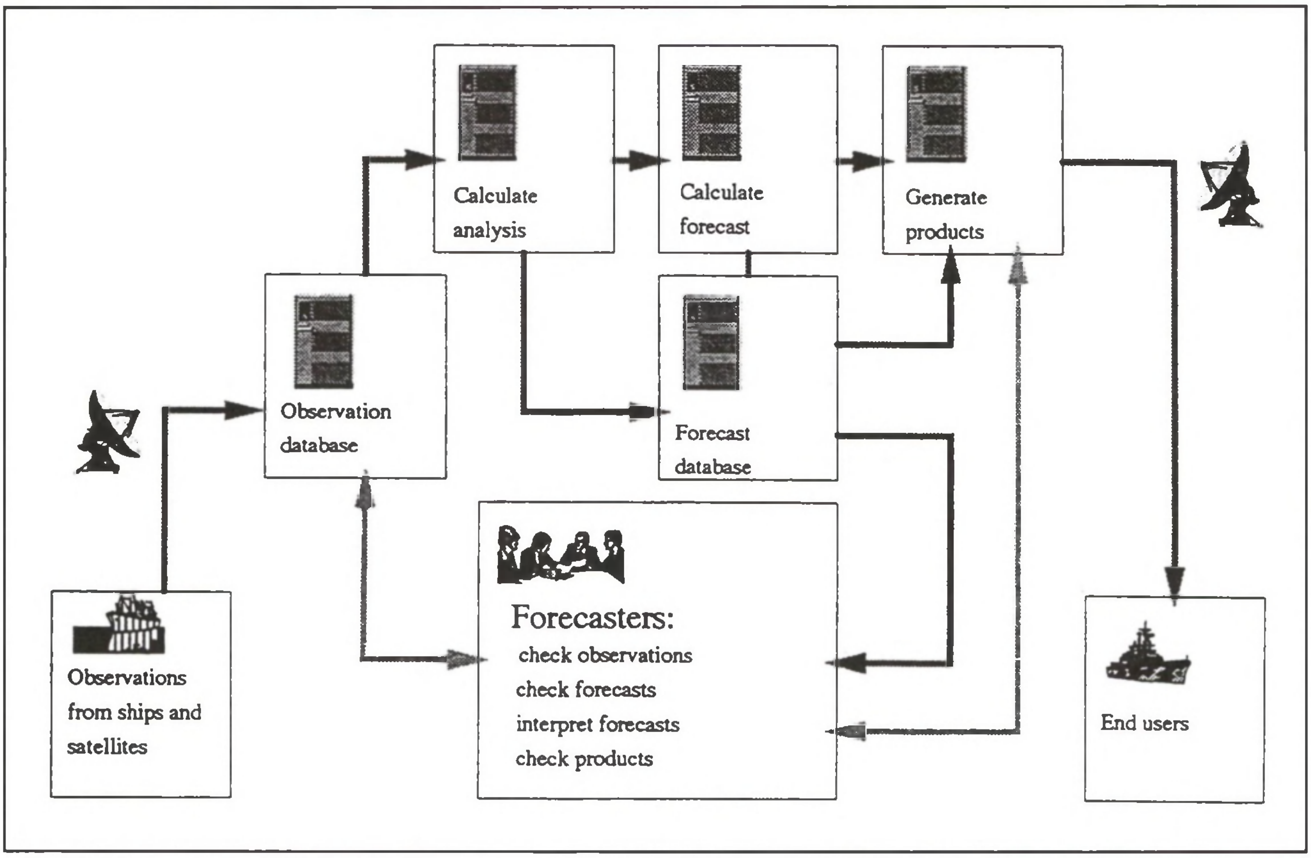

Figure 3.2 Processing of meteorological observations
Flow diagram of how observations are processed in models to generate products which are distributed to operational users. Monitoring how users apply the information is then used to improve the system. Source: The Met Office

GEOGRAPHICAL SCOPE

The geographical scope of European interests in operational oceanography are:

- The coastal waters and estuaries of all European states which are either Members of the EU, or within which national institutions are Members of the ESF.
- The European shelf seas, and adjacent semi-enclosed seas, including the Baltic, North Sea and north west European shelf seas, the adjacent Arctic Ocean, and the Mediterranean.
- The Atlantic Ocean.
- European interests in operational oceanography extend to collaboration with the major participants in GOOS, Canada, USA, Japan, Russia, China and Australia so as to take up the responsibility of the technically developed countries for providing the resources and technical infrastructure for GOOS.
- European enterprises in operational oceanography will provide their services competitively in the support of any legitimate coastal or marine industry or service in any coastal state, or in support of European industries operating outside Europe.
- European agencies skilled in operational oceanography will participate in the planning and implementation of the infrastructure and global components of GOOS.
- Other oceans of commercial and geopolitical interest to Europe.

Chapter 4

The strategy for EuroGOOS: 1996-2006 and beyond

Introduction

Strategic Sectors

1. Identification of customers, users, and beneficiary groups
2. Economics of EuroGOOS and the estimation of the benefits of operational oceanography
3. The scientific basis of EuroGOOS
4. The technology of EuroGOOS
5. Trials, development, and case studies
6. Design and optimisation of the observing system
7. Numerical modelling and forecasting
8. Products and services, value added and the end user
9. The global dimension
10. Links to European organisations

Synthesis

Conclusions

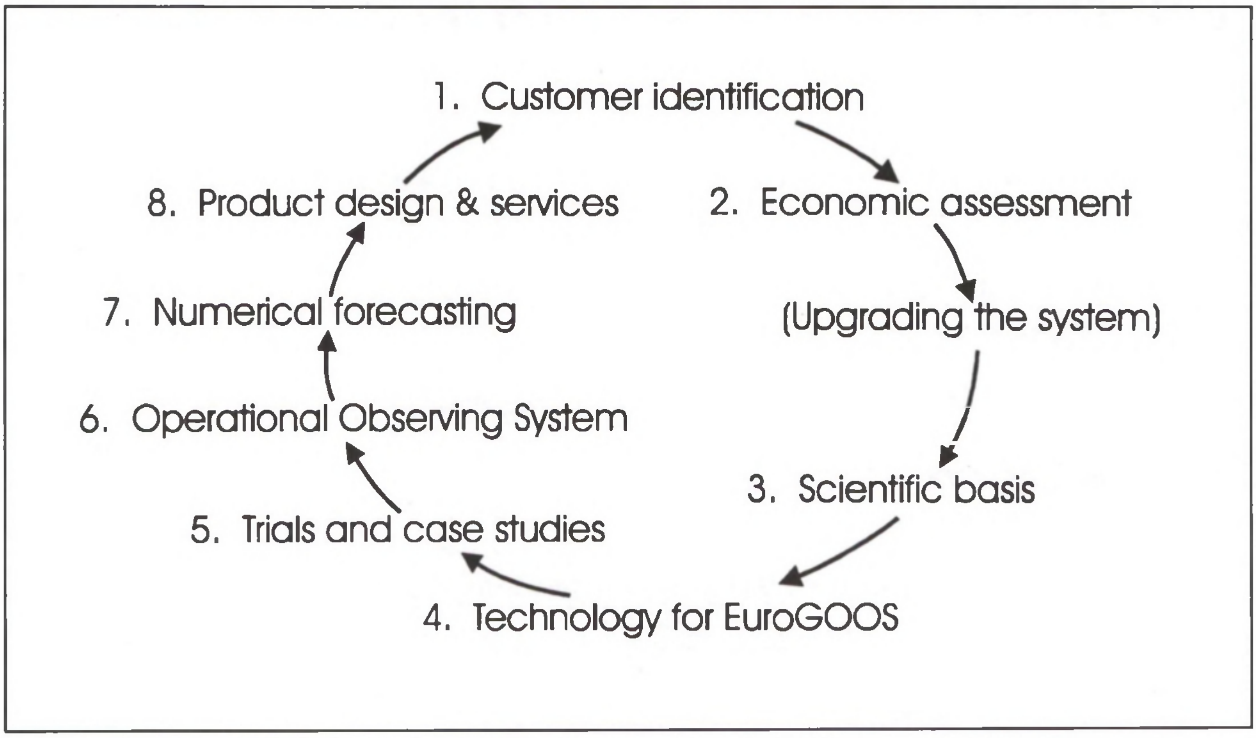

Figure 4.1 Diagram showing links between activity sectors of the EuroGOOS Strategy

Chapter 4

The strategy for EuroGOOS: 1996-2006 and beyond

INTRODUCTION

We have identified the need for EuroGOOS (Chapter 1), the Objectives which must be met to meet that need (Chapter 2), and the Guiding Principles which EuroGOOS recognises for developing operational oceanography (Chapter 3). This Chapter defines the strategy which EuroGOOS Members agree for the design and implementation of EuroGOOS in the next 10 years. Subsequent Chapters outline the methods, resources, and immediate next steps.

Our strategic objective is to promote operational oceanography in and for Europe within the context of GOOS. EuroGOOS development will be structured in phases with the same timescales as the European Framework Programmes. We have analysed the strategy needed to improve operational oceanographic forecasts and services, and have identified 10 sectors for action:

1. Identification of customers, users, and beneficiary groups
2. Economics of EuroGOOS and the estimation of the benefits of operational oceanography.
3. The Scientific Basis of EuroGOOS and GOOS.
4 The Technology needed for EuroGOOS and GOOS.
5. Development, Trials, and Case Studies
6. Design and optimisation of the civil operational marine observing system
7. Numerical modelling and forecasting.
8. Products, services, value added, and services to the end user.
9. The global dimension and interface with I-GOOS and J-GOOS.
10. Links to other European scale organisations and programmes.

It is axiomatic that we will not duplicate the activities of existing European agencies or national agencies. The above sectors of activity are not the principal objectives of any other organisation in Europe, and do not overlap seriously with any organisation. These activities do support the interests of many other European agencies and organisations, and there are many organisations and programmes which are conducting activities important to EuroGOOS. We will therefore maintain close links or mutual Observer Status with those organisations. In many cases the activities listed above could not be carried out by any body other than EuroGOOS.

The activities listed above are not related by a simple linear chain of cause and effect, or progressive development in a time sequence. They need to be implemented concurrently and in parallel. It is convenient to envisage some of the activities being related in a circular fashion (Fig. 4.1).

This is still an over-simplification, since many of the activities would be linked across the diagram in a star fashion. In summary, all the activities listed are essential, and must be pursued in parallel. The links between them will be developed as required, but without adding to the complexity of the system or the workload if possible.

Within each sector of activity this Strategy Document presents the following information:

- Overall strategic objective, with comments.
- Short term objective of EuroGOOS up to end 1998, including decisions taken or actions started during 1995 and 1996.
- Objectives to 2002, and to 2006 and beyond.
- Expected rate of progress in the immediate future; actions or support required in the Medium Term.
- Actions and support required on the longer timescale.

STRATEGIC SECTOR 1

OVERALL STRATEGIC OBJECTIVE

To identify and maintain contact with a customer base of many hundreds of organisations; to understand their needs for marine environmental data and forecasts; to up-date this information regularly; to develop a dialogue between EuroGOOS Members and customers and potential customers.

Comment:
Identification of customers and describing their requirements for operational information and data products is definitely possible but not easy. There are different classes of customers for each level of processing of the data, starting with raw observational data, and working through stages of data quality control, assembly, gridding, assimilation, modelling, and high level product generation. Each industrial/commercial/governmental sector also requires different parameters and variables, processed in different combinations, predicting different impacts (see Chapter 2).

EuroGOOS must undertake this exercise. No other organisation will do it on the right scale.

We must identify the agencies, organisations, and companies which can benefit from operational marine data, work with them to clarify their needs and data requirements, identify the services they require, and relate these needs to intermediate data processing agencies and value-added companies. The benefits identified in this sector can be used to improve estimates in the analysis of the economics of operational oceanography.

It is not possible to solve this problem by inviting one or two so-called users to be Members of EuroGOOS, or to set up a small WG including 3-6 users. No group of only 3 or 6 specific users of data would understand the needs of the 1,000 potential other users who are not represented. They would also tend to be biased towards their own requirements. We must make a thorough inventory of user organisations, including commercial companies, and relate this list to the economic assessment of benefits, and to the data requirements of each type of user.

SHORT TERM OBJECTIVE FOR EuroGOOS UP TO END 1998

Identify the addresses and personal contacts for at least 100 potential customers and user agencies for operational oceanographic information and forecasts in each country which has a Member Agency in EuroGOOS. Identify a check-list of non-European users.

Comment:
We have already identified many potential user groups through requirements surveys in UK and by ESA, through EUROMAR, through the MAST-EUROMAR Conference in Sorrento, and the Oceanology International-96 Exhibition in the UK. CNR has translated the EuroGOOS data requirements survey in Italy, and CICYT is ready to circulate it in Spain. These surveys, combined with attendance at trade exhibitions and conferences have provided hundreds of contacts with commercial companies and trade organisations requiring data. EuroGOOS Members themselves have a statutory requirement to meet environmental objectives, and therefore will be data users. We also have to identify the needs of EC DGs and the EEA.EuroGOOS Officers will visit and work with representatives of EU/EC DGs in order to identify their needs for operational oceanographic data and forecasts in fulfilment of their objectives. We will also establish working relations with OSPARCOM, HELCOM, EEA and ECMWF.

The First EuroGOOS Conference, 7-11 October 1996, will enable us to present its strategy to a selected audience of decision-makers largely representative of the user community, and to listen to users.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002

Develop a routine system of acquiring customer address lists from exhibition catalogues, conferences, and surveys of product users. Continue a regular schedule of dialogues with customers and user groups through conferences and workshops, surveys, and feedback exercises. Check the lists against performance or up-take of information and forecast products.

Comment:
We can use the customer base list to refine economic calculations of what information is used for, and hence the benefit to the European economy. Use customer base list to identify and prioritise activities of user groups outside Europe, and hence improve European activities in operational oceanography globally, and in relation to aid programmes and technology transfer to developing countries.

LONG TERM OBJECTIVES FOR EuroGOOS UP TO 2006 AND BEYOND

To broaden the customer base by strengthening links to climate variability forecasting, and land-based users of climate data.

Expected rate of progress, and support required in the medium term
This activity is progressing steadily but slowly through the initiative of Members. More effort is needed at the national level to identify user groups, and to classify them by type if it is deemed commercially sensitive to release address lists. We must have quantitative evidence of the number and type of customers.

Actions and support required on the longer timescale
The existence of EuroGOOS is based on the premise that there are large communities of users of operational oceanographic data. It is an obligation that Members should work continuously to maintain up to date the customer base, and to provide impartial information to EuroGOOS on the range and type of the customers. This is an internal matter for EuroGOOS Members.

STRATEGIC SECTOR 2

OVERALL STRATEGIC OBJECTIVE

To analyse and publicise the economic facts about the need for operational oceanographic data and forecasts; to improve the techniques of gathering economic information on marine industries and services; to develop a standard methodology for all European countries to use in estimating the economic and social scale of marine industries and services; to promote theoretical analysis and publication of economic models for international operational oceanography. To justify investment in operational oceanography.

Comment:
EuroGOOS has been established by its Member Agencies with the firm belief, based on experience, that there is a need for and a market for real time and near real time civil operational oceanographic data and information products. There are hundreds of technically developed potential users of operational marine data who can use the data themselves, or convert it into more practical presentations for thousands of end-users. The benefits of operational monitoring and forecasting of the ocean and coastal seas have been estimated approximately in the USA, and with more detailed inventories in Australia, and UK. Some broad calculations have been made for global benefits by OECD. (For discussion of the economic issues see Chapters 1 and 2).

OBJECTIVE FOR EuroGOOS UP TO END 1998

Participate in workshops on economics and cost benefit analysis of GOOS at I-GOOS Planning Meeting in Washington May 1996; organise sessions on economics of operational oceanography at the First EuroGOOS Conference, October 1996; ensure that the study of the economics of GOOS is supported at an international level with particular attention to the needs of developing countries.

Comment:
Economic analysis of the value of GOOS and EuroGOOS has been carried furthest so far in USA and UK. Detailed work on an industry by industry basis has started in the Netherlands. The Norwegian experience with the inter-agency collaborative HOV project is also relevant. The space industry, both at national and European levels (BNSC, CNES, ESA) has carried out some research into the economic value of remote sensed operational oceanographic data, using commercial consultants. OECD Megascience Forum Secretariat has discussed provisionally with I-GOOS and EuroGOOS the following studies:

a) Analysis of standard methodology for assessing the contribution to GNP of marine industries and services within a developed state.

b.) Analysis of methodology to help developing countries to assess the contribution of marine activities to their GNP, and possible benefits from GOOS.

c) To work with I-GOOS and NOAA to improve methodology for global assessment of benefits and costs of GOOS.

We will work with DG-XII and NOAA to organise workshops on standardised methodology. IOC-I-GOOS has invited EuroGOOS to co-sponsor a workshop on capacity building for developing countries needing to participate in GOOS.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002

Complete country-by-country descriptions of scale of national maritime industries and services on a standard basis, and aggregating results to produce a European overview. Develop intermediate models of international economics of GOOS and EuroGOOS. Complete economic modelling of the benefits of climate change forecasting in collaboration with GOOS and GCOS.

Comment:
The biggest problem is the shortage of skilled personnel with sufficient experience of economic modelling, information gathering, marine industries, and oceanography. With the best of intentions, individuals or groups who are very skilled in some of the necessary disciplines, but lack others, can conduct substantial studies and produce very inaccurate and misleading results. In the short term we have identified a small number of well-qualified experts, but as the need to carry out these studies continues, there will be an urgent need to recruit more staff to work on the problem. This is the limiting factor.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

Complete multi-parameter models combining economic models of marine industries and services, models of the up-take and application of forecast information, and the resulting economic and social benefits. Adapt or develop economic and social models for the non-tangible benefits of GOOS and EuroGOOS, especially social and environmental benefits.

Comment:
As for Medium term.

Expected rate of progress, and support required in the medium term
Good progress is being made already in a sporadic way through the chance interests and skills of a small number of people in Netherlands, UK, USA, and OECD. NOAA has supported professional studies of the impact of ENSO cycle on agriculture. Overall this is unsystematic, and will not be sufficient effort. Extra resources and personnel are needed, firstly to help develop workshops and instructional sessions, and later on a continuing basis. We will have to seek collaborative partners and additional funds to conduct this work.

Actions and support required on the longer timescale
The skills needed for this analysis are similar for all countries, but are in short supply. In the long term EuroGOOS Members will collaborate globally to conduct these studies, to provide guidance for investment in operational oceanography in each country to maximise its own benefits. This is an essential task since developing countries will be unable to identify the benefits of GOOS to their economy or society without assistance, and will then lose interest in GOOS. Financial support will be needed from a number of sources both within and external to Europe.

STRATEGIC SECTOR 3

OVERALL STRATEGIC OBJECTIVE

We will obtain the best available scientific advice for the design and implementation of an observing system; ensure that numerical models are developed and tested with the capability to meet the requirements of EuroGOOS; analyse plans for the implementation of EuroGOOS and detect if there are scientific flaws which would undermine the system; analyse the limits of predictability of models, and develop scientifically sound procedures for assimilation of data into models.

Comment:
A Science Advisory Working Group (SAWG) has been set up by EuroGOOS (see Annexe 2 for ToR). The Science Advisory WG of EuroGOOS has the responsibility of defining the scientific basis for the operational system; pointing out new opportunities which are available because of scientific advances; and warning Members when intended or planned projects are likely to be undermined by lack of scientific information or understanding. The SAWG maintains close contact with the Joint Scientific and Technical Committee for GOOS (J-GOOS). The GOOS Module Panels of J-GOOS (Climate, Health of the Ocean, Living Marine Resources, Coastal, and Marine Services) are now starting to have regular meetings, and there is effective cross-membership between EuroGOOS Members and most of the Panels. An ESF Conference on Forecasting the Mediterranean was held in Toulon in 1995, and further ESF Conferences on the underpinning science for operational oceanography would be welcomed.

OBJECTIVE FOR EuroGOOS UP TO END 1998

The SAWG will produce a draft Scientific Plan for incorporation in the EuroGOOS Plan by end 1996. This Plan will establish a work programme and priorities for the next few years. We will foster research aimed at establishing the limits to predictability for each of its target forecasting products.

Comment:
EuroGOOS analysis of the results of MAST-II projects shows that 50% of projects consist of research which is either essential for the design of operational oceanographic systems, or contributes strongly to the development. The MAST-III second call for proposals, April 1996, identifies theme III "Operational Forecasting", with reference to the need for research to underpin the development of EuroGOOS. MAST includes a Modelling Group, and much of the achievement of the Group in recent years will serve to strengthen the design of regional observing systems and modelling within EuroGOOS. EuroGOOS will seek to collaborate with EU-EC DGs VII, XI, XII, XIV, and XVII to identify research projects under way, or planned, which will contribute to the development of operational oceanography.

In the short term emphasis will be on improving the knowledge of processes relevant to modelling and forecasting the physical parameters of shelf seas, tides, meteorological forcing of sea level, wind stress, waves, surface currents and sea ice. Work will be carried out in the SAWG on specifying the optimum sampling strategy and limits of predictability.

The next stage is to incorporate in physical models the variables of temperature, salinity, density, and current profiles.

During the next 12 months the SAWG will report on the theoretical limits of predictability of different shelf seas and oceanic conditions, and the possible levels of prediction which might be achieved with various sampling strategies. Looking further ahead, the SAWG will analyse the programmes already in existence in European seas, and suggest the criteria for trade-offs between different options. Only a full scientific understanding of the processes, and a knowledge of the variability and predictability of each process, will enable the design of an optimum sampling strategy.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002

Confirm the scientific criteria to support practical modelling and prediction of shelf seas in terms of water chemistry, nutrients and oxygen. Significant progress should be made in process studies and specification of operational modelling criteria for the North Atlantic and Arctic.

Comment:
In the Medium Term EuroGOOS Members will need to derive the correct balance of resource allocation between improving high resolution multi-variable operational shelf sea models, testing prototype ocean basin scale models, and experimental global coupled ocean-atmosphere models. These are not alternative options, but all need developing in parallel, with appropriate levels of effort to obtain the maximum benefit.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

Scientific criteria thoroughly established for observing system needed for climate monitoring and forecasting, based on completion of WOCE analysis, and much of CLIVAR. EuroGOOS Members participation in data gathering for climate forecasting. In shelf seas, the science base established for water quality modelling, including suspended particulate matter, ecosystems, and aspects of fisheries recruitment.

Comment:
Improvements in computer power, advances resulting from major science research programmes, and improvements in modelling procedures, will provide the basis for operational modelling of the North Atlantic, including the prediction of fluctuations in the Gulf Stream, the Irminger current, the North Atlantic current, processes and fluctuations on the Greenland-Iceland-UK sill, and the occurrence of ventilation, convection and deep water formation. Recent reports (Feb. 1996) show that there has been less ice formed off the coast of Greenland for 3 successive years. Improved data and analysis of decadal fluctuations of Atlantic heat content and transport are needed.

A hydrographic section along 24°N in the Atlantic has been occupied several times over the last 35 years, in 1957, 1981 and 1992 (Parrilla et al., 1993). The temperature differences between occupations show warming of up to 0.25°C of the western half of the section from 1957 to 1981 and warming of the eastern half from 1981 to 1992. The net effect is a 35-year warming of 0.25°C from 500 to 2000 m in this section across the subtropical gyre. Sections in 1981 and 1991 across the sub-polar gyre from Greenland to the United Kingdom tell quite a different story (Read and Gould, 1992). There cooling is apparent over the last decade, and Read and Gould were able to infer, from a long Canadian time series in the Labrador Sea, that cooling will continue for the next decade. Time series in the eastern North Atlantic (Ellett and Turrell, 1992) also show decadal changes, with major shifts occurring within one to three years. This is most likely caused by a change in ocean circulation near the eastern boundary of the North Atlantic.

These examples show that decadal change in the ocean does not have a simple large-scale pattern. At 24°N the Atlantic has warmed in the last decade while at 54°N it has cooled. At 24°N the western half of the section warmed in one decade, the eastern half in the next. Paleoclimatological records

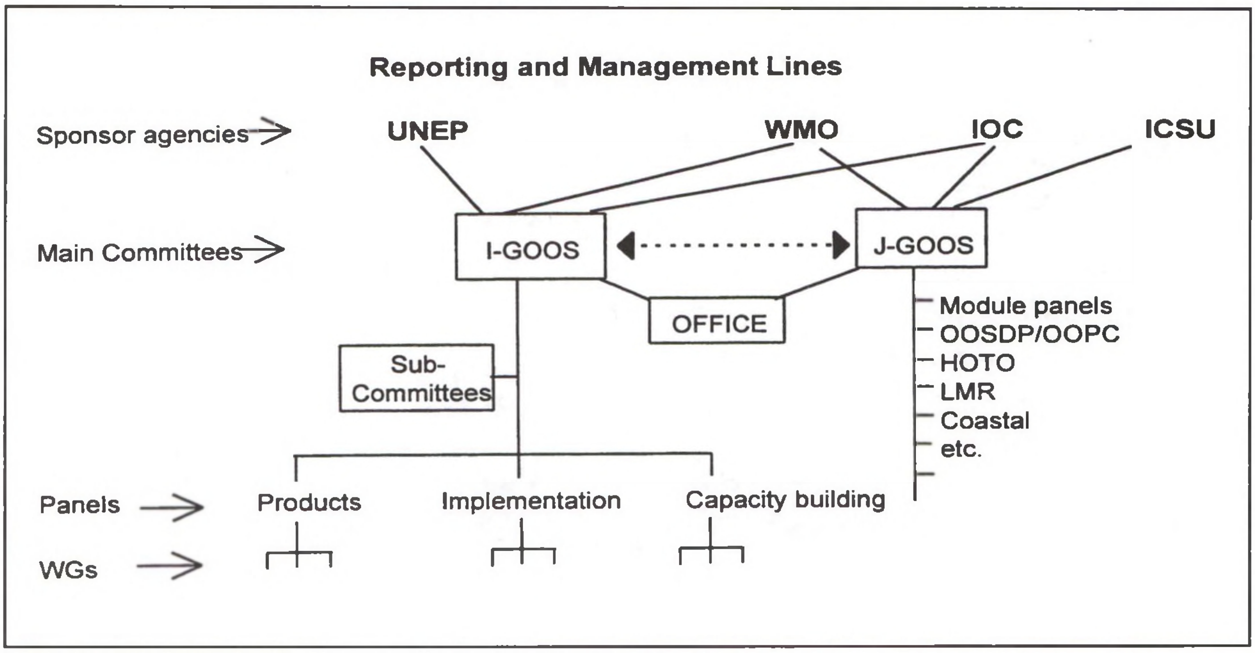

Figure 4.2 Structure of the committees and sponsor agencies in GOOS

Definitions:	***UNEP***	*United Nations Environment Programme*
	ICSU	*International Council of Scientific Unions*
	WMO	*World Meteorological Organization*
	IOC	*Intergovernmental Oceanographic Commission*
	I-GOOS	*IOC Committee for GOOS*
	J-GOOS	*Joint Scientific and Technical Committee for GOOS*
	OOSDP	*Ocean Observing System Development Panel/Ocean Observing Panel for Climate*
	HOTO	*Health of the Ocean*
	LMR	*Living Marine Resources*

show decadal changes occurring in the North Atlantic, but there is no evidence of simultaneous changes occurring in Antarctica. The changes are certainly linked to ocean circulation, and indeed are almost certainly controlled by it.

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 discussed above 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.

As TOGA has shown, changes in ocean circulation have strong atmospheric impact and directly affect the environment. If we can learn the causes of decadal change, spot its precursors, and forecast it, there will result substantial economic benefits to humanity. Observing and understanding such change is a challenge that must be taken up in the next two decades as a precursor to routine decadal forecasting in the next century.

It is important to emphasise the differences between computer models of the ocean circulation that we have at present and those we shall need if we are genuinely to forecast changes in ocean circulation. There are two major categories of models:

- Eddy-resolving ocean models used to understand ocean physics and the role of ocean weather;
- Non-eddy resolving atmosphere-ocean models used to explore how the ocean-atmosphere system might respond to climate change over decades to centuries.

We use the term eddy-resolving to refer to models that seek to resolve ocean weather. Because the scales of ocean weather are ten times smaller than those of atmospheric weather, ocean models require ten times more resolution in each horizontal dimension. This, in turn, requires ten times more temporal resolution. Thus, to run an ocean model with resolution equivalent to that of an atmospheric weather forecasting model requires a computer a thousand times more powerful. While computing power is increasing rapidly, present eddy-resolving models have to compromise between spatial resolution and the computing time taken to complete a model run. FRAM, for example, had a 30km horizontal resolution (10km would have been preferable) and had supercomputer time sufficient to run the model for only 16 simulated years.

Eddy-resolving models can thus simulate perhaps one to a few decades, but cannot be run forward for centuries. In particular, they can simulate the wind-driven circulation, but cannot be run long enough for the slower-responding, vertical thermohaline circulation to settle.

Because of computer limitations, models presently used to explore climate change decades to centuries ahead have limited spatial resolution. These are not forecast models but research tools, used to examine different hypotheses about how climate might change in response to different forcing. Such models have known, and possibly serious, limitations. They tend not to converge to a steady state, and transfers of properties between the atmosphere and the ocean have to be adjusted to prevent the models from drifting unrealistically. They do not, by definition, resolve ocean weather, and it is a matter of current research and much debate whether it is satisfactory to represent the physics of ocean weather by approximation in climate models. Despite these limitations, current climate models provide intriguing pointers to how ocean circulation may vary over decades to centuries.

EXPECTED RATE OF PROGRESS, AND SUPPORT REQUIRED IN THE MEDIUM TERM

In the short term the application of existing science and modelling techniques to the problems of forecasting physical variables in coastal and shelf seas should proceed rapidly.

Present resources will be more or less sufficient, with some additional support for meetings of workshops. In the Medium Term, 1998-2002,

Figure 4.3 Deployment of a conductivity, temperature and depth (CTD) sensor rosette array at sea
Source: SOC

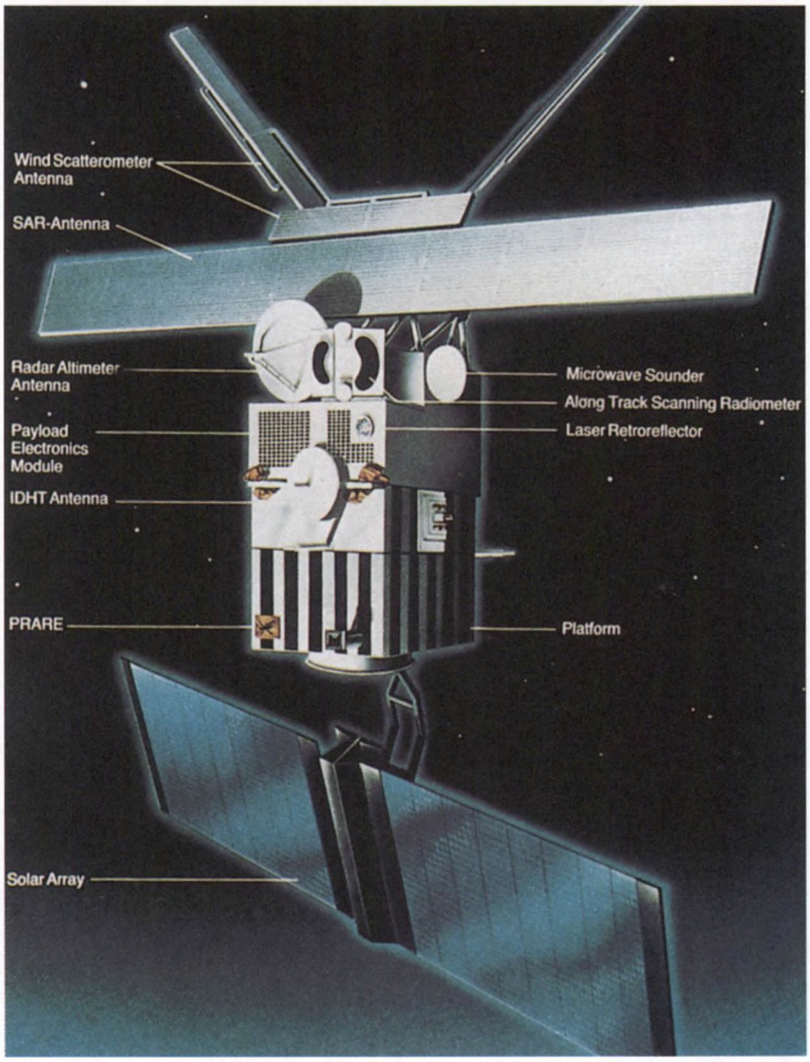

Figure 4.4 ERS-1
The ERS-1 and ERS-2 Satellites use a variety of radars and radiometers to monitor the ocean surface globally.
Source: ESA

resources for additional meetings, workshops, training sessions, summer schools, and publications will become necessary. Funding may be needed for experiments and trials in order to test the limits of predictability, simulation experiments, and sensitivity experiments to establish optimum sampling strategies. Within this time scale scientific research centres, or modelling centres, may be established to support the strategic research needed by EuroGOOS.

ACTIONS AND SUPPORT REQUIRED ON THE LONGER TIMESCALE

The scientific underpinning of EuroGOOS will certainly require experiments and tests, including modelling trials, which would not otherwise be carried out by single agencies. At some point the allocation of responsibilities and division of tasks between EuroGOOS Members will require the establishment of new centres or groups, concentrating either on strategic research, or on the actual implementation of operational models. It is too early to say how such centres will be funded, either within the funding arrangements of individual national agencies, collaboratively, or from European supra-national sources.

Modelling and forecasting the Atlantic and adjacent Arctic Oceans is a major objective of EuroGOOS, and the research to underpin this will inevitably be expensive. The need to test models and data assimilation on a large scale is described more fully later. These developments will have to be funded by governments.

STRATEGIC SECTOR 4

OVERALL STRATEGIC OBJECTIVE

We will analyse existing technological systems available for operational oceanography, estimate the optimum technology needed to implement different phases of an operational forecasting service, identify the gaps in technology, and foster the development and application of new technology to improve forecasting.

Comment:
The Technology Plan Working Group was set up in spring 1995, and had its first meeting at Sopot, Poland, in May. For Terms of Reference see Annexe 2. The TPWG logically has links to the Technology Supporting Initiatives of DG-XII MAST, to EUROMAR, and to industrial instrument manufacturers.

OBJECTIVE FOR EuroGOOS UP TO END 1998

The TPWG will create an inventory of instruments used at present in operational oceanography in Europe, and identify the gaps and equipment needed in the short, medium, and long terms. TPWG will submit reports on these requirements, and suggest means to promote the development of the most urgently required devices.

Comment:
The Technology Plan Working Group of EuroGOOS has the responsibility to report within the next 12 months on the priorities for EuroGOOS in the improved utilisation of existing operational technology, and the requirements for new technology. The EuroGOOS Conference in October 1996 will be an opportunity to present information on requirements, and to meet manufacturers of instruments and systems.

The Technology Plan WG has conducted a survey of its Members and associated agencies to obtain details of all operational instruments and observing platforms and supporting systems presently in use, and future requirements. Over 300 devices and systems have been described by respondents to the survey, and the data were analysed early in 1996 for presentation at the conference OI 96, in March 1996.

The Categories of devices and systems in the TPWG Survey are:

- i) Instruments and sensors
- ii) Platforms and carriers of instrument systems.
- iii) Support systems
- iv) Telematics, information transmission, data banking, archiving.
- v) Numerical modelling and forecasting.
- vi) Data products and information systems.

The results of this survey will be analysed to show those devices which are found to be most satisfactory and standardised already; those areas which are prototype or in the first phases of operational use; and those areas where no satisfactory instruments or systems yet exist. The Report of the WG will then recommend to EuroGOOS a strategy for the improvement of systems, the specification of required devices, and recommendations concerning the progressive introduction of new technology in operational oceanography.

The information in the Report of the TPWG will be published so as to assist manufacturers and commercial service organisations to estimate the opportunities for commercial developments.

The TPWG is conducting an analysis of the potential value of multi-parameter sensors installed on European ferries (Fig. 4.6). This study includes a statistical analysis of all routine ferry routes, and an engineering study of the feasibility and costs of

Figure 4.5 (a)

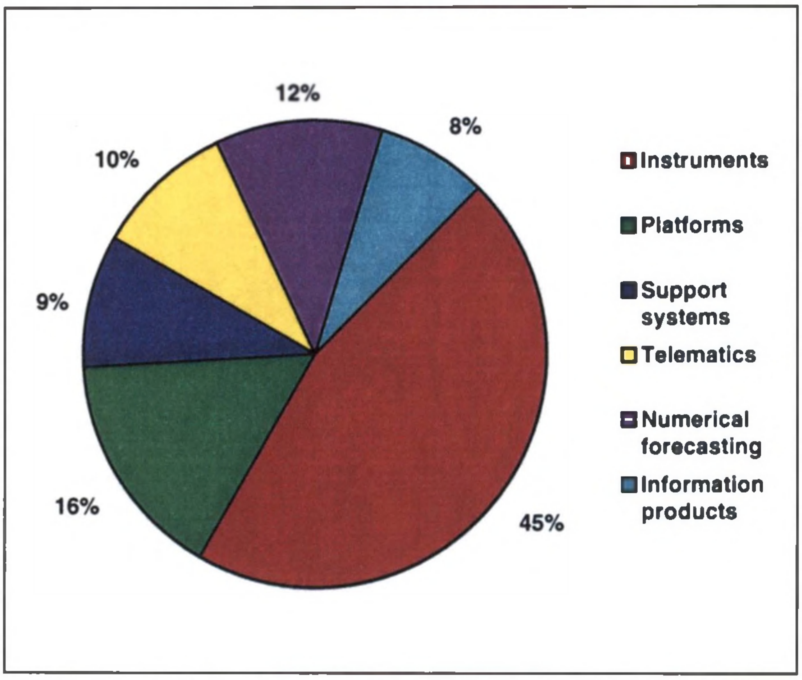

Figure 4.5 (b)

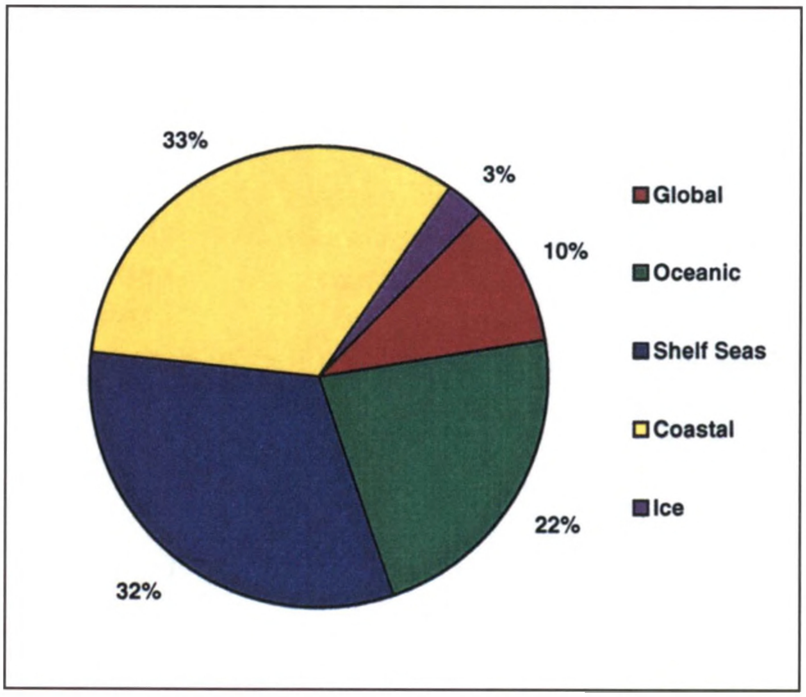

Figure 4.5 EuroGOOS Technology Survey

During 1995 EuroGOOS surveyed the availability of instruments and systems for operational oceanography in Europe. The survey produced more than 300 replies. Figure 4.5(a) shows a provisional analysis of the number of replies describing devices in each category shown on the pie diagram. Figure 4.5(b) shows the geographical environments in which each of the devices are being used. Source: Bosman, *et al.*, 1996 ship installations. All technology systems developed in the context of EuroGOOS will also be marketable globally.

We need to negotiate with the space agencies, especially ESA and CNES, to ensure that satellites are launched which carry sensor packages measuring the variables which are most important to EuroGOOS Members, and especially that calibration and continuity of sensors is such that data sets can be treated in a consistent way over many years. A Meeting of CEOS in Seattle March 1996 stressed very strongly the importance of involving representatives of user agencies in the forward planning of missions. We support this policy. Eumetsat has studied the feasibility of providing operational real-time data sets for a number of ocean variables. EuroGOOS Members are participating in studies of the economics of operational remote sensed ocean data, and the different options for funding operational space missions.

The EuroGOOS Technology Plan WG will report at the end of 1996 with recommendations for inclusion in the EuroGOOS Plan.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002

EuroGOOS Members will investigate the practical applications on a routine basis of techniques at present experimental, such as tomography, new sensors for chemical and biological variables, combinations of sensors and telecommunications, automatic data quality control and data assimilation, and the potential use of AUVs. Explore the use of midwater floats and acoustic tracking on a routine basis.

Comment:
Techniques are being used now in an experimental mode which need further development and trials before they can be used routinely. These include a wide range of chemical sensors, automated data processing and management techniques, data assimilation into models, and novel platforms such as AUVs and midwater floats. There is an important potential for negotiating further utilisation of techniques which have been limited to military use in the past. On the scale of GOOS at an international global level there is a need for instrument deployment systems in the Southern Ocean, which might be met by European innovations. Technological consultation will continue between EuroGOOS and the space agencies to ensure that new and appropriate sensors are flown on future missions. ESA has consulted EuroGOOS with regard to optimum configuration of satellite missions for operational oceanography after the year 2000.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

EuroGOOS Members intend to utilise the most cost-effective and advanced technology which supports the gathering of operational data, and the running of operational models at the Teraflop level. On this timescale there will be a great increase in the use of automated unmanned instrument systems, data retrieval from beneath the Arctic ice, and from the Southern Ocean, and other un-monitored oceans.

Comment:
On a timescale of 10 years and more massively parallel processing will provide great improvements in spatial resolution and ability to model dozens of variables simultaneously. The data needed to constrain such models will have to be gathered by instrument systems which are not yet being designed. Alternatively, highly specialised models may be developed for small groups of variables, and the models interconnected to produce different types of forecast. Automatic unmanned instrument packages will be needed wherever possible.

EXPECTED RATE OF PROGRESS, AND SUPPORT REQUIRED IN THE MEDIUM TERM

The analysis of technological requirements within EuroGOOS will proceed on predictable tracks up to mid 1997. The outcome of EuroGOOS investigations under way at present will result in recommendations for technological improvements and trials which will require funding, either as part of existing programmes such as MAST, or from national Agency budgets. Collaborative arrangements may be needed. It may be appropriate for parts of the EuroGOOS Plan, to be designated as a COST Action. This would provide support for meetings and publications and the additional costs of collaboration, and would be valid for 3 years.

ACTIONS AND SUPPORT REQUIRED ON THE LONGER TIMESCALE

The development and testing of new technology is expensive. As the requirements become clearer and priorities are identified, major collaborative programmes or European investment may be appropriate. At present it is not yet possible to identify the key targets.

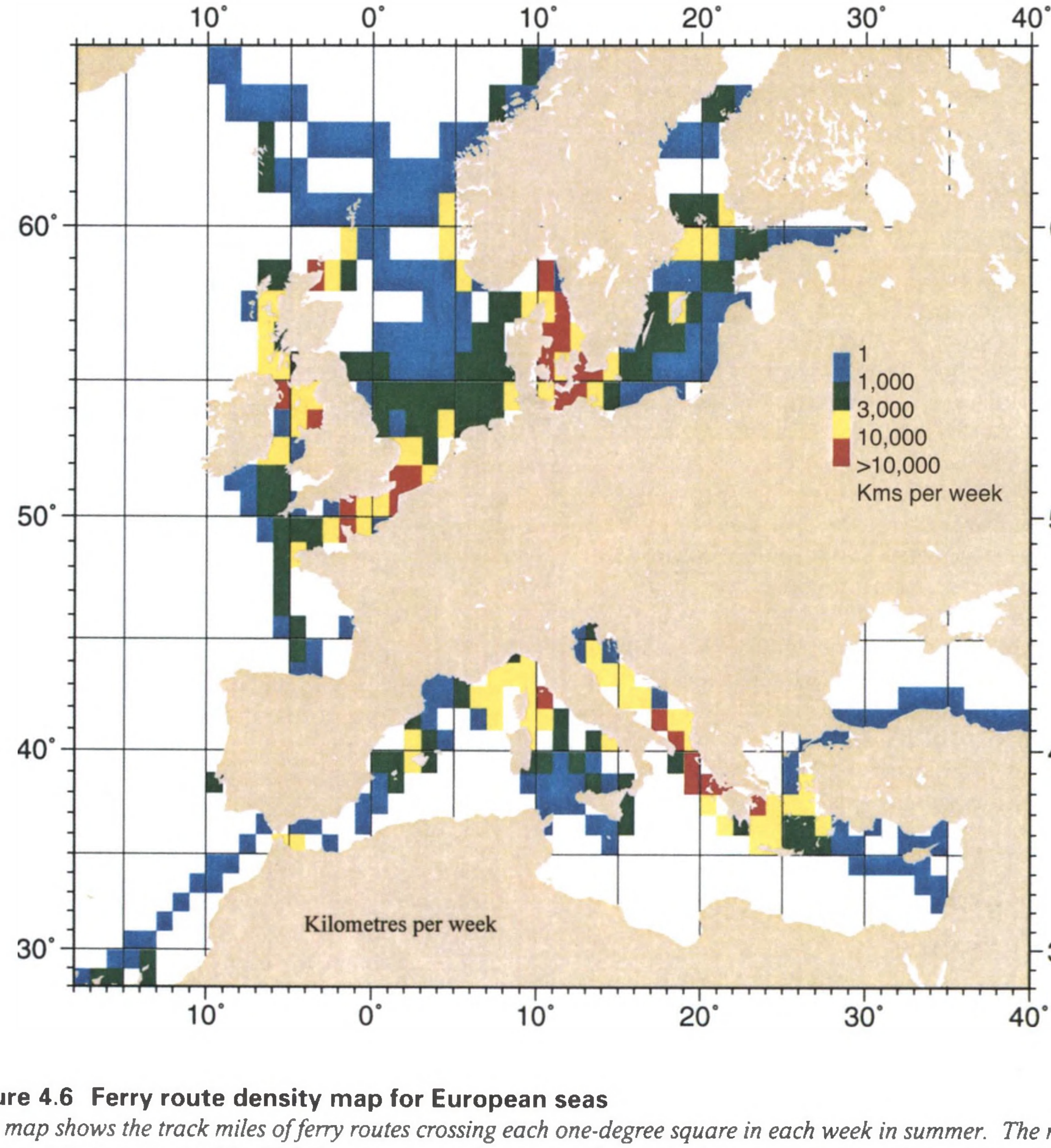

Figure 4.6 Ferry route density map for European seas

This map shows the track miles of ferry routes crossing each one-degree square in each week in summer. The number of ships and the frequency with which they traverse each sea area determines how much data could be obtained by placing automatic instruments on ferries

STRATEGIC SECTOR 5

OVERALL STRATEGIC OBJECTIVE

EuroGOOS Members will conduct paper studies to identify the trials and tests which are needed, and then establish collaborative arrangements between the relevant groups of Members to carry out trials, or pilot projects, as required, in the European Regional Seas, and in the Atlantic. Identify the need for one or more European Centre(s) for modelling trials, data assimilation, and optimisation of sampling strategy.

Comment:
The conduct of collaborative trials, prototype operational exercises, and pilot projects is a central policy within the EuroGOOS Strategy. The nucleus for such collaborative projects already exists in various operational programmes especially in the Baltic and North Sea (HELCOM, SeaNet, etc.). Other less developed projects also exist in the Arctic and the Mediterranean. EuroGOOS Members will work with these organisations, and create new initiatives, especially in the Mediterranean, to bring together the results of science programmes, new technology, and the design of prototype operational systems and services. At the Atlantic and global scales we will collaborate internationally in trials within GOOS. Manufacturers of new instruments, or providers of new services, infrastructure, or software, may be invited to participate in trials.

OBJECTIVE FOR EuroGOOS UP TO END 1998

To identify the priority systems and technologies which need development and testing in each region and at each geographical scale to meet the requirements in that region; to combine the recommendations of the Science Advisory WG, the Technology Plan WG, and regional requirements so as to design trials of systems and pilot projects; to consult with manufacturers who may be interested in participating in such trials.

Comment :
We have set up 4 Task Teams with the responsibility of evaluating the observational strategy needed in each marine region: Arctic, Baltic, North West Shelf Seas, and Mediterranean. These groups will report within 12 months. EuroGOOS has further identified a strong interest in modelling and forecasting the Atlantic.

EuroGOOS Members will need to develop trial procedures for numerical models, field tests and trials of operational instruments, trials of operational data assimilation from satellite remote sensing, and case studies of the effectiveness of operational services.

A study has already started on the availability of different types of ocean data in operational mode, and the reasons for shortfalls in required data: inadequate sensors, insufficient coverage, poor temporal resolution, low accuracy, poor data recovery.

In the design of tests and trials we will seek to involve manufacturers and service providers who have prototype equipment which they wish to test or demonstrate to the user community. Previous attempts to enhance the rate of development of new marine environmental technology have tended to produce prototypes which were demonstrated, but not taken up by operational agencies or industry. Since EuroGOOS Members represent a substantial part of the user community in Europe, joint trials in which manufacturers seek to demonstrate equipment which matches the requirements identified by EuroGOOS should cut through this problem.

In November 1995 the USA agency NOAA announced that an International Climate Research Institute would be established to analyse and predict the ENSO cycle. In February 1996 NASA is proposing a centre for oceanographic modelling and data assimilation. Within a short time the USA may therefore establish two major programmes and centres for ocean data assimilation and climate forecasting. EuroGOOS will develop its plans for operational modelling and forecasting of the Atlantic, and its commitment to global modelling, in parallel with the USA initiatives. There will be many different options and alternatives in the development of techniques, so that groups on both sides of the Atlantic can compare results, or collaborate, as appropriate. We are organising a workshop on ocean data assimilation in September 1996.

In November 1995 the USA agency NOAA announced that an International Climate Research Institute would be established to analyse and predict the ENSO cycle. In February 1996 NASA is proposing a centre for oceanographic modelling and data assimilation. Within a short time the USA may therefore establish two major programmes and centres for ocean data assimilation and climate forecasting. The EuroGOOS intention to promote modelling and forecasting of the Atlantic should be treated as a matter of urgency. This requires formation of a Task Team and development of an outline plan within 12 months.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002

EuroGOOS Members will conduct trials of new operational systems, technology, data transmission networks, data assimilation, and testing of products at regional seas scale, Atlantic scale, and globally.

Comment:

In the timescale of 1998-2002 EuroGOOS Members will need to be engaged in an intense programme of development trials and the introduction of equipment and systems which are already known, but not used routinely. The range of devices in the trials and pilot studies will be determined by the outcome of the Technology Plan and the reports of Regional Task Teams at the end of 1996. Series of Trials over the 4 year period will start with short runs or experiments during which data are acquired and tested for quality, but not necessarily processed in real time, through to trials in which the data have to be transmitted, quality controlled, and assimilated into models within prescribed time schedules. The field trial could then be suspended for a period during which the performance of the system was analysed and improved.

In general, such trials are likely to include:

- Regional seas trials of integrated fixed stations, moorings, and drifting or in situ instruments delivering data in real time, or near real time, for trial periods of months, for system evaluation.
- Trials of instrument packages mounted on European Ferries, starting with a small number, and steadily increasing on the basis of experience.
- Trials of operational data gathering, sub-surface and by remote sensing with tests of data assimilation for the North Atlantic.
- Advanced trials in the Baltic and North Seas of multi-parameter forecasting, linking sub-models of dynamics, chemistry, primary productivity and suspended sediments, leading to plot ecological models.
- Trials of integrated data transmission formats, or groups of formats which are compatible and can be translated automatically for the assembly of merged data sets in real time.
- First trials of operational forecasting in the Mediterranean probably restricted to physical dynamics in the early stages, with full depth in situ data and remote sensing. Trials of tomography for forecasting on the Mediterranean scale.
- Later, multi-variable models and trial forecasts for the Mediterranean.
- Trials of under ice routine data acquisition systems in the Arctic.
- Operational trials of coupled global ocean atmosphere models with data assimilation.
- Automatic data quality validation systems for in situ and remote sensed data.
- Data assimilation trials, sensitivity studies.
- Tests of design optimisation, allocation of resources to different parts of the system.
- Operational trials of data acquisition and assimilation from remote sensing systems

already planned in 1996, but which serve as proto- types for operational missions launched after 2002.

- Tests and trials of individual technological systems and sensors, particularly chemical sensors, optical sensors, high data rate systems possibly based on fibre optics, tomography, AUVs, and multi-parameter buoy moorings.
- New data and product distribution systems to improve services to customers.

During the early stages of trials and pilot projects it will be necessary to decide whether Europe needs one or more specialised centres to support the trials, and analyse data, or run prototype operational models.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

Ten years from now the trial systems being tested by EuroGOOS Members will include models on very high power computers, sea-going technology for which the research has not yet been commissioned, and satellite remote sensing for which the missions are now being planned.

Comment:

Discussions are under way with space agencies with respect to the trials needed. The objective by this date should be to have achieved trials with very high data rates from large numbers of unmanned instrument systems which have periods of untended operation of several years. By this stage the decisions will have been taken regarding European Centres for operational oceanography.

EXPECTED RATE OF PROGRESS, AND SUPPORT REQUIRED IN THE MEDIUM TERM

The EuroGOOS Plan, to be produced early in 1997, will include the recommendations of the Regional Task Teams, the Technology Plan WG and the Science Advisory WG, all of which will contain elements requiring trials and pilot projects. Some field trials and tests will be identical to and funded from existing approved programmes and projects of Member Agencies. By early 1997 it will be clear where the greatest increase of expenditure is likely to occur for trials not previously planned. This will be the most expensive component of EuroGOOS activities, prior to actual implementation of new observing and forecasting services. EuroGOOS Members will wish consider new sources of funding, and in particular the advantages of collaboration and/or the involvement of EU EC partners. During this stage it will become clear whether Europe needs a major centre for trials and development of an ocean observing system.

ACTIONS AND SUPPORT REQUIRED ON THE LONGER TIMESCALE

Trials and pilot projects are the most expensive phase of development prior to implementation of new observing systems by EuroGOOS Members. There is a necessary incurring of costs and expenses in the field, the costs of running prototype modelling and forecasting systems, and the risk of failure, with no income yet being generated by the new system. Good business planning and assessment of risks are essential. Manufacturers who are prepared to invest in new operational oceanographic instrument systems, and wish to test and calibrate them in the context of realistic trials conducted to the specification of users, will be approached with a view to participation in trials. In view of the importance of reducing risk and avoiding expensive duplication of trials, there is a very strong case for collaboration on the European scale, or "variable geometry" collaboration at the regional scale, or in trials for specific instruments, so that all Members obtain the maximum benefits for minimum costs. Collaboration creates its own costs through overheads and delays, but some of these costs should be suitable for funding from EU sources. The investment in one or more European Centres for trials and/or implementation of the operational oceanographic services will have to be carried out and justified on the basis of economic and social benefits to Europe.

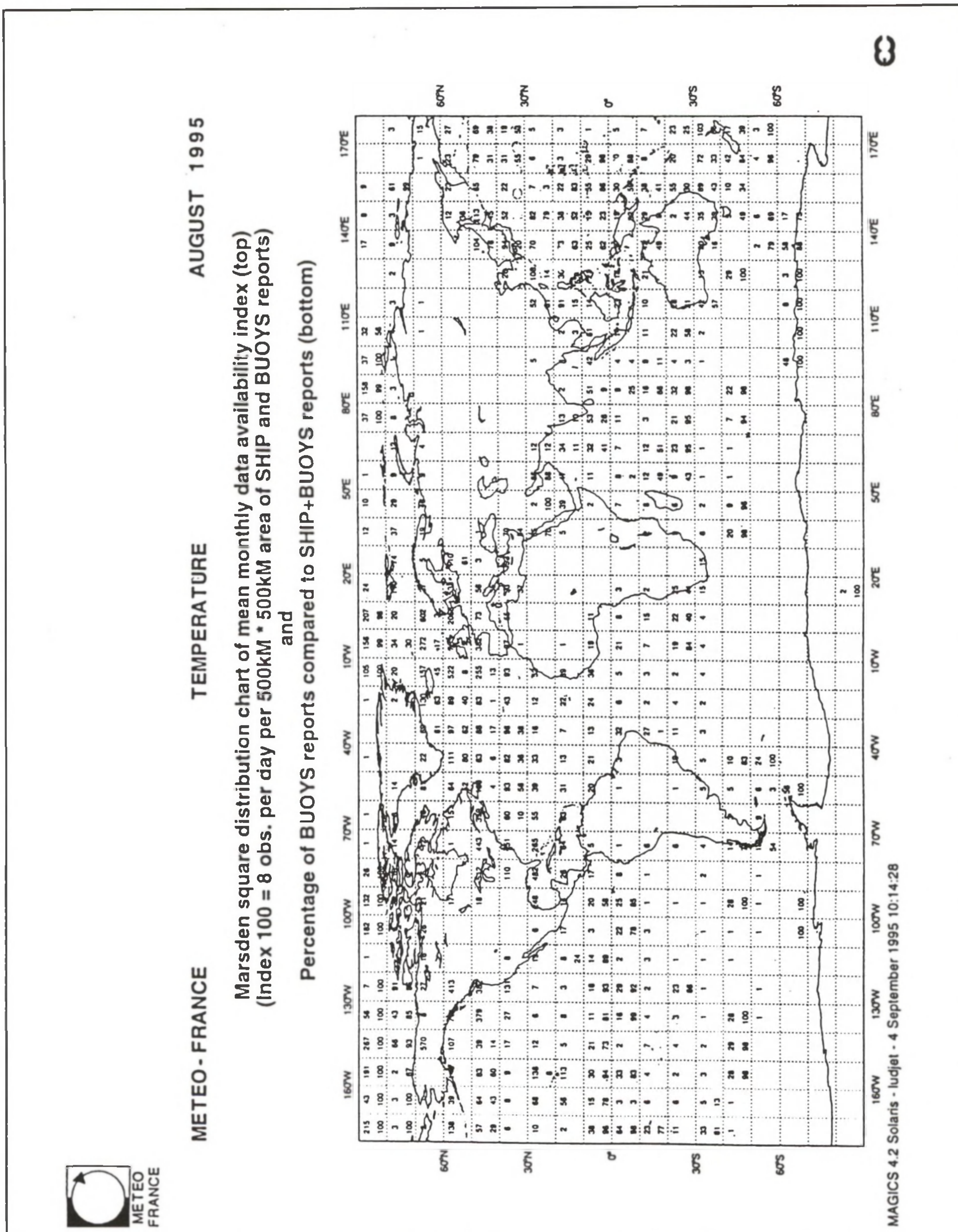

Figure 4.7
Global distribution of sea surface temperature observations obtained from ships and drifting buoys
Source: Meteo-France

STRATEGIC SECTOR 6

OVERALL STRATEGIC OBJECTIVE

To implement progressively new observational instruments, data transmission systems, and modelling centres in such a way as to provide a continuously improving range of economically useful products, and to generate these products with the optimum observing and sampling design and the lowest feasible cost.

Comment:
Through the Technology Plan WG and the Scientific Advisory WG, together with the Reports from the Regional Test Cases, EuroGOOS Members will be in a position to define the observational strategy which is most suitable in each region, including the open Atlantic.

We assume that all potential observing technologies must be evaluated: satellite remote sensing, airborne, ship-borne, towed instruments, shore-based stations, subsurface installations, drifting buoys, subsurface buoys, and AUVs. EuroGOOS Members will review the technical performance of the available and future instruments, and the potential and limitations of predictability, so as to derive the most cost-effective observing strategy.

An operational system must be introduced gradually, with trial phases, and periods of evaluation when users can compare the actions which they would have taken with and without the operational predictions. We will use the advice from the WGs to develop methods for assessing the trade-offs between different options in the design of the observing system. For example, given a planned increase in investment in the system, should the extra resources be allocated to improved remote sensing, better assimilation procedures, a higher spatial resolution in numerical modelling, improved instrument sensors, or higher temporal and spatial resolution of in situ observations?

We regard the solution, or at least partial solution, of this problem as one of our key objectives.

OBJECTIVE FOR EuroGOOS UP TO END 1998

Establish procedures for defining the optimum observing scheme and rate of development for each Region and the Atlantic, drawing on the results of subsidiary bodies of EuroGOOS. Begin testing and implementing these procedures in the Regions which are most advanced.

Comment:
The SAWG will report on the necessary steps towards defining the limits of predictability for each range of variables, while the data requirements surveys and Regional TTs report on each Region will provide guidance on priorities. From this information it will be possible to identify the strengths and weaknesses of the available observing systems and modelling centres in each Region, and the most urgent additions or improvements. There are well established observing networks already in several Regions and sub-Regions, collecting data on a restricted range of variables and for differing purposes. The data from these systems should be incorporated in the EuroGOOS data flow whenever possible, without detracting from the existing objectives of the sub-Regional networks. Given the required products and services in the Region, and the theoretical limits of predictability and sensitivity of models to provision of data, a sampling strategy could in theory be designed and implemented. By end 1998 it is probable that the information and procedures for doing this can be set out, but that the conduct of trials of different options have not yet been tested.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002

Improve procedures for optimising the observing system and conduct trials of different options through varying assumptions and boundary conditions in models, using or not using far-field

information from global models, inclusion or deletion of available instruments, and improvements in the accuracy and number of data acquisition sites.

Comment:
This stage is at the core of the logic of EuroGOOS. Agencies could develop a wide range of regional and sub-regional limited-objective observing programmes without GOOS or EuroGOOS, but the efficiency and benefits of an integrated system covering the whole European and Atlantic area can only be achieved at an affordable price by carrying out the trials and design proposed. All countries and agencies in the EuroGOOS community would benefit from collaboration and cost-sharing in these studies and trials. The results of the first stages of trials will provide data for improving the design of models and instrumentation, emphasise which instruments or data types are most important for constraining models, or which geographical locations are most sensitive regarding presence or absence of data at certain seasons. The trials conducted at this stage therefore profoundly influence the subsequent development of technology, including instrumentation, size of computers required, and modelling software.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

The optimisation of the observing system and correct allocation of resources is a continuing obligation as the system is developed. There must be a continuous review and trial procedure to assist in phasing the introduction of new technology, new communications systems, and new modelling capabilities.

Comment:
The design and optimisation of the observing network providing data to the EuroGOOS Member Agencies should be under continuous or regular review, assessment, and up-grading. In the time-frame 2002-2006 new variables will still be being added to the system, and new operational satellites with new systems will be launched. The need for trials and review will therefore not be diminished. On this timescale there will be radical improvements in in situ instrentation, producing reliable availability of chemical, biogeochemical, and sedimentological data. These data streams will have to be included in fresh evaluation of model design and observing optimisation.

EXPECTED RATE OF PROGRESS, AND SUPPORT REQUIRED IN THE MEDIUM TERM

Preliminary assessment of the options for design optimisation will be completed by early in 1997, but a significant attack on the problem will take several years, and require resources. Design optimisation at the Regional level, e.g. Baltic or Mediterranean, can probably be conducted largely by the Agencies of the riparian states, with other participants chosen with a free "variable geometry". Experience will have to be shared between Regions, and there will have to be a full European dimension for analysing the models and observing requirements at the Atlantic-European scale, and the interface of this scale with the global models. There is a strong case for European funding at this stage.

ACTIONS AND SUPPORT REQUIRED ON THE LONGER TIMESCALE

Europe has the experience and ability to design and manage a near-optimal observing system in the Atlantic-European- Mediterranean area. On the Medium Term it will already be necessary to consider collaborative or EU investment in special Centres to get the advantage of combining both data and expertise. On the longer timescale, as the benefits of operational oceanography materialise and the customer base is strengthened, enhanced levels of collaboration and investment will be necessary. Economic analysis of the products of EuroGOOS and its benefits will then become important.

STRATEGIC SECTOR 7

OVERALL STRATEGIC OBJECTIVE

To develop, test, implement and up-grade the most efficient numerical models for those marine variables and parameters which are of highest priority for users of operational forecasts; to identify and compare the best modelling systems for different variables, regions, and scales; to develop the most efficient data assimilation methods for operational ocean modelling and forecasting.

Comment:
Operational numerical modelling of the marine environment is at the heart of the EuroGOOS strategy. Data gathered from all types of sensors and platforms must be transmitted rapidly to data management centres, and processed for use in numerical models. The resulting analyses and forecasts must then be distributed rapidly to users or value-added organisations.

Surveys of data product requirements so far indicate that there are 10-20 physical parameters and 4-5 chemical parameters describing the marine environment which are most frequently required by most users of operational data. Of these, numerical modelling capability at present permits operational services for wind, waves, tides, meteorological forcing of the sea surface, storm surges, currents, temperature, salinity, and floating sea ice. There are urgent requirements for further chemical, biological and sedimentological parameters which can not yet be reliably modelled in an operational mode.

It is inconceivable that an observing scheme will ever be so intensive that a mere contouring of the data would present a usable product for most customers, since every user tends to need very local site-specific information. By assimilating new data into numerical models, whenever possible, and generating products based on the diagnostics and predictions of the models, EuroGOOS Members can distribute high quality information whilst keeping observation costs within practical limits.

We place a high priority on speeding the process of validating research models and transferring them to operational agencies. Within the operational agencies further effort is then needed to engineer the modelling procedures into a robust form which can be operated routinely, cope with defaults in the data flow, and operate round the clock. There are many problems still to be solved, especially in the area of data assimilation.

There are some types of important marine data, especially those applicable to fisheries, pollution monitoring, and other biological processes, which cannot be modelled yet, or which depend upon lengthy chemical analysis or human identification of species. These data types produce important operational information, even if they will not be subject to real-time numerical modelling in the foreseeable future.

OBJECTIVE FOR EuroGOOS UP TO END 1998

Transfer existing research models and prototype models into the operational sector where appropriate; emphasise data assimilation software, and models of physical variables including tides, meteorological forcing, sea level, wind stress, waves, surface currents and sea ice; subsequently introduce temperature profiles, salinity, chlorophyll, and current profiles; start process of developing Atlantic research models as operational models; define limits of predictability for different variables, models, and scales.

Comment:
The EuroGOOS Scientific Advisory WG includes experts who are concerned with the development of new numerical models. Models which are at present used operationally have usually been developed in research laboratories where they have

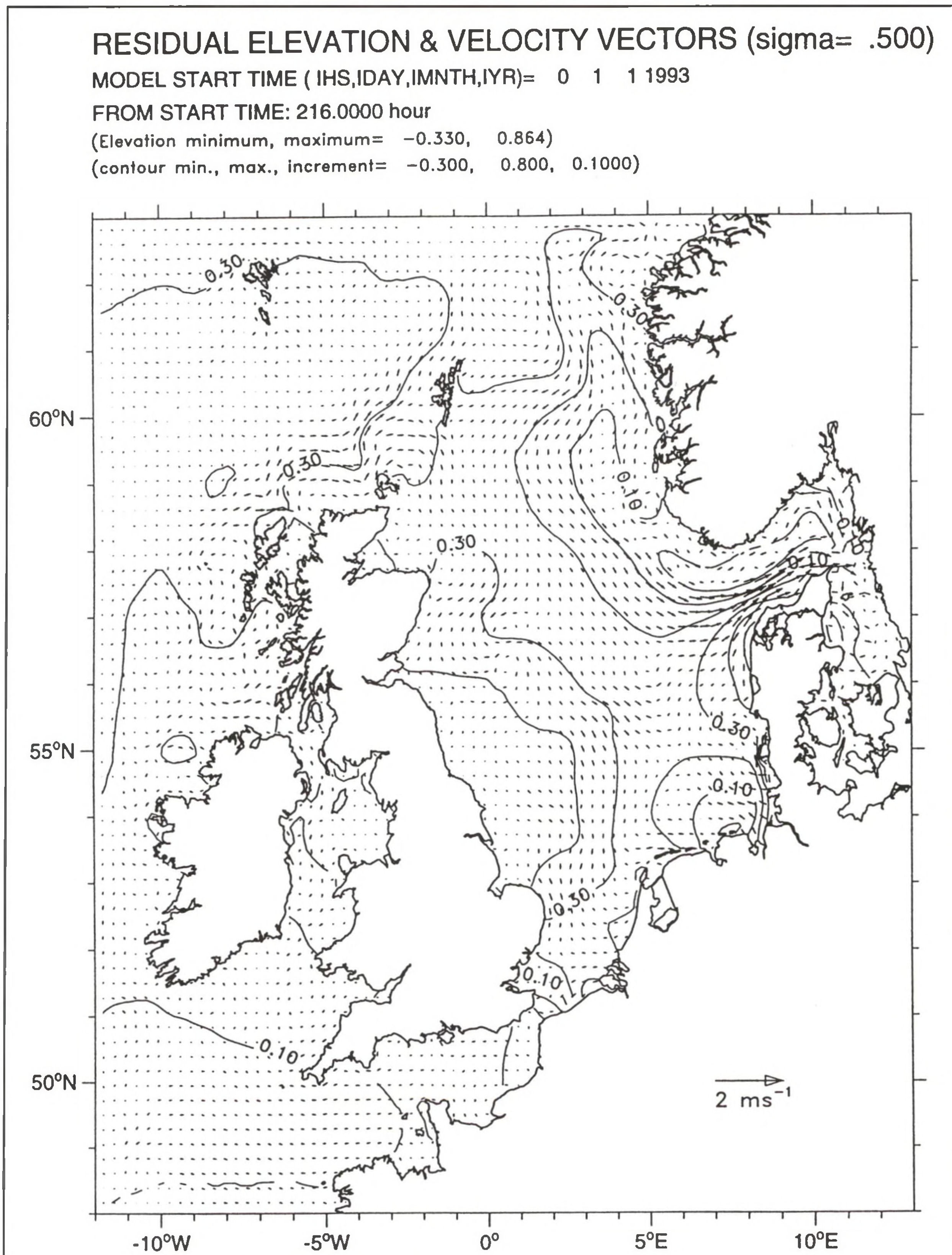

Figure 4.8 Model output showing the predicted mid-depth currents and surface elevation at the time of the Braer oil spill. The model is for 00 hours on 10 January 1993

Source: R A Flather and S C M Kwong, Proudman Oceanographic Laboratory several years of adjustment and improvement before transfer to an operational agency. Within EuroGOOS, the SAWG will be able to monitor the development of models which are in the research phase, and advise when they are ready for transfer and investment as operational tools. Conversely, the SAWG will be aware of the needs of EuroGOOS, and hence will be able to focus attention on those models which are most likely to meet the requirements of EuroGOOS Members.

In November 1995 NOAA announced plans for an ENSO modelling and forecasting centre. In February 1996 there were discussions in the USA about NASA support for an ocean data assimilation centre, with global remit.

For several years the DG-XII MAST Modelling Group has provided a forum for the discussion of all kinds of marine numerical modelling, and ESF has funded two recent meetings, one on ocean modelling, and one on forecasting the Mediterranean. An enormous variety of numerical models have been developed ranging from coastal morphodynamics and predictions, through to ocean basin climate modelling, advanced global wave modelling (WAM), and the Fine Resolution Antarctic Model (FRAM). Models are based on a variety of different scientific and mathematical assumptions and approximations, use different coding procedures, different programming languages, and are hosted on different types of machines from Cray-type super-computers to massively parallel systems. In each case the modelling team has used the best criteria to design a model for their special objectives.

It has been suggested that in order to allow scientists and development groups to continue using specialist models, while gaining the benefits of compatibility and integration between operational models, there is need for a Common Model Environment organised as an open system. This proposition has been analysed most fully in the Netherlands.

The most effective shelf seas models at present produce grid resolution of the order of 0.5km for physical hydrodynamic parameters These models can be interfaced to smaller nested models for estuaries and coastal processes, and interfaced to larger ocean models and global meteorological forcing. Operational and near operational models for the Arctic and Atlantic include BOAT, AIM, FOAM, GIM, SOAP, MAESTRO, and OCCAM.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002

Implement operational models in all European Shelf Seas, the Mediterranean and adjacent Arctic predicting hydrodynamic parameters, chlorophyll, nutrients, water quality, primary productivity, suspended sediment load, coastal sediment transport, and coastal erosion; implement operational models for the Atlantic and Arctic Oceans monitoring and forecasting sea surface temperature, upper ocean heat content, full depth temperature and salinity profiles, sea ice cover, wind stress, directional wave spectrum, surface currents, mesoscale eddy fields, 3-D circulation, estimates and predictions of ventilation and convection, upper ocean nutrients, chlorophyll, CO2, primary productivity.

Comment:

The development of coastal and shelf seas modelling will be a logical and technological continuation of techniques already identified. The Mediterranean will be a special case since the characteristics of the Mediterranean basin require consideration of ocean depth processes as well as coastal and shelf seas processes, within close proximity. The Arctic is also a special case, requiring analysis of ice formation and melting, as well as the technical problem of obtaining routine data from beneath the sea ice. The Mediterranean modelling, once it approaches operational status, requires complex political negotiations to ensure full involvement of all riparian states. Arctic and Atlantic operational modelling will require collaboration, or at least a division of responsibilities, with respect to North and South American countries, and Arctic riparian states.

The WOCE Analysis, Interpretation, Modelling and Synthesis Phase to 2002 provides a valuable opportunity to phase across the experience of the research phase of observations and modelling of the Atlantic towards operational model design. The planning and implementation of CLIVAR should also provide useful information at the Atlantic and Arctic scales.

On this timescale the establishment of European modelling centres becomes important . The capability of existing centres and operational agencies will need to be assessed, and consultation will be needed with ECMWF.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

EuroGOOS Members need the best modelling capability available in the world in order to achieve the objectives of modelling and forecasting the shelf seas and oceans. Through collaboration within Europe, and through participation in global GOOS, and partnership with similar programmes in North America, Asia, and Australia, EuroGOOS will achieve and maintain this standard of modelling.

Comment:
The change and advance in modelling procedures is rapid, and European agencies will need to participate in and learn from global programmes, both research and operational, in order to keep up with the state of the art. The increase in computing power, increase in data transmission rates, and increased availability of small portable and powerful computers will create a totally novel environment for modelling and the distribution of products.

EXPECTED RATE OF PROGRESS, AND SUPPORT REQUIRED IN THE MEDIUM TERM

There are some well-proven research models functioning in European institutions in 1996 which are ready for transfer to operational status, with the provision of adequate trials and engineering. In most cases the cost of this transfer is part of the approved objectives and funding of the operational agencies. By 1998 the complexity of models, team size needed to write the large volumes of code, and the cost of up-grading computers, will all produce a premium on collaboration and cost-sharing. In the Medium Term the discussion about modelling centres will lead to necessary decisions on investment on the largest super-computers and massively parallel systems.

Trials of such large computers and modelling systems may be eligible for EU-EC support for technology development, telematics, or IT.

ACTIONS AND SUPPORT REQUIRED ON THE LONGER TIMESCALE

As with the Medium Term, there will be a strong case for collective investment, or central EU-EC funding in the most advanced computer systems for ocean modelling, and coupled ocean atmosphere modelling.

STRATEGIC SECTOR 8

OVERALL STRATEGIC OBJECTIVE

To produce regularly a full range of competitive marine data products and services which are designed to meet economic, social, and environmental applications, and which can be transmitted through an array of value-added data processing organisations to wide range of end users.

Comment:
There is a hierarchy of data types and products which must be delivered appropriately to many tens of different user classes, and potentially many thousands of final end users. This implies a chain of intermediate data processing and product generation organisations, successively making more and more complex or subtle derived multi-parameter products. EuroGOOS Members are able to define some of the initial data requirements at the input level, and the basic level of marine modelling.

We have started a survey of end user data requirements, using a questionnaire which will be sent to several hundred potential usersuser of operational information in each country. The survey has been distributed to potential customer in Italy, is ready to run in Spain, and Greece, and almost ready to run in several other countries. The survey has already been run successfully in the UK, and to a limited set of users of coastal data by ESA. In Ireland the survey has been adapted and applied to a limited number of customers. This survey will provide essential guidance on what users require in each European region.

Assuming that Members are willing to compile the address lists of data users, or at least publish the number of users in each application category, it will be possible to see which observations, data processing methods, and models will satisfy the requirements of most users. This in turn will show what observations will have the greatest economic benefit in each region.

OBJECTIVE FOR EuroGOOS UP TO END 1998

Complete the user data requirement survey; compile an address list of at least 2000 potential users of operational marine data; correlate the variables and products required to classes of end-user and regions; prioritise the design of products; conduct dialogue with user groups through the EuroGOOS Conference in October 1996.

Comment:
The customer data requirement survey will be completed during 1996 in most countries with EuroGOOS Members. This will provide an address list of at least 2000 potential customers. During the next two years contacts with customers will be improved by consultation during the EuroGOOS Conference, and regular mailings to chosen sectors. Information on EuroGOOS and operational products will, at a suitable date, be made available through the World Wide Web.

The media for communication and distribution of products are changing rapidly. EuroGOOS Members are in a position to experiment with variants of CD ROMs, networks and e-mail, fax transmission, Web Pages, 3-D visualisation of complex fields, electronic charting and navigation, automatic up-dating of data sets. Some products which are already available can be greatly improved by combining the expertise, observations, and distribution services around given sea areas.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002

Improved communications with customers; establishing a core list of large commercial organisations and government and international agencies prepared to participate in developing a funding base for operational ocean satellites; using the customer list to conduct surveys for improved data products and services.

Comment:
As product range increases, and the forecast horizon is extended, EuroGOOS Members will gain a much more detailed picture of the user community, the range of value-added organisations re-processing EuroGOOS data, and the economic scale of the final end users. This information can be used to improve economic assessment of the value of operational marine forecasting, to improve the product range, and to identify appropriate methods for funding.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

Establish continuous automatic customer service monitoring system which records products being used most frequently, scales and parameters most frequently required, problems most frequently encountered in satisfying requests. Routine comparison of services required within Europe and globally. Maximise promotion of European operational oceanographic services globally.

Comment:
Within a system which is dedicated to automatic information handling it will be possible to maintain automatic logging of the frequency of demand of products and services. This can be developed to provide a constant feedback of information to guide development of the system.

EXPECTED RATE OF PROGRESS, AND SUPPORT REQUIRED IN THE MEDIUM TERM

Most EuroGOOS Members already provide some range of operational or off-line services. The surveys of customers will be completed on this timescale, and new products introduced based on improved collaboration around Regional Seas. MAST has funded some projects based on new methods of data processing and data visualisation and distribution. EuroGOOS Members have a primary interest in improving products and product delivery, and there may be a case for joint research or innovation in this sector. Consideration should be given to assessing the adequacy of communications links for product distribution.

ACTIONS AND SUPPORT REQUIRED ON THE LONGER TIMESCALE

The long term development of new products and delivery systems is an iterative process. Different stages of the development may be eligible for funding under the headings of Informatics, Telecommunications, Data Management, Computer development, etc.

STRATEGIC SECTOR 9

OVERALL STRATEGIC OBJECTIVE

To develop policies for the furtherance of GOOS and co-ordinating the best European participation in GOOS, identifying where the greatest value is added by collaboration. To ensure that GOOS plans and implementation globally are balanced to provide the best data sets and models which produce scientific, economic, and environmental benefits on an equitable basis.

Comment:

EuroGOOS is planned within the context of the Global Ocean Observing System (GOOS). All documents are copied to the I-GOOS Office in IOC Paris, and correspondence is maintained with J-GOOS. EuroGOOS is ready to work with the North East Asian Region of GOOS (NEAR-GOOS), and conducts close collaboration with the US-GOOS Office.

The USA has declared its intention of forming an International Research Institute (IRI) to conduct trials into the forecasting of the El-NiÔoNino-Southern Oscillation (ENSO) cycle. These forecasts will be of great benefit to all nations in the tropical region. Our strategic policy is that the Member Agencies have a common interest in monitoring and forecasting the Atlantic Ocean. This policy includes monitoring and predicting the Arctic Ocean insofar as it influences the economic activities of the northern European states, and determines climate in Europe. Activities on the oceanic scale, both Atlantic and Arctic will be planned in close co-operation with non-European countries, and with existing international bodies. Since modelling on an ocean basin scale from pole-to-pole necessitates inclusion of interactions between ocean basins, and between the ocean and the global atmosphere, we must have global objectives.

We must ensure that the benefits of operational oceanography are available to developing countries, and that developing countries are assisted to participate in GOOS from the start.

OBJECTIVE FOR EuroGOOS UP TO END 1998

To specify EuroGOOS objectives and capabilities for observing and modelling the Atlantic and Arctic within the framework of GOOS; identify those global components of the observing system which could be contributed by Europe, especially with regard to remote sensing; to identify regions in other oceans (Indian, Pacific, Antarctic) where European skills could contribute to GOOS.

Comment:

The general principle of EuroGOOS Members supporting and promoting the objectives of GOOS is agreed, and some Members are already involved in global research projects which include sections and stations that will probably be continued as part of GOOS. The publication of the Draft Priorities Agreement Document for GOOS indicates those variables which will have to be monitored globally, and Members can see where they can best contribute to the system. We will now analyse in more detail the actions which we can take to support GOOS, but this is in part limited by the rate of progress of GOOS itself in setting goals. There will be iterative interactions.

EuroGOOS Members will participate in the meetings and programmes of GOOS, its workshops and task teams. In particular, EuroGOOS Members will participate in those activities which are designed to assist capacity building in developing countries, and to assist developing countries in identifying their potential benefits from GOOS.

EuroGOOS Members will seek to ensure that they contribute resources and materiel at an appropriate level towards to the total global infrastructure and operations of GOOS, in collaboration with other agencies from all IOC Member States. EuroGOOS Members will seek to ensure a successful outcome to the planned GOOS Priorities Meeting in early 1997 September 1996.

In order to promote assistance to developing countries, two sessions of the First EuroGOOS Conference will be devoted to this subject.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002 AND BEYOND

EuroGOOS Members will participate in the design and development of GOOS on this timescale, and will make available to GOOS the results of test cases and trials in the European Regional Seas and in the Atlantic.

Comment:
The technologically developed countries and their regional groupings will tend to make the most rapid progress in he development and implementation of the component systems of GOOS. This will happen in parallel with capacity building and technology transfer to developing countries. The regions of most rapid technological development of GOOS are likely to be Europe, North America, North East Asia (where a GOOS Region has been set up), and Australia, possibly in collaboration with some South East Asian countries. When equipment or procedures have been demonstrated and proved to work operationally in the European region, it will be the policy of EuroGOOS to contribute the data to the Global data transmission network of GOOS, and to make available the results of trials and development of equipment.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

EuroGOOS will seek to maximise its contribution to and return from participation in GOOS by co-ordinating research and operational cruises, advising on the plans for operational satellite schedules, and exploiting the technological systems developed in Europe. We will promote aid and technology transfer to developing countries to help facilitate their full participation in GOOS.

Comment:
As for Medium Term Objective.

EXPECTED RATE OF PROGRESS, AND SUPPORT REQUIRED IN THE MEDIUM TERM

Progress will tend to be restricted to analysis and planning in the first few years, and EuroGOOS Members will tend to emphasis implementation in the Regional Seas and in the Atlantic and Arctic. As the plans for GOOS itself become clearer, the most useful objectives for EuroGOOS in GOOS will be defined. At this point it may be appropriate for Europe to offer to host a major component of GOOS, such as a global modelling centre, remote sensed ocean data processing centre, or to take responsibility for repeated surveys in a part of the world ocean which would otherwise be completely unsampled. Collaboration between Members, and/or the allocation of EU funds might then be appropriate.

ACTIONS AND SUPPORT REQUIRED ON THE LONGER TIMESCALE

As for Medium Term.

STRATEGIC SECTOR 10

OVERALL STRATEGIC OBJECTIVE

To link efficiently with other European organisations so as to promote the rapid development of operational oceanography without duplication, overlap, or excessive bureaucracy.

Comment:
The list of European organisations relevant to EuroGOOS is given in Chapter 5. At present ESA, ICES, and EUROMAR have Observer status in EuroGOOS, and documents are copied routinely to EC-DG-XII, ESF, EOPSP, EMaPS,, and IOC. EuroGOOS Secretariat staff have attended meetings of the north Sea Fixed Station Workshop/SeaNet. It is an urgent task for EuroGOOS to establish working relations with many other bodies in Europe, and to define as economically and efficiently as possible the communications or contacts required, without wasting peoples' time. The EuroGOOS Strategy Document is designed to start the process of communications.

OBJECTIVE FOR EuroGOOS UP TO END 1998

To make first contact with most organisations listed in Chapter 5, if they are not already part of the EuroGOOS communications system.

Comment:
EuroGOOS depends upon the underpinning scientific research of many programmes and projects. The output and benefits of EuroGOOS operational oceanography will directly support the objectives of DG VII, DG XI, DG XII and DG XIV, as well as the EEA, and OSPARCOM. EuroGOOS participated in the recent EUROMAR-MAST Conference at Sorrento (Nov. 1995) and established good scientific and technical links to the DG-XII MAST programme.

The EuroGOOS Conference will take place in October 1996 and is a forum where the objectives and achievements of EuroGOOS can be discussed with representatives of various DGs.

MEDIUM TERM OBJECTIVE FOR EuroGOOS UP TO END 2002 AND BEYOND

Build up routine communications with other European agencies and organisations, and, where relevant, enter into joint projects or programmes.

Comment:
There are many national and regional data gathering exercises in European waters, which are conducted to meet statutory obligations for maritime safety, water quality monitoring, pollution control, meteorological forecasting, flood forecasting, and fisheries management. We cannot and should not disturb existing arrangements where they are adequate and appropriate to their objectives. From the EuroGOOS point of view these data streams are under-exploited, in that they are not collected, transmitted, or formatted in such a way that the data from different programmes could be merged or processed in a single model. Exercises are already under way, especially through SeaNet in the North Sea, and through collaborative arrangements in the Baltic, to develop more consistent data management within some of these programmes. Inventories and reports of instrument types and data formats have been provided by these programmes to EuroGOOS. Wherever possible we will seek to encourage this increase in compatibility, and to add further observing stations or systems, such as routine observations from ferries, and to develop extra data transmission links and automatic data quality control, so that these data can be assembled and assimilated into forecasting models.

This approach will avoid unnecessary duplication, build on the expertise of specialist groups who have send many years developing successful systems, and will provide extra information through multi-variable models.

LONG TERM OBJECTIVE FOR EuroGOOS TO END 2006 AND BEYOND

Maintain communications and joint projects and programmes with other European agencies and organisations.

Comment:
As for Medium Term.

EXPECTED RATE OF PROGRESS, AND SUPPORT REQUIRED IN THE MEDIUM TERM

EuroGOOS Officers will visit as many other organisations as possible during 1996, and hope to establish working relations and possible funding or joint projects in the Medium Term.

ACTIONS AND SUPPORT REQUIRED ON THE LONGER TIMESCALE

We will develop standard data transmission routines for gathering data to modelling centres, and these will evolve so as to ensure compatibility wherever possible with existing observing systems and data sources. Considerable investment will be needed in new procedures for data transmission, algorithms for converting data between formats, and automatic data quality control systems. Since these developments will be of value to the local and regional observing networks, and to EuroGOOS as a whole, there is the possibility of collaborative funding, with EU support.

THE STRATEGY FOR EuroGOOS

SYNTHESIS

The framework of strategic objectives for EuroGOOS under 10 headings, and 3 timescales, provides a checklist of actions and the basis for a complete Implementation Plan. Previous Chapters have established the reasons for EuroGOOS, and the economic and other external objectives. This Chapter has shown how the future actions of EuroGOOS Members can be structured to achieve the overall objectives at the level of technical decisions. It will be possible to specify the subsidiary objectives more precisely, to monitor progress, and provide the feedback for further decisions, using this framework.

Applications for financial support for any one of the objectives identified here can be justified on the basis that it is a necessary component of the logically constructed programme.

CONCLUSIONS

The analysis of strategic objectives and subsidiary objectives outlined in this Chapter is sufficient for the development of a First Implementation Plan for EuroGOOS, which itself should be revised and developed on a rolling basis. The strategy and objectives described here can serve as guidance for the future development and design of EuroGOOS, and for the actions of its Members, as appropriate. If Members take unilateral or multilateral decisions which are consistent with these objectives, the goals of EuroGOOS will be promoted with minimum bureaucratic overheads.

Chapter 5

Resources, Assets and Opportunities

Strong science and technology community with increasing European cohesion arising from MAST, EUROMAR, ERS-1, ERS-2 and TOPEX-POSEIDON

Effective national agencies with relevant skills, national GOOS Committees, and national co-ordination

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Strength of relevant European Agencies and Institutions

Ocean services already exist in the public and private sectors

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Strong customer base with direct interest in European Regional seas and additional world-wide interests

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Growing European Commitment to improving the health of the marine environment

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Global and European Commitment to Climate prediction requiring ocean forecasting

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Commitment to Biodiversity Convention including protection of marine biodiversity

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Figure 5.1a Technology for EuroGOOS

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

Chapter 5

Resources, Assets and Opportunities

STRONG SCIENCE AND TECHNOLOGY COMMUNITY WITH INCREASING EUROPEAN COHESION ARISING FROM MAST, EUROMAR, ERS-1&2, AND TOPEX-POSEIDON

Figure 5.1b Discoid buoy 'META-1'
The buoy has a diameter of 12m and a draught of 1.6m. It is fitted with solar panels and a diesel generator. The sensors are installed in a sensor frame undernearth the bottom of the buoy in a depth of about 2m. Access to the sensors is via a moon-pool of about 70cm diameter. On the mast navigational lights, antennae and meteorological sensors are installed. The buoy is located in the salinity gradient of the Elbe in front of the Kiel canal near Brunsb,üttel.
Source: EUROMAR-Mermaid, GKSS

Europe possesses skills, organisation, assets, experience, and opportunities which place it in a very strong position to develop an operational oceanographic capability of world class. The assets are necessary ingredients in carrying out the Strategy described in Chapter 4. The assets are summarised in this chapter.

The marine scientific and technological community in Europe has become increasingly and consciously European in the last 10 years. Collaborative projects supported by EC and ESF have created linkages and trans-national understanding which encourages scientists and institutional managers to think automatically of conducting research and operations at the European level. Contributory factors have been the Marine Forum, the MAST Programme of DGXII, EUROMAR of Eureka, the Fisheries Research programme of DG-XII, and the Task Force on Marine Systems of the Future. The First Call for Proposals for MAST-III identified operational marine forecasting as an important theme, and the second call for proposals (March 1995) specifically refers to the importance of research projects which will support the development of EuroGOOS. EuroGOOS will monitor the project proposals submitted, and maintain close contact with groups conducting research which is of the highest priority.

THE MARINE SCIENCE AND TECHNOLOGY COMMUNITY IN EUROPE POSSESSES THE FOLLOWING SPECIAL SKILLS AND ASSETS:

- World class numerical modelling groups in several universities, government laboratories, and meteorological offices.
- Access to the skills of the European Centre for Medium term Weather Forecasting.
- Access to advanced super-computers and powerful regional and national data transmission networks.
- Oceanographic data centres in most countries, already familiar with cross-border collaboration through participation in the DG-XII MAST Data Committee, and the IOC Committee for International Oceanographic Data and Information Exchange.
- Long historical records of oceanographic conditions in coastal seas, in the Mediterranean, and in the North Atlantic. These data sets are being retrieved, validated, and converted into machine readable formats.
- Close collaboration between marine scientists and the European Space Agency and CNES through frequent workshops, consultative meetings, user groups, and conferenes related to coastal oceanography, operational oceanography, and polar research and forecasting.
- Good working relations between individuals and agencies working in strategic research and in operations.
- A fleet of ocean-going and coastal seas research vessels.
- Networks of buoys and coastal measurement stations which provide an embryo structure for an observing system.
- Experience of developing research models and operational models for existing regional services such as storm surge forecasting, and wave modelling and forecasting.
- Access to specialist groups working on data quality control, instrument calibration, chemical standards, and other necessary elements of a consistent observing system.
- Innovative groups working within research departments and commercial companies developing new oceanographic instrumentation.
- Advanced technology in Remote Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs).

EFFECTIVE NATIONAL AGENCIES WITH RELEVANT SKILLS, NATIONAL GOOS COMMITTEES, AND NATIONAL CO-ORDINATION

In 1993 ESF compiled a list of all identifiable European marine research laboratories, governmental and university, but excluding private and industrial facilities. Over 350 establishments were identified. This catalogue was used by ESF as the basis for establishing the European Marine & Polar Sciences Board (EMaPS).

The 22 EuroGOOS Members from 14 countries are all national agencies or organisations with established track records in operational meteorology, operational oceanography, or strategic research in support of operational oceanography. The list of Members is given in Annexe 1.

EuroGOOS Members are almost all involved in internal national negotiations to establish co-ordination for GOOS and EuroGOOS participation. In a typical technically advanced country there are between 5 and 10 national agencies or departments with strong interest either in monitoring and forecasting the state of the sea, or in using the data from such observation systems. Although the structure and division of responsibilities varies between countries, the agencies involved are usually the following:

- Department of the Environment,
- Environment Protection Agency
- Ministry of Fisheries
- Department of Transport and Shipping
- Department of Harbours and Ports.
- Ministry of Technology and Science
- Department of Energy
- National Meteorological Agency
- Department of the Navy
- Ministry of local government, Coastal protection and Flood prevention.
- Department of Foreign Affairs

The planning and conduct of operational oceanography within a country requires a level of technical co-operation between the major players within this group. The style and procedural arrangements adopted to support this co-operation varies considerably. EuroGOOS Members (August 1996) report different stages of agreed collaboration ranging from a formal national GOOS Committee, through inter-agency working groups, and informal working arrangements between experts. In all countries with EuroGOOS Member Agencies the negotiations are continuing to strengthen the collaboration.

The cohesion between agencies and research groups in different countries across Europe is strengthening steadily in support of operational oceanography (see Chapter 1).

STRENGTH OF EUROPEAN AGENCIES AND INSTITUTIONS

There are nineteen international bodies with exclusively or dominantly European national membership which provide a strong infrastructure for the development and utilisation of operational oceanography in Europe. The existence of these bodies is a major European asset in the planning of EuroGOOS and GOOS.

The following bodies will be reviewed briefly in the context of their role or relevance in developing operational oceanography for the benefit of Europe:

ORGANISATIONS WHICH ARE EXCLUSIVELY EUROPEAN

EU/EC	**European Union, Commission of the European Communities**
WEU	**Western European Union**
Eureka	**European Research Programme (EUROMAR)**
CoE	**Council of Europe**
ECOPS	**European Committee on Ocean and Polar Science**
ESF	**European Science Foundation**
EMaPS	**European Marine & Polar Science**
Eumetsat	**European Meteorological Satellite organisation**
ESA	**European Space Agency**
EEA	**European Environmental Agency**
OSPARCOM	**Oslo and Paris Commission**
ECMWF	**European Centre for Medium Range Weather Forecasting**
MIF	**Marine Industries Forum**

LEADING INTERNATIONAL ORGANISATIONS WITH SOME NON-EUROPEAN MEMBERS

G7	**Group of Seven**
OECD	**Organisation for Economic Co-operation and Development**
NATO	**North Atlantic Treaty Organisation**
ICES	**International Council for Exploration of the Sea**
UNEP-MAP	**United Nations Environment Programme, Mediterranean Action Plan**
HELCOM	**Helsinki Commission**

• EU/EC

Members: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, UK.

Strongest European political and financial body. Includes almost all the big oceanographic players. Has a strong commitment to promoting science, technology, economic development and environmental protection on a European and global scale. Supports a number of environmental and marine research programmes. Marine industry and trade have been discussed at European Parliament level, and there is a Marine Industries Forum. Also note Research-Industry Task Force for Marine Systems of the Future. EuroGOOS is an operational system, not exclusively science driven, and several EC DGs would be involved, namely DG-III, DG-VII, DG-XI, DG-XII, and DG-XIV.

• WEU

Members: Belgium, France, Germany, Italy, Luxembourg, Netherlands, Portugal, Spain, UK.

Has access to navies. It is keen to find active roles.

• EUREKA

Members: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Turkey, UK.

Dedicated to technology development, and has strong EUROMAR programme which involves European industrial companies. Russia has applied to join, and has been accepted in principle, subject to conditions.

• COUNCIL OF EUROPE

Members: Austria, Belgium, Bulgaria, Cyprus, (Czech Lands, Slovakia), Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Russia, San Marino, Spain, Sweden, Switzerland, Turkey, UK. Guest status: Albania, Croatia, Estonia, Latvia, Lithuania, Romania, and Slovenia.

The most broadly representative of all European bodies. Member states have coastal access to the whole Baltic, the whole northern coast of the Mediterranean, and most of the Black Sea coast.

• ECOPS

Members: A joint advisory committee of ESF and EC. Members selected ad hominem, coming from the following countries: Belgium, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, UK.

A small professional body able to provide very high level influential advice to key agencies. Long term strategic review, and able to make fast decisions. Organised the governmental Bremen Conference on the Grand Challenges of Oceanography in 1993. Recommendations of ECOPS led to the formation of the European Marine and Polar Sciences Board (see below).

• ESF

Members: 59 National research councils and institutions from 21 countries, including all EU countries.

The member organisations have direct control over their own R&D budgets, and can therefore commit resources. Central funding of FF60 million/yr. Good wide membership. Used to taking the long view. Expertise and ToR imply that ESF could support and participate in the design and research leading up to GOOS, but not in its implementation. Has organised several European conferences on ocean science subjects (see also ECOPS).

• EMAPS

Members: Individual marine research institutes, laboratories, and university departments are members of the EMaPS. 23 institutions are members of the EMaPS Board. The Secretariat is provided by ESF. The potential membership could include of the order of 300 institutions.

EMaPS provides a direct route of communication to all the establishments where marine research is likely to be conducted in Europe. Conversely, the needs of these institutions for instrumentation or data, or the news of new discoveries or technologies, may be made known through EMaPS.

• EUMETSAT

Members: Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, UK.

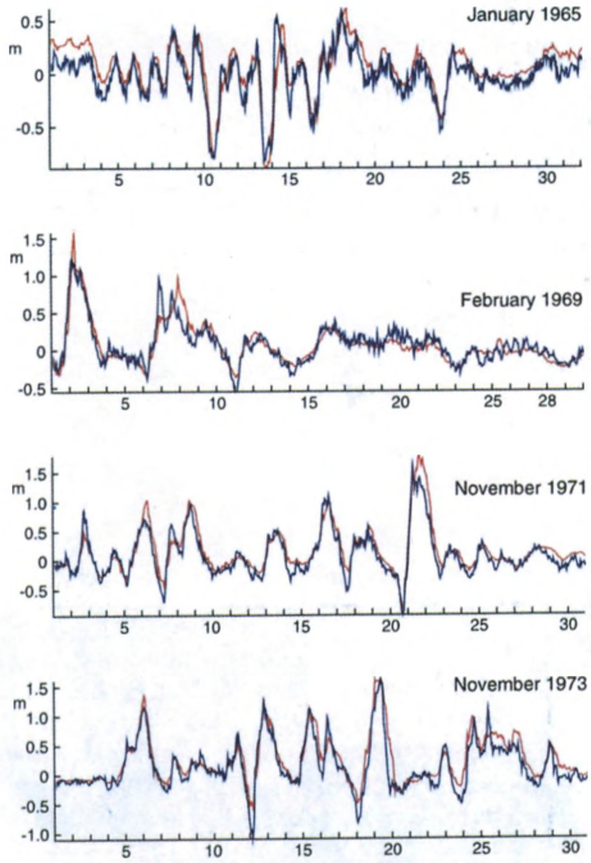


Figure 5.2a 40-year storm surge model
Comparison between model hindcasts based on recorded wind and tide conditions and the actual observed storm surge sea levels on the UK east coast close to London. The storm surge height is driven by the meteorological conditions, and is additional to the tide. The storm surge can thus add 1.5m to the highest tide level. The blue line is the observed surge level, and the red line is the model calculation.
Source: Proudman Oceanographic Laboratory.

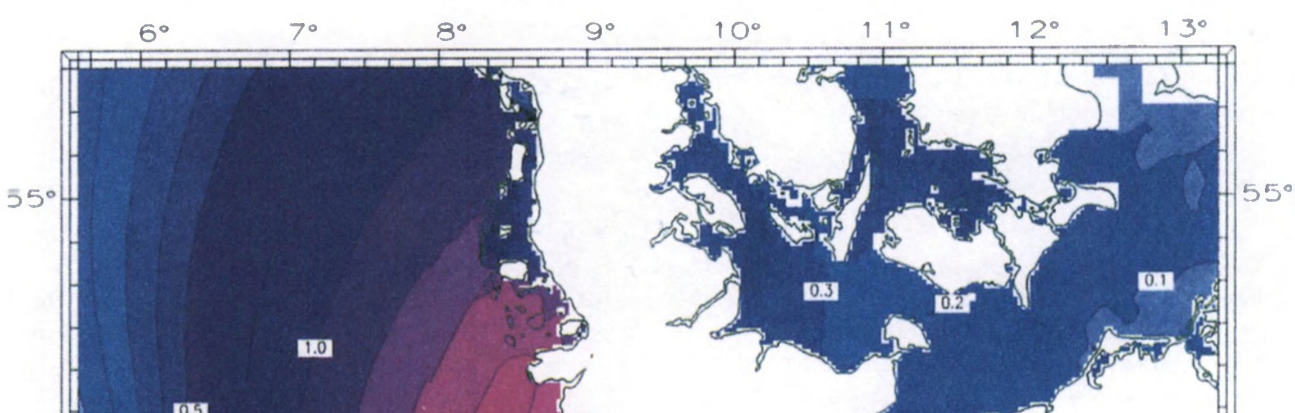


Figure 5.2b Sea level surge levels in the German Bight
Source: BSH.

An agency which exists to establish, maintain, and exploit operational European meteorological satellites. An executive inter-governmental agency, with funding, a procedure for establishing goals, and attaining them. Its charter is similar to that of ECMWF. The experience with operational meteorological satellites and data handling is an excellent pre-cursor for a similar structure for oceanographic remote-sensing.

• ESA

Members: Austria, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Spain, Sweden, Switzerland, UK.

Governmental, substantial budget, high technology, strong interest in remote sensing, powerful and permanent infrastructure. Emphasis on products and users. Has organised large consultative meetings with the ocean user community, and several smaller workshops on operational remote sensing for the coastal zone, and for oil pollution management. Is debating the development of operational Earth Watch satellites.

• EEA

The European Environment Agency was established by the Council of the European Union in 1990. It is independent from the Commission. It began work in 1993, with Headquarters in Copenhagen, Denmark. The mission is to provide the EU and Member States with objective, reliable and comparable information at European level enabling them to take the requisite measures to protect the environment, assess the results of such measures, and to ensure that the public is properly informed about the state of the environment. One of the priorities of the EEA is coastal protection.

The mission of EEA is very relevant in the coastal and marine area, and there is a very strong requirement for reliable and consistent data which can be analysed rapidly. EuroGOOS should be able to provide such data for many components of the marine environment.

• OSPARCOM

Members: Belgium, Denmark, EC-EU, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK.

Signatories to the Oslo and Paris Conventions for the protection of the Marine Environment of the North East Atlantic. The Commission has a Joint Monitoring Programme for measuring contaminants in biota, water, and sediments. The Commission has strong links to ICES.

OSPARCOM works within a strict legal and managerial framework to provide data and advice to the signatories. The objectives are totally consistent with the objectives of EuroGOOS, and data gathered by OSPARCOM may possibly be incorporated into EuroGOOS models. Conversely, the outputs and predictions of EuroGOOS models may assist OSPARCOM to meet its objectives.

• ECMWF

Members: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Switzerland, Sweden, Turkey, UK, (Yugoslavia).

The European Centre for Medium Range Weather Forecasts was established in 1973, and inaugurated in its centre in 1979. The aim is to develop dynamic models of the atmosphere suitable for providing reliable weather forecasts of periods 4-10 days ahead. More recently programmes have been started to analyse the predictability of the atmosphere at seasonal timescales, and to study seasonal prediction with a coupled ocean-atmosphere model. ECMWF represents a key focus of modelling skills in Europe, and already has a range of products used world-wide, such as the ECMWF wind-field. The experience of ECMWF will be valuable in developing European modelling skills for ocean forecasting. ECMWF has a unique role in global modelling.

• MIF

Members: Established by the Council of Ministers of Industry of the EU in 1991. Participants are the Governments of Member States, plus representatives of maritime industries.

The Marine Industries Forum grew from a series of EU studies which started in 1990. It has the objective of improving the competitiveness of the EU maritime industries both within Europe and globally. The analysis carried out by MIF helps to establish the essential role of maritime industries in Europe, their economic scale, strategic importance, and levels of employment. This information is important to EuroGOOS. Conversely, the maritime industries identified by MIF will have a steadily increasing requirement for improved forecasts of marine conditions in order to increase their competitiveness.

LEADING INTERNATIONAL ORGANISATIONS WITH SOME NON-EUROPEAN MEMBERS

G7	**Group of Seven**
OECD	**Organisation for Economic Co-operation and Development**
NATO	**North Atlantic Treaty Organisation**
ICES	**International Council for Exploration of the Sea**
UNEP-MAP	**United Nations Environment Programme, Mediterranean Action Plan**
HELCOM	**Helsinki Commission**

• G7

Members: Canada, France, Germany, Italy, Japan, UK, USA.

Links the richest capitalist countries in the world. Russia attends most meetings. G7 is primarily economic and political. Members have placed discussion of GOOS on the agenda for discussion by Science Ministers on 3 occasions since 1992. In February 1995, as part of the G7 Global Information Society initiative, G7 launched the Marine Information Service (MARIS) Project. MARIS promotes the industrial application of information technology and telematics in the maritime sector.

• ICES

Members: Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, UK, USA.

Science based, and wholly marine based. Excellent long-term track record. Has access to very long term data banks of oceanographic, environmental/ pollution and living marine resources data. Provides a possible vehicle for collaboration with Russia. Very strong in the Baltic, North Sea, and North Atlantic. Has collaborated in several DG-XII MAST Projects.

• OECD

Members: Australia, Austria, Belgium, Canada, Denmark, Finland France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, UK, USA.

Includes all 15 EU countries. Objectives are largely economic and technical aspects of development. Has launched the Megascience Forum on Oceanography. Links the 24 richest capitalist countries in the world. Has permanent headquarters and staff in Paris. Includes many European non-EC Members. Very high reputation for analysis of trends and statistics. Highly respected as a professional straight-talking organisation. Runs some active organisations such as International Energy Agency which have some executive authority. OECD through its Megascience Forum Office organised a meeting on operational oceanography in Tokyo in late September 1993, and published a book of proceedings and analysis. Continuing interest in the economics of global development, and possibly the analysis of the value of GOOS to developing countries.

• NATO

Members: Belgium, Canada, Denmark, (France), Germany, Greece, Iceland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Turkey, UK, USA.

All EU countries are members with the exception of Ireland, Finland, Sweden, Austria, and France. France is still a member of the over-arching North Atlantic Treaty Alliance, but not of the key military command and organisational boards. France is getting closer to NATO. Strong tradition of promoting high quality science. Strong tradition of oceanographic, coastal, and sub-sea science and technology. Strong Atlantic and polar dimension. Getting closer to eastern Europe and Russia. Would be constructive to involve navies in peacetime. There is a NATO North Atlantic Co-operation Council. There is a North Atlantic Treaty Alliance, which is the civil parliament of NATO. Operates a marine research laboratory at La Spezia, Italy, and a modern research vessel "Alliance".

• UNEP-MAP

Members: UNEP Mediterranean Action Plan was established in 1980. All Mediterranean states are members.

A multi-disciplinary marine organisation with a strong secretariat in Athens, Greece. Provides the secretariat functions also for the Barcelona Convention. From the EuroGOOS point of view this provides a good mechanism for working will all the relevant operational agencies in Mediterranean coastal states.

• HELCOM

Members: EU, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden.

The Baltic Marine Environmental Commission (Helsinki Commission) was established in 1974 and now has the status of an intergovernmental convention. Its objectives are the assessment of environmental conditions in the Baltic Sea, measurement of airborne pollution, water protection, prevention of pollution from ships, dumping of waste in the Baltic Sea area, and land-based sources of marine pollution.

Figure 5.3 The Thames Barrage

While global sea level has been rising at about 1mm per year during this century, South East England has been subsiding, and the London area has been subsiding fastest at nearly 2mm per year. Tidal amplitude has increased so as to raise flood levels by 75 cm per century. The Thames Barrage was completed in 1984 to prevent disastrous flooding when times of high tide combined with storm surges caused by meteorological conditions. The gates are raised when a high level is predicted by the East Coast Storm Tide Warning Service. The predictions are derived from computer numerical models.

Source: Proudman Oceanographic Laboratory.

OCEAN SERVICES ALREADY EXIST IN THE PUBLIC AND PRIVATE SECTORS

European national agencies and commercial companies have experience of providing observation systems and forecasting models for use in sea areas outside Europe, especially in South East Asia. This background of existing skills in marine forecasting is an essential part of the European capability to play a global role in ocean modelling and forecasting.

An important component of developing operational oceanographic services is the design of the logistics and operational routines. European agencies already have valuable experience at local, regional, and global scale of solving these problems. This experience includes transmitting data in real time and assimilating data into predictive models. Systems which are already in operation include:

- Dutch storm surge and flood warnings based on tide gauge and meteorological data. This system now combines data from UK and Dutch tide gauges. This is a vital element in protection of the Dutch coast, and protection of life and property. Numerical models developed and operated by RIKZ.
- The East Coasts Storm Tide Warning Service based at the Met Office, using operational models developed at the Proudman Oceanographic Laboratory (see Figs. 5.2a and 5.3). The inputs of tidal and meteorological data are used to predict the sea level on the east coast of the UK, and in particular the flood risk threatening London. The gates of the Thames barrage are closed one hour after low water preceding the predicted storm surge.
- Wind-wave models are operated in the North Sea and Western Approaches to provide warnings of extreme conditions for offshore oil and gas rigs and pipe-laying operations.
- Wind-wave models are operated to provide warnings of conditions in the approach to major harbours.
- Global wind-wave models are run by the WAM group and ECMWF, and provide valuable input for ship routeing. The service is run in collaboration by ECMWF, UK Met Office, Metéo France and KNMI.
- Wind, wave and sea level models are run operationally to predict the limiting conditions for entry to ports, and the earliest and latest times of entry in relation to the tide and atmospheric conditions. Such operational models exist for the North Sea and for the main ports on the coast of Spain.
- ECMWF runs global operational sea surface wind models based on satellite measurements and data from drifting buoys (see Fig. 5.4).
- SMHI, in collaboration with other meteorological and hydrological services around the Baltic Sea, already runs operational models forecasting wind, waves, sea level and floating sea ice (see Fig. 6.1). The agencies in the Baltic Sea are developing operational models on a schedule which will result in the ability to predict ecological conditions, nutrients, and the movement of fish eggs and larvae soon after the year 2001 (see Fig. 6.1).
- UK Met Office runs an operational Atlantic Ocean model providing temperature and salinity structure.
- A range of services exist on the coast of Norway, and in the adjacent Arctic, providing forecasts of sea ice, oil pollution, and algae which may be damaging to fish farms.
- BSH provides operational forecasts of sea level and storm surge in the southern Baltic and the German Bight, currents and predictions of the dispersion of pollutants and floating oil by means of operational numerical models, and forecasts of ice extent in the Baltic. Weekly services of processed data include sea surface temperature maps.
- European commercial companies provide a wide range of proprietary forecasting services, especially for the offshore oil and gas companies, and for coastal engineering and waste disposal. These services include continuous monitoring and forecasting of sub-surface current profiles, predictions of extreme co-occurrences of wind+waves+currents, predictions of the dispersal of contaminants, models of drifting oil slicks, and models of coastal erosion and sediment transport.

STRONG CUSTOMER BASE WITH DIRECT INTEREST IN EUROPEAN REGIONAL SEAS AND ADDITIONAL WORLD-WIDE INTERESTS

Investigations by EuroGOOS Members show that the potential customer base is very much alert to the future possibilities of operational oceanography. The evidence is:

- A questionnaire distributed at the Oceanology International 1994 conference to 500 exhibitors produced a response that 160 companies were interested either in providing equipment and services to GOOS, or in obtaining data from GOOS. Many of those that did not reply were in sectors of manufacture which would inherently have very little interest.
- Two workshops organised by ESA to investigate user requirements for coastal remote sensed operational data revealed a strong interest from users who were, in general, well informed as to the future potential.

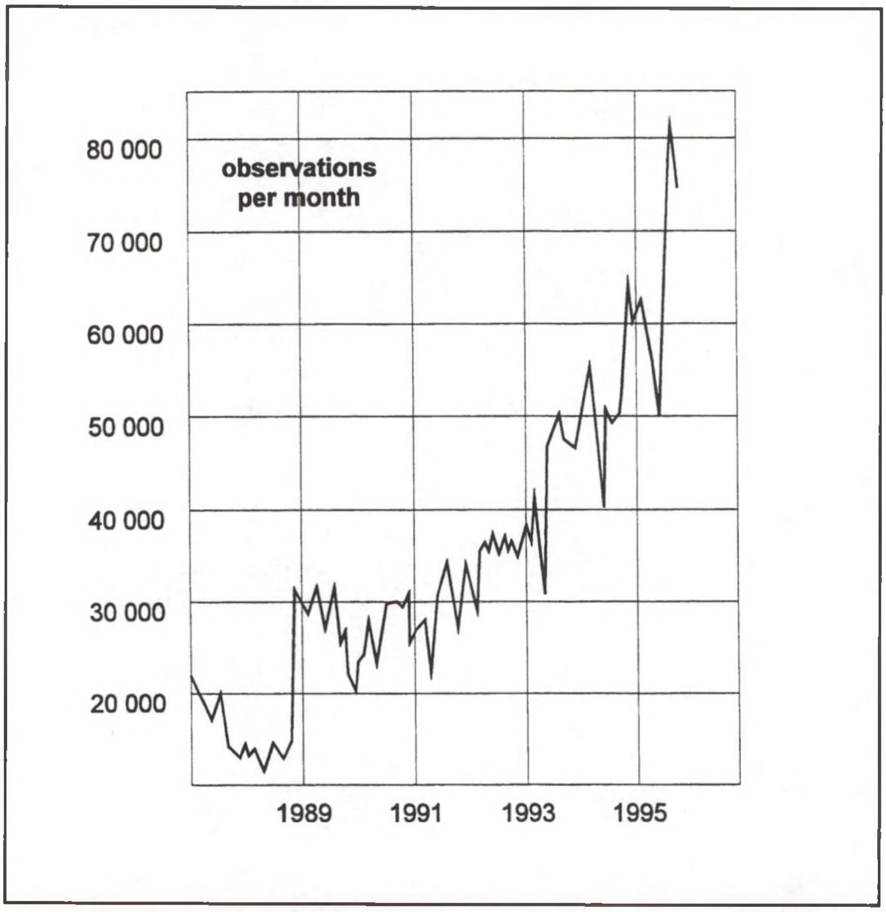


Figure 5.4 Number of drifting buoy air pressure observations received at the European Centre for Medium Range Forecasts Source: ECMWF

- Survey questionnaires distributed in UK reveal that potential user companies have a sophisticated view of their future data requirements, and have analysed the probable rate of technological development, and hence the available data in 5-10 years time. This applies to the largest offshore operating companies, and to a wide range of medium sized specialist companies providing value-added data and advice to customers.
- At the EUROMAR-MAST Conference at Sorrento, November 1995, a dominant theme of many sessions was operational oceanography in general, and EuroGOOS in particular. There was detailed discussion of the economics of operational oceanography, and the benefits to industry.
- The Oceanology International 1996 Conference attracted 600 exhibiting companies, of which the majority were European. The theme of the Conference was "Towards Operational Oceanography".
- Europe has a large number of global companies which conduct engineering, offshore oil and gas, and other operations world wide. These companies require marine environmental services and forecasts world-wide.

GROWING EUROPEAN COMMITMENT TO IMPROVING THE HEALTH OF THE MARINE ENVIRONMENT

At national and at European level there is a strong public demand for improved management of water quality in rivers and in the sea. Politically this demand is expressed through legislation, regulations, and European Directives, and through the creation of new environmental agencies with increased powers.

This serves as creating a strong customer group for EuroGOOS.

GLOBAL AND EUROPEAN COMMITMENT TO CLIMATE PREDICTION REQUIRING OCEAN FORECASTING

Most, if not all, European countries have been active participants in preparing and ratifying a series of important international meetings, agreements and conventions relating to marine resources, management of the sea, marine conservation, and climate control. These include the UN Convention on the Law of the Sea, the Second World Climate Conference and Ministerial Declaration, the United Nations Conference on Environment and Development, the Framework Climate Convention, and Convention on Biodiversity. Both GOOS and GCOS evolved as ways of implementing some of the principles expressed in these agreements.

COMMITMENT TO BIODIVERSITY CONVENTION INCLUDING PROTECTION OF MARINE BIODIVERSITY

The UNCED (1992) resulted in the Biodiversity Convention, with a framework of signatory states to oversee implementation of the Convention. The definition of biodiversity is itself a controversial topic, and the subject of marine biodiversity has only recently received attention. (Rex et al, 1993). In this document we will assume a pragmatic definition of biodiversity which implies merely that, so far as possible, no species should be threatened to the point of extinction, and that ecosystems are preserved at a robust level with all their normal component species intact.

The zones or conditions in which marine biodiversity is most threatened are:

- Commercial fisheries, especially in the Black Sea, where many fish species have been damaged by pollution and over-fishing to the verge of extinction.
- Coral reefs, where damage from increased land runoff, pollution, rock mining, and souvenir hunting have eliminated large sections of reefs
- Estuarine environments which tend to be heavily exploited by industry and large urban populations so that the full range of fauna and flora tends to be reduced to a smaller number of species able to withstand the pollution.
- Coastal wetlands and marshes which are frequently drained and reclaimed as building land.
- Mangrove forests which are frequently destroyed to make way for mariculture, or drained and reclaimed for building land.

The determination in many countries, and internationally, to maintain and preserve marine biodiversity creates a demand for marine monitoring, especially the measurement and prediction of variables describing the biota and the concentrations of nutrients and contaminants. Complex models will be needed to predict the levels of disturbance or pollution which are likely become a threat to different ecosystems.

This requirement provides a further range of customers for operational oceanographic services. Several European research institutes specialise in tropical biology, and as a result Europe is in a good position to provide services to developing countries wishing to manage and preserve their coastal and adjacent sea environments.

Chapter 6

EuroGOOS Methodology and Activities

Introduction

Investigations, surveys, and design studies

Organise collaboration between EuroGOOS and the programmes of European Agencies

Regional Test Cases

Demonstration Projects

Trials

Pilot projects

Supporting activities

Communications and training

Communications with the outside world

EuroGOOS meetings for its Members, services to Members

Directorate and the EuroGOOS Office

Summary

Chapter 6

EuroGOOS Methodology and Activities

INTRODUCTION

This Chapter lists the tools and methods available to EuroGOOS with which we can achieve the objectives in the timescale established in the Strategy, Chapter 4. Each method, procedure, or action is listed by type, followed by actions already initiated, or planned by EuroGOOS.

The types of action are:

- Investigations, surveys, and paper studies
  Organise collaboration between EuroGOOS and the programmes of European Agencies
- Regional Test Cases, Baltic, Arctic, NW Shelf, Mediterranean, Atlantic
- Demonstration projects
- Trials
- Pilot projects
- Supporting activities
- Communications and training
- Communications with the outside world
- EuroGOOS Meetings for its Members, Services to Members
- Directorate and the EuroGOOS Office

Investigations, surveys, and design studies

Actions carried out and planned:

The **Technology Plan WG** has conducted a survey of agencies and their utilisation of marine instruments, sensors, platforms, and remote sensing systems. Approximately 300 replies have been received from all over Europe, and a preliminary report on the data was presented at the Conference Oceanology International 96. The full data are being analysed statistically, and a digest will be made available to all Members, and distributed electronically for general access.

The **Technology Plan WG** is preparing a Report on available technology for operational oceanography, gaps in technology, and the most urgent requirements on short, medium, and long timescales. This report will be produced by the end of 1996, and included as part of the EuroGOOS Plan.

The **Science Advisory WG** is preparing a report for the end of 1996 which will analyse the scientific underpinning of EuroGOOS, variables which are prioritised in each sea area and scale, the limits of predictability for each variable, and scale, and look forward to the likely rate of development of different types of numerical model over the next 5-10 years.

We will publish a 5-10 Year Plan in early 1997. This will be based on the Reports of the TPWG, SAWG, the discussions and papers at the First EuroGOOS Conference, studies of economic requirements for marine forecasting, regional studies of forecast requirements and regional observation systems, and analysis of remote sensed applications in operational ocean forecasting.

We have started **a survey** of the types of forecast data and maps that users require. This is being carried out in several European countries, and will give priorities to each type of observation and forecast. This study will be complete before the end of 1996.

We have completed a paper study of the density of **Ferry Routes** in European waters, the number of tracks per degree square, the number of km of track per degree square, and the total number of track-km per week per degree square. The most densely traversed squares have more than 10,000 km of track per week. The next part of the study is to analyse which parameters could most efficiently be measured from ferries, and estimate the availability of suitable sensors.

Regional Task Team studies. Each sea area of interest to EuroGOOS has a Regional Task Team which is starting the process of designing the operational observing scheme and output services for that region. This logically starts with paper studies, which will proceed throughout 1996. These will lead to trials and pilot projects (see below).

EuroGOOS documents. Our objective is to promote the development of operational oceanography in Europe, and to assist those bodies, organisations, and industries which contribute to that goal. In consequence, the Minutes and Records of EuroGOOS Meetings are in general not confidential, and are available to any organisation on request.

Organise collaboration between EuroGOOS and the programmes of European Agencies

We intend to develop operational oceanography in the most efficient and economical way, building upon existing systems wherever possible. Provided that data sets have the appropriate quality control, the same observations can be used for multiple purposes. This can be achieved provided that the data communications and data processing are sufficiently rapid to transmit the same data to multiple users. EuroGOOS has arranged reciprocal or Observer status with ESA, IOC-GOOS, ICES, and EUROMAR. EuroGOOS Secretariat staff have attended meetings of the bureau of the North Sea Fixed Station Monitoring Workshop (now SeaNet), and this connection will be strengthened. EuroGOOS is in correspondence with OSPARCOM, ECMWF, EuroGLOSS, and NOSS. In the near future EuroGOOS will explore the logical connections with EEA.

REGIONAL TEST CASES

The EuroGOOS definition of a Test Case was drawn up so as to permit groups of experts to work on the problems inherent in developing operational oceanographic services within a region, and allowing each region to come up with priorities and solutions to problems which are identified in the region. EuroGOOS Members are planning on a timescale of a few years to run demonstration projects and pilot projects in which significant resources are deployed in field trials, to transmit data in operational mode, to run test models, and generate prototype products. The Terms of Reference for the Test Case task Teams are set out in Annexe 2. The 5 Regional Test Cases already established will start as paper studies, and develop as pilot projects (see below).

High resolution modelling and forecasting, that is with a resolution substantially finer than 1km, is limited in its accuracy by the errors in the bathymetry of the shelf seas and ocean basins. In shallow shelf seas the bottom effects are very important, and small errors in presumed water depth cause errors in the models. In water depths of thousands of metres, as in the Mediterranean and Atlantic, the previous measurements are sparse, and errors are again significant in proportion to water depth. EuroGOOS modelling experts and Regional Task Teams identify improved bathymetry as an important element in developing more accurate forecasts. Projects to develop improved standard bathymetric maps for European adjacent seas are being discussed with bathymetric charting groups in UK and Germany.

As the regional projects progress, the requirements for instrumentation and other technological systems will be communicated to industry, and commercial companies will be invited to test equipment under realistic prototype conditions, or participate jointly in trials.

Baltic

Member Agencies:
Bundesamt für Seeschiffahrt und Hydrographie (Germany), Polish Institute of Oceanology, Finnish Institute of Marine Research, Royal Danish Administration of Navigation and Hydrography, Swedish Meteorological and Hydrological Institute

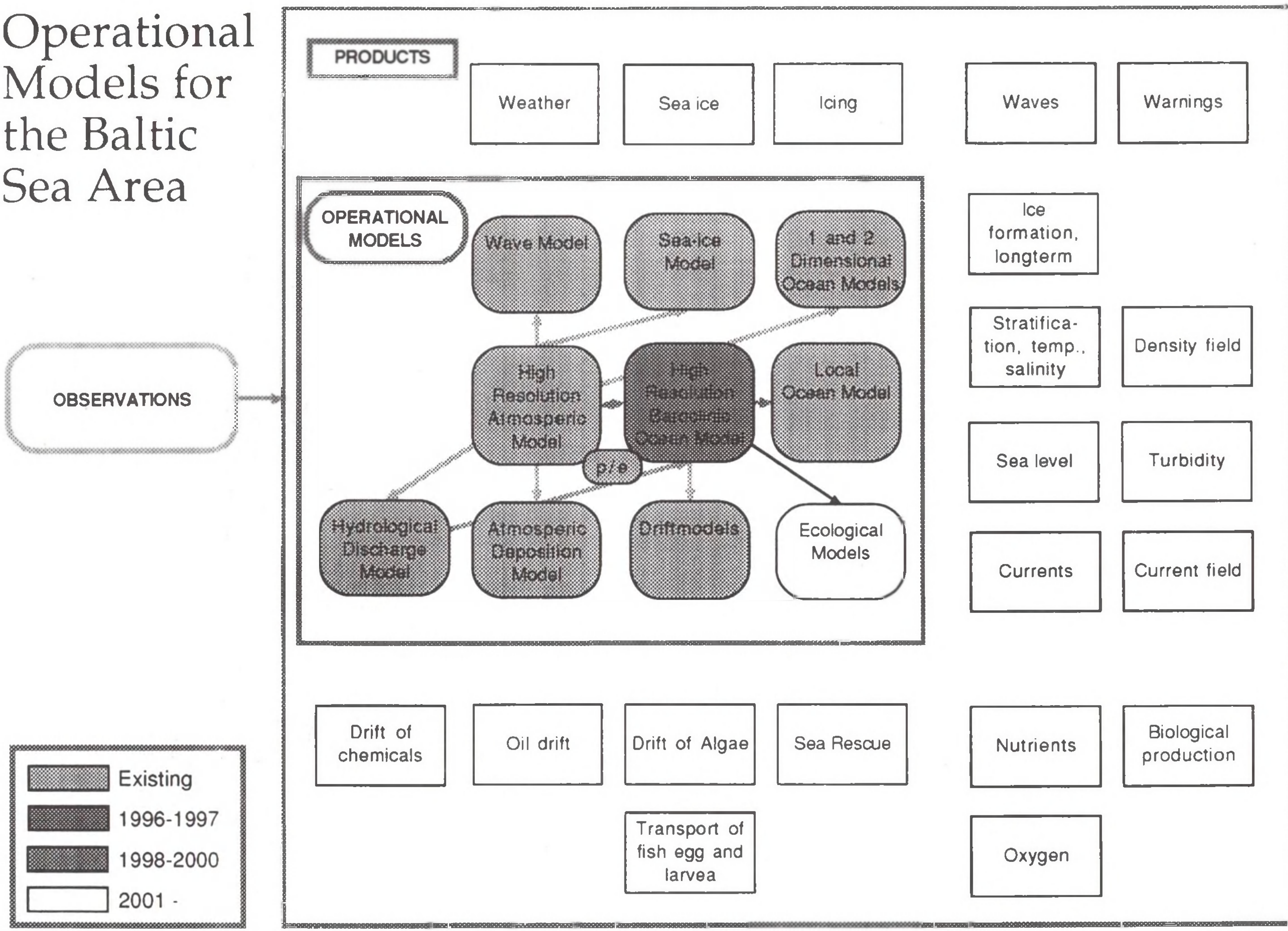
Collaboration between agencies and institutions in the Baltic area has been well advanced for several years. The Regional Task Team is lead by SMHI, which has close contacts with ongoing programmes in the Baltic, and official contacts with agencies in all coastal states. An advanced modelling programme is run by SMHI, with data supplied from all parts of the Baltic. Other regional and more specialised models are run by each national agency. Although some of this collaboration would have developed without EuroGOOS, the Baltic agencies are keen to adopt the objectives and policies of EuroGOOS because they gives continuity and logical coherence to observations, modelling, forecasts, and economic and social benefits.

Figure 6.1 shows the phasing of operational models planned for the Baltic area. These developments are planned in conjunction with ICES and HELCOM. SMHI is running a workshop on data assimilation in September 1996, and there is a general conference on oceanography in the Baltic on October 22-26, the "Baltic Marine Science Conference". A new programme "Baltex" has been planned to study the water cycle in the Baltic region, within the framework of the WCRP and GEWEX.

EuroGOOS plans for the Baltic will be structured to utilise the strong collaborative arrangements already in place, to focus data and observations on operational forecasts, and to provide the missing components for a complete system.

Figure 6.1
Operational models of the Baltic Sea area, and the expected rate of implementation of new model components and forecasts
Source: Hans Dahlin, SMHI

Operational Models for the Baltic Sea Area



Arctic

Member Agencies:
Bundesamt für Seeschiffahrt und Hydrographie (BSH) (Germany), Finnish Institute of Marine Research, Institute of Marine Research (Norway), Meteorological Office (UK), Nansen Center (Norway), Royal Danish Administration of Navigation and Hydrography.

The Arctic Task Team is headed by the Nansen Environmental and Remote Sensing Center, Norway. The area of the study includes the coastal seas of Norway, the Norwegian Sea between Norway, Iceland and Greenland, the Greenland Sea, and the Arctic Ocean proper in the region of Norway, Svarlbard, and Novaya Zemlya.

The development of operational forecasts of value to Europe will be carried out in the context of the existing collaborative agreements involving all countries working in the Arctic, especially the Arctic Monitoring and Assessment Programme (AMAP), the International Arctic Buoy Programme (IABP), and the Arctic Climate System Study (ACSYS). EuroGOOS will participate in the joint IABP-ACSYS meeting in June 1996.

Objectives of the Arctic Regional TT relate to sea ice forecasts and fisheries, as well as prediction of algal blooms and the movement of pollutants near the coast where they may damage fish farms. The latest climate prediction models from IPCC suggest that the most enhanced warming will take place in the polar regions. The Arctic ocean may thus be an early indicator of the onset of greenhouse gas induced global warming. Satellite observations by passive microwave sensors from 1978 to 1995 detect an overall reduction in sea ice cover of 2.1%. There have been several recent scientific reports of multi-year thinning of Arctic sea ice, and reduced cold water formation off the coast of Greenland.

The EuroGOOS Arctic TT will emphasise remote sensing of the ocean and sea ice by passive microwave sensors, SAR, ocean colour monitoring, combined with in situ measurements and coupled ice-ocean-atmosphere models. The Arctic Ocean and coastal seas are a very fragile ecological environment, and it will be important to predict water pollution and algal blooms in the regions of fresh water input from the major north-flowing rivers.

Figure 6.2
Drilling to measure the thickness of the marine ice and to recover samples, North Polar Sea
Source: H Grobe, Alfred Wegener Institute for Polar and Marine Research, Bremerhaven

In summary:

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

Sub-objectives:
To detect trends in the large- and meso-scale sea ice parameters as they help the prediction of climate change

- To monitor meso-scale sea ice parameters and ice dynamics as aid to shipping, fishing, and offshore industries working in ice-covered areas
- To monitor and predict meso-scale ocean pollution, algal blooms and spread of radionuclides

Figure 6.3 Tide gauges maintained on the coast of Greenland by the Royal Danish Administration for Navigation and Hydrography
Source: RDANH

North West Shelf

Member Agencies:
Irish Marine Institute, Royal Danish Navigation and Hydrographic Office, BSH (Germany), RIKZ (Netherlands), Department of the Environment MUMM (Belgium), Meteorological Office (UK); and IFREMER (France). The TT is led by the UK Meteorological Office.

The European NW Shelf region consists of shallow seas forced by strong tides and winds. There is a complex interface with the Atlantic Ocean along a sinuous shelf edge from Portugal to Norway. The sea areas are amongst the busiest in the world, with intense maritime traffic, and heavy loads of contaminants introduced by rivers. There are highly developed fishing industries and recreational activities. The NW shelf seas are bordered by technically developed countries with high population densities. There are numerous existing organisations, projects, treaties, and agreements on many aspects of observing, monitoring, and regulating the state of these shallow seas.

The first action of the NW Shelf TT has been to analyse the activities of existing organisations, and the viability of the data gathered by them as contributions to an operational service. Relevant organisations include the tide-gauge and flood prediction systems in several countries; meteorological buoys operated by many countries; storm surge prediction models already in operation; the data gathered by a large number of offshore oil and gas platforms; data assembly and modelling projects supported by DGXII-MAST; OSPARCOM; ICES; the fixed station monitoring network known as SeaNet; and other data streams gathered by various organisations to meet statutory obligations, especially in regard to pollution management.

Because of the intensive commercial use of the NW shelf seas it is particularly important to identify the data products and forecasts most needed by commercial operators and by regulatory and controlling authorities. Analyses of these requirements will be used to determine the most appropriate forecasting products needed, and the observation system needed to generate them.

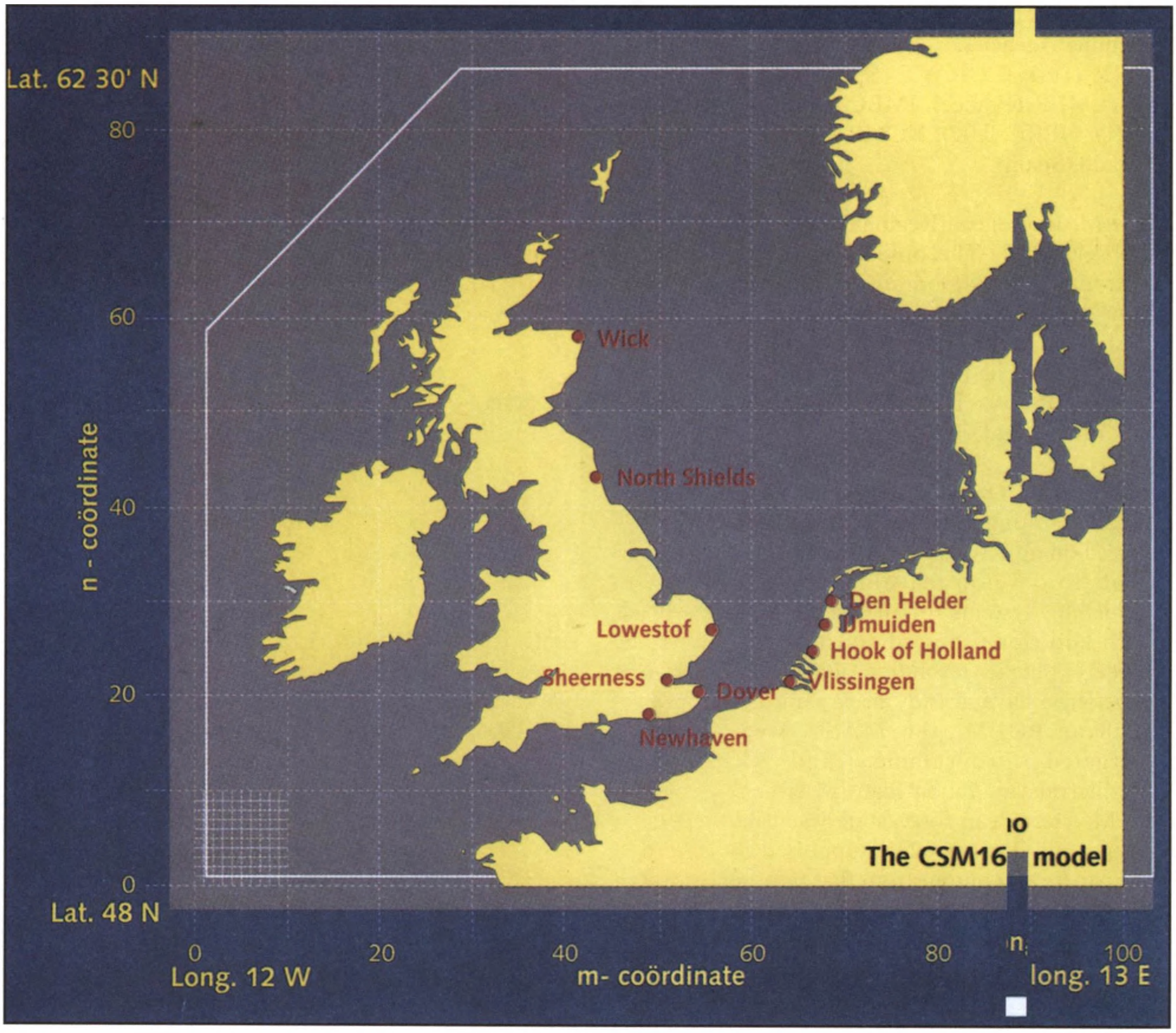


Figure 6.4 The computer grid used by the Netherlands Continental Shelf Model (CSM).
Water levels and velocities are computed within individual (16 x 16km) grid-squares at 10-minute intervals. The stations used for the data assimilation are shown in red. Source: RIKZ and Delft Hydraulics

Mediterranean

Meetings of this TT are planned for later in 1996.
Member Agencies:
CNR (Italy), CICYT (Spain), ENEA (Italy), IFREMER (France), IMBC (Greece), Met. Office (UK), NERC (UK), NCMR (Greece), Puertos del Estado (Spain)

The Mediterranean Regional Task Team is led by CNR (Italy). The objective is to use existing operational buoy moorings, remote sensed on line data (Altimetry, AVHRR) and a new system of real time data from XBTs. Ultimately the objective will be to operate also a system of deep-moored buoys like the Pacific TAO array, reporting in real time.

The EuroGOOS Mediterranean Task Team held three planning meetings during 1996. The TT agreed on objectives for a series of experiments and trials to develop real time observational and modelling systems for the whole Mediterranean, with additional nested coastal and shelf scale models at higher resolution. Background data and experience have already been gained from project such as POEM, the MAST Mediterranean Targeted Programme, and the UNEP Mediterranean Action Plan (MAP). A workshop on Mediterranean forecasting was held at Toulon, France, in October 1995, supported by ESF, and the papers and output from that meeting have been utilised by the EuroGOOS TT.

Modelling and forecasting the Mediterranean will be of great benefit to the maritime industries of the Mediterranean region, especially the control of pollution, management of fisheries, and improvement of marine conditions for tourism. Forecasting the climatic condition for the Mediterranean over several years will have a large economic and humanitarian benefit for North Africa and the Sahel region, since rainfall seems to be correlated with the state of the Mediterranean.

The EuroGOOS Mediterranean TT presently includes most of the developed countries on the northern Mediterranean shore. Agencies from Greece, Turkey, and Israel are in correspondence with the TT, and may join soon. It is essential that the EuroGOOS TT establishes formal links with the Agencies from the Levant and North African countries, both at the working scientist level, and at the official departmental/operational level. EuroGOOS has exchanged informal correspondence with oceanographers in most of the North African states. There are several EU programmes which exist to promote collaboration between Europe and the southern Mediterranean, and all Mediterranean countries are associated with UNEP-MAP. EuroGOOS will use these links to ensure full participation of all Mediterranean countries in the forecasting of the state of the Mediterranean Sea, and the utilisation of the benefits of forecasts.

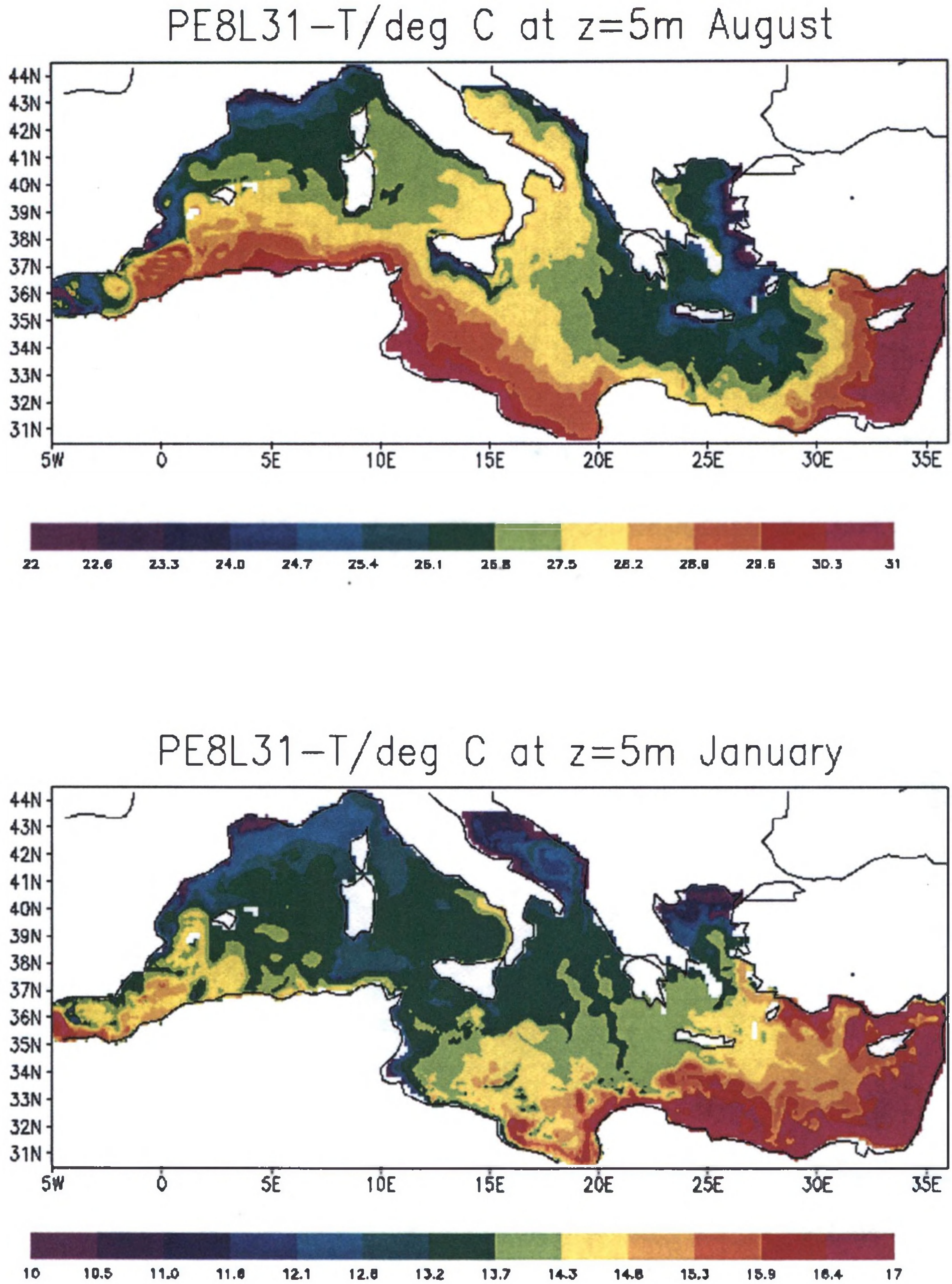


Figure 6.5 The figure represents model simulations for a depth of 5 meters, average temperature fields in August (top panel) and January (lower panel).

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.

Atlantic

A formal Task Team for the Atlantic will be established at the next meeting of EuroGOOS in the Hague, in October 1996. Experimental and operational models of the Atlantic including the principal physical variables are already being run to support meteorological and military requirements, e.g. SOAP and FOAM. Studies of multi-decade archives of sub-surface temperature data, and repeat sections across the North Atlantic show fluctuations in different areas, both warming and cooling, of the order of 0.25C° over several decades down to depths of 2000m. There are short term reasons for improving the oceanographic forecasting models on timescale of days to improve weather forecasting and ship-routeing; medium term reasons to improve the understanding of coupling between the Atlantic and the shelf seas which influences all processes on the shelf, including fisheries; and long term reasons to support climate forecasting.

Many European countries operate traditional oceanographic cruises in the Atlantic, and there are a number of repeat sections and routine observations which provide the nucleus for an operational system. A systematic observing scheme in the Atlantic to provide the boundary conditions for European waters, to support climate forecasts in Europe, and to provide a European contribution to GOOS, will be improved by collaboration with other states bordering the Atlantic. Extensive use will be made of the understanding, data, and models provided by the final stages of WOCE and OMEX. Remote sensed observations will be essential for this region. Discussions have been held with some of the modelling groups specialising in the North Atlantic.

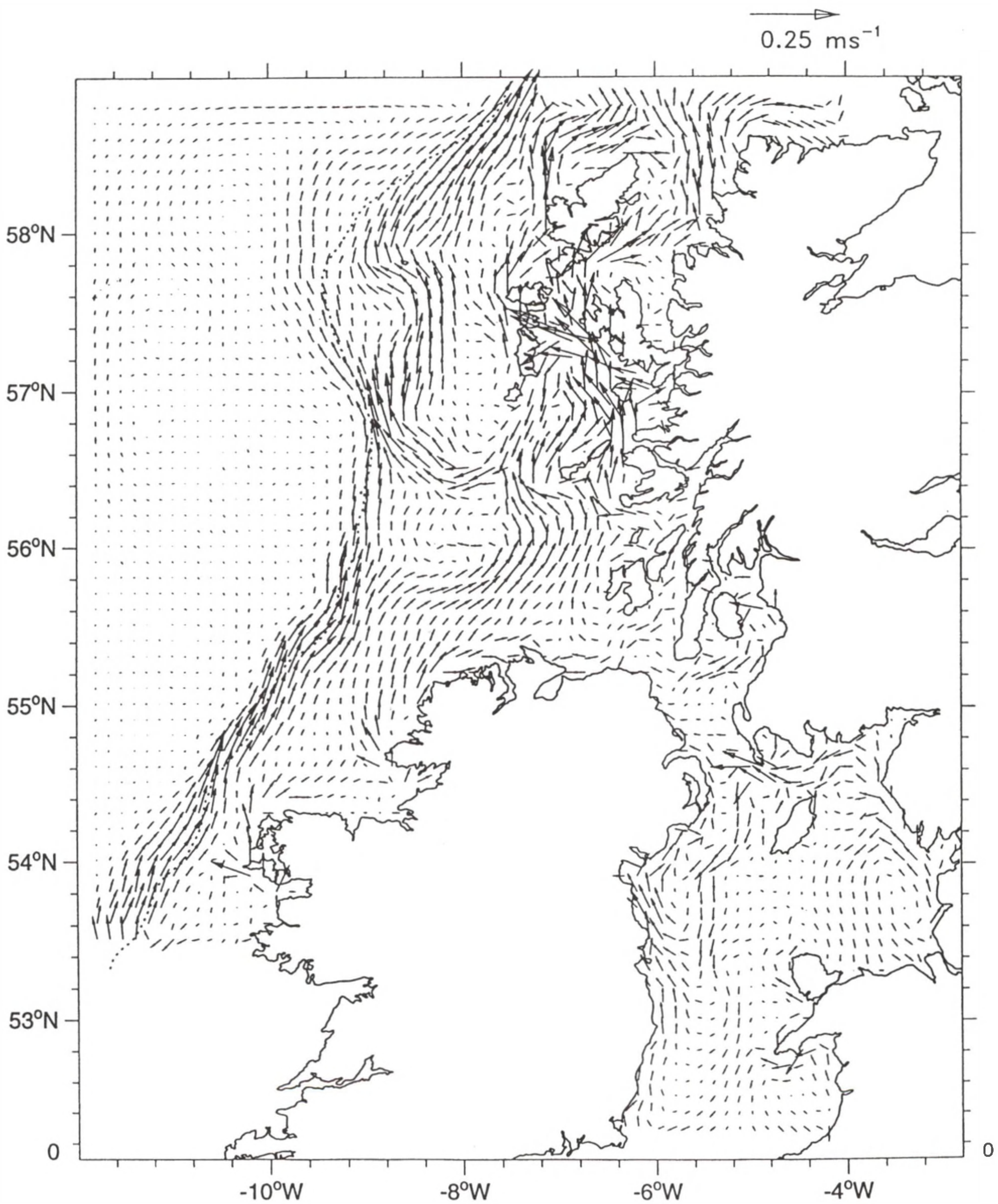


Figure 6.6 Example of a high resolution shelf-edge model showing the mid-depth currents due to a uniform Southerly wind and an oceanic input
Source: J Xing, Proudman Oceanographic Laboratory

DEMONSTRATION PROJECTS

We have started to develop activities which will grow through paper studies, test case analysis, pilot projects, and trials into full scale prototypes of operational oceanographic services. One stage of this development will be that of carrying out a part of an operation at a level which demonstrates the feasibility of the whole system, and provides learning experience in operations and improved design.

We envisage demonstration projects to test early stages of real time data gathering and transmission, The "Ferry Box" instrument system with data transmission, and new packages of sensors and deployment platforms. For example, the EuroGOOS Mediterranean Test Case requires rapid and precise launching of XBTs from voluntary observing ships of opportunity. The technology to do this may be developed as a demonstration project.

TRIALS

Trials will be required for new instruments and sensors, combining and merging data streams from in situ and remote sensed platforms, data assimilation, sensitivity trials of models, and practical attempts to identify or verify the limits of operational predictability.

PILOT PROJECTS

Pilot Projects involve an integration of many of the components needed to run an operational observing and forecasting system. EuroGOOS Members intend to organise Pilot Projects at an appropriate stage when the scientific basis for integrated modelling of different variables in each area is firmly established. Within a region, or globally, this implies identification of the most relevant variables and products, and running a prototype observing system for some time, with realistic conduct of the data transmission in real time, data assimilation, modelling, and distribution of test data products and forecasts. The Pilot Projects will be followed by analysis of the results and experience, so as to improve system design. An important stage in the development of European operational oceanography will be the decision to allocate the responsibility for identified modelling tasks to designated centres. At the regional seas level this process will evolve naturally from the interests of the agencies bordering each regional sea. For those tasks which have to be carried out at a fully European or global level, the decision is more complex. Some Pilot Projects will involve using different configurations of centres to assimilate and analyse different variables, or run models based on different underlying assumptions, so as to arrive at the best solution for Europe as a whole.

SUPPORTING ACTIVITIES

EuroGOOS Office circulates information packages every 2-3 weeks to all its Members, and to a limited range of additional Observers and associated organisations and agencies. The covering report contains up-dates on all decisions and incomplete actions which are being carried out by EuroGOOS. A EuroGOOS information page has been set up on the World Wide Web during summer 1996. EuroGOOS Office staff represent EuroGOOS at working meetings and committees, usually within Europe (e.g. with ESA, EUROMAR, SeaNet etc.), and participate in conferences and exhibitions (e.g. Sorrento MAST-EUROMAR, Oceanology International 96).

The organisation of national committees or co-ordination groups for GOOS and EuroGOOS has evolved steadily during 1994-96. EuroGOOS provides information to all Members on the progress of different structures of co-ordination in each European country, so that Members can work to improve their own co-ordination, in the confidence that other countries are doing the same. This progress is an asset both to GOOS and EuroGOOS.

COMMUNICATIONS AND TRAINING

EuroGOOS has spent its first year in developing its own internal organisation, clarifying objectives, and establishing a working methodology. A public relations information brochure was published in October 1995. EuroGOOS exhibited a display stand at the EUROMAR-MAST days at Sorrento in November 1995. A paper on EuroGOOS Technology was presented at the Oceanology International '96 Conference and published in the Proceedings. During 1996 and early 1997 the following publications are planned:

- EuroGOOS Marine Technology Survey and Review.
- The Strategy for EuroGOOS (this document).
- EuroGOOS Handbook
- The "Ferry Box" feasibility report.
- Papers presented at the First EuroGOOS Conference.
- Report of the Technology Plan WG.
- Report of the Science Advisory WG
- The EuroGOOS Plan.

EuroGOOS Members are providing information on available courses in Meteorological Colleges and equivalent establishments where students can be given instruction in operational oceanographic techniques, ocean forecasting methods. and the underlying science, technology. Some courses have been identified, largely concerned with surface marine meteorology and wave forecasting. It will be a EuroGOOS objective to promote an increased range of courses providing training for those

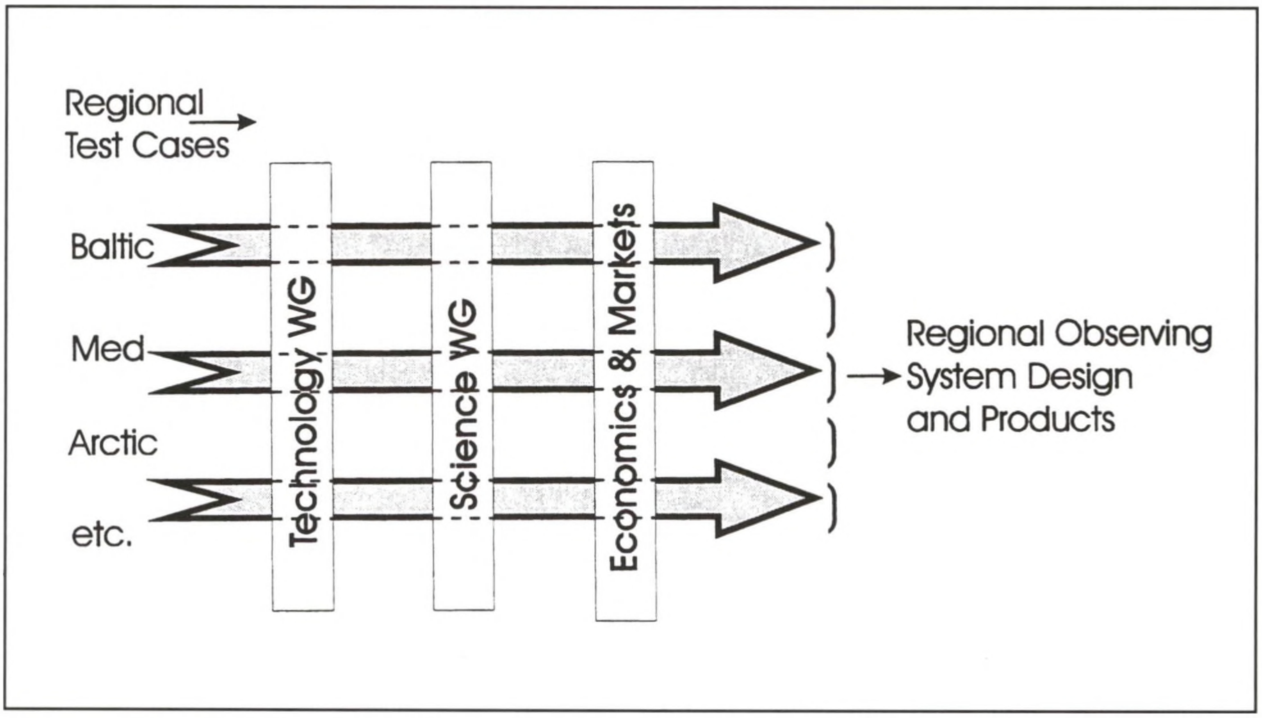


Figure 6.7 Relation of EuroGOOS Regional Test Cases to the structure of EuroGOOS
The generic analysis of markets, science, and technology is used to support the development of operational systems appropriate to each region

people who wish to develop a career in operational oceanography, either governmental or commercial.

COMMUNICATIONS WITH THE OUTSIDE WORLD

The major vehicle for EuroGOOS communication with the public, government, and industry during 1996 is the First EuroGOOS Conference, at the Haag, Netherlands, 7-11 October 1996. Programme planning, receipt of abstracts, and preliminary registration of participants are well advanced (see Annexe 5).

There will be a strong press and TV campaign associated with the EuroGOOS Conference. A press contact list has already been circulated.

The various surveys conducted by EuroGOOS result in extensive address lists, especially for commercial organisations, and these lists will used to communicate news of EuroGOOS activities and requirements.

In future EuroGOOS will organise small workshops, or seminars, to strengthen relation-ships with industry on special topics.

There was a strong interest in EuroGOOS at the OI-96 Conference, and good press coverage provided by several newspapers. The objectives of EuroGOOS are undoubtedly attractive to the science correspondents of the quality newspapers. However, public relations for its own sake would not be useful, and EuroGOOS is focusing its communications efforts on maritime industry and sub-contractors, technology and service companies, government agencies, and scientific research establishments. It is important that EuroGOOS should have concrete achievements, and make realistic progress, before embarking on public relations. Communications must be focused both for reasons of economy and objectives.

EuroGOOS MEETINGS FOR ITS MEMBERS, SERVICES TO MEMBERS

We hold an Annual Meeting of Full Members once each year.

The two main WGs, Science Advisory WG and Technology Plan WG are meeting approximately twice per year, and this is likely to continue.

The Officers of EuroGOOS meet every 2-3 months.

We hold a Plenary Meeting of all Members, Associate Members, and Observers at intervals of approximately 2 years, usually in association with a conference.

Communications within EuroGOOS include routine reports which go to all Members and related organisations every 2-3 weeks.

The EuroGOOS Office up-dates a complete address list with e-mail and fax numbers for all Members and related organisations. The Office provides distribution services for Members when required.

DIRECTORATE AND THE EuroGOOS OFFICE

The support staff in the EuroGOOS Office are:

- N C Flemming, Director
- M Gauthier, Deputy Director
- S M Marine, Secretary
- Part-time seconded staff from Member Agencies.

Seconded staff have been provided by CNR (Italy), NRA/EA (UK), and support has been offered by ENEA (Italy). RIKZ (Netherlands) is providing substantial support staff for planning the EuroGOOS Conference.

NERC (UK) provides office space at the Southampton Oceanography Centre, and supports the salaries for N C Flemming and S M Marine. IFREMER (France) supports the salary and costs of M Gauthier.

Through the institutional facilities available to NERC and IFREMER the EuroGOOS Office has access to computing support an networks, libraries, and regular contacts with full time professional scientists and engineers.

SUMMARY

EuroGOOS has available to it a wide range of methods for successfully achieving its objectives within the constraints of its budget and staff resources.

Chapter 7

Next Steps

Introduction

Foster partnerships, projects, and joint ventures between Members of EuroGOOS

Develop relations with existing and potential users and partners

Foster European industries providing the tools needed for operational oceanographic services

Develop relations with European Institutions

Develop relations between EuroGOOS and International GOOS, other regional bodies in GOOS, and other international organisations

Organise European summer schools and seminars

Strengthen the EuroGOOS Association

Summary

Chapter 7

Next Steps

INTRODUCTION

Our long term detailed plans will be set out in The EuroGOOS Plan, to be published in the first half of 1997.

The objectives of EuroGOOS have been outlined in Chapter 4 of this Strategy, and the actions taken to develop the objectives have been listed in Chapter 6. The present Chapter emphasises the immediate next steps, the question of funds and resources, access to skills, and co-ordination of effort. It is about strengthening the foundations. The Strategy for EuroGOOS concludes by indicating the actions needed during the next 12 months, and the initial projects which will be set in train while the EuroGOOS Plan is being prepared.

The analysis in this report shows that operational oceanography is a business which is ripe for development. The assets, the market, the demand, the skills, the science and the technology are all available in the necessary critical mass in Europe, and need co-ordinating and fostering to ensure take-off. However, the necessity for European-scale collaboration and co-ordination means that successful development is not inevitable. If EuroGOOS did not exist, development might be very slow, or fail. The successes already achieved, and the positive attitude shown by many regions and by industry towards EuroGOOS, and the comments from outside Europe, show that we are on the right track.

Inherent in many of the immediate actions is the need to obtain funding, but this will be considered on a project basis. We will make submissions to a range of appropriate funding agencies. Funds for co-ordination and management of EuroGOOS activities will be sought only in the form of MAST Concerted Action, or as a COST Action. Discussions on these proposals will be arranged during 1996.

The immediate next steps must be to:

- Foster partnerships, projects, and joint ventures between Members of EuroGOOS
- Develop relations with existing and potential users and partners
- Foster European industries providing the tools needed for operational oceanographic services
- Develop relations with European Institutions
- Develop relations between EuroGOOS and International GOOS, other regional bodies in GOOS, and other international organisations Organise European summer schools and seminars
- Strengthen the EuroGOOS Association

FOSTER PARTNERSHIPS, PROJECTS, AND JOINT VENTURES BETWEEN MEMBERS OF EuroGOOS

The strongest and most efficient method for ensuring progress is through "variable geometry" groupings of EuroGOOS Members who share common objectives. The Regional Task Teams are excellent examples, but other sub-sets are practical, as for example with the Ferry Box Project, special projects in remote sensing, or global operational modelling. Such groupings combine focused objectives with the necessary technology and resources in each case, and a minimum of bureaucracy.

In the immediate future, additional resources may be obtained by creating such groups, possibly with additional members from industry or academia, and seeking additional funding project by project. The skills and assets available in Europe, as outlined in Chapter 5, should be mobilised in different configurations for each project.

DEVELOP RELATIONS WITH EXISTING AND POTENTIAL USERS AND PARTNERS

The market research on user groups and their forecast and data requirements can be used in each Region to justify the investment in pre-operational research, new technology, demonstration projects, and pilot projects.

This approach will be used to obtain collaborative partners and joint funding. Potential users of operational forecasts know best what they require, and have a strong interest in having the results of experiments and trials which are developing the products they need. The companies of the value-added sector are both potential customers of EuroGOOS, but also possess many relevant skills and technologies, particularly in communications and data processing.

FOSTER EUROPEAN INDUSTRIES PROVIDING THE TOOLS NEEDED FOR OPERATIONAL OCEANOGRAPHIC SERVICES

We will use our contacts with EUROMAR and other industrial and commercial associations, to release data and information which will help to promote European marine industries. At the same time, we will use these contacts to listen to industry and commercial companies so as to understand better their requirements and uncertainties. It is not our objective to try and eliminate reasonable commercial risk or reduce competition, but, since EuroGOOS Members are in many cases the potential users of a large range of instruments and systems, it is reasonable to make our requirements known.

The response from industry towards EuroGOOS is uniformly positive. All parties recognise that it will take years to develop a fully automatic data gathering system for a wide range of variables, but both potential users of the products, and manufacturers and service providers who may participate in developing the system, are convinced that it is possible and it will be economically effective.

We will ensure that information which has potential commercial implications is released equitably to a wide range of companies so as to avoid bias or discrimination.

Companies at present complain that they have no indication what standards may be acceptable for different kinds of operational instruments, which systems or instruments may be developed by agencies as a priority or which postponed indefinitely, or which data types may be managed in real time or in delayed mode. We will seek to establish preferred options in these matters, and make the information available to European industry on an equitable basis. We have no intention at present of trying to establish mandatory standards, but merely to indicate what is needed most, and with acceptable levels of performance, will give a strong guiding signal to industry.

Commercial organisations will be encouraged to participate in trials and demonstration projects.

DEVELOP RELATIONS WITH EUROPEAN INSTITUTIONS

As shown in Chapter 5 of this Report there are many European organisations and institutions with skills and assets which can play an important contributory role in the success of European operational oceanography. These include remote sensing satellites, measuring systems on moored buoys, sophisticated computer models, and basic scientific understanding.

During 1996-97 EuroGOOS Officers will communicate with, and where appropriate visit, those organisations which are likely to have the strongest mutual interests. Copies of the Strategy for EuroGOOS will be distributed. Representatives of key organisations have been invited to attend the First EuroGOOS Conference. One objective will be to add momentum to the growing co-operation between civil and military organisations, which is already beginning to produce significant benefits.

With each organisation we will try to identify common interests, customer-contractor relations, the possibility of joint projects or collaboration, and joint interests in solving problems.

DEVELOP RELATIONS BETWEEN EuroGOOS AND INTERNATIONAL GOOS, OTHER REGIONAL BODIES IN GOOS, AND OTHER INTERNATIONAL ORGANISATIONS

We have strong working relations with both I-GOOS and J-GOOS. We are in correspondence with representatives of the regional grouping in NE Asia, NEAR-GOOS. Attention will be given to further analysis of the best way in which EuroGOOS can in practice contribute to the global scale activities within GOOS. These activities will possibly include allocation of research ship time; collaborative scheduling of research cruises; studying the relations between numerical models at different scales from global, through ocean basin scale, to local; optimal use of satellite remote sensed data; and contribution of European data to the global system.

ORGANISE EUROPEAN SUMMER SCHOOLS AND SEMINARS

There is a need for continuing exchange of ideas, discussions, workshops, and short courses relating to operational oceanography in Europe. The subject is advancing very rapidly on many fronts, and the benefits of these advances need to be transferred. EuroGOOS Members will examine ways of exchanging experience on best practice, and transferring research knowledge and skills to the various organisations engaged in operational oceanography.

Figure 7.1 The Royal Research Ship 'Discovery' Source: SOC

STRENGTHEN THE EuroGOOS ASSOCIATION

Membership of EuroGOOS needs to be extended to include agencies from Portugal and Turkey, and possibly Iceland. EuroGOOS will explore the possibility of extending Membership to include agencies from the Baltic States (Latvia, Lithuania and Estonia), and from Russia. Correspondence will be continued with appropriate bodies. Some countries will wish to strengthen the co-ordination between agencies at national level. We would welcome additional Members from those countries which at present only have one agency in EuroGOOS.

SUMMARY

During the next 12 months we will work as quickly as possible to implement the actions and projects set out in this Chapter. These steps are the preparatory work for the full range of tasks and projects described in outline in Chapters 4 and 6 of this Strategy. The detailed Plan for implementing EuroGOOS will be published in 1997.

ANNEXE 1

Members and Associate Members of EuroGOOS

Member or Associate Member	Contact Address
Bundesamt für Seeschiffahrt und Hydrographie (BSH), Germany (M)	Prof Dieter Kohnke Bundesamt für Seeschiffahrt und Hydrographie (BSH) Bernhard-Nocht-Str. 78 D 20305 Hamburg Germany Tel: +49 40 3190 3400 Fax: +49 40 3190 5000 E-mail: Kohnke@M4.Hamburg.BSH.D400.DE
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ENEA, Italy (A)	Dr Vincenzo Ferrara Task Force on Global Environment & Climate Change ENEA Casaccia Via Anguillarese 301 00060 S. Maria di Galeria Roma Italy Tel: +39 6 30483608 Fax: +39 6 30486678 E-mail:
Finnish Institute of Marine Research, Finland (M)	Dr Pentti Mälkki Finnish Institute of Marine Research PO Box 33 FIN-00931 Helsinki Finland Tel: +358 0 613941 Fax: +358 0 613 94494 E-mail: malkki@fimr.fi

Member or Associate Member	Contact Address
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IFREMER, France (M)	Prof Michel Glass IFREMER Technopolis 40 155, rue Jean Jacques Rousseau 92138 Issy-les-Moulineaux France Tel: +331 4648 2222 Fax: +331 4648 2224 E-mail: michel.glass@ifremer.fr
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Member or Associate Member	Contact Address
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MUMM, Department of Environment, Belgium (M)	Dr G Pichot Management Unit of the North Sea and Scheldt Estuary Mathematical Models (MUMM) Ministère de la Santé Publique et de l'Environnement Gulledelle 100 B-1200 Bruxelles Belgium Tel: +32 2 7732111 Fax: +32 2 7706972 E-mail: mummgp@camme.ac.be
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National Institute for Coastal and Marine Management (RIKZ), Rijkswaterstaat, Netherlands (M)	Dr Leendert J Droppert National Institute for Coastal and Marine Management/RIKZ Directoraat-Generaal Rijkswaterstaat PO Box 20907 2500 EX The Hague The Netherlands Tel: +31 70 3114551 Fax: +31 70 3114321 E-mail: droppert@rikz.rws.minvenw.nl

Member or Associate Member	Contact Address
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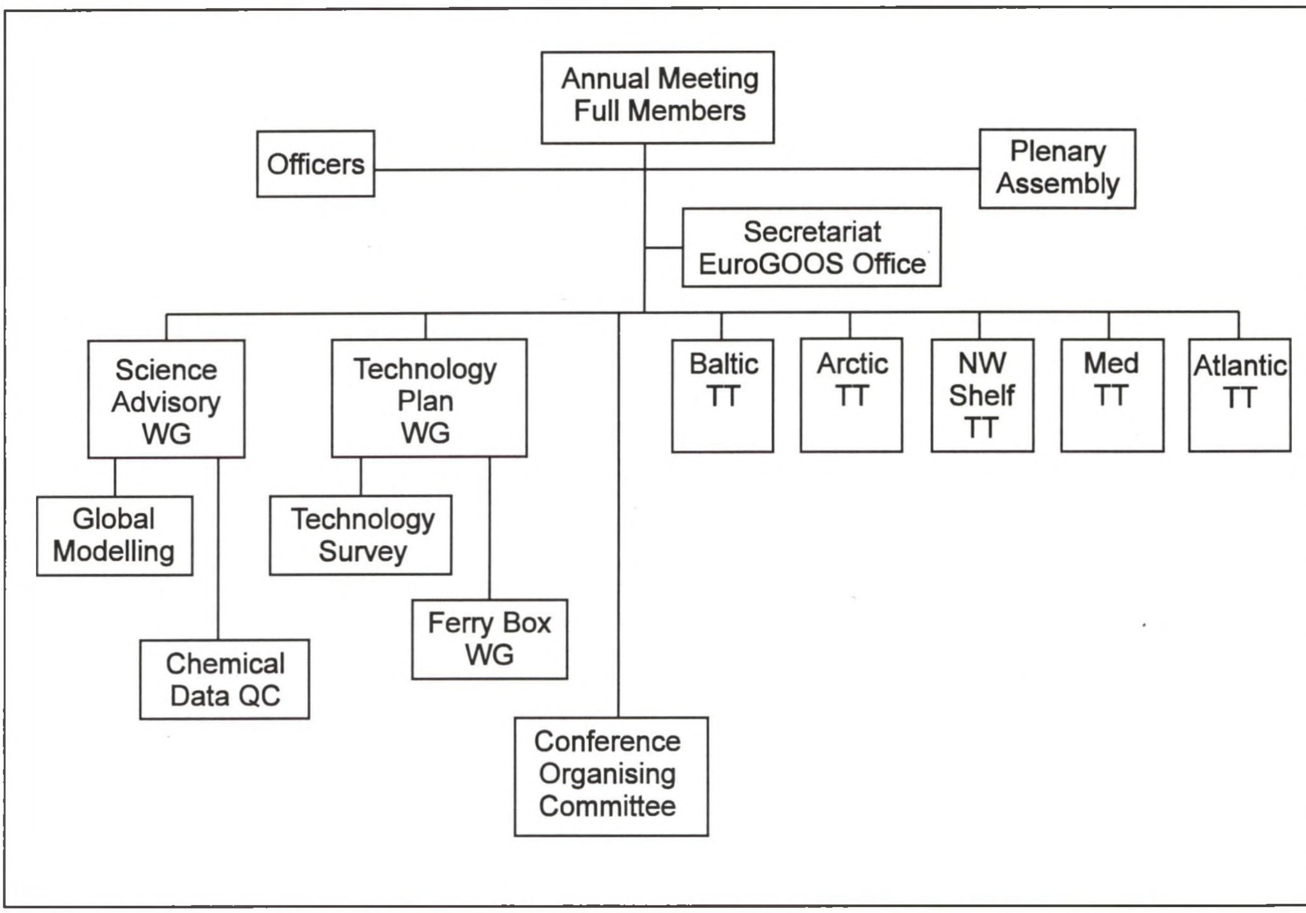
Natural Environment Research Council (NERC), UK (M)	Prof J G Shepherd Director, Southampton Oceanography Centre Empress Dock, European Way Southampton SO14 3ZH Tel: +1703-595106 Fax: +1703-595107 E-mail: j.g.shepherd@southampton.ac.uk
Netherlands Geosciences Foundation (GOA), Netherlands (A)	Dr Jan H Stel Director, Netherlands Geosciences Foundation PO Box 93120 2509 AC The Hague The Netherlands Tel: +31 70 344 07 80 Fax: +31 70 383 21 73 E-mail: goa@nwo.nl
Puertos del Estado, Clima Marítimo, Spain (A)	Sr A Ruiz de Elvira Puertos del Estado Clima Marítimo Avda. del Partenón 10 E-28042 Madrid Spain Tel: +341 524 5568 Fax: 341 524 5506 341 524 5502 E-mail: ant@puertos.es
Royal Danish Administration of Navigation and Hydrography, Denmark (M)	Dr Erik Buch Royal Danish Administration of Navigation & Hydrography P O Box 1919 DK 1023 Copenhagen K Denmark Tel: +45 32 68 95 00 Fax: +45 31 57 43 41 E-mail:
Swedish Meteorological and Hydrological Institute, Sweden (M)	Hans Dahlin Swedish Meteorological and Hydrological Institute S-601 76 Norrköping Sweden Tel: +46 11 15 83 05 Fax: +46 11 15 83 50 E-mail: hdahlin@smhi.se

EuroGOOS Organisation



WG = Working Group
TT = Task Team
see following pages for terms of reference

TECHNOLOGY PLAN WORKING GROUP

Terms of Reference and Objectives

1. The TPWG shall consist of a Chairman, appointed in the first case by the Officers after consultation with Members, and experts nominated by Members. The Chairman TPWG on subsequent occasions shall be elected by the Members after consultation with the Officers. Members of EuroGOOS may propose experts from their own staff to join the TPWG, or, if they wish, experts from other agencies in their own country whom they think would best represent the appropriate skills. Members may propose experts to the TPWG who are not themselves employed by Member Agencies.

2. The term of appointment of the Chairman TPWG shall be for three years, with the option for re-appointment. Change of Chairmanship TPWG during an appointment period will proceed through the Director EuroGOOS.

3. Between Meetings of EuroGOOS Chairman TPWG shall report to Chairman EuroGOOS, and will work in collaboration with, and supported by, Director EuroGOOS.

4. Meetings of the WG should whenever possible be attended by a member of the Secretariat who will ensure that, so far as possible, proposed actions can be supported by the staff effort available from the Secretariat.

5. The TPWG shall draw on previous analyses conducted by Members, by ECOPS, I-GOOS, the Fixed Monitoring Network, MAST Technology Programme, MAST Supporting Initiatives, ESA, EUROMAR, ICES, and other programmes or agencies where relevant.

6. The activities of the TPWG shall be determined by Meetings of EuroGOOS, and Chairman TPWG shall prepare an outline of actions to be carried out between Meetings of EuroGOOS. If Chairman TPWG is not an Officer of EuroGOOS, he shall be invited to attend Officers Meetings when relevant. Between Meetings of EuroGOOS variations in the tasks of the Technology Plan WG shall be agreed in advance by the Chairman EuroGOOS in consultation with the Officers.

7. The TPWG shall operate through a programme meetings, workshops, publications, surveys, pilot studies and trials, including projects involving several Members. Activities approved between Meetings of EuroGOOS shall be reviewed for confirmation at the next Meeting of EuroGOOS.

8. All activities initiated by the TPWG shall be funded by the Member Agencies participating, or by obtaining outside grants or funding for the project.

9. If the TPWG wishes to enter jointly into an arrangement with another organisation, not being a Member of EuroGOOS, the proposed arrangement should be notified to the Director, and reported at the next Meeting.

10. These Terms of Reference can be modified only by decision of a Meeting of EuroGOOS.

OBJECTIVES

1. The TPWG shall prepare a Technology Plan identifying:

   - Existing European marine technology which is adequately developed and tested to support operational oceanography.
   - New technology which is under development and is needed by EuroGOOS.
   - Gaps in technology or operational problems or procedures which at present cannot be solved, but which are needed in the near future.

2. The Technology Plan should be drafted within a 5-10 year framework, with special attention to the first 5 years.

3. The Technology required by EuroGOOS should be identified and assessed in terms of its commercial availability, proven track record, existing operational installations and compatibility with expanded systems proposed within EuroGOOS. Attention should be given to the need for compatibility of systems and data throughout the EuroGOOS area.

4. The assessment of European operational ocean technology undertaken by the TPWG should be conducted in terms of categories of technology, and their present and future status. For some categories of technology it may be necessary to record that there is no experience of this technology in Europe.

5. The Technology Plan should identify shortcomings in present technological capability which threaten to undermine the operational efficiency, reliability, and economic viability of GOOS or EuroGOOS, and identify where possible the groups or programmes conducting the technological development relevant to solving these problems.

6. Where further research or development of technology is required, the new effort should be related where possible to existing programmes or budget lines in the EU *Framework Programmes* (MAST, ENVIRONMENT, ENRICH, and others), *or* EUREKA (EUROMAR, ENVIRONMENT, *and others).*

7. The TPWG should seek to identify Pilot Projects where new technology, or combinations of technologies can be tested and implemented on a trial basis to demonstrate how operational projects will function, including demonstration and trails of data transmission and data assimilation in trial operational conditions. For these purposes the TPWG should be informed regularly of progress in the proposed Pilot Studies and Test Cases.

8. The TPWG will hold meetings with user communities.

9. *These Objectives can be modified only by decision of a Meeting of EuroGOOS.*

SCIENCE ADVISORY WORKING GROUP

Terms of Reference and Objectives

1. The purpose of the Science Advisory WG is to establish, and thence update, a scientific base to guide the EuroGOOS Plan.

2. The SAWG shall consist of a Chairman, appointed in the first case by the Officers after consultation with Members, and experts nominated by Members. The Chairman SAWG on subsequent occasions shall be elected by the Members after consultation with the Officers. Members of EuroGOOS may propose experts from their own staff to join the SAWG, or, if they wish, experts from other agencies in their own country whom they think would best represent the appropriate skills. Members may propose experts to the SAWG who are not themselves employed by Member Agencies.

3. The size of the WG may be limited if this is deemed necessary by the members of the WG, and the WG shall refer such a decision to the Chairman and Director of EuroGOOS for approval.

4. The term of appointment of the Chairman SAWG shall be for three years, with the option for re-appointment. Change of Chairmanship SAWG during an appointment period will proceed through the Director EuroGOOS.

5. Between Meetings of EuroGOOS Chairman SAWG shall report to Chairman EuroGOOS, and will work in collaboration with, and supported by, Director EuroGOOS.

6. Meetings of the WG should whenever possible be attended by a member of the Secretariat who will ensure that, so far as possible, proposed actions can be supported by the staff effort available from the Secretariat.

7. The SAWG shall draw on previous strategic science analyses conducted by EuroGOOS Members or any other relevant organisations in order to establish the appropriate applications for EuroGOOS. EuroGOOS is a vehicle for applying scientific research results to operational marine forecasting.

8. The activities of the SAWG shall be determined by Meetings of EuroGOOS, and Chairman SAWG shall prepare an outline of actions to be carried out between Meetings of EuroGOOS. If Chairman SAWG is not an Officer of EuroGOOS, he shall be invited to attend Officers Meetings when relevant. Between Meetings of EuroGOOS variations in the tasks of the Science Plan WG shall be agreed in advance by the Chairman EuroGOOS in consultation with the Officers.

9. The SAWG may operate through a programme meetings, workshops, publications, surveys, pilot studies and trials, including projects involving several Members. Activities approved between Meetings of EuroGOOS shall be reviewed for confirmation at the next Meeting of EuroGOOS.

10. All activities initiated by the SAWG shall be funded by the Member Agencies participating, or by obtaining outside grants or funding for the project.

11. If the SAWG wishes to enter jointly into an arrangement with another organisation, not being a Member of EuroGOOS, the proposed arrangement should be notified to the Director, and reported at the next Meeting.

12. These Terms of Reference can be modified only by decision of a Meeting of EuroGOOS.

OBJECTIVES

1. The WG shall prepare during 1996 a provisional Science Plan which defines the scientific basis for EuroGOOS, bearing in mind the stipulations of the MoU, and with particular attention to the limits of predictability, sampling design, required accuracy and precision of observations, numerical modelling techniques, data assimilation, and sensitivity trials of models.

2. The WG shall work mainly by correspondence, but may hold a 1-day meeting immediately prior to a meeting of EuroGOOS, and other meetings as required, at the cost of the Members concerned.

3. A preliminary summary of progress shall be presented at the October 1996 Meeting, and a draft Report at the December Annual Meeting 1996.

4. The WG should consult with the Technology Plan WG on matters of joint interest, especially the transfer of models from research mode to operational mode. The WG should consider different types of models or observing schemes needed in the different regional seas of Europe, and global models.

5. The Science Plan should address a 5-10 year framework, with special attention to the first 5 years.

6. The SAWG should identify developments in present scientific knowledge required to expand the reliability or predictive capabilities of GOOS or EuroGOOS, and liaise with groups and programmes conducting research into the relevant problems including: The EU Fourth Framework, MAST-3, environment and climate programmes, and other European CEC programmes.

7. The SAWG may stimulate proposals for Pilot Projects or Demonstration Projects to explore or prove scientific methodology or principles essential to the development of GOOS or EuroGOOS in conjunction with the Task Teams for Regional Test Cases.

8. These Objectives may be altered at the December Meeting 1996 to allow for further revision or extension of the Science Plan.

EuroGOOS Regional Test Cases

Terms of Reference and Objectives

TERMS OF REFERENCE (All Regional Test Cases)

1. The group responsible for developing the Case Study in each Region shall be called the Test Case Task Team (TCTT). There is no absolute limit fixed for maximum membership of the TT, but it is expected that there will be about 5-6 Members in each TT.

2. The TCTT shall consist of a Rapporteur and members appointed at EuroGOOS Meetings. A report of progress shall be submitted to each Meeting of EuroGOOS. The Rapporteur shall report to Chairman EuroGOOS between Meetings, and work in collaboration with Director EuroGOOS. Extra Members of the TT may be co-opted between Meetings after notifying Director EuroGOOS.

3. The TCTT is appointed for one year, and the extension or termination of the Terms of Reference will be reviewed every year at the closest Meeting to the elapsed period of 12 months since the previous review.

4. Members of EuroGOOS may propose experts from their own staff to join the TCTT, or, if they wish, experts from other agencies in their own country whom they think would best represent the appropriate skills. Members may propose experts to the TCTT who are not themselves employed by Member Agencies.

5. Change of Rapporteur of the TCTT during an appointment period will proceed through correspondence with the Director EuroGOOS.

6. The TCTT shall work so far as possible through correspondence. Actions proposed by the TT should be referred to the Director to ensure that appropriate EuroGOOS Secretariat support is available.

7. The TCTT shall draw on previous analyses conducted by Members, by ECOPS, ESF Ocean Sciences Board, I-GOOS, the Fixed Monitoring Network, MAST Technology Programme, MAST Supporting Initiatives, ESA, EUROMAR, ICES, and other programmes or agencies where relevant, especially regional and local projects which are already in place to develop or operate operational marine forecasts. In particular, the TCTT shall take into account programmes, reports, or surveys conducted by the Technology Plan WG and the Science Plan WG which are relevant in their Region.

8. The activities of the TPWG shall be determined by Meetings of EuroGOOS, and Lead Person/ Chairperson of the TCTT shall prepare an outline of actions to be carried out between Meetings of EuroGOOS.

9. The objective of the TCTT is to examine the observational requirements for operational data and forecasts in each region, and to consider the optimal characteristics of an observational system in that region which would integrate operational data from space, meteorology, sea surface, and sub-surface observations so as to meet the regional requirements. The study should be at the level of concept outline or feasibility study, with no attempt to embark on a full design or field trials. The final report shall recommend the next stages. The objectives are listed more fully below.

10. All activities initiated by the TCTT shall be funded by the Member Agencies participating, or by obtaining outside grants or funding for the project.

11. If the TCTT wishes to enter jointly into an arrangement with another organisation, not being a Member of EuroGOOS, the proposed arrangement should be notified to the Director, and reported at the next Meeting.

12. These Terms of Reference can be modified only by decision of a Meeting of EuroGOOS.

OBJECTIVES

1. Within one year the TCTT shall prepare a report to the EuroGOOS Meeting including a review and recommendations covering the topics listed in these Objectives. The level of detail and working out of plans should be in the form of Concept Definition.

2. Identify the agencies, national bodies, collaborative arrangements, and multi-national bodies operating in the defined sea/ocean Region carrying out projects or programmes of relevance to the development and implementation of operational oceanography. Identify centres of excellence and expertise which could provide focus for particular activities such as data centres, satellite communication ground stations, modelling centres, research vessel bases, etc.

3. Identify the observations and data products needed in the Region which are common for all European sea/ocean Regions, and check this identification with the other TTs. This exercise will minimise duplication. Observations and required data products should be categorised as needed or available on timescales of 2 years, 5 years, 10, and 15 years.

4. Examine customer requirements, major proxy customer organisations, and agencies with data requirements in the Region which are unique or special to that Region; e.g. sea ice forecasting, formation of freshwater stratification, storm surges, toxic algal blooms. Data for this can be extracted from the national EuroGOOS Data User Requirements Surveys.

5. Identify the technology, installations, operational models, and other necessary components of an operational system which are already available, or potentially available in the Region. Data can be extracted from the EuroGOOS TPWG Survey of Operational Technology. Indicate technological shortfall, or outstanding technological requirements, with timescales of 2 years, 5, 10, and 15 years.

6. Specify unique or special observations needed in the Region, ocean boundary conditions, characteristics and processes in straits, sea ice and ice-melting, stratification, seasonal river flows, dumping areas, industrial pollution, major polluting rivers, etc.

7. Catalogue those models and forecasting systems in the Region already under trial, or in operation. Use TPWG survey as a starting point. Consult MAST and EUROMAR.

8. The first annual report of the TCTT to EuroGOOS in December 1996 shall be a Concept Definition or interim report recommending the next stages of development of operational oceanography in the region, estimating the scope of work required, timescales to key benchmarks, and the logical sequence of development. Progress reports should be provided for review by the Officers 1 March 1996; and by the EuroGOOS Meeting in September 1996.

SPECIAL TASKS IN EACH REGION

The following notes are provisional, and should be revised by the members of the TCTT at an early stage. For each Region possible unique factors are listed which require inclusion in the design of an operational system, but would not be included in other Regions, or would be of low priority.

Arctic

Ocean depth modelling of the adjacent Arctic Ocean, ocean-shelf coupling, sea ice, seasonal variations in sea ice, variations or trends in sea ice thickness, fisheries, deep cold water formation, storms, accessibility of the North East Passage to navigation, services to the offshore oil industry in Arctic and Russian waters, indicators of climate change, plankton blooms, toxic algae, monitoring of radionuclide contamination from the Nova Zemlya region.

North West European Shelf Seas

Atlantic boundary and slope processes, Atlantic convection and deep water formation, seasonal and inter-annual variations in the North Atlantic, tidal and meteorological forcing of the shallow shelf seas, sediment transport, coastal erosion, storm surges and flooding, co-occurrence of extremes, services to the offshore oil and gas industry- especially on the shelf edge, services to sand and gravel dredging, support to regulatory authorities, monitoring of pollution from major rivers and point sources, primary productivity and plankton blooms as input data to fisheries management.

Baltic

Fluxes between Baltic and North Sea, oxygen levels and eutrophication, fisheries productivity, floating sea ice, pollution monitoring and prediction, river inputs.

Mediterranean

Basin scale modelling and circulation, full ocean depth modelling of the Mediterranean basins, deep water formation, fluxes at key straits, (Gibraltar, Sicily, Aegean, Bosphorus), precipitation-evaporation balance, river inputs, pollution transport modelling, assessment of the side effects of the tourist industry and intensive use of the coastal zone, impact of earthquakes and tsunamis, effect of the Nile dam, influx of species through the Suez Canal, impacts of pollution in a closed sea, climate linkage to Sahel.

ANNEXE 3

Members of EuroGOOS Subsidiary Bodies

General Meeting

Chairman Professor J D Woods. At a General Meeting of EuroGOOS only the Full Members can attend, that is, the representative of the lead agency from each country. The Lead Agency Members are indicated in Annexe 1.

Plenary Meeting

All Members and Associate Members can attend the Plenary Meeting of EuroGOOS, which is held approximately once every two years.

Technology Plan WG

Representative	Agency	Country
J Bosman (Chairman)	RIKZ	The Netherlands
A Arteggiani/F Raicich/S Vallerga	CNR	Italy
B Barnouin/P Marchant	IFREMER	France
E Buch	RDANH	Denmark
H Cattle/S Foreman	Met. Office	UK
H Dahlin/B Broman	SMHI	Sweden
J Diaz	CSIC	Spain
T Guymer	SOC	UK
D Kohnke	BSH	Germany
P Koske	Universität Kiel	Germany
D Palmer/N Holden	NRA/EA	UK
B Papalia	ENEA	Italy
J L Pelegri	Universidad Las Palmas	Spain
J Piechura/S Sagan	PAS	Poland
P Seifert	EUROMAR	Germany
C Tziavos	NCMR	Greece
M White	Marine Institute	Ireland

Science Advisory WG

Representative	Agency	Country
D Prandle (Chairman)	NERC	UK
E Buch	RDANH	Denmark
H Cattle	Met. Office	UK
H Dahlin	SMHI	Sweden
L Droppert	RIKZ	The Netherlands
M Glass	IFREMER	France
T Guymer	SOC	UK
O Johannessen	Nansen Center	Norway
P Mälkki/K Kahma	FIMR	Finland
B McCartney	POL	UK
G Parrilla	CICYT	Spain
N Pinardi	CNR	Italy
A Ruiz de Elvira	Puertos del Estado	Spain
R Saetre	IMR	Norway
F Schott	Universität Kiel	Germany
G Triantafyllou	IMBC	Greece
S Vallerga	CNR	Italy
H van Aken	NIOZ	The Netherlands

Baltic Region Test Case TT

Representative	Agency	Country
H Dahlin (Chairman)	SMHI	Sweden
E Buch	RDANH	Denmark
D Kohnke	BSH	Germany
P Mälkki	FIMR	Finland
J Piechura	PAS	Poland

Arctic Region Test Case TT

O Johannessen (Chairman)	Nansen Center	Norway
E Buch	RDANH	Denmark
H Cattle	Met. Office	UK
D Kohnke	BSH	Germany
P Mälkki	FIMR	Finland
R Saetre	IMR	Norway

NW Shelf Test Case TT

H Cattle (Chairman)	Met. Office	UK
E Buch	RDANH	Denmark
L Droppert	RIKZ	The Netherlands
M Glass	IFREMER	France
D Kohnke	BSH	Germany
G Pichot	MUMM	Belgium
M White	Marine Institute	Ireland

Mediterranean Test Case TT

N Pinardi (Chairman)	CNR	Italy
H Cattle/S Foreman	Met. Office	UK
V Ferrara	ENEA	Italy
M Glass	IFREMER	France
G Parrilla	CICYT	Spain
A Ruiz de Elvira	Puertos del Estado	Spain
J Shepherd	NERC	UK
G Triantafyllou	IMBC	Greece
C Tziavos	NCMR	Greece

Atlantic Test Case

J D Woods

Global Modelling Consultation Group

Being established, spring 1996.

SECRETARIAT

N C Flemming, Director
M Gauthier, Deputy Director
S M Marine, Secretary

ANNEXE 4

EuroGOOS

Memorandum of Understanding

14 December 1994

EuroGOOS

An informal association fostering European co-operation on the Global Ocean Observing System

The EuroGOOS Memorandum of Understanding

14 December 1994

This Memorandum of Understanding (to be known in brief as the EuroGOOS MoU) serves as the initial document establishing EuroGOOS, an informal association whose members seek to foster European co-operation on the Global Ocean Observing System. EuroGOOS is established with full recognition of the importance of existing systems in research and operational oceanography in Europe at national and European scales. By signing the MoU organisations become members of EuroGOOS, and agree to co-operate in promoting GOOS in Europe.

Aims of EuroGOOS

Members of EuroGOOS will co-operate to establish a concerted European approach to the following goals: contributing to international planning and implementation of GOOS and promoting it at national, European and global level; identifying European priorities for operational oceanography, promoting the development of the scientific, technology and computer systems for operational oceanography, assessing the economic and social benefits from operational oceanography,

Activities

EuroGOOS activities will be designed to collaborate with and maximise the benefits from existing activities in operational oceanography, promoting the integration of these activities within the framework of GOOS. Members of EuroGOOS will collaborate and support the following groups of activities:

Policy in promoting GOOS

i) To develop policies for the furtherance of GOOS and co-ordinating the best European participation in GOOS, identifying where greatest value is added by collaboration.
ii) To promote collaboration between existing European multi-national agencies, programmes, organisations, and initiatives having expertise in oceanography, operational systems, and remote sensing of the ocean.
iii) To provide, as appropriate, expertise, WGs, consultants, etc., to J-GOOS and I-GOOS.
iv) To promote studies and evaluation of the economic and social benefits produced by operational oceanography.

v) To co-operate as appropriate with organisations concerned with climate change, global environmental research, and the impacts of climate variability and climate change.

vi) To publish findings of meetings, workshops, studies, and other documents commissioned by the EuroGOOS members, joint representation at and submission of documents to international meetings related to GOOS, and collective representation of GOOS to European and national Agencies, when requested by members.

vii) To co-ordinate GOOS data acquisition with existing European and national data gathering under Agreements and Conventions relating to pollution monitoring, marine meteorology, navigation and safety at sea.

Advancing European operational oceanography in GOOS

viii) Promoting development of European regional and local operational oceanography, taking into account the Modules of GOOS for the Coastal Zone, Health of the Ocean, Living Marine Resources, Climate, and Ocean Services.

ix) Promoting development of common European operational data procedures and services, including data quality control and data management for operational oceanography.

x) Promoting research and pre-operational research which will solve problems relating to operational oceanography.

xi) Promoting development of common infrastructure and to promote major systems or capital installations required to support European operational oceanography.

xii) Promoting pilot studies in GOOS operations, local, regional, or global.

xiii) Promoting development of common European operational oceanographic services and products of maximum value to European Governments and Agencies, furtherance of European industries and service companies, and the protection of the environment and health in the European coastal and shelf seas.

Promotion of Instrumentation and Technology

xiv) To promote the development of low cost efficient operational instrumentation, observing systems, and data acquisition systems.

xv) To support operational oceanography and services in collaboration with public and private sector organisations and programmes in Europe concerned with ocean technology.

xvi) To promote collaboration with space agencies and remote sensing scientists and engineers so as to ensure optimum integration of both in situ and remote sensed data in operational oceanography.

Aid and Capacity building

xvi) To promote aid, technology transfer, and collaboration with developing countries within the framework of GOOS.

xvii) To promote collaboration between European institutes and agencies in providing aid and assistance to developing countries for operational oceanography, and the necessary capacity building.

Membership

EuroGOOS Members will be national organisations (authorities, agencies, institutes) willing to advance GOOS in their country and actively to contribute to its extension at the European level. The initial list of Members will be the organisations listed in Appendix 1 invited to sign this MoU. EuroGOOS Members participate in the activities listed above (section headed Activities) and contribute to the costs of running those activities. Where there is more than one agency in a country wishing to join EuroGOOS and entitled to join, the institutes and agencies in that country will designate a lead agency or authority which will be their representative at the Annual Meetings. Members of EuroGOOS other than the national lead agency or authority shall be designated Associate Members. New Members, either Members from countries not yet represented or new Associate Members, shall be designated by the Annual Meeting. The guidelines for recognition of new Members and Associate Members shall be the subject of separate addendum not part of this MoU, which may be revised by the Members from time to time. A current set of guidelines shall be available at the time of signature of this MoU.

European multi-national organisations

European multi-national organisations and non-governmental organisations with a European emphasis, or components or subsidiaries of such organisations, provided that they have aims and objectives consistent with this MoU, may be invited to become Observers or Associate Members at the discretion of the Members.

EuroGOOS Officers

The Members will appoint at the Annual Meeting a Chairman, one or more Vice-chairmen, and a Secretary/Treasurer, who will serve as EuroGOOS Officers for two years, and be responsible for all EuroGOOS activities between Annual Meetings. The Officers will meet as necessary. They will be eligible for re-appointment for up to a maximum of eight successive years. The Secretary/Treasurer will be responsible for EuroGOOS financial arrangements, and for the management of EuroGOOS funds if any central funds are agreed or created. The Secretary/Treasurer will be responsible for the EuroGOOS office; the Director will report to him.

Annual meeting

EuroGOOS will hold regular yearly meetings (called Annual Meetings) in order to define the overall policy of EuroGOOS, review the progress of ongoing activities and suggest new operational programmes. Decisions will be taken jointly by EuroGOOS Members at the Annual Meeting. The attendance at the Annual Meeting will consist of one representative per country, being the designated EuroGOOS Member for that country agreed by the Associate Members from that country. Each representative at the Annual Meeting will act as the intermediary between EuroGOOS and the

Associate EuroGOOS Members in his/her country. For meetings other than the Annual Meeting the Associate Members may participate in the proceedings directly.

Delegates

Each Member organisation entitled to attend will nominate one delegate to participate in the Annual EuroGOOS Meeting.

Other Meetings

EuroGOOS activities will include meetings of delegates of member organisations, other informal meetings of experts as required, workshops, seminars, and pilot projects.

EuroGOOS funding

Members and Associate Members shall bear their own costs for attending meetings and participation in the activities of EuroGOOS. Members and Associate Members shall contribute to the costs of running EuroGOOS by contributions in kind to activities such as hosting meetings, organising workshops, ad hoc study groups or pilot projects, consulting services to national and multilateral bodies, employing consultants, financing publications, providing for their own costs of communications, and other items as agreed upon by Members at the Annual Meeting. The costs of the EuroGOOS Office shall be met by one or more Member offering to provide accommodation, support services, and/or professional staff for a number of years. Members or Associate Members may second additional staff to the EuroGOOS Office. The location of the EuroGOOS Office may be rotated from Member to Member as agreed by Members at an Annual Meeting.

Notwithstanding the general principle that the costs of EuroGOOS activities and the EuroGOOS Office are met by contributions in kind by members, this shall not exclude the raising of funds from time to time by applications for grants or support for special projects as agreed and defined by Members at an annual Meeting. The Secretary/Treasurer shall be responsible for any funds raised by EuroGOOS, and shall be accountable for their expenditure to the Annual Meeting.

EuroGOOS Office

The EuroGOOS Office will be established at a leading oceanographic research establishment in Europe. The Director and staff will be based at the Office. Offers to host the Office will be sought from Members. The day-to-day functioning of the Office will follow the practice of the host establishment. The location of the Office may be rotated from one Member to another by agreement of Members at an Annual Meeting at least one year in advance of the date of transfer. By agreement of the preparatory meeting of 18.7.94, and in response to the offer from the UK, the first location of the EuroGOOS Office shall be at the Southampton Oceanography Centre, Southampton, UK.

EuroGOOS Director

The EuroGOOS Director will be appointed by the Officers. He will be responsible for ensuring the satisfactory implementation of all decisions made by the Annual Meeting and between Annual Meetings by the Officers. He will prepare papers for the Annual and other meetings and represent EuroGOOS at international organisations as required by the Officers. He will direct the EuroGOOS staff and manage all activities of the Office. He will report to the EuroGOOS Officers through the Secretary.

Foundation meeting

The Convenors will invite representatives of organisations listed in Appendix 1 to attend a Foundation Meeting of EuroGOOS to be held during 1994. At the preparatory meeting of interested agencies on 18 July 1994 it was agreed that a minimum quorum of 5 signatories shall be sufficient to establish EuroGOOS. The Foundation Meeting will approve the Memorandum of Understanding, appoint a Chairman and Officers, fix a date for the first Annual Meeting, confirm the proposals for establishing the GOOS Office and on an initial programme of work.

Duration

EuroGOOS will come into effect at the Foundation Meeting on the signing of the EuroGOOS MoU by at least five Members. It will continue until such time as an Annual Meeting of Members decides that it should end or the number of Members falls below five.

ADDENDUM 1

Convenors

The European Committee on Ocean and Polar Sciences (ECOPS) appointed the following Convenors, J Woods (UK, chairman), J Dronkers (Netherlands), O Johannessen (Norway) and P Papon (France), to carry out actions agreed in discussion on European collaboration on GOOS at the ECOPS planning meeting for a European Ocean Science Forum held in Strasbourg on 21 March 1994. Specifically, the Convenors were charged with preparing an MoU on European Co-operation on GOOS, identifying an initial list of organisations to be invited to sign the MoU and thereby become members of EuroGOOS, to organise a foundation meeting for EuroGOOS members in 1994, and to seek offers to host the EuroGOOS Office and second staff to it. Representatives of Agencies and Institutes who are potential members of EuroGOOS met on 18 July 1994 to review the draft MoU and agree on the location of the proposed EuroGOOS Office. The Preparatory Group met again at Bremen on 14 September 1994, and agreed the final draft of the MoU, and a revised draft of Guidelines for Members. It was agreed that the EuroGOOS Office in the first instance should be located at the Southampton Oceanography Centre.

Foundation Members of EuroGOOS

Institution	Signature	Name
Bundesamt für Seeschiffahrt und Hydrographie (BSH), Germany		D Kohnke
Comision Interministerial de Ciencia y Technologie (CICYT), Spain		*Authorised proxy for* E Banda
Consiglio Nazionale Delle Ricerche (CNR), Italy		E Garaci
Directoraat-Generaal Rijkswaterstaat, Netherlands		L J Droppert
ENEA, Italy		N Cabibbo
Finnish Institute of Marine Research, Finland		P Mälkki
GeoHydrodynamics and Environment Research (GHER), Belgium		*Authorised proxy for* J C J Nihoul
IFREMER, France		P Papon
Institute of Oceanology, Polish Academy of Sciences, Poland		J Piechura

Foundation Members of EuroGOOS

Institution	Signature	Name
Marine Institute, Ireland		J Wallace
Meteorological Office, UK		*Authorised proxy for* P J Mason
MUMM, Department of Environment, Belgium		G Pichot
Nansen Environmental and Remote Sensing Center, Norway		O M Johannessen
National Rivers Authority (NRA), UK		D Palmer
Natural Environment Research Council (NERC), UK		J G Shepherd
Netherlands Geosciences Foundation, (GOA), Netherlands		*Authorised proxy for* J H Stel
Swedish Meteorological and Hydrological Institute, Sweden		H Dahlin

Members of EuroGOOS

31 May 1995

Signatories to the EuroGOOS Memorandum of Understanding

Institution	Signature	Name
National Centre for Marine Research of Greece		C Tziavos *appointed by* D Papanicolaou
Institution of Marine Biology of Crete		G Triantafyllou *appointed by* A Eleftheriou

29 November 1995

Institution	Signature	Name
Royal Danish Administration of Navigation and Hydrography		E Buch *appointed by* S T Petersen
Institute of Marine Research, Bergen		R Saetre
Puertos del Estado, Clima Marítimo		A Ruiz de Elvira *appointed by* L F Palao Taboada

SECOND AND FINAL ANNOUNCEMENT

First International Conference on

EuroGOOS

European Global Ocean Observing System

A25

Operational Oceanography

The Challenge for European Co-operation

7 - 11 October 1996

The Hague
The Netherlands

Ministry of Transport, Public Works and Water Management
Directorate-General for Public Works and Water Management
National Institute for Coastal and Marine Management/*RIKZ*

EUROGOOS 1996 - FIRST INTERNATIONAL CONFERENCE

This promotional conference is an important occasion for the Organizing Committee and the officers of EuroGOOS to establish working relations with the European organizations, commercial companies, institutes and individuals which are involved and interested in operational oceanography. Not only on a global scale, but also on a European scale.

We are confident that we have succeeded in creating a very challenging programme with a high quality of selected papers and invited speakers. We are quite convinced that every participant of the conference will find new opportunities to meet his future demands for information and forecasts about the ocean, climate changes, coastal zone problems, technology and science, economic influences and cost/benefit relations.

Parallel to the conference, there will be an exhibition which will give a wide variety of GOOS-objectives: technology, related science-projects, regional and national implementations of EuroGOOS.

We are proud to welcome a great number of people of almost all European countries and from other continents. The global challenging and demanding perspective of GOOS will require an interested and dynamic group of people to attend the conference in The Netherlands.

We hope that there will be enough time for you to meet old and new colleagues in the field of operational oceanography and your commercial partners for discussing the challenges of the future. The Hague and other places in Holland will also provide you the opportunities to meet the Dutch, their culture and history and their neverending struggle with and against the water in the Delta of the rivers Rhine, Meuse and Scheldt. We are pleased to offer you some possibilities to have your own Dutch adventure during the conference.

This first conference on EuroGOOS will be the starting point for a dynamic implementation of GOOS. We trust and are convinced that it will be an opportunity for all participants to start a real European collaboration for the coming 21st century with an outcome on a global scale.

The success of EuroGOOS and its aims depends entirely upon the members of EuroGOOS, all the participants of the conference and the sponsoring organizations.
The Organizing Committee will be pleased to welcome all the members (commercial and non-commercial) of the European marine and ocean-related community.

We hope to welcome you and are looking forward to be your host on the EuroGOOS conference 1996 at The Hague. Please send your registration form as soon as possible.

Kind regards,
Leen Droppert, Chairman Organizing Committee
The Hague, May 1996

International Advisory Committee

EuroGOOS	Woods J.D.; Chairman; Imperial College, London University.
	Flemming N.C.; Director
	EuroGOOS members
Belgium	Nihoul, J.C.J.; GeoHydrodynamics and Environment Research (GHER)
Belgium	Pichot, G.; MUMM, Department of Environment
Denmark	Buch, E.; Royal Danish Administration of Navigation and Hydrography
Finland	Mälkki, P.; Finnish Institute of Marine Research
France	David, P.; IFREMER
Germany	Kohnke, D; Bundesamt für Seeschiffart und Hydrographie
Greece	Triantafyllou, G.; Institution of Marine Biology of Crete
Greece	Tziavos, C.; National Centre for Marine Research
Ireland	Wallace, J.; Marine Institute
Italy	Cabibbo, N.; ENEA
Italy	Garaci, E.; Consiglio Nazionale Delle Ricerche (CNR)
Netherlands	Droppert, L.J.; National Institute for Coastal and Marine Management (RIKZ)
Netherlands	Stel, J.H.; Netherlands Geosciences Foundation (GOA)
Norway	Johannessen, O.M.; Nansen Environmental and Remote Sensing Center
Norway	Saetre, R.; Institute of Marine Research, Bergen
Poland	Piechura, J; Institute of Oceanology, Polish Academy of Sciences
Spain	Banda, E.; Comision Interministerial de Cienca y Technologie
Spain	Ruiz de Elvira, A.; Puertos del Estado, Clima Maritima
Sweden	Dahlin, H.; Swedish Meteorological and Hydrological Institute
United Kingdom	Mason, P.J.; Meteorological Office
United Kingdom	Palmer, D.; National Rivers Authority (NRA)
United Kingdom	Shepherd, J.G.; Natural Environment Research Council (NERC)

Steering (Scientific) Committee

Flemming, N.C.	Director EuroGOOS, UK, Chairman
Dahlin, H.	SMHI, Sweden
Droppert, L.J.	RIKZ, Netherlands
Glass, M.	IFREMER, France
Vallerga, S.	CNR, Italy

Organizing Committee

Akkerman, R.	North Sea Directorate
Behrens, H.W.A.	National Institute for Coastal and Marine Management (RIKZ)
Borst, J.C.	EuroGOOS-Netherlands secretariat
Dongen, F. van	Oceanographic Company of the Netherlands
Droppert, L.J.	National Institute for Coastal and Marine Management (RIKZ)
Flemming, N.C.	EuroGOOS secretariat, Southampton, UK
Kersbergen, T.	Ministry of Transport, Public Works and Water Management
Onvlee, J.	Royal Netherlands Meteorological Institute
Stel, J.H.	Netherlands Geosciences Foundation
Thiemann, R.	Delft Hydraulics
Wensink, H.	Advisory and Research Group on GEO Observation Systems and Services
Wolf, R. de	EDS

Sponsors

The following sponsors have already supported the conference:

European Commission
IOC (Intergovernmental Oceanographic Commission)
EUROMAR (Eureka Project on Marine Technology)
ESA (European Space Agency)
The Netherlands EuroGOOS Group

PRELIMINARY PROGRAMME

7 October 1996

17.00 - 19.00 hrs. Registration at the Netherlands Conference Centre

18.00 - 19.30 hrs. Get-together party offered by the National Institute for Coastal and Marine Management/RIKZ, The Hague, The Netherlands

8 October 1996

8.30 - 10.00 hrs. Registration

Opening Ceremony

10.00 - 10.15 hrs. Welcome *by L.J. Droppert*, the Conference Chairman, National Institute for Coastal and Marine Management/RIKZ, Rijkswaterstaat, The Netherlands

Opening Address *by P.H.A. Hoogweg* Director RIKZ, The Netherlands

Introductions

10.15 - 10.45 hrs. The needs for GOOS *by D.J. Baker*, Under Secretary of Oceans and Atmosphere, and Administrator of NOAA (National Oceanic and Atmospheric Administration)

10.45 - 11.15 hrs. The Strategy of EuroGOOS *by J.D. Woods* Chairman EuroGOOS; Imperial College, London University, United Kingdom

11.15 - 11.45 hrs. Break

Case Studies

11.45 - 12.35 hrs. ENSO-Climate variability forecasting *by a representative of ENSO-Forecasting Group*

A World Weather Watch concept for operational oceanography *by P. Dexter* (WMO)

Challenge/Philosophy

12.35 - 13.00 hrs. The challenge to observe the world ocean circulation *by W.P.M. de Ruijter*, Utrecht University, The Netherlands

13.00 - 14.30 hrs. Lunch

14.30 - 14.45 hrs. The Netherlands and EuroGOOS *by Mrs. A. Jorritsma-Lebbink* Minister of Transport, Public Works and Water Management, The Netherlands

14.45 - 15.15 hrs. European dimensions of ocean and climate forecasting *by a representive of the European Commission*

15.15 - 15.45 hrs. Break

15.45 - 16.15 hrs. Regional GOOS for sustainable development and management *by G. Kullenberg* Executive Secretary Intergovernmental Oceanographic Commission (IOC), Paris

Economic Dimensions

16.15 - 17.15 hrs. Global aspects of megascience *by P.A.J. Tindemans*, The Netherlands Chairman OECD Megascience Forum on Oceanography

Costs and benefits of operational oceanography: the effects of scale and aggregation *by N.C. Flemming*, Director EuroGOOS, United Kingdom

Benefits/costs analysis: specific cases *by B.F. Mannix (invited)* Buckland Mill Associates, USA

17.15 hrs. Closure

17.30 - 19.00 hrs. Reception offered by the Mayor of The Hague
The location of this reception will be the Municipal Museum

Schedule 9 October 1996

08.45-10.30 hrs.	11.00-12.30 hrs.	14.00-15.30 hrs.	16.00-17.15hrs.
Technology		Economics	
A1 Instruments/ Monitoring Networks	A2 Remote Sensing	A3 Benefits/ Costs	A4 Logistics and Structure
EuroGOOS Regions			
B1 Baltic	B2 Arctic	B3 Atlantic I	B4 Atlantic II
EuroGOOS Regions			GOOS
C1 North-West Shelf (Fysical Models)	C2 North-West Shelf (Ecological Models)	C3 Mediterranean	C4 Global and Climate
GOOS			
D1 Regional GOOS	D2 GOOS Modules	D3 Developing Countries I	D4 Developing Countries II

19.00 hrs. Conference dinner at the Pier Scheveningen

PRELIMINARY PROGRAMME

9 October 1996

The conference is intended to be a working meeting where we all learn, exchange ideas and even change our opinions. Especially on this day feel free to circulate between the parallel sessions and listen to the speeches on other subjects in addition to your own speciality.
Due to logistic matters we would like to be informed on your preferences. Please be so kind to fill out the schedule printed on the registration form.

8.45 - 10.30 hrs. - A1 Technology: Instruments/Monitoring Networks
Chairman: **F. de Strobel, Italy**
Rapporteur: **A. Ruiz de Elvira, Spain,** has been invited

(K) *S.E. Hansen, T. Audunson, J.H. Stel, Norway/The Netherlands*
SEAWATCH, performance and future

J. Rozema, R. van der Poel, The Netherlands
SEANET; European workshop on fixed monitoring networks in the North Sea region

R.J. Burt, R. Williams, United Kingdom
A proposed new ship-of-opportunity towed vehicle and sensor suite designed for coastal, shelf and ocean basin survey

J. Crook, C. Schofield, United Kingdom
Sampling strategies for oceanographic features

11.00 - 12.30 hrs. - A2 Technology: Remote Sensing
Chairman: **G. Duchoissois, France**
Rapporteur: **V. Barale, Italy**

(K) *G. Duchoissois, France*
Current and future plans of ESA in support of operational oceanography

O.M. Johannessen, E. Bjørgo, S. Sandven, A. Jenkins, G. Evensen, L.H. Pettersson, M. Miles, Norway
Proposed strategy for the use of remote sensing in EuroGOOS

Nominated speaker from European Centre for Medium-term Weather Forecasting (ECMWF)
Operational use of ERS-1 and 2 data: seasonal forecasting

G.J. Wensink, C.J. Calkoen, G.H.F.M. Hesselmans, J. Vogelzang, The Netherlands
The bathymetry assessment system

(K) : *Keynote speaker*

14.00 - 15.30 hrs. - A3 Economics: Benefits/Costs
Chairman: **R. Weiher, USA**
Rapporteur: **N.C. Flemming, United Kingdom**

(K) *N.C. Flemming, United Kingdom*
Economics of the use of ocean forecasts at the single industry level

M. White, Ireland
Implications of EuroGOOS on marine policy making in a small maritime economy

M. Brown, France
Cost/benefit analysis of GOOS - Some methodological issues

C.J. Shaw, The Netherlands
Metocean data collection: short-term costs and long term benefits?

16.00 - 17.15 hrs. - A4 Economics: Logistics and Structure
Chairman and Rapporteur: **N.C. Flemming, United Kingdom**

(K) *P. Ryder, United Kingdom*
The economics of operational oceanographic services

A.C. van Tol, The Netherlands
System Architecture for GOOS: lessons learned from another sector

I. Leggett, I. Bellamy, F. Dolan, United Kingdom
Development of METNET- an operational offshore meteorological and oceanographic data network

8.45 - 10.30 hrs. - B1 EuroGOOS Regions: Baltic
Chairman: **D. Kohnke, Germany**
Rapporteur: **H. Dahlin, Sweden**

(K) *H. Dahlin, Sweden*
The Baltic oceanographical operational sytem BOOS

J. Gajewski, Poland
Organisational and functional design of an international operational data exchange network

H. Grönvall, Finland
Finnish operational oceanographical service

E. Buch, Denmark
Oceanographic monitoring network in the Danish waters

11.00 - 12.30 hrs. - B2 EuroGOOS Regions: Arctic
Chairman: M.M. Tilzer, Germany
Rapporteur: O.M. Johanessen, Norway

(K) *O.M. Johannessen, E. Bjørgo, M. Miles, Norway*
Operational climate monitoring program of the Arctic ice cover

P. Wadhams, United Kingdom
Variability of Arctic Sea ice thickness

M. Spindler, Germany
Coupled ecosystems of the ice covered Arctic ocean

H. Sandler, L. Grönland, Finland
Biological and chemical studies in the Petshora Sea

14.00 - 15.30 hrs. - B3 EuroGOOS Regions: Atlantic I
Chairman: J-F. Minster, France
Rapporteur: A. Navarra, Italy

(K) *Keynote speaker to be announced*

A. Navarra, K. Miyakoda, N. Pinardi, Italy
Global Ocean data assimilation experiments with in situ and satellite altimeter data

J.-P. Guinard, France
EMMA: A cost/efficient system for generating time series of profiling measurements at fixed locations

Invited contribution from the European Meteorological Satellite Organisation (EUMETSAT)

16.00 - 17.15 hrs. - B4 EuroGOOS Regions: Atlantic II
Chairman: To be announced
Rapporteur: A. Navarra, Italy

J.P. van der Meulen, The Netherlands
Strategic approach to real time data acquisition and dissemination on a global scale

M. Alves, A. Simoes, Portugal
Azores current system modelling and monitoring

P. De Mey, France
Forecasting and nowcasting with regional and global ocean data assimilation systems (ODAS)

8.45 - 10.30 hrs. - C1 EuroGOOS Regions: North-West Shelf (Fysical Models)
Chairman: B. S. McCartney, United Kingdom
Rapporteur: H. Cattle, United Kingdom

(K) *A. Davies, United Kingdom*
Dynamic coupling open ocean and shelf seas models

A. Voorrips, H. Hersbach, F. Koek, G. Komen, V. Makin, J. Onvlee, The Netherlands
Wave prediction and data assimilation at the North Sea

J. Backhaus, Germany
D-3 modelling for the North-West European shelf

E.V.L. Kuijper, M. Verlaan, M.E. Philippart, E.A. Mouthaan, J. van der Linden, The Netherlands
Data-assimilation techniques used in continental storm surge models

11.00 - 12.30 hrs. - C2 EuroGOOS Regions: North-West Shelf (Ecological Models)
Chairman: F. Colijn, Germany
Rapporteur: J. Baretta, Denmark

(K) *J. Baretta, Denmark*
The importance of high frequency observations in ecological modelling of marine systems

R.J. Vos, M.T. Villars, H. van Pagee, B. Althuis, J.N. Roozekrans, The Netherlands
An integrated data-model system to support monitoring and assessment of marine systems

P.M.J. Herman, The Netherlands
A honking GOOSe? Ecological modelling and the global Ocean Observing System.

G. Evensen, H. Drange, Norway
Data assimilation for coastal zone monitoring and forecasting

14.00 - 15.30 hrs. - C3 EuroGOOS Regions: Mediterranean
Chairman: To be announced
Rapporteur: N. Pinardi, Italy

(K) *N. Pinardi, Italy*
A numerical forecasting system for the Mediterranean Sea

G. Tacconi, Italy
Experimental data quality for the assesment of underwater acoustic modelling

U. Send, Germany
Monitoring the ocean with acoustic tomography

G. Petihakis, G. Triantafyllou, D. Koutsoubas, K. Dounas, Greece
Modelling the annual cycles of nutrient and primary production on a lagoon dynamical system (Gialova lagoon Greece)

16.00 - 17.15 hrs. - C4 GOOS: Global and Climate
Chairman: **Representative of GCOS**
Rapporteur: To be announced

(K) *L. Bengtsson, Germany*
Climate modelling and observations

J.-F. Minster, France
Aspects of global ocean modelling

H. Cattle, United Kingdom
Global ocean models for forecasting

8.45 - 10.30 hrs. - D1 GOOS: Regional GOOS
Chairman: **Officer from IOC**
Rapporteur: **A. Bijlsma, The Netherlands**

E. Lindström, USA
Practice of US - GOOS

Dong Yong Lee, Korea
Developments of NearGOOS

P.J. van Leeuwen, The Netherlands
A monitor system for the Indian-Atlantic connection

P. Riley, Australia
Australian GOOS

11.00 - 12.30 hrs. - D2 GOOS: GOOS Modules
Chairman and Rapporteur: M. Glass, France

(K) *J.M. Leppinen, Finland*
Health of the ocean-module: The HELCOM example

J. Dronkers, The Netherlands
Why is EuroGOOS important for Coastal Zone managers

E. Kjerkegaard, R. Baïly, Denmark
Living marine resources-module: the provision of the scientific advices on fisheries

J. Guddal, Norway
The role of the services-module in the integrated GOOS programme

14.00 - 15.30 hrs. - D3 GOOS: Developing Countries I
Chairman: **G. Kullenberg, France**
Rapporteur: **J.H. Stel, The Netherlands**

(K) *J.H. Stel, The Netherlands*
Lego for capacity building

A. Soegiarto, Indonesia
Increasing the involvement of member states in GOOS through capacity building: The Indonesian experience

E. Okemwa, Kenya
Capacity building for GOOS: developments, needs and requirements for Eastern Africa

16.00 - 17.15 hrs. - D4 GOOS: Developing Countries II
Chairman: **G. Kullenberg, France**
Rapporteur: **J.H. Stel, The Netherlands**

A. Reyes, Columbia
Capacity building for GOOS: developments, needs and requirements for the Carribean

M.J.F. Stive, The Netherlands
Victims of technology push or leading the market pool?

PRELIMINARY PROGRAMME

10 October 1996

9.00 - 10.30 hrs. Summary & conclusions and future plans

Next steps for EuroGOOS *by N.C. Flemming*
Director of EuroGOOS, United Kingdom

Future technology requirements *by J.J. Bosman*
Chairman of the EuroGOOS Technical Plan Working Group (TPWG), The Netherlands

Specifying scientific inputs for EuroGOOS *by D. Prandle*
Chairman of the EuroGOOS Scientific Advisory Group (SAG), United Kingdom

GOOS concepts for the European regional seas *by J.D. Woods,*
Chairman EuroGOOS;
Imperial College, London University, United Kingdom

10.30 - 11.00 hrs. Break

11.00 - 12.30 hrs. Round table discussion
The panel will consist of EuroGOOS Officers, European organizations and End-users

12.30 - 12.45 hrs. Conference Statements & Conclusions
Closing

The afternoon is available for related project meetings

11 October 1996 Optional Excursions, for details see the general information

Possible data products from GOOS

- Globally consistent, long term, quality controlled data sets, made available and updated operationally, for a wide range of oceanographic parameters such as temperature, salinity, precipitation, heat flux, upper layer thickness, geostrophic currents, global sea level topography, etc., in such a way that the data can be assimilated into ocean climate models, and coupled ocean-atmosphere climate models.

- The global perspective obtained through global data sets and model outputs consistently through time should permit the early detection of the onset of non-linear events, such as formation of unusually persistent layers of low salinity water, changes of ocean circulation patterns. The same global approach maximises the chance of detecting complex patterns or 'fingerprints' which can be attributed to known causes.

- Products on an ocean basin scale, and continental marginal sea scale, which provide data on physical and chemical parameters, and data on primary and secondary productivity, for the guidance of fisheries managers and regulatory agencies.

- Global overview of data and information related to living resources and their changes which will permit the identification of trends and problems occurring on global, as opposed to regional and/or local scales, leading to co-operating efforts to analyse and address these issues.

- Ocean basis scale products of physical, chemical and biological parameters which will provide boundary conditions for coastal models.

- Global and regional data sets which will permit analysis and correlation of the factors causing harmful algal blooms.

- Coastal phytoplankton, productivity and standing crop data, based on SEAWIFS satellite measurements and *in situ* data sources.

- Integrated data products based on predictions of sea level, storm extreme events, and storm surges, related to coastal erosion and flooding.

- Global data sets related to the physical and chemical parameters determining productivity and survival of major ecosystem habitats such as coral reefs, and mangrove forests.

- Basin scale and continental shelf sea scale data sets designed to facilitate and support local modelling of estuaries and wetlands.

- Global maps and profiles of distribution of contaminants and pollutants designated as potentially dangerous for the health of the open ocean, such as PCBs, lead, plastics, and the distribution of nuclear waste.

- Distribution of nutrients, excess nutrients, and the probability of eutrophication on basin scale and continental shelf seas scale.

- Data products indicating nutrient ratios.

- Global and basin scale products showing production of methane from clathrates, and venting of methane to the atmosphere.

- Products indicating optical properties of the upper ocean, light transmission at a range of wavelengths and water depths, including the effects of possible increases in UV.

- Global and basin scale products indicating variability in ecosystems, species diversity, and environmental factors causing changes in primary productivity and fisheries.

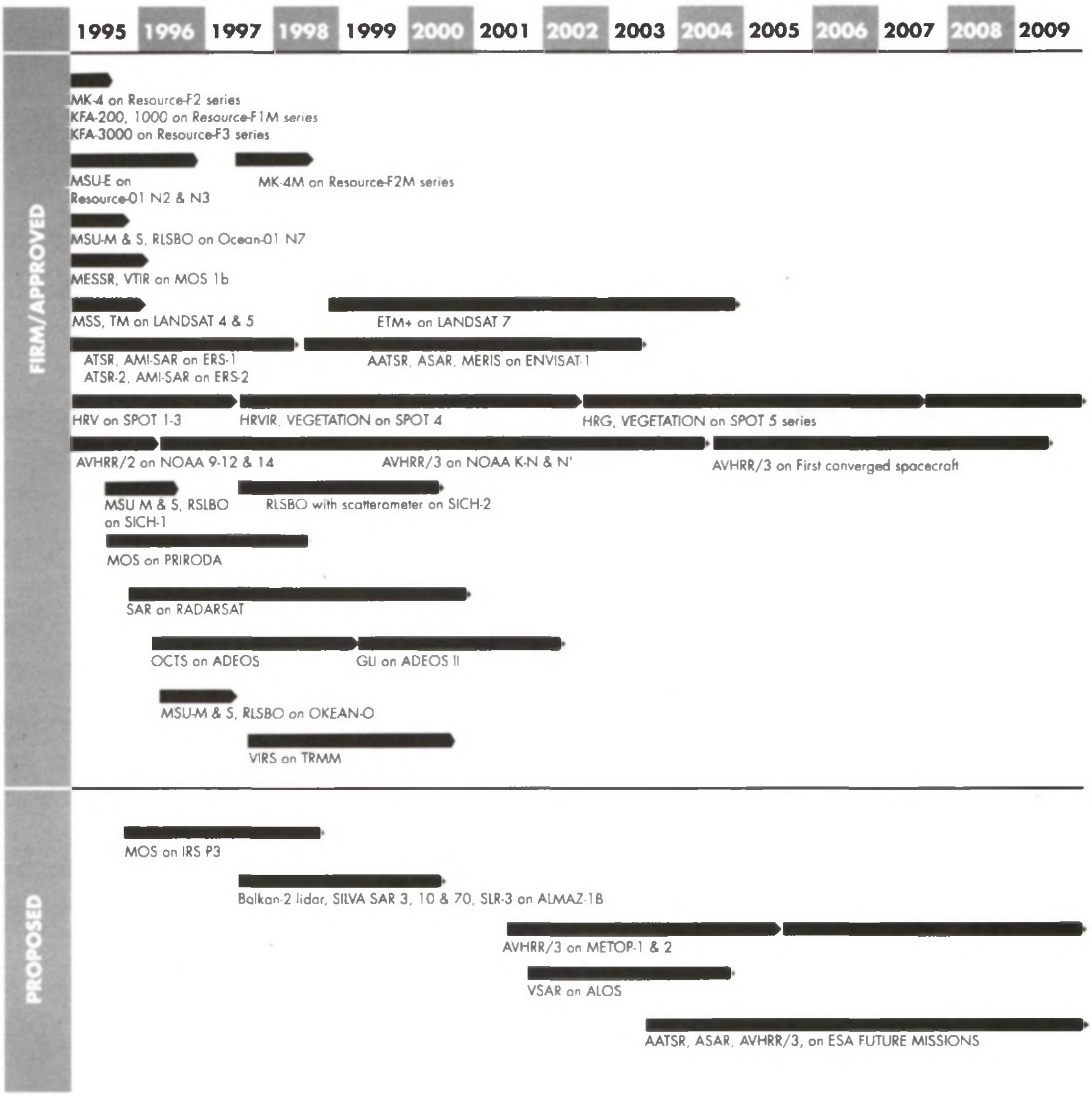
- Trans-ocean Continuous Plankton Recorder data sets.
- Global and regional sea ice products, based on modelling and prediction including data from radar sat, SAR, wind data, sea-surface temperature, currents, upper ocean thermal balance, convection, etc.
- Improved data on ice thickness, ice front, navigability, etc.
- Global and regional predictions of icing conditions on ships' structure and rigging, based on wind, wave, spray, SST, air-temperature, etc.
- A combination of Radar Altimetry, improved geoid by the gravity field satellite 'Aristoteles', ship-borne and moored ADCP, and currents derived from dead-reckoning and GPS, and data from sea level gauges, will allow derivation of global maps showing surface geostrophic and wind-driven currents.
- Global and regional products will predict the position of western boundary currents, large scale gyres, warm and cold rings and associated currents.
- These products will be valuable in ship-routing, and in the fishing industry.
- Products could include current information with salinity and frontal data.
- Weather forecasts to ships in the prediction range 10-30 days could be improved by the inclusion of global data on upper ocean, heat flux, precipitation over the ocean, precipitation-evaporation data, etc.
- Wind-wave products are part of the routine services of meteorological offices, but enhanced observation, generated through GOOS should permit improvements in quality as well as scale coverage. The data are important in ship-routing, ship design, oil field operations, safety at sea, and design of offshore structures.
- Wind and wave products are important for the prediction of movement and dispersion of oil slicks, other hazardous spills, or nuclear contamination.
- Sea surface temperature maps, predicting temperatures and the positions of fronts are relevant to fisheries exploitation and management, and long term policy for the sustainability of fisheries.
- Additional sub-surface thermal data products are relevant in connection with mixed-layer depth and the formation of fronts.

(From 'The Case for GOOS, IOC, Paris, 1992)

ANNEXE 7

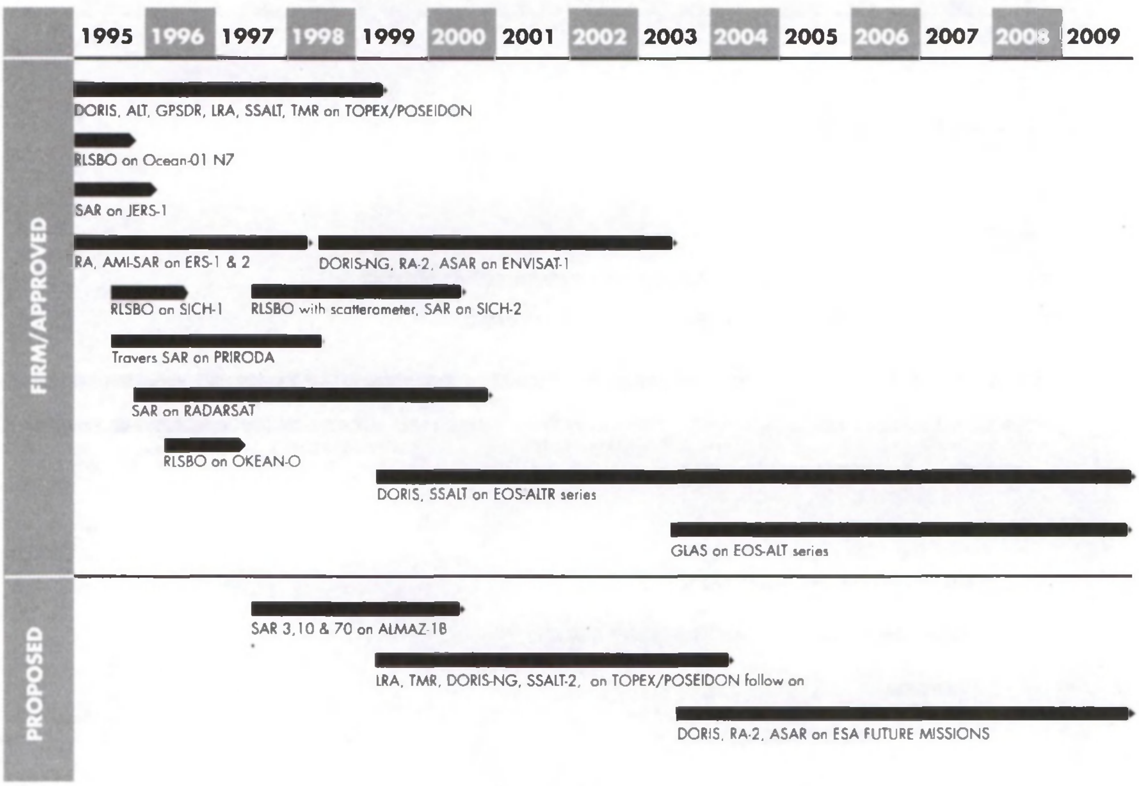
List of ocean-observing missions *Source: CEOS, 1995*

(a) Multi-purpose imagery (ocean)



List of ocean-observing missions	*Source: CEOS, 1995*

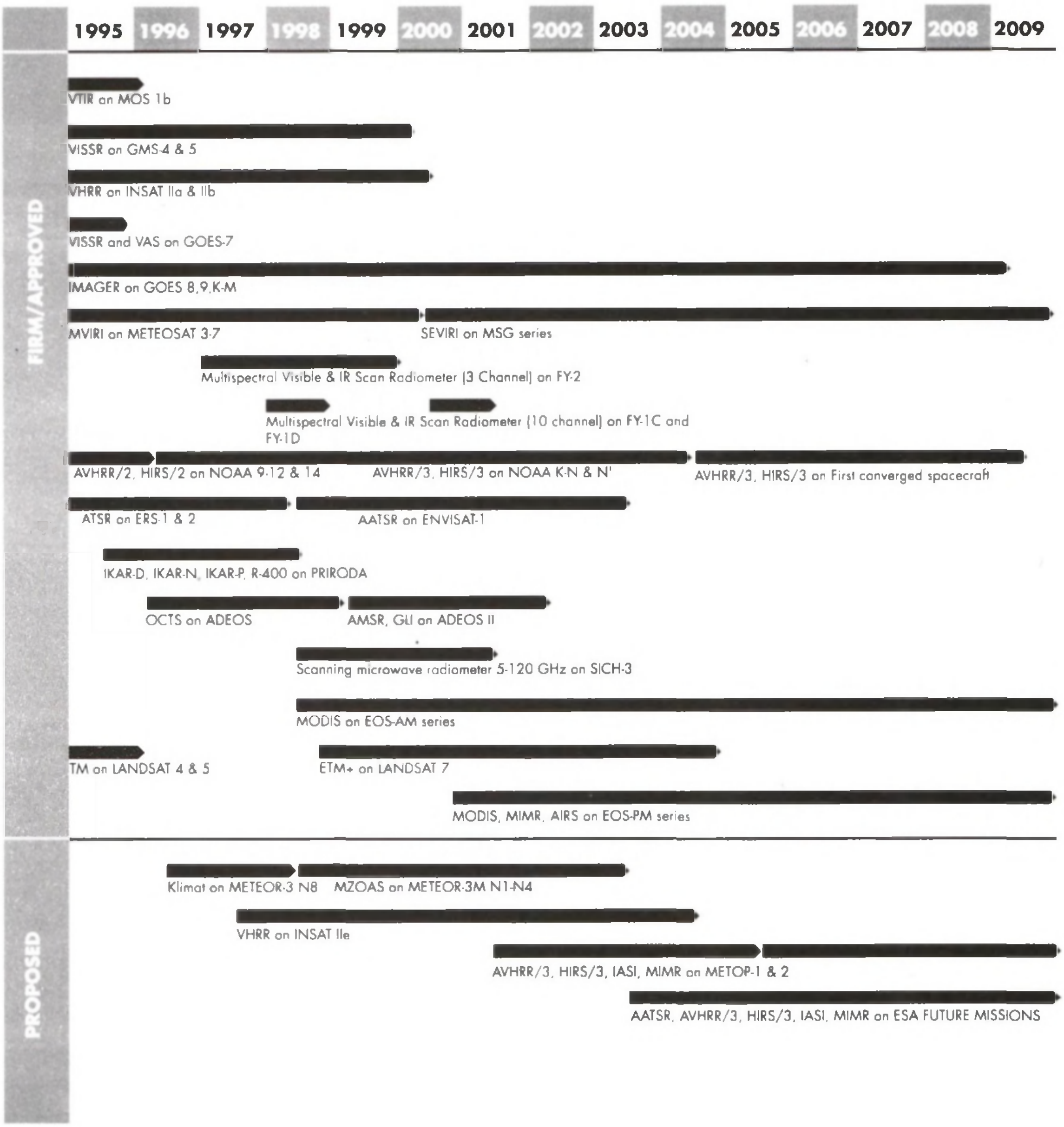
(b) Ocean Topography/Currents



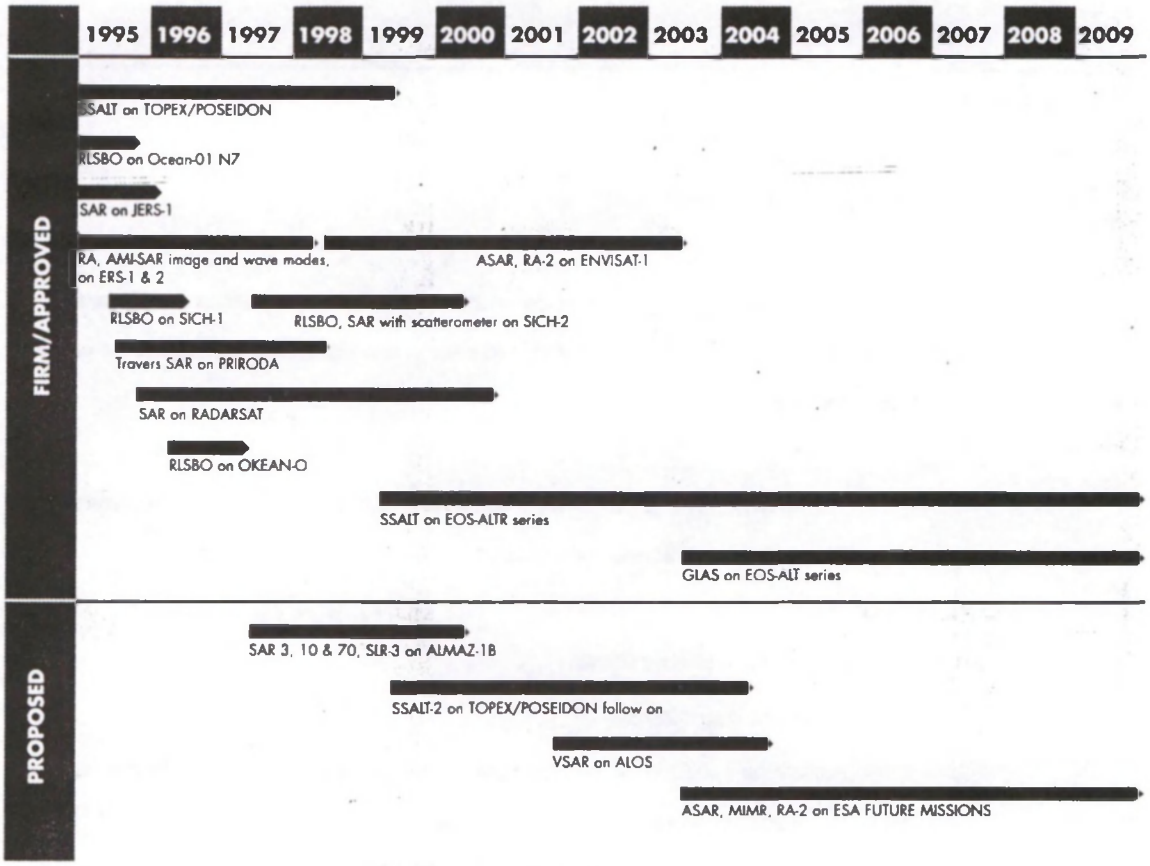
List of ocean-observing missions

Source: CEOS, 1995

(c) Surface temperature (sea)

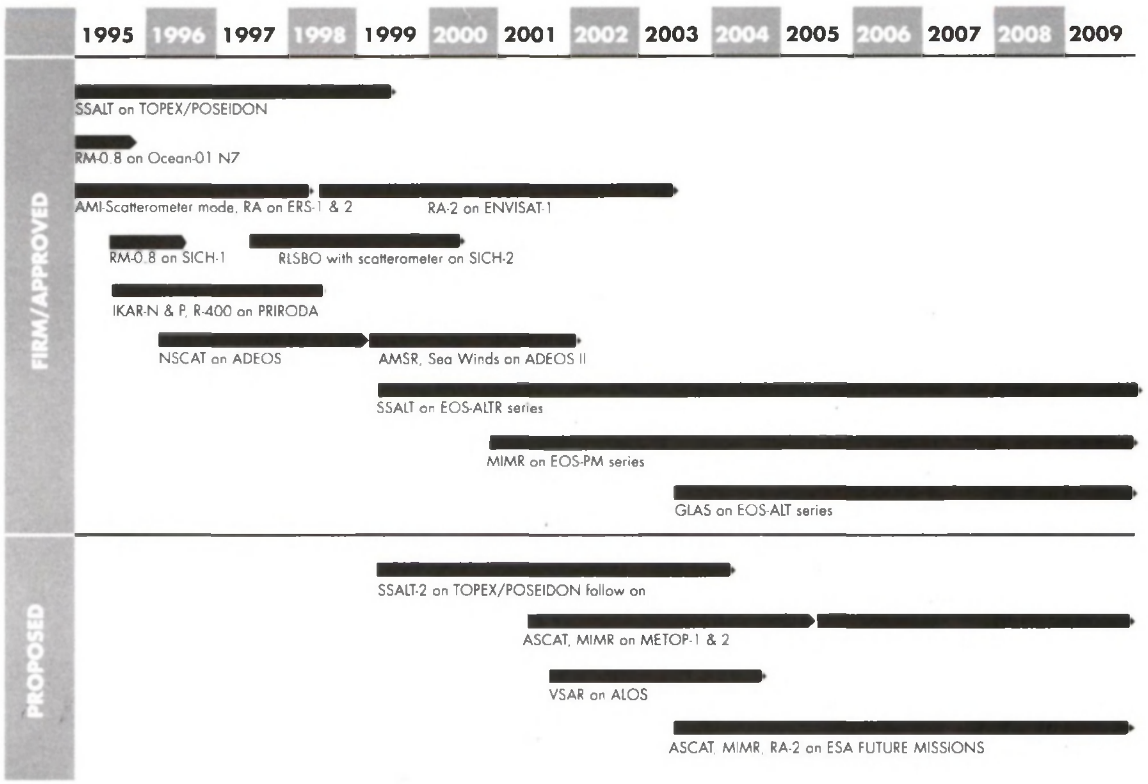


(d) Wave height and spectrum



List of ocean-observing missions *Source: CEOS, 1995*

(e) Sea surface winds



ANNEXE 8

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ACRONYMS

ACSYS	Arctic Climate System Study
AIM	Atlantic Isopycnic Model
AMAP	Arctic Monitoring and Assessment Programme
AODC	Australian Oceanographic Data Centre
ASW	Anti-Submarine Warfare
AUV	Autonomous Underwater Vehicle
AVHRR	Advanced Very High Resolution Radiometer
BNSC	British National Space Centre
BOAT	Bulletin Ocean Atlantique Tropical (Fr)
BSH	Bundesamt für Seeschiffahrt und Hydrographie
CCMST	Co-ordinating Committee on Marine Science and Technology
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
CSM	Continental Shelf Model
CTD	Conductivity Temperature Depth
DG	Directorate General
EA	Environment Agency, UK (formerly National Rivers Authority)
EC	European Commission
ECMWF	European Centre for Medium Term Weather Forecasting
ECOPS	European Committee on Ocean and Polar Science.
EEA	European Environmental Agency
EEZ	Exclusive Economic Zone
EMaPS	European Marine & Polar Science
ENEA	ENEA, Italy
ENSO	El Niño Southern Oscillation
EOPSB	European Ocean and Polar Sciences Boards
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ESF	European Science Foundation
EU	European Union
Eumetsat	European Meteorological Satellite organisation
Eureka	European Research Programme
EuroGLOSS	European Global Sea Level Observing System
EUROMAR	European Marine Research Programme within EUREKA
EuroGOOS	European Global Ocean Observing System
FAO	Food and Agriculture Organization (UN)
FIMR	Finnish Institute of Marine Research
FOAM	Forecasting Ocean Atmosphere Model
FRAM	Fine Resolution Antarctic Model
G7	Group of Seven
GCOS	Global Climate Observing System
GEWEX	Global Energy and Water-cycle Experiment (WCRP)
GHER	GeoHydrodynamics and Environment Research, Belgium
GIM	Global Isopycnic Model
GLOBEC	Global Ecosystem Experiment
GLORIA	Geological Long-Range Inclined Asdic
GOA	Netherlands Geosciences Foundation
GOOS	Global Ocean Observing System
HELCOM	Helsinki Commission (Baltic Marine Environment Protection Commission)
HOTO	Health of the Ocean
HOV	Havovervåkning og Varsling (Norwegian integrated ocean monitoring and forecasting programme)
IABP	International Arctic Buoy Programme
IACMST	Inter-Agency Committee on Marine Science and Technology (UK)

ICES	International Council for Exploration of the Sea
ICSU	International Council of Scientific Unions
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer (Fr)
I-GOOS	Intergovernmental Committee for GOOS
IMBC	Institution of Marine Biology of Crete
IOC	Intergovernmental Oceanographic Commission (Unesco)
IPCC	Intergovernmental Panel on Climate Change (UNEP-WMO)
IPO-WOCE	International Project Office of the World Ocean Circulation Experiment
IRI	International Research Institute
JGOFS	Joint Global Ocean Flux Study
J-GOOS	Joint Scientific and Technical Committee for GOOS
JSTC-GCOS	Joint Scientific and Technical Committee for GCOS
LMR	Living Marine Resources
MAESTRO	Marine Information System to Support Offshore Operations
MARIS	Marine Information Service
MAST	Marine Science and Technology (DG-XII CEC)
MIF	Marine Industries Forum
MUMM	Department of Environment, Belgium
NASA	National Aeronautics and Space Administration (USA)
NATO/NATA	North Atlantic Treaty Organisation/ Alliance
NERC	Natural Environment Research Council
NOAA	National Oceanographic and Atmospheric Administration (USA)
NOSS	North Sea Region Sea Level Observing System
NRA	National Rivers Authority (UK) (now Environment Agency, EA)
NRC	National Research Council
OCCAM	Ocean Circulation and Climate Advanced Modelling
OECD	Organisation for Economic Co-operation and Development
OI94	Oceanology International 1994, UK
OI96	Oceanology International 1996, UK
OMEX	Ocean Margin Exchange (MAST)
OOSDP	Ocean Observing System Development Panel
OSPARCOM	Oslo and Paris Commission
OTEC	Ocean Thermal Energy Conversion
POEM	Physical Oceanography of the Eastern Mediterranean
POL	Proudman Ocenaographic Laboratory
RDANH	Royal Danish Administration of Navigation and Hydrography
RIKZ	Directoraat-Generaal Rijkswaterstaat, The Netherlands
ROV	Remote Operated Vehicle
SAR	Synthetic Aperture Radar
SAWG	Science Advisory Working Group
SMHI	Swedish Meteorological and Hydrological Institute
SOAP	Service Operationel d'Analyse et Prevision
SOC	Southampton Oceanography Centre
TOGA	Tropical Ocean Global Atmosphere Experiment
TOPEX/POSEIDON	Joint US/French Ocean Topography Experiment
TPWG	Technology Plan Working Group
TT	Task Team
UNCED	United Nations Conference on Environment and Development
UNCTAD	United Nations Conference on Trade and Development
UNEP-MAP	United Nations Environment Programme, Mediterranean Action Plan
WAM	Advanced Wave Modelling
WCRP	World Climate Research Programme (WMO, ICSU)
WEU	Western European Union
WG	Working Group
WMO	World Meteorological Organisation
WOCE	World Ocean Circulation Experiment
WQ	Water Quality
WWW	World Weather Watch (of WMO)
XBT	Expendable Bathythermograph

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