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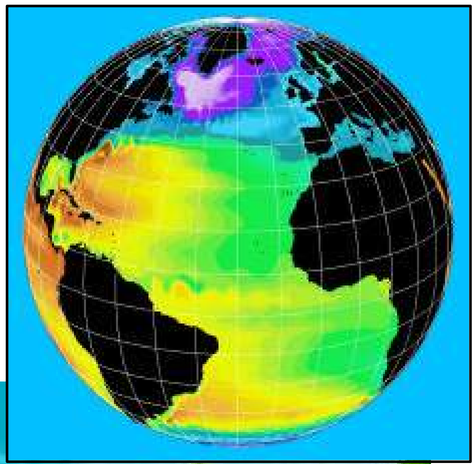
NOOS - Strategic Plan

North West Shelf Operational Oceanographic System 2002 - 2006



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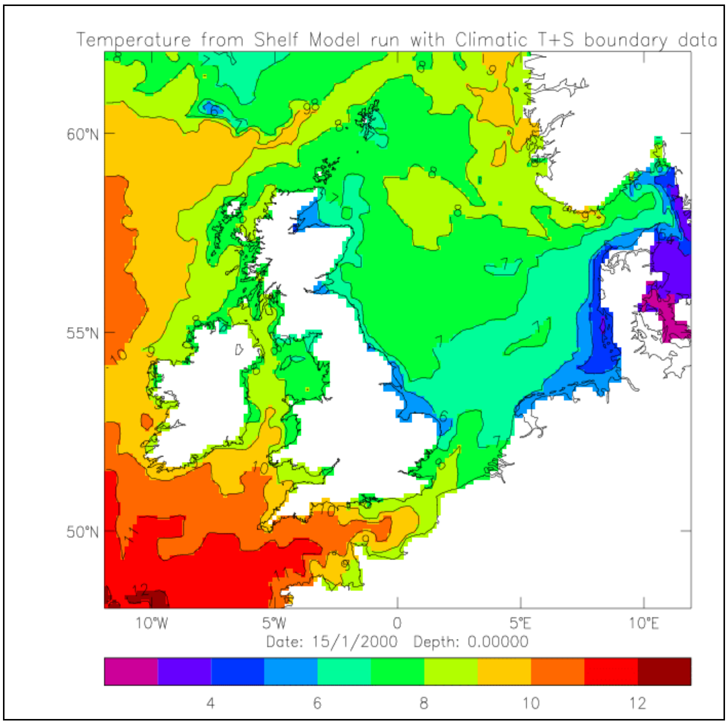
Cover picture

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.

NOOS - Strategic Plan



North West Shelf Operational Oceanographic System 2002 - 2006

Edited by L J Droppert, H Cattle, J H Stel and H W A Behrens

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Contents

Annexes

Executive Summary

This plan for a North West Shelf Operational Oceanographic System (NOOS), has been developed by the EuroGOOS North West Shelf Task Team (NWSTT). NOOS will be operated by participating partners from the 9 countries bordering the extended North Sea and European North West Shelf (Belgium, Denmark, France, Germany, Ireland, Netherlands, Norway, Sweden, and UK), collaborating to develop and implement ocean observing systems for the NWS area, with delivery of real time operational data products and services.

The goals of NOOS are:

- To develop and implement online operational marine data and information services.
- Give a reliable description of the actual marine condition of the NWS area, including physical, sedimentological, and ecosystem variables.
- Provide analysis, forecasts, and model-based products describing the marine conditions.
- Establish a marine database from which time-series and statistical analyses can be obtained, including trends and changes in the marine environment, and the economic, environmental, and social impacts.
- Collaborate with national and multi-national agencies in the NWS area to maximise the efficiency of the ocean observing system, and to maximise the value of the information products.

This Strategic Plan analyses the benefits of NOOS, defines Strategic Principles for the development of NOOS, and summarises the key points which will be needed to prepare a full Implementation Plan.

An operational service to the marine industries and government regulatory authorities of the NWS area will help to improve the efficiency of marine operations, reduce the risk of accidents, optimise the monitoring of the marine environment, provide guidance for policy-makers and regulatory authorities, support climate research, improve recreational use of the sea, help to improve public health, and improve the foundations of marine management in the public interest.

Consistent with the Strategic Design Plan for the Coastal component of GOOS (IOC/UNESCO 2000), the NOOS Plan recommends that the key variables to be measured and analysed through modelling are variability of sea level (tides, atmospheric forcing, storm surges, mean sea level change), waves, sea surface marine meteorology, surface and sub-surface currents, temperature and salinity (surface and sub-surface), dissolved oxygen, nutrients, primary productivity, chlorophyll, total suspended sediments, ocean colour, optical properties, and photosynthetically available radiation (PAR). Other variables may be important within local regions, or for special applications, such as surface oil slicks, river discharge, harmful algal blooms, or higher trophic level biological parameters.

The NWS area is one of the most complex in the world in terms of intensity of marine exploitation; multiplicity of industries, services, and social amenities; potential for conflict between maritime users; complexity and detail of regulation and legislation on every scale from estuarine to continental and oceanic; population density; intense industrialisation; input from large continental rivers; agricultural run-off; sensitivity to climate change; and advanced status of environmental conservation and ecosystem regulation. Arising from these factors there are many existing national and multi-national bodies already measuring, monitoring, and predicting aspects of the marine environment in order to facilitate marine management and comply with regulations.

The NOOS Strategic Plan takes into account the wide range of observing systems and services already in place, and identifies the benefits to users of implementing the NOOS Plan as far as possible in cash terms, as broad socio-economic gains, or qualitative social and political benefits. The following activities are analysed: offshore oil and gas; shipping and port operations; fisheries and aquaculture; environmental management; coastal protection; marine leisure; scientific research; and response to global climate variability and climate change.

User requirements are analysed in terms of application or user, variable and product required, sea area, and instrument platform. Observing platforms considered include spacecraft, ships, drifting buoys, profiling floats, moored buoys, towed vehicles, aircraft, sea-bed installations, shore-mounted platforms, autonomous underwater vehicles, and offshore structures such as oil and gas platforms. The analysis of existing national and multi-national agencies, and the existing data gathering systems and models shows that the integration and optimum design of an operational observing system will provide significant economies, and a greatly increased value of the final products. Maximum added value is obtained by sharing the data from the observing system, running large integrated models, and co-production of the output data and forecasts. National and European agencies have the required skills and resources so that a modest investment in integration, co-production, and data sharing will produce very significant gains. In the longer term there will have to be investment in new technology for observing systems providing more accurate data over larger areas, especially bio-ecological data, and in modelling software, computers, and communications systems.

An extensive review is given of existing operational models available in the area, with reference to a further range of ecosystem models in prototype stage and under development. The scientific background information is provided in Annexe 1, with special emphasis on water quality monitoring, and the data and modelling systems needed for ecosystem management in Annexe 2.

EuroGOOS has established regular working relationships with European Agencies and Conventions such as ICES, EEA, ESA, OSPAR, EUMETSAT, and these bodies will be consulted and fully involved in relevant workshops, plans, and implementation in the NWS area. Joint workshops and publications have already been completed with ICES, EUMETSAT, and EEA.

The NOOS STRATEGY is defined as a set of Strategic Principles:

1. Make formal agreements and commitments between participating agencies to create networks of existing systems and services, delivering operational ocean data products.
2. NOOS must plan and innovate so as to fill the gaps in existing systems, creating new structures, and introducing new technology, new hardware, and exploiting new scientific developments.
3. NOOS will be developed in the context of GOOS, EuroGOOS, and Coastal Ocean GOOS.
4. NOOS will maintain and strengthen working relations with other European agencies and bodies concerned with the North West European Shelf seas.
5. NOOS will consult user communities on a routine basis to improve products and services, and introduce new components into the observing system.

The next steps towards full Implementation are to:

1. Agree and sign an MoU defining the commitment of participating organisations in the NWS coastal States.
2. Prepare Implementation Plan on the basis of commitments by Members to Projects.
3. Review extension of range of qualifications required for Members of the NWSTT and NOOS Plan.
4. Establish management structure and procedures for implementation of the NOOS Plan.
5. Emphasise the development of water quality and ecological monitoring systems and models.
6. Work with ICES to develop products which are of maximum value to ecosystem management and fisheries management.
7. Prepare a NOOS Data and Information Management Plan within the EuroGOOS Data Policy.
8. Define routine procedures for consultation with user communities, industries, services, and other agencies in the NWS area, so as to up-date and improve NOOS services and products.

1 Introduction

The Global Ocean Observing System (GOOS) was created in 1991 in response to the desire of many nations to improve forecasts of climate change, management of marine resources, to mitigate natural hazards and improve utilisation and environmental protection in the coastal zone (IOC, 1998). 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 scale. The objectives of EuroGOOS are set out in the Strategy for EuroGOOS (Woods et al. 1996) and the Forward Look 1999-2007 (EuroGOOS Document EG00.21). (See also the EuroGOOS website at www.EuroGOOS.org).

EuroGOOS aims at co-operation 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.

Each sea area of interest to EuroGOOS has a regional Task Team. One of these Task Teams is the North West European Shelf Task Team (NWSTT) The first meeting of the NWSTT was in 1996.

1.1 EuroGOOS Goals and Objectives for the North West European Shelf

The goals and objectives of the North West European Shelf Task Team are to:

- Design and start the implementation of an integrated observing and forecasting system, making use of already existing building blocks, common national projects, ongoing international projects like ESODAE and EDIOS, and the working relations with SeaNet.
- Improve the quality of existing products by evaluation teams
- Couple the activities with the GOOS modules
- Establish working relations with inter-national organisations like ICES, EEA, OSPAR, etc.
- Strengthen the co-operation with SeaNet
- Make pragmatic planning for a 5 year period

The North West European shelf region seas include all the shallow seas from Norway, round the Shetland Isles, Scotland, Ireland, the South West UK, and to southern Brittany. See Figure 1.1. This 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 (Cunliffe 2001). The sea areas are amongst the busiest of the world, with intense marine traffic, and heavy loads of contaminants introduced by rivers. There are highly developed fishing industries and recreational activities. The North West 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. Optimum management of these seas depends absolutely on an adequate flow of real time data from in situ and space observations, and predictive models. This document sets out a plan to meet these needs.

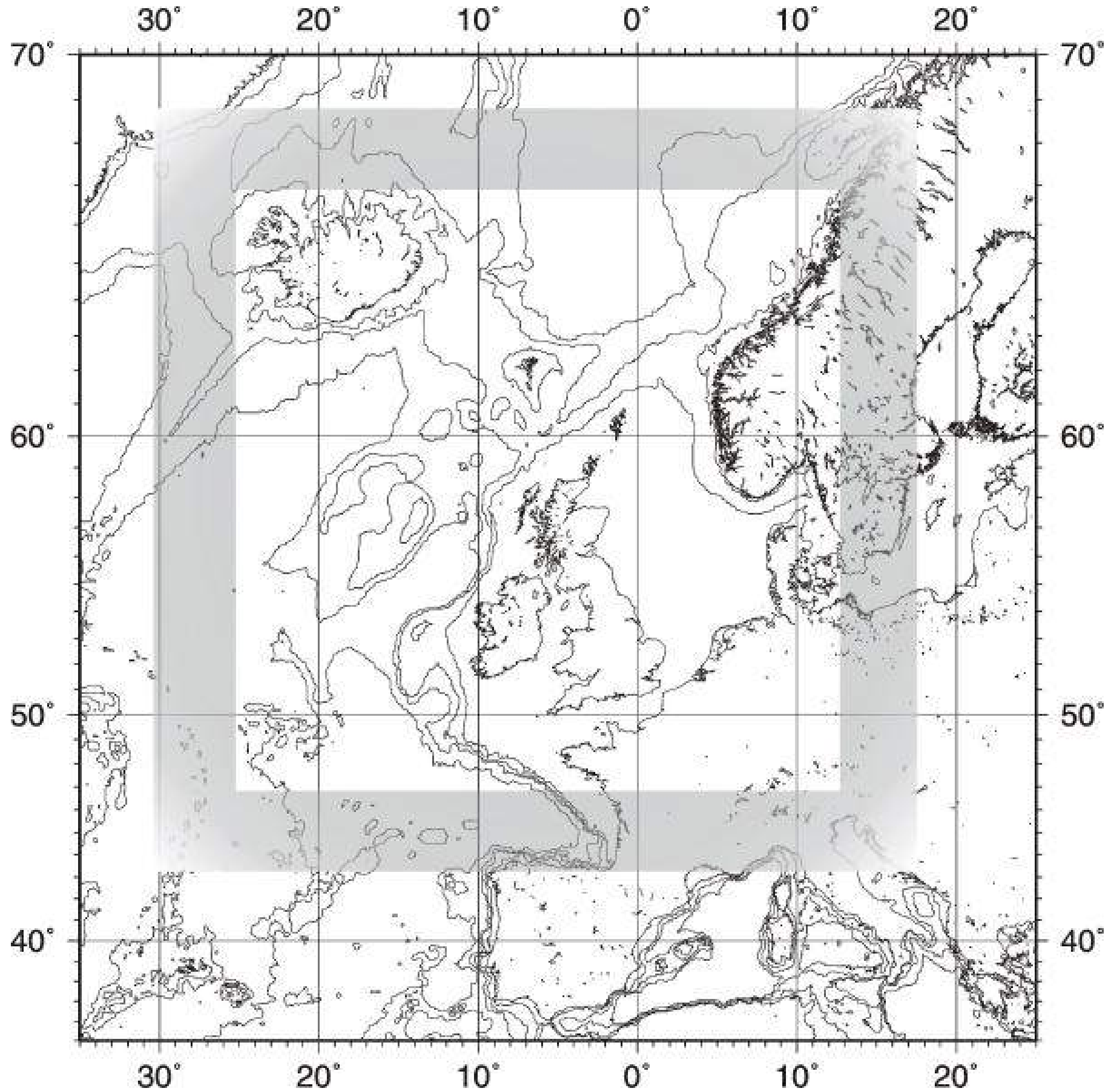


Figure 1.1 North West Shelf Boundaries

The boundaries of the NW Shelf area are not defined rigidly, and can be adjusted for different purposes such as examining the interface between Atlantic and shelf models, meteorological forcing, or coastal ecosystem processes. Iceland has no Member Agency in EuroGOOS, but we are in correspondence with some agencies in Iceland. The northern limit in Norway exceeds the conventional boundaries of the North Sea, and it is practical to extend the NOOS Plan to the point where there is a clear connection with the EuroGOOS Arctic Task Team. The southern limit is in the Bay of Biscay. Source: SOC, UK

The European community of scientists, agencies, and commercial companies in the NWS area has evolved and developed rapidly in the last decade, thanks largely to the funding for research and technology projects provided by successive programmes of DG XII, Directorate for Research, of the European Commission. Throughout this period the oil and gas industry has extended its activities further west to the shelf edge, utilising new technology in deeper water, often sensitive to extreme environmental conditions. Research agencies, commercial organisations, and national meteorological agencies have steadily improved their modelling and forecasting of the physics of coastal seas, while global programmes have been dedicated to coupled ocean-atmosphere modelling, and research on climate variability and climate change.

NOOS is a component of EuroGOOS and GOOS itself and collectively the development of these programmes in the European area constitute a valuable contribution to Global Monitoring for the Environment and Security (GMES).

The decade of the nineties saw a progressively increasing concern about environmental degradation, pollution, and climate change. Marine research at national and international level focused on understanding the natural processes at work, and the anthropogenic perturbations and contaminant inputs. Experts from the areas of meteorological numerical weather prediction, military oceanography, and computer modelling developed increasingly sophisticated models which could simulate first the meteorological forcing of the ocean surface, including waves, then the temperature and salinity structure, and the internal currents. Over the years the spatial resolution and accuracy of the models has been refined, the accuracy of simulation increased, and the forecast horizon extended (OECD 1994; Siedler et al, 2001).

There is still a great deal of work to be done on the improvement of oceanographic models, but the different groups working at the global, oceanic, and shelf seas scales, can now claim considerable skill at representing the physical state of the ocean. The challenge now is to include water chemistry, light transmission, photosynthesis, sediment transport, and primary productivity of phytoplankton in truly ecological models.

While research projects funded by the EU have by definition been international, almost all operational and routine observing systems are managed by single national agencies for a single national objective. ICES and OSPAR and EEA make data available internationally, but after substantial delays for national processing, archiving, and analysis. These data sets are not at present available for modelling and forecasting in real time.

It follows that one of the first objectives of NOOS is to examine all existing observing systems and networks of instruments in place, including satellite missions providing marine remote sensed data, and to ascertain which data streams are of such a nature that the data can be reliably used with a minimum time for checking the quality of the data (or automatic quality control (QC)), and how such data can be transmitted rapidly to data assembly and modelling centres. It should be noted that the same data may be used by many modelling centres to replicate equivalent or competitive models, or the same data may be selected in quite different ways to be used in radically different models for different purposes. Thus a very wide range of potential customers can benefit from the same initial installation of observing instruments and platforms.

The benefits to be achieved by this line of development obviously require a gradual break-down of institutional boundaries between national agencies as regards attitudes to the confidentiality or availability of data, and a similar evolution at the multi-national or regional level. The importance of this change has been noted by many national agencies, and indeed by many institutions at a European level, but the transition is not easy, and experienced administrators and scientists are justifiably cautious. EuroGOOS Member Agencies, and the Members of the NWSTT in particular, are dedicated to facilitating the institutional, legal, technical, and scientific changes which are needed.

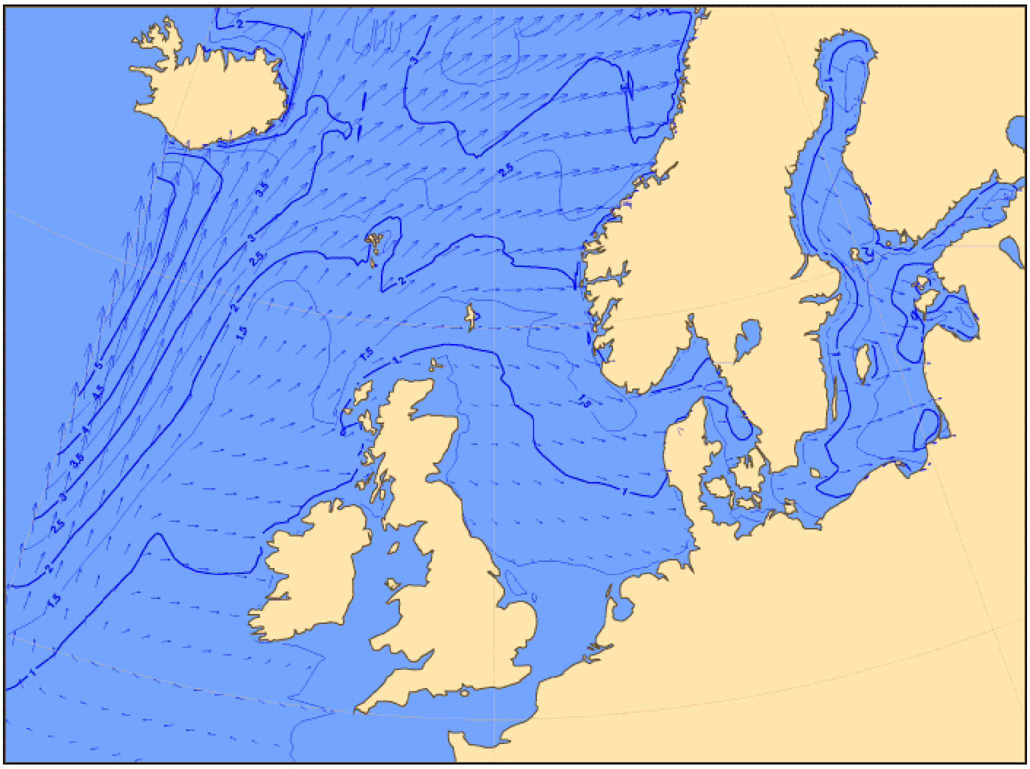


Figure 1.2 Example of a wave forecast for the Northeast Atlantic area including the North Sea and the Baltic Sea
Source: Danish Meteorological Institute

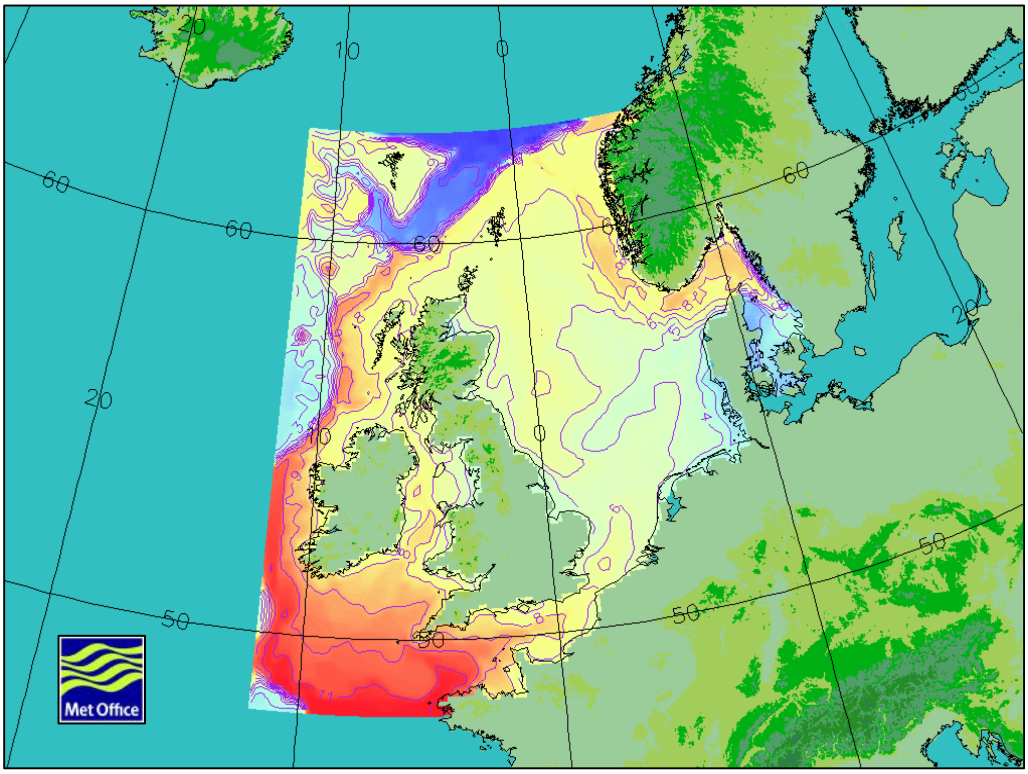


Figure 1.3 Shelf seas model on HORACE. Bottom temperature 5/3/2001
Source: Met Office, UK

At present the physical parameters can be modelled and forecast with considerable skill, while water quality, primary productivity, suspended sediments, and bio-ecological factors are only just within the limits of foreseeable capability. Many years of testing prototype models are still required, but the time has as come to start using such models in parallel with older and well-tried systems, in order to calibrate and refine the techniques. As the benefits of integrated modelling from coast-to-coast, integrated availability of data, and the release of data from agencies with a focused statutory obligation for use by other agencies, become more generally accepted, it will be essential to provide a flexible and rapid communication and data transmission system, backed by an agreed data policy.

Many of these topics have already been addressed by EuroGOOS as a whole at a fairly broad-brush level, and it is now timely to establish an observing and modelling system which can cope with the intensely complex natural processes and human activities of the NWS area.

We will therefore consider first the importance of scientific understanding of oceanographic processes on the shelf, and then the user requirements.

1.2 Scientific background on the North West Shelf Ocean Processes

1.2.1 Ocean dynamics

The North West European Shelf is a dynamically active regime dominated by strong tides and frequent passages of mid-latitude synoptic weather systems. The waters are mostly shallow (depth < 150 m) in the region, with the exception being the Norwegian Trench where water depths significantly exceed 200 m.

As tides from the deep Atlantic Ocean enter the North West European shelf, they propagate around the coast in the form of long gravity waves. Conservation of energy flux requires an increase in tidal height and current amplitude as water depths decrease. The increase in tidal currents gives rise to strong bottom friction and generation of intense turbulence, dissipating a large amount of energy. (It has been estimated that the North West European shelf accounts for about 10% of the global shallow water tidal dissipation).

The combined effects of Coriolis and frictional forces and the geometry of the North West European shelf result in complex tidal patterns in this region. In the semi-enclosed North Sea, for example, the tide originating from the North Atlantic enters from the north as a progressive Kelvin wave, travelling southward along the eastern side of the UK coast. Much of the wave energy is dissipated in the Southern Bight, but a portion is reflected as a damped wave, propagating northward along the continental coast. When the incoming and reflected Kelvin waves are superimposed together, three amphidromic systems are established in the North Sea. The one in the Southern Bight lies about halfway between East Anglia and the Netherlands. The two further north are displaced progressively eastward from the mid-distance as the reflected wave is damped gradually when travelling northward.

The North Sea has moderate fetch for easterly or westerly wind directions, and a long fetch for northerly winds. The highest recorded waves have been generated by northerly winds, for example significant wave heights up to 11m in the central North Sea in early January 1995. Waves of return period 50 years have significant wave height 16 m in the Northern North Sea and 8 m in the South. Within the North Sea and North West European shelf waters, bottom friction is important in limiting growth of the longer period waves (e.g. waves of around 7 seconds over Dogger Bank), and this must be accounted for in numerical wave models.

For a more detailed discussion, see Annexe 1.

1.2.3 Water quality

The intensive, and conflicting, uses of the North Sea cause difficulties with maintaining a sustainable healthy ecosystem. The main human pressures stem from the effects of fisheries, discharges of hazardous substances and eutrophication. In addition to direct human pressures the ecosystem alters in reaction to short term climatic cycles (e.g. North Atlantic Oscillation) and long term drift in the climate (Global Warming). These problems and influences are known but even in the relatively intensively studied area of fisheries the scientific understanding lags behind our knowledge of observed changes. Current mathematical modelling efforts are reaching a stage of maturity in which they can improve our understanding of how the ecosystem functions. A NOOS programme will be based on and developed from an integration of existing sampling and assessment programmes. Both at a national level as well as an international level within Europe better use can be made of existing operations by improved co-ordination of existing sampling programmes (e.g. Portmann, 2000). An aim of NOOS is to implement the use of bio-ecological models in an operational framework (Moll & Radach 2001). We are already in a position to be able to use these models to define and plan the spatio-temporal resolution of measurements required for monitoring to be done most efficiently. Considerable potential now exists in the form of new instrumentation and platforms (such as "smart" moorings or "ferry box" Tziavos & Flemming, 1998) that can provide high frequency monitoring. The collection appropriate for regular high frequency data is critical for the calibration and validation of prognostic water quality and eco-system models. An operational framework for data gathering for water quality and ecosystems studies will have to take into account the ranges of time scale that encompass both:- (i) acute effects such as oil spills which may require study over periods of days, and (ii) chronic effects such as those associated with anthropogenic inputs from rivers and eco-systems shifts related to climatic variations with time scales of decades (see Annexe 2).

1.3 User requirements

User requirements are to a very high degree concentrated on information on a few oceanographic parameters although the demands on resolution in time and space may be very different, as are the high level derived data products (Fischer and Flemming, 1999).

The most important marine related areas, which require operational oceanography in the North West European Shelf area, are:

- Shipping - all kinds
- Navigation in shallow areas and entrances to harbours
- Rescue operations, drift forecasting
- Aviation (helicopter operations)
- Military purposes
- Storm surge warnings
- Flood protection
- Coastal protection
- Transport calculations of water, substances and biological material, e.g. algae and fish eggs
- Coastal engineering
- Hydrographic surveying
- Environmental protection, impact assessment and management
- Ecosystem assessment
- Fisheries/aquaculture planning and management
- Support of off-shore oil industry, design criteria, and operations
- Recreation
- Public warnings
- Research
- Climate variability and climate change

For a table correlating user groups and applications with data variables and types of data product or forecast, see Annexe 3.

An operational oceanographic service supporting these activities shall primarily focus on observations, analysis and model predictions of water level, waves, currents, temperature, salinity, sea ice, oxygen, nutrients, algae and chlorophyll, as well as the drift and fate of pollutants and floating objects. Most of the activities listed in the table above, and in Annexe 3 are represented nationally and internationally by trade associations, professional societies, or learned bodies, and EuroGOOS has already made contact with many of them. For a list of Internet web pages of relevant organisations, see Annexe 5.

Products will mostly result from analysis of observed data, forecasting and extrapolation by models. Basically operational oceanography can give:

- Continuous forecasts of the future condition of the sea-based user requirements
- Provide the most usefully accurate description of the present state of the sea
- Assemble climate long term data set which provide data for description of past states, and time series showing trends and changes.

In the present document the implementation plan for the period 2002-2006 of the North West Shelf Operational Oceanographic Plan is outlined. The plan will be under continuous revision for which reason the present version reflects the state of the planning at the end of 2001.

As explained above, the scientific background of NOOS is presented in Annexes 1 and 2. In the main text of this report we set out the argument for multi-national and multi-agency commitment to and investment in NOOS by analysing factors in the following order:-

- The benefits of NOOS
- Existing activities, installations, measuring systems, platforms, infrastructure
- Other international bodies and their involvement in NOOS
- A set of Strategic Principles for NOOS
- An outline of the first steps to Implementation.

The essential step recommended in the outline of the Implementation Plan will be the agreement on a Memorandum of Understanding which will define the levels of commitment from Member organisations and Agencies, and give them the legal and administrative structure which will enable them to contribute data and engineering components or staff time to NOOS, while being assured that they will obtain the full benefits of the multi-national data flow protected by the EuroGOOS Data Policy.

The Implementation Plan is by no means complete at this stage, but the first steps are set out in Chapter 6.

2 Benefits of NOOS

2.1 Human activities

A series of Conventions such as the UN Convention on Environment and Development (UNCED), UN Convention on the Law of the Sea (UNCLOS), Climate Change (FCCC) and Biodiversity, as well as the implementation of the Kyoto Protocol form an international political framework of future human activities in the ocean space of the North West European Shelf. Sustainable use of the available resources is the primary economic rationale for NOOS. Based upon the operational oceanographic information obtained with NOOS, a more efficient use of the resources of the North West European Shelf becomes within reach. This could manifest itself in strategic and tactical decisions that minimise the use/consumption of resources and achieve a maximum possible useful output in the prevailing circumstances. The strategic decisions concern such long term issues as the choice of whether or not to ban certain activities such as fisheries, in certain areas of the North West Shelf or the choice of investment and the design of structures, equipment and procedures needed to exploit the resources. The tactical decisions relate to the short term deployment or management of the assets created by those strategic decisions. Integrated assessment will be an interesting management tool to support decision making in the near future. Use/consumption of resources minimisation includes cost reduction and the avoidance of loss of life and property, including degradation of the environment itself.

Interest in the sea and its resources has grown considerably following the introduction of UNCLOS in 1982. Future development in the marine sector may be expected to lead to increased utilisation of marine resources depending on how technology develops. In turn, this is linked to economic and social development in different parts of the region, (GOOS 1998; Adams et al, 2000).

In the report of the Independent World Commission on the Oceans (1998) the ecosystem service value of the coastal area is an estimated 12,568 billion US$. In contrast the value of this service of the land which has a five times larger surface area as the coast is an estimated 12,319 billion US$. The traditional marine industry has always been an integrated and well-established part of business community in the countries bordering the North Western European Shelf. Pugh and Skinner (1996) estimated that marine related activities contribute £27.8 billion, or 4.8% of the GDP, to the UK economy in 1994-95. They also estimated the individual importance of the various marine related activities, Fig 2.1. See also IFREMER, (1997 and 1999), and Irish Marine Institute (1998).

There are differences in the individual importance of the various marine related activities to the GNP of the countries bordering the North West European Shelf area but in general it can be stated that the most important user groups for operational oceanographic products in the region are oil and gas and shipping including naval activities and ports, and also fishery, environment, coastal protection, and leisure.

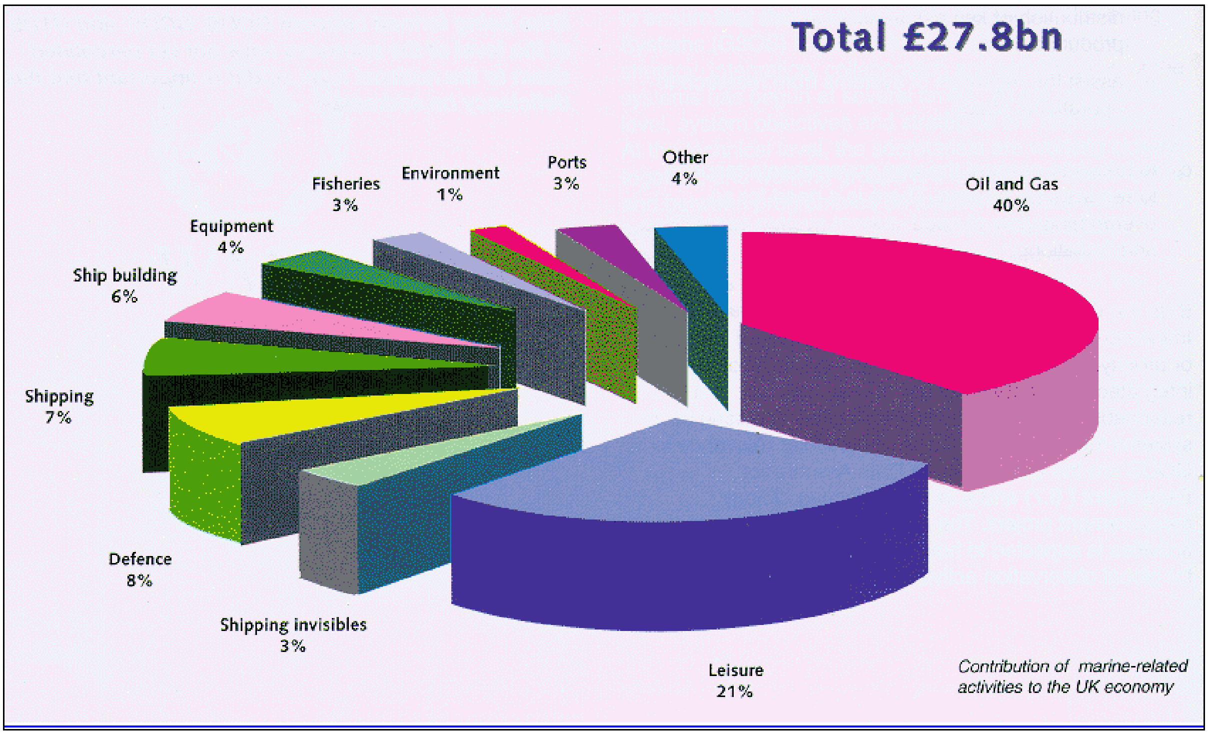
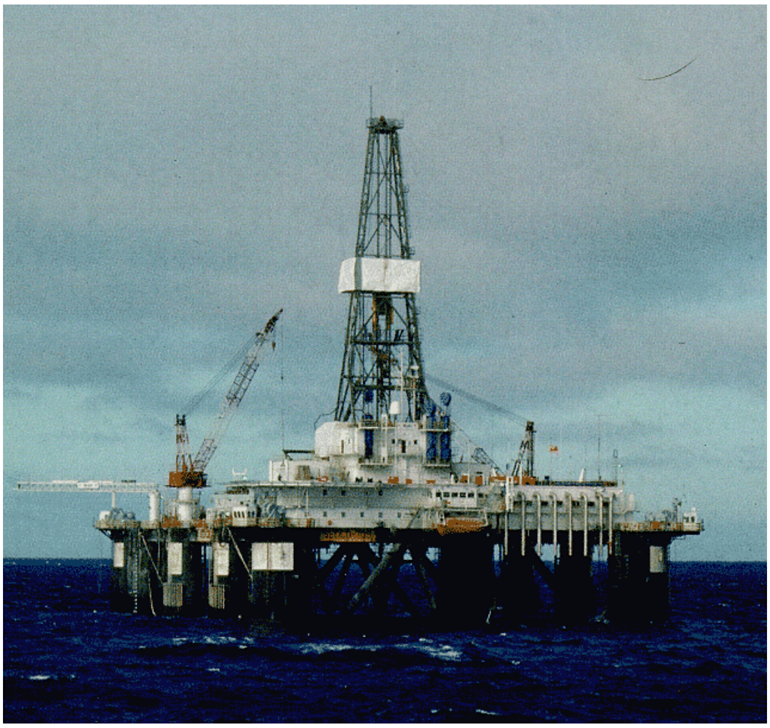


Figure 2.1 Pie diagram of UK maritime economic sector
Source: Pugh and Skinner (1996)

2.1.1 Oil and gas



Offshore oil and gas, with its associated support and service industries, has been the most important offshore economic activity since the 1970's for 6 countries in the NWS Region. In addition to the operation of production platforms, the service industries include pipe-laying, geophysical surveying, prospecting, drilling, maintenance and inspection, safety support, supply boats, helicopter operations, environmental forecasting, heavy lifting, certification of structures, and numerous other specialised activities.

Table 2.1. shows the offshore oil production for 5 countries in 1999. During the last 3 years the oil price has ranged from less than 10$ per barrel to over 30$ per barrel. To give a cautious estimate of the range of values to countries, and to the whole of NW Europe, the values are shown on the basis of oil landing prices at 10$/barrel and 25$/barrel. On the assumption that production quantities vary less than the price, the value calculated on this basis ranges from 21.49 bn $/yr to 53.65 bn $/yr.

Table 2.1 Offshore Oil Production, 1999, NOOS Region
Source: Oil & Gas Journal, (98.51), 2000; p.124. et seq.

	Barrels/day	Barrels/year x 10^6	Value at 10$/b	Value at 25$/b
Belgium				
Denmark	299,400	109.3	1.09 bn$	2.73 bn$
France				
Germany	17,951	6.55	0.065 bn$	0.163 bn$
Ireland				
Netherlands	6,188	2.25	0.025 bn$	0.056 bn$
Norway	2,929,788	1069	10.69 bn$	26.7 bn$
Sweden				
UK	2,634,376	961	9.61 bn$	24 bn$
TOTAL	**5,887,703**	**2148.1x 10^6**	**21.49 bn$**	**53.65 bn$**

Legend: Offshore Oil production in average barrels/day is converted into barrels/year, and then into cash value at the upper and lower values in recent years.

Table 2.2 shows offshore gas production for 6 countries in 2000. The data source does not separate offshore and onshore production, but only the Netherlands has significant onshore production, and even in that case the majority is offshore. The value is calculated on the basis of oil equivalent, with the same range of prices as for Table 2.1. On this basis, the value of offshore gas production per year for the whole NOOS Region ranges from 16.1 bn$/yr to 40.25 bn$/yr.

Table 2.2 Offshore Gas Production, 2000, NOOS Region
Source: BP Statistical Review of World Energy, (2001).

	Million tons oil equivalent	Million barrels/yr	Value at 10$/b	Value at 25$/b
Belgium				
Denmark	7.3	53.51	0.53 bn$	1.34 bn$
France				
Germany	15.2	111.42	1.11 bn$	2.79 bn$
Ireland	1.20	8.81	0.088 bn$	0.22 bn$
Netherlands	51.6	378.2	3.78 bn$	9.45 bn$
Norway	47.2	345.9	3.46 bn$	8.64 bn$
Sweden				
UK	97.3	713.2	7.13 bn$	17.83 bn$
TOTAL	**219.04**	**1,611.04**	**16.1 bn$**	**40.25 bn$**

Legend: Gas production shown is total, but only Netherlands has significant onshore production. Value at upper and lower equivalent oil prices in recent years.

In the last 5 years oil and gas prospecting has migrated into progressively deep waters on the NWS Shelf Atlantic Margin, with production from depths of over 500m. Production is only possible from Floating Production Ships, which store the oil temporarily for transfer to tankers which take the oil ashore. These systems are highly vulnerable to extreme environmental conditions, as are the drilling rigs which explore the outer shelf and slope, and drill the initial production wells. Extreme conditions of waves, storms, wind, icing, and sub-surface current profiles are all of the greatest importance. Offshore oil production for North West Europe as a whole has increased by 51% in the last ten years, partly by new discoveries, and partly by greatly increased exploitation of small marginal fields in the North Sea which were previously neglected.

EuroGOOS Member Agencies provide a range of forecasts and data products to the Offshore Oil and Gas industry, and its supporting services. The larger oil companies maintain their own met-ocean observing stations on rigs, and many of these data are contributed to the public domain.

Offshore oil and gas structures and operational facilities are designed to function efficiently for 20-30 years, and thus extremes of conditions, or change in the mean climate conditions, can have a very serious effect on both efficiency and safety. Accumulated data provides the climate estimates and forecasts of extreme conditions which govern design and certification criteria for offshore structures.

The benefits of improved forecasts, based on integrated observations and modelling, combined with emphasis on key variables, could improve the efficiency and profitability of offshore production of oil and gas by the order of 1%. This would result in gains of the order of 375-939 million $/yr, or in round terms, 340-840 million Euro per year.

Figure 2.2 To support operational modelling, the exchange of water and substances between the Baltic and the North Sea is monitored continuously by a network of oceanographic buoys and by frequent (> 25/year) monitoring cruises in the transition area. (The exchange monitoring is a Danish-Swedish contribution to the HELCOM environmental monitoring programme, COMBINE)
Source: SMHI, Sweden

2.1.2 Shipping

For centuries - dating back to the Viking age - internal transport related to trade between the individual countries has been an important business in the North West European Shelf area and so has transport related to trade with the world outside. Some of Europe's largest ports are situated in the area and the English Channel is one of the most heavily trafficked sea areas of the world. This places high demands on all systems that contribute to navigational safety in so much that:

- the fairway shall be well mapped
- the fairway shall be well marked with lighthouses and buoys
- a variety of radio navigation systems shall always be operational
- well educated pilots shall be available

Through traffic separation and radar surveillance the authorities try to create safe circumstances for the most intensive shipping in the world.

The following data are taken from UNCTAD (2000). World seaborne trade grew to its largest ever volume in 1999, at 5.23 billion tonnes. World seaborne trade has doubled in the last 30 years, and almost 50% of this trade is oil and oil products. World container port traffic in 1999 was 165 million Twenty-Foot Equivalent Units (TEUs). World shipping fleet increased 1.3% in 1999 to 799 million tons deadweight (dwt).

Thirty five countries control 94.2% of the whole world merchant fleet, counting all vessels over 1000 tons dwt. The definition of control includes vessels owned and registered in that country, and also those vessels owned and controlled in that country, but registered elsewhere under a flag of convenience. Thirteen of these top 35 countries are European, and 8 of them operate on the coasts and ports of the NOOS Region. Table 2.3. shows the tonnage owned and controlled by European countries.

Table 2.3 Registered tonnage controlled in each European country in 1999
Source: UNCTAD (2000)

World Rank	Country	Fleet tonnage, millions dwt.
1	Greece	133
3	Norway	55
7	Germany	29
10	UK	19
12	Denmark	16
14	Sweden	15
15	Italy	13
18	Turkey	10
20	Belgium	7.6
24	Netherlands	6.1
25	France	5.4
29	Spain	3.7
33	Monaco	3.0
TOTAL		**316**

European countries collectively own 316 million tons dwt of shipping, that is 40% of the world fleet. For the NOOS Region the coastal states own 153 million tons dwt, that is 19%. Europe therefore owns and controls a world fleet which is proportional to its GNP, and which can provide it with the vital lifeline for oil and gas, as well as other exports and imports. These ships require and benefit from a regional and global service of marine meteorological and oceanographic data to maintain safety and efficiency.

Global trade carried by ships has increased from 17 trillion ton-miles in 1990 to 21.5 trillion ton-miles in 1999 (UNCTAD, 2000, Table 24). On a pro rata basis, European controlled vessels carried about 40% of this trade.

Twenty large container companies own 1447 large container ships out of the world fleet of 3696 ships, that is 39% of the ships. Of these 20 companies, 5 are European, and all based in the NOOS Region or northern Europe. See Table 2.4.

Table 2.4 Leading Container Operating Companies 1999
Source: UNCTAD (2000) Table 31

World Rank	Company name	Country	Number of Ships
1	Maersk	Denmark	244
3	P&O/Nedlloyd	UK-Netherlands	114
5	Med.Ship	Switzerland	112
9	CMA/CGA/ANL	France	61
17	Hapag Lloyd	Germany	26
TOTAL			**557**

The total number of container ships owned in northern Europe is therefore 557 vessels, that is 15% of the world total.

UNCTAD (2000) (Table 41) states that the value of sea-borne imports for the Technically Developed Countries, approximately equal to the OECD countries, is of the order of 3.8 trillion $ in 1999, and that freight costs are 4.07% of the value of the cargo. On the basis of GNP Europe represents approximately one third of the scale of OECD as a whole, and therefore the cost of shipping the imports into Europe is of the order of 51 billion $/yr.

Most of this trade has to pass through the narrow congested channels and shallow seas of the English Channel and the North Sea, or through the Skagerrak into the Baltic. These areas require intense traffic monitoring and traffic separation to ensure safety. The occasional collisions or sinkings of tankers create enormous public interest, as well as environmental damage and financial loss. More accurate environmental data and forecasts will improve the efficiency of the trade, reduce costs, and reduce damage to the environment.

Most non-oil/gas sea-borne cargo is transported in containers. Of the 20 largest container ports in the world, 5 are in Northern Europe, in the NOOS Region. The scale of container throughput in these ports is shown in Table 2.5.

Table 2.5 Largest European container ports
Source: UNCTAD (2000) (Table 41). TEU= Twenty-foot container Equivalent Unit

World Rank	Port Name	Million TEUs
5	Rotterdam	6.4
9	Hamburg	3.8
10	Antwerp	3.6
13	Felixstowe	2.7
18	Bremerhaven	2.2
TOTAL		**18.7**

The total container traffic through major European ports is therefore 11.3% of the total global port traffic for containers. These large ports, as well as the many smaller ports in the NOOS Region, require continuous engineering works, extensions, and services such as dredging, tugs, pilotage, navigation lights, radar surveillance etc. All these services benefit from improved environmental data.

With the increase in use of electronic charts and the Electronic Chart Display System (ECDIS), it is becoming increasingly practical to consider the display of environmental and forecast data on electronic display systems in real time.

In addition to these traditional navigational aids, real-time data and forecasts of oceanographic parameters such as: water level, current velocity and direction, waves, buoyancy and wind speed and direction are required by captains and pilots in order to secure a safe voyage of ship, cargo and crew.

2.1.3 Fishery

Fishing has for centuries been an important occupation in the North West European Shelf area, where the most important species are cod, haddock, plaice, whiting, sole, sand-eel, saithe, Norway pout.

The recruitment and distribution of the various fish stock is highly dependent on the ocean climate and thereby on the distribution of water masses, Chusing and Dickson (1976); Fischer, J, Baretta, J, Colijn, F, and Flemming, N C (2000). The fishing industry - fishermen, processing industry, fishery managers etc. - therefore are very dependent on oceanographic information not only for safe and efficient daily operations but also for improvement of their long term planning and investments.

The world fish capture production has been more or less stable since 1992, with a slight drop in recent years. The total catch has fluctuated between 85 and 94 million tons per year (FAO, 2000a, Table A1, p.95). Almost all fisheries are subsidised by the coastal states, and there is intense competition between industrialised fleets. This results in a tendency towards over-fishing, and hence a strong requirement for close monitoring and management, both of the fish stock, and of the regulations and enforcement regime. In March 1997, the Intermediate Ministerial Meeting on the North Sea adopted several guiding principles of which one stated: "further integration of fisheries and environmental protection, conservation, and management measures, shall draw upon the development and application of the ecosystem approach". This approach necessarily requires a combination of all data types from the meteorological to the oceanographic, nutrient and ecosystem parameters. EuroGOOS is in discussion with ICES, OSPAR, and EEA to promote the development of integrated observing systems and models of this kind (ICES 2001).

The landed catch of fish captured by coastal states in the NOOS Region is shown in Table 2.6.

Table 2.6 Marine fish catch by country, 1998

Source: "Performances économiques d'une sélection de flottes de pêches européennes" rapport annuel 1999 - AC FAIR PL 97-3541 - Commission Européenne - doc N°10 final

	Volume - thousand tons	Turn over - million Euros
Belgium	27	86
Denmark	1575	484
France	598	990
Germany	245	182
Ireland	343	156
Netherlands	443	389
Norway	3024	1231
Sweden	401	117
UK	924	963
TOTAL	**7580**	**4598**

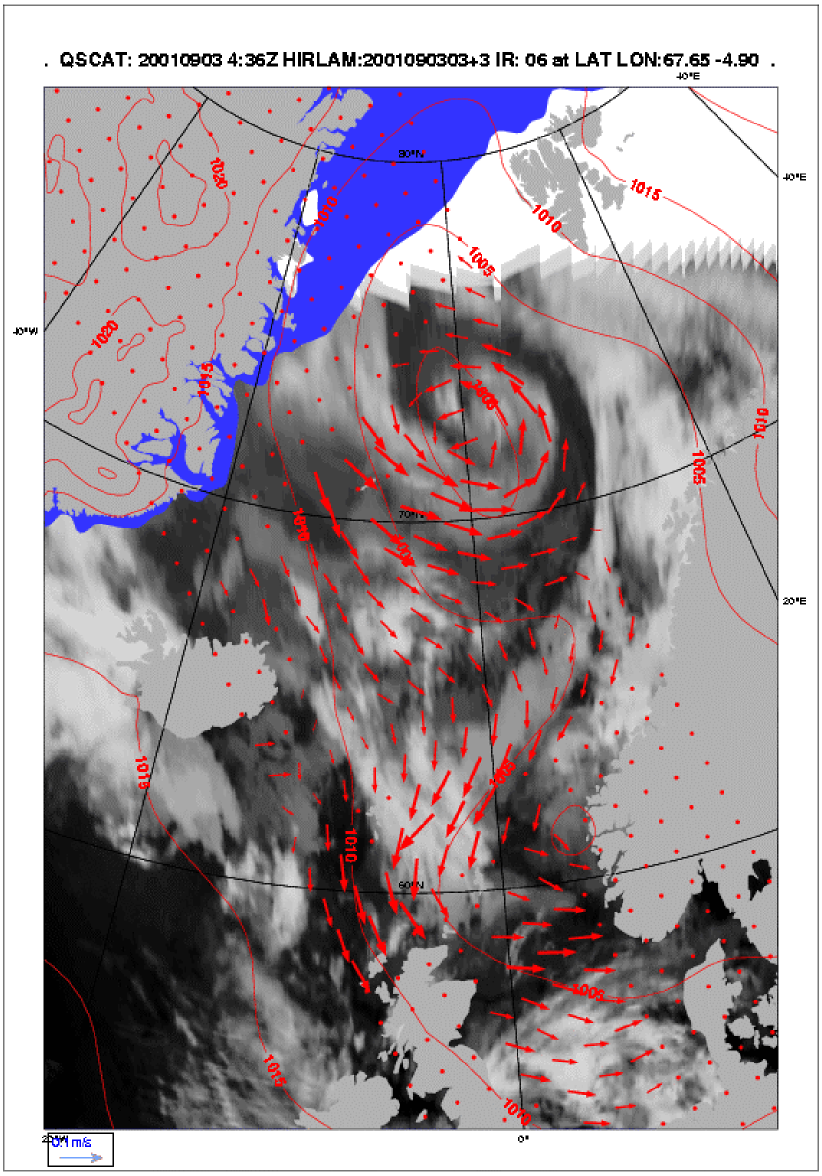
Figure 2.3

Trawl net in the North Sea

Figure 2.4

KNMI surface wind product from the QuikScat scatterometer for 3 September 2001. See web site http://www.knmi.nl/ scatterometer. The KNMI work is part of the EUMETSAT Ocean and Sea Ice Satellite Application Facility

Source: KNMI, Netherlands



Total value of captured fish by fishing fleets originating in the NOOS Region is therefore of the order of 4.6bn Euro.

FAO (2000b) give statistics of production for aquaculture, including marine and freshwater fish, as well as crustacea, shellfish, and sea-weeds. For the whole of Europe the production by aquaculture of all types produced 1,954,060 tons of product, with a value of 4.3bn $ US.

Table 2.7 shows the production of freshwater fish, marine fish, and crustacea+molluscs, with the valued recorded by FAO (2000b, Table C-1).

Table 2.7 Marine Aquaculture Production, 1998
mt = metric tonnes. Source: FAO (2000b)

	Freshwater mt	Marine Fish mt	Molluscs mt	Value x 1000$	Value $m
Belgium	300	546		3,800	3.8
Denmark		33,059		152,359	152
France	10,812	54,147	208,900	614,153	614
Germany	10,700	25,030	31,288	79,933	80
Ireland		17,155	23,200	81,446	81
Netherlands	1,799	2,561	115,639	87,563	88
Norway		407,612	267	1,113,580	1,114
Sweden	40	5,404	455	18,375	18.4
UK	??	127,480	9,941	427,895	428
TOTALS	**23,651**	**672,630**	**389,690**	**2,579,104**	**2,579.2**

Freshwater production is only equal to 3.5% of the total, and internal evidence indicates that the freshwater fish have the lowest value per tonne. Thus the composite aggregates of total values published by FAO need only be reduced by 1-2% to give the value of the marine production. This is probably within the margin of error. It follows that the value of marine aquaculture in the NOOS Region is approximately 2.58 bn $ US for 1998.

The EuroGOOS Bio-Ecology Workshop report (Fischer et al., 2000) shows that marine aquaculture depends critically on oceano-graphic information on changes of water temperature, nutrients, pollution, and the movement of oil slicks. All these factors will be forecast more accurately, and with longer horizon, by the systems developed by NOOS.

2.1.4 Environment

For decades industry, agriculture and forestry in the densely populated drainage area - a number of Europe's largest rivers enters the southern North Sea - have put a strong environmental pressure on the North West European Shelf region and so have the intensive gas and oil exploitation activities during the recent 3-4 decades. The response has been international co-operation to set up measures to restrict and reduce discharges of pollutants as well as for an intensive monitoring effort. The main responsibility to lead this work is the Oslo and Paris Commission (OSPAR), which works within a strict legal and managerial framework to provide data and advice to the member nations. OSPAR runs a joint monitoring program for measuring contaminants in biota, water and sediments. OSPAR and the national environ-mental agencies are one group of main clients for an operational and regular production of information about the state of the marine environment and its forcing factors.(Ref OSR 2000).

Modelling activities have been initiated to calculate transports of nutrients, radionuclides and other substances and to predict the drift of oil and chemicals, which may be released, into sea as a result of ship accidents or "blowouts" from the many oil platforms. Monitoring of harmful algae blooms has been initiated using traditional sampling techniques, ships of opportunity and satellites.

Figure 2.5 IFREMER's research ship Thalassa working during the INTERCAL cruise in the North Sea. *Source: IFREMER*

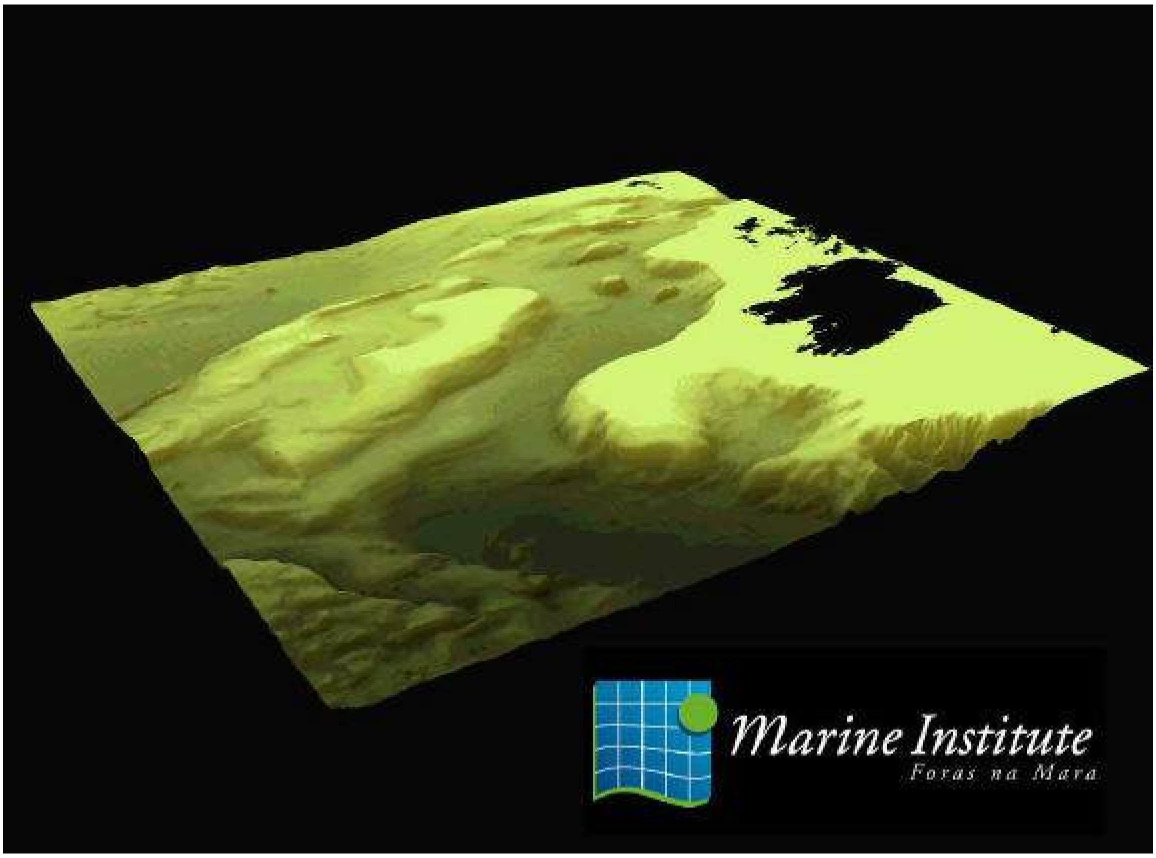


Figure 2.6 The North East Atlantic sub-sea terrain around Ireland
Source: Marine Institute, Ireland

2.1.5 Coastal protection

Large parts of the coastline in the countries bordering the North West European Shelf are exposed to flooding and erosion under extreme weather conditions. In these localities, great efforts are made to protect land and people from natural disasters originating from the sea. In the Netherlands for instance large part of the country would have been flooded if an effective system of dikes had not been built. There are also low-lying areas subject to coastal flooding and protected by sea walls in South East England, and the German Bight Coastal protection activities requires both operational warnings of extreme events for the planning of emergency actions as well as predictions of variations of water level, currents etc. on climatic time scales for long term planning of protection initiatives. All countries have for decades operated a network of tide gauges and on a national level established an efficient storm surge prediction system. Recently the national responsible agencies have agreed on a closer co-operation with the purpose of improving the storm surge forecasts and thereby the entire storm surge warning system. Reliable data are required both for climatic statistics and operationally so that government agencies can assess the options for managed retreat of the coast.

2.1.6 Leisure

The shoreline of the North West European Shelf has for generations attracted people for recreation purposes, an activity that has increased dramatically during the 1 - 2 recent decades. In the UK, the marine leisure industry contributes 21% of the revenue to the marine total (Fig. 1). Especially leisure boating and wind surfing have increased, which has resulted in higher frequencies of rescue operations and also fatalities. More traditional recreational activities such as fishing and bathing are also a cause of death for several people. The generally cold water restricts the search time to a few hours or less and calls for well focused search areas. Ocean forecasts and warnings are improving the safety connected to leisure activities in the region.

2.1.7 Scientific community

Marine science activities have, as mentioned above, long traditions in the North West European Shelf area, and large research projects are at present carried out focusing on climate, physical, chemical and biological oceanography, fishery, environment, geology etc. These projects do already relate highly to the existing network of observation sites and will benefit on the NOOS activities in the future as NOOS will rely on the outcome of the scientific activities. Even if the mutual benefit is obvious the access to data is or is regarded as a major problem for researchers. The NOOS member agencies regard the scientific community as one of its most important partners and intend to create a system for easy access and a clear policy for rights to use data collected by the agencies.

2.1.8 Management and administration

The increased use of marine resources will also lead to requirements for a developed system in order to be able to handle different demands and to solve conflicts. A system of this kind must be based on knowledge of administrative boundaries, laws and regulations within different sectors, different interests and environmental conditions as well as on effective surveillance and utilisation of marine resources and environment. Overall physical planning should be developed into an instrument for a co-ordinated approach to the use and protection of marine resources.

Sustainable use of the ocean therefore requires political decisions and administrative measures. Increased competition between conflicting uses of the sea is also driving the need for better decision-making tools. The decisions have to be based on the available knowledge of the state of and the processes in the sea. Bad decisions are today more frequent than necessary due to poor access to existing up to date knowledge. Even if there is a long tradition of informing decision-makers on all levels, the availability of high quality, aggregated and up to date information is still very much required. NOOS will develop an operational chain from observations to end user products with a current implementation of results from research and based on user requirements.

2.2 Other marine industries

Other marine industries are certainly of importance in the North West European Shelf area, but the above mentioned are the most important in relation to operational oceanography. Wind Farms consisting of groups of 10-20 large offshore wind turbines have already been established on the coast of Denmark, whilst similar plans exist in the UK. This technology is likely to grow rapidly.

3 Existing Activities in Operational Oceanography

3.1 Introduction

NOOS will constitute a close co-operation between national governmental agencies in the countries bordering the North West European Shelf Seas responsible for collection of observations, model operations and production of forecasts, services and information for the industry, the public and other end users.

The existing ocean observing systems in the North West European Shelf Seas region have been developed and are operated to meet their own purpose, like managing of fish stocks for sustainable exploitation, ensuring public safety and health safe and efficient navigation and preserving healthy marine ecosystems. (See also section 1.3 and Annexe 3).

These purposes, which serve the broad public good, require long term observations and consequently financial commitments as well as international co-operation which may be executed only through involvement from governments and governmental institutions.

The work of the Intergovernmental Oceanographic Commission (IOC), the International Council for the Exploration of the Sea (ICES), the Oslo Paris Commission (OSPAR), the International Hydrographic Organisation (IHO), the International Maritime Organization (IMO) and World Meteorological Organization (WMO) and the North Sea Ministers Conferences builds on intergovernmental agreements. The activities within these organisations are important for the establishment of an oceanographic operational observing system in the North West European Shelf Seas.

Each of the observing systems, which has been established or initiated by these organisations, serves its own needs and has its own data and information management system, although steps have been taken to create national inter-agency networks connecting marine data archives. Therefore, the key issue for the establishment of an operational oceanographic observing system in the North West Shelf Sea is integration and further development of the existing observational systems and data sets and to improve the speed of data transmission. The objective is to maximise their utility for the specific purpose for which they have been originally designed and, by combinations of data sets with further stages of modelling and forecasting, to make them available for other relevant purposes and user groups. The combination of data types into a single system will permit higher resolution in models, more rapid delivery of products, and longer forecast horizons. (See: Alcock & Rickards, (2002); ICES SG-GOOS report 2001; EEA, Marinebase 2001)

The existing observation systems should adapt and integrate improved and new technologies to make observations more complete, more effective and more affordable and the data infrastructure and management system should be complementary to existing systems and attuned to multiple sources of data and their multiple uses.

This chapter describes a number of aspects which we have to deal with in the strategic plan concerning the infrastructure for the NOOS-information system. This system is going to produce the information products based on integrated modelling systems consisting on national nodes in the NOOS network.

The EuroGOOS-infrastructure contains the following technology components (Bosman et al 1997)*(EuroGOOS No. 4)*:

- Measuring devices, sensors, instruments
- Platforms, carriers
- Support systems
- Telematics, data-communication
- Operational numerical forecasting
- Service delivery systems.

We will discuss some examples of these components which are already in place.

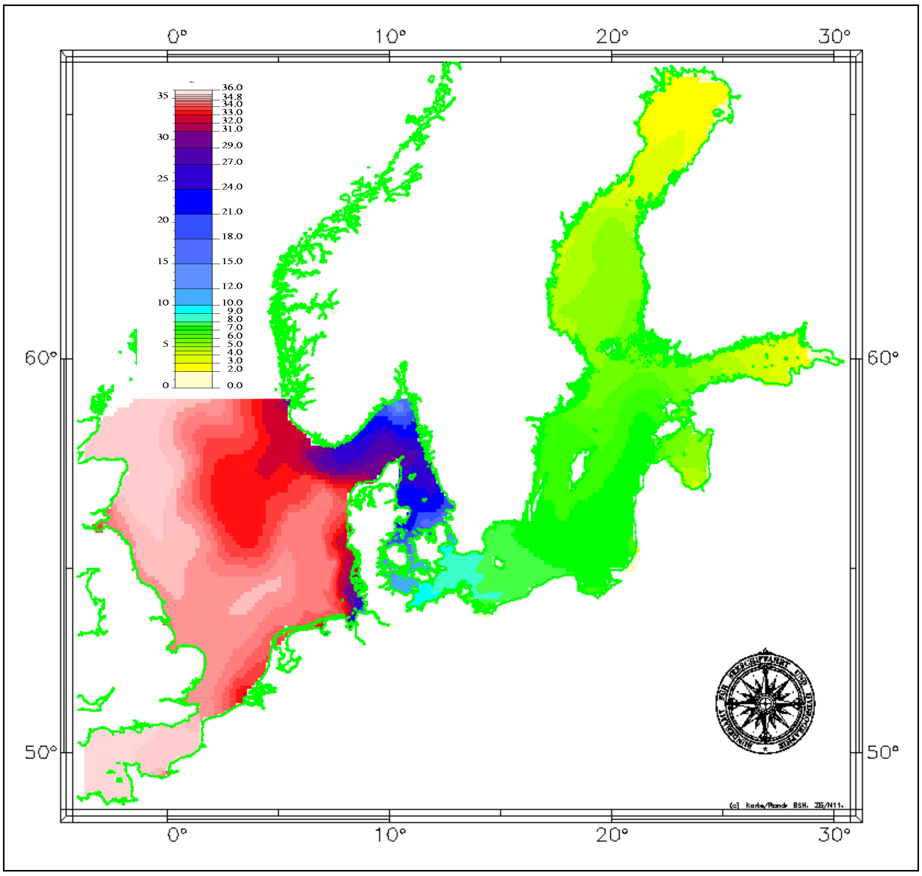


Figure 3.1 **Model forecast of BSHcmod. Surface salinity on 07.09.2001**
Source: BSH, Germany

Figure 3.2 MAREL Estuarine station
Source: IFREMER, France

3.2 Existing activities, Observations Platforms and Technology Infrastructure

3.2.1 Background

Every country bordering the North West European Shelf Seas has its own monitoring programs and activities at sea and at the coastline. Oceanographic Observations are based on historical background like the need for monitoring related to storm surge warning or fish-farming.

Protecting this economical value has resulted in operational, real-time or on line monitoring systems. The collected monitoring data fulfils operational needs as well as temporary and long-term demands like scientific research, national policy on sustainable use of coastal regions and calamity prevention. Because of the scale of the phenomena it is obvious that these activities and demands cannot be restricted to one part of the continental shelf. Waves, currents, storms, and pollutants move freely across political boundaries. Therefore more co-operation between the North West European coastal countries in their ship-based programs and fixed monitoring activities will achieve benefits for all. Examples of such initiatives of co-operation are:

- SeaNet as a permanent "workshop" platform for co-operating agencies around the North Sea, dealing with national fixed monitoring station programmes and exchange of real time data;
- ESODAE co-operation between modelling institutes in preparing a large North West European Shelf data-assimilation Experiment in 2003-2005 (as a contribution to GODAE, the global data-assimilation experiment)
- Sea-Search, a European co-operative network on Marine data, Information, products and services from 16 National Oceanographic Data Centres or institutes
- Water quality monitoring station (ICES and OSPAR)
- The European Directory of the Initial Observing System (EDIOS) will provide a database of all operational observing stations in European waters.

Improvement of the forecasting systems with model components all over the North West Continental Shelf increases the need for operational data. Also new technology mainly developed from MAST and EUREKA-framework has resulted in new measurement systems. The applications for this new technology can be found in demand driven strategy from EuroGOOS.

The following factors determine the value of a particular measuring instrument, and the data from that instrument:

- Real-time/on line availability
- Spatial and temporal resolution and coverage in sampling
- Operational status of the measuring system
- Monitoring status of the observations: routine based or project oriented monitoring

Most of these aspects are determined by the observation platform being used.

3.2.2 Observation platforms

Most physical parameters can be measured with sensors from most platforms. However profiling or remote sensing systems can substitute for need for spatial variability for some parameters. The list of platforms is not complete but is an example of (pre)operational systems (Bosman et al, EuroGOOS Technology Survey Report No. 4); Tziavos and Flemming (1998).

Fixed structures

- National (fixed) monitoring networks using Off shore/ light-towers/specific platforms
- Seafloor stations (ADCP, sediment, wave pressure)
- Tide gauges
- River discharge gauges
- Yo-yo profiling buoys

Buoys

- Moored buoys with on line data communication
- Free drifting buoys (EGOS)
- Drifters, including profiling floats (Argo)

Ships

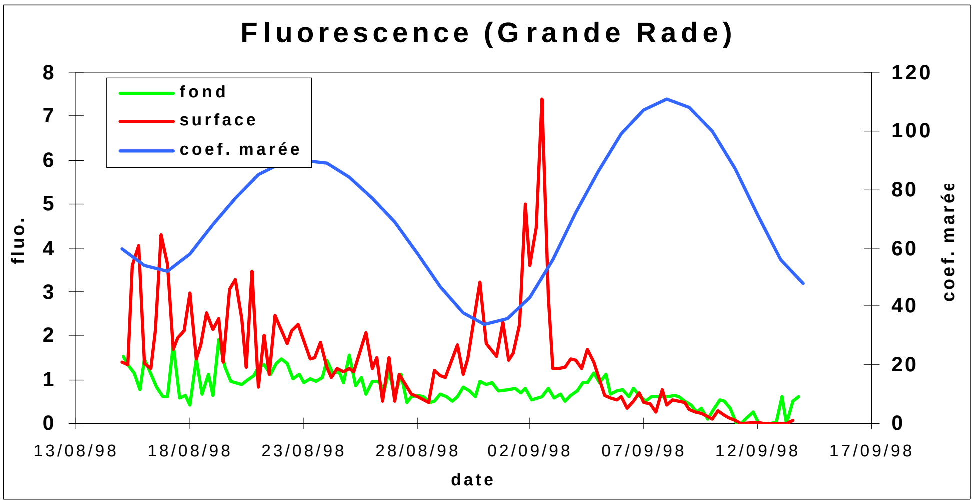
- Routine based national monitoring programs (mainly biological and chemical)
- Profiling instruments from ships (XBT, CTD)
- Ships of opportunity (like fishermen for Norwegian CTD-monitoring)
- Towed bodies for profiling
- Acoustic profiling systems
- Multi sensor ferry box

Remote sensing

- Satellite Meteorological synoptic data
- Satellite Oceanographic data (temperature, salinity, waves, chlorophyll, sea level elevation, sea ice)
- Shore based sensor arrays for surface mapping (HF-radar current) or transect mapping (acoustic tomography and EM-fields)
- Airborne sensor suites for high spatial resolution mapping of coastal processes

Initiatives are or have been taken to build information networks where data on available marine observation platforms, vessels etc. can be found (EDIOS, SeaQuip). The objective is to support the multiple use of existing infra-structure.

Table 3.1 presents an overview of the operational and actual monitoring state of specific observation vs. various operational platforms. Colour coding is used to show the gaps in availability of ocean observations.



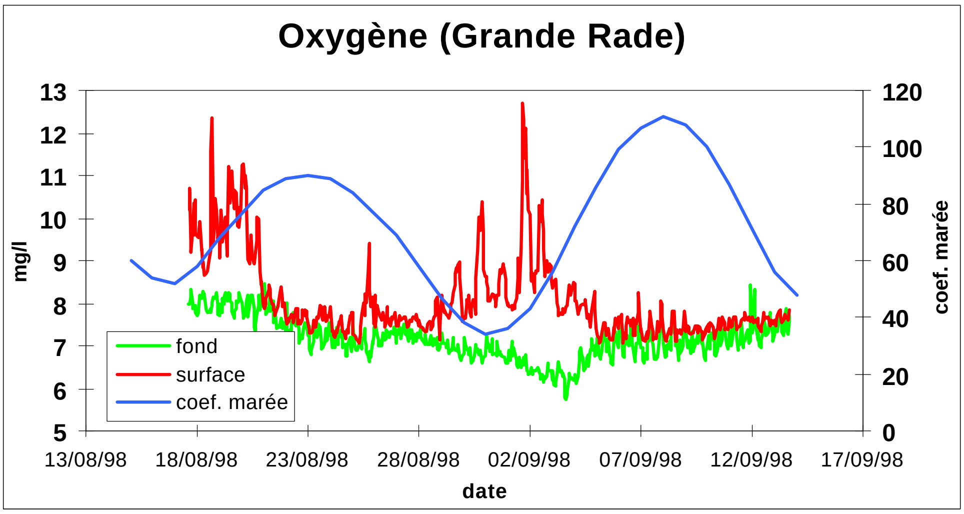


Figure 3.3 MAREL Bay of Seine network - examples of data. *Source: IFREMER, France*

Table 3.1 Operational status and pre-operational status of various types of observation as available from different types of observing platform (see also ESODAE plan)

For any given observation such as temperature or currents, the parameters can be observed from several different types of platforms, and some systems are already fully operational, while others are still under development as research products, or not available at all. Those combinations of data type and platform which are already operational are further sub-divided and colour-coded into those which are being measured as part of a limited project, those which are fully established at national level, and those which are routinely available as international operational data products.

		Platform					
		IN - SITU			REMOTE SENSING		
		Fixed structures	**Buoy**	**SHIP**	**Shore based Sensor array**	**Airborne**	**Space-borne**
PARAMETERS	**STATUS**						
TEMP Surface	Operational Monitoring				XXXXXX XXXXXX		
TEMP Profile	Operational Monitoring				XXXXXX XXXXXX	XXXXXX XXXXXX	XXXXXX XXXXXX
SALINITY Surface	Operational Monitoring				XXXXXX XXXXXX		
SALINITY Profile	Operational Monitoring					XXXXXX XXXXXX	XXXXXX XXXXXX
SEALEVEL	Operational Monitoring		XXXXXX XXXXXX	XXXXXX XXXXXX	XXXXXX XXXXXX		
CURRENTS Surface	Operational Monitoring						
CURRENTS Profile	Operational Monitoring					XXXXXX XXXXXX	XXXXXX XXXXXX
CURRENTS Trajectory	Operational Monitoring	XXXXXX XXXXXX			XXXXXX XXXXXX	XXXXXX XXXXXX	
WAVES Heights	Operational Monitoring			XXXXXX XXXXXX			
WAVES Dir/Spectrum	Operational Monitoring			XXXXXX XXXXXX		XXXXXX XXXXXX	XXXXXX XXXXXX
WIND	Operational Monitoring						
BATHYMETRY	Operational Monitoring	XXXXXX XXXXXX	XXXXXX XXXXXX		XXXXXX XXXXXX		
SEDIMENTS Concentr	Operational Monitoring						
CHLOROPHYL Concentr	Operational Monitoring				XXXXXX XXXXXX		
BIOLOGICAL (nutrients)	Operational Monitoring				XXXXXX XXXXXX	XXXXXX XXXXXX	XXXXXX XXXXXX
FLUX Concentr	Operational Monitoring					XXXXXX XXXXXX	XXXXXX XXXXXX

STATUS operational monitoring	Operational	Pre- Operational	R&D	Not available
Project based				XXXXXXXXX XXXXXXXXX
Routine National				
Routine International				

3.2.3 Communications and data Infrastructure

Observations from the past have resulted and in the future will result in a large amount of data, which have to be processed, archived and distributed to various users. The infrastructure needed to bring the data real time, on line or off-line to data-archives consists of a large number of components. Most of them are described in the Marine Technology Survey (EuroGOOS No. 4). A few relevant issues are mentioned here:

Communication

- Analogue and digital lines (ISDN, ADSL)
- Used protocols (FTP, XML, IP)
- Communication systems (GTS, SNDI, Internet, bi-lateral etc.)
- Used metadata (EDMED, ROSCOP, CDS, GF3, "special national metadata", etc.

Operational and archive databases

- National (local) operational databases and archives
- National Oceanographic Data Centres (NODCs)
- OSPAR, ICES, EEA, EU databases
- Project databases; MAST science projects and data bases.

Standards

- Good measuring practice
- ISO, CEN
- Etc.

The NOOS objective is to ensure compatibility of standards and sufficient bandwidth.

3.3 Modelling

There is a wide variety of oceanographic models covering the North West European continental shelf. They can be classified into 3-dimensional circulation, storm surge, wave, ecosystem and dispersion models. Table nos. 3.2 to 3.5 give a short (and certainly not complete) overview of different models in Northwest European countries. The tables mainly focus on operational models which are used in daily routine to generate real time numerical forecasts. Other models are pre-operational and may be quickly entered into real-time forecasts service, while semi-operational models are used to generate hindcasts, nowcasts or forecasts on demand.

Nearly every country on the North West European Shelf has a fully operational system for the generation of numerical ocean forecasts. The primary forecast products are water level for storm surge warning and surface waves. In many countries the operational forecast models are run by the national weather forecasting agency. However, forecasting of currents and hydrography with the aid of 3D models is becoming more widespread. In each country, models have been developed and applied for the greater North Sea area or for certain sub-regions of national interest. These models have widely differing spatial and temporal scales, reflecting the different goals for which they were originally developed. The spatial coverage of the models ranges from the whole northern European shelf (with grid sizes up 30 km) to coastal/estuarine areas (with grid sizes down to 1 km or less to resolve steep concentration gradients), as well as box models with no spatial variability (e.g. chemical equilibrium model).

The fully operational models are nearly all run at national institutions. They have been developed and implemented using mainly national funds and are focused on national applications. Aside from the ECMWF wave model, there is no European-wide community forecasting activity covering the North West European Shelf. There are single examples for trans-national exchange of forecast products (mainly water level forecasts), but the routine exchange of model forecasts between several countries as well as of other predicted model parameters has not yet been established. In addition to the operational models described so far, there are many other ocean models which reside at non-operational institutions or companies.

Operational wave models (Table 3.2) are mainly run by national weather forecasting services. Some countries use hybrid second generation models while others and the ECMWF use the third generation model WAM.

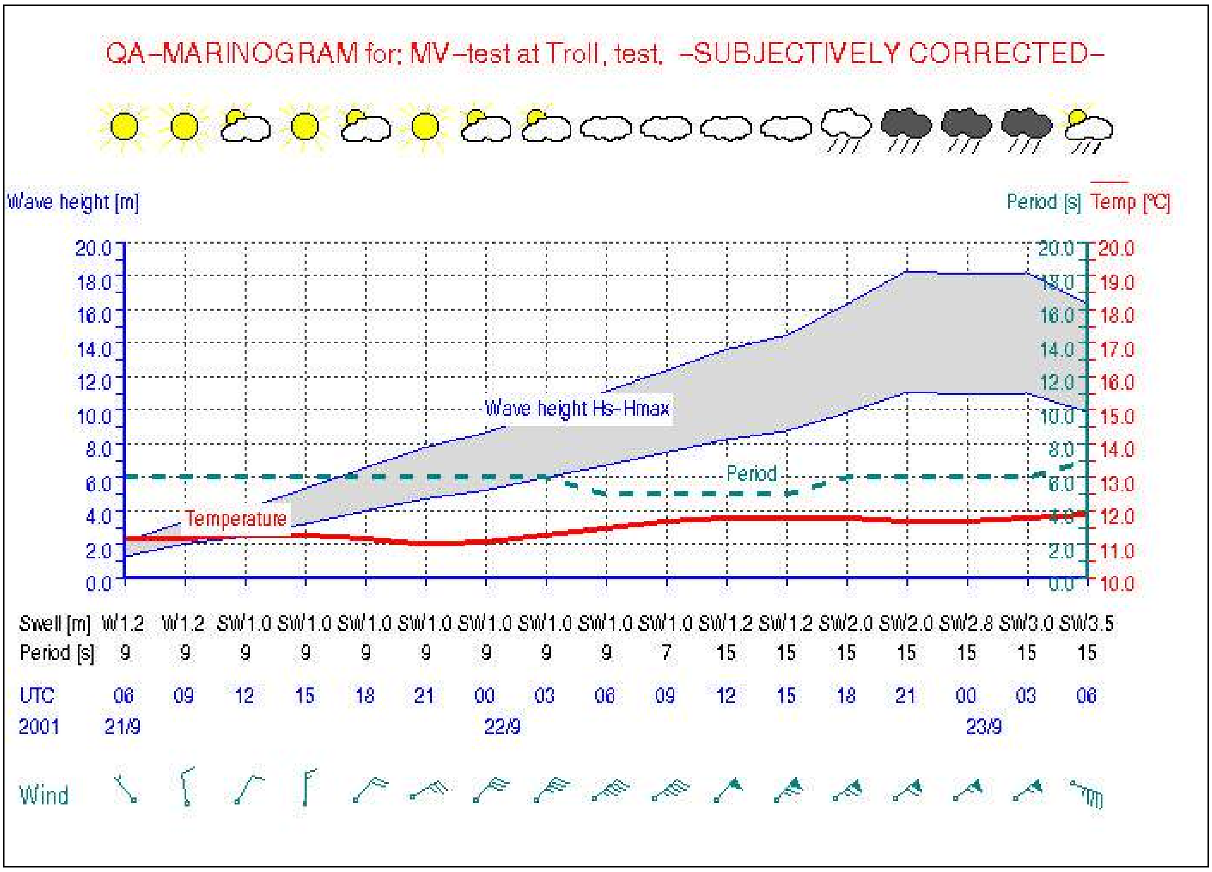


Figure 3.4 *Demonstration plot of hypothetical 48 hour forecast of wave height (significant wave height and maximum wave height), mean wave period and swell component (direction, height and period), along with weather parameters (air temperature, 10m wind and weather symbol), at a North Sea platform. The data are obtained from DNMI's forecast models HIRLAM and WAM (values shown are fictitious, for demonstration). Source: DNMI.*

There is a wide range of circulation and storm surge models for the North West European Shelf (Table 3.3). They differ from one another not only in spatial and temporal resolution but also in the physical processes included (e.g., barotropic/baroclinic, dispersion formulations), numerical solution techniques, calibration and forcing. The time resolution of the external forcing also affects the temporal variability of the models. The forecast length of operational circulation and surge models is typically 48 hours.

In dispersion models (Table 3.4), the temporal scale of forcing ranges from actual meteorological (hourly to daily) data to long-term average conditions. For the chemical and biological processes relevant to pollution transport and fate, models also incorporate very different degrees of complexity. Process complexity ranges from simple transport of passive, conservative contaminants to detailed reactions including contaminant adsorption, desorption, sedimentation, resuspension, oxidation, reduction, volatilisation, degradation, uptake in organisms and concentration in the food chain.

Dispersion models (mostly oil spill) are running semi-operationally (fast response during emergencies) at several national forecasting centres. In addition, there is a large number of off-line dispersion models available for hindcast/nowcast use. There are probably many commercial models available, as well.

At present, there are few operational ecosystem models in forecast service (DNMI/IMR in Norway is one), while there are several scientific or pre-operational models. These models show large differences in construction, and applicability depending on the aim for which they were built but all include processes describing the primary production and the interactions with one or more nutrients and show all reasonable to good fit to nutrient and chlorophyll concentrations (Table 3.5).

A broad literature survey of ecological modelling is presented in Moll, A., Radach, G., (2001). At commercial institutes other models are also available.

The differences between the models are shown in the number of material cycles (e.g. C, N, P and Si cycles) number of functional groups (e.g. types of phytoplankton, zooplankton) and associated process descriptions, and the coupling to benthic processes.

The choice of a model for forecasting has to be depended on the desired resolution in time and in detail and on the requested space scale. The forecasting with a model of some eutrophication processes such as blooming and the fate of harmful alga needs detailed process descriptions on the dynamics of these algae in the model.

Forecasting of primary production in a mixed area such as the Southern Bight of the North Sea with a model is only reliable when the role of the sediment and the benthic system is taken in account (55% of the mineralisation of the primary production takes place in the sediment). Hence some process descriptions on benthic nutrient regeneration processes should be present.

Forecasting by models on longer time scales of slower growing and larger organisms such as zooplankton and macrobenthos (e.g. filter feeders) is still unsatisfactory and this is caused by insufficient knowledge on physiological and behaviour aspects of these groups. Hence model estimations of the potential food supply for the higher trophic levels such as (commercial) fish is still unreliable.

Trans-national co-operation in model development started to grow in various projects funded by the EU within the frame of its MAST research program. It will continue in the FP5 with even more emphasis on operational oceanography. One may expect to have some of these jointly developed systems in operation in a few years. Some MAST projects with strong modelling components in the North West European Shelf area include ERSEM, PROFILE, NOMADS, COHERENS, DIADEM, EuroROSE and ESODAE.

One focus of some recent MAST projects (DIADEM, EuroROSE and ESODAE) is to promote data assimilation in numerical modelling. At the moment, aside from some operational wave models (ECMWF, DNMI), data assimilation in operational forecast models is very limited. In the Netherlands (KNMI in co-operation with RWS/RIKZ), measured water levels are assimilated in operational surge models, but up to now, the assimilation of other parameters (e.g. water temperature) has only been realised in scientific models.

Figure 3.5 A new data buoy deployed off Dublin as part of the Irish Marine Data Buoy Network, a joint project between the Marine Institute, Met Eireann, the UK Met Office and the Irish Department of Marine & Natural Resources. Web site: http://www.marine.ie.datacentre/projects/databuoy
Source: Marine Institute, Ireland

Table 3.2 Wave Models (after WMO, 1998)

Country	Institution	Model Name	Model Area	Resolution	Type[1]	Characteristics
EU	ECMWF	WAM	Global	1.5° x 1.5°	Op.	Deep/shallow water modes, coupled spectral
NL	KNMI	NED WAM	50.666° - 70° N; 7.5° W - 16.5° E	1/3° lat. x 1/2° long.	Op.	Deep/shallow water modes, coupled spectral (limited area WAM version). Data assimilation with buoy spectra.
D	DWD	WAM	North Sea / Baltic Sea	10 km	Op.	Deep/shallow water modes, coupled spectral
	Amt für Wehr-geophysik		Greater North West European Shelf	50 km	Op.	Coupled hybrid
DK	DMI	WAM	North Sea / Baltic	1/6° lat. x 1/6° long.	Op.	Deep/shallow water modes, coupled spectral
N	DNMI	WAM	Greater North European Shelf	75 km polar stereographic	Op.	Deep/shallow water modes, coupled spectral. Assimilates of ERS-2 altimeter data.
UK	UKMO	The Met Office wave model	Global	5/6° long by 5/9° lat	Op.	Includes shallow water physics. Second generation coupled discrete. Assimilates ERS-2 altimeter data
			Greater European Shelf (30.5N to 66.75N, east of 14W), plus Mediterranean, Black Sea and Baltic	0.25° lat. x 0.4° long.	Op.	
			UK waters 48N to 63N 12W to 13E	1/9° lat by 1/6° long.	Op.	Includes shallow water physics and effect of time-varying currents on waves, using currents from storm surge model.
F		VAG-ATLA	North Atlantic	150 km polar stereographic at 60°N	Op.	Deep water, coupled discrete model, 2nd generation
B	MUMM/ AWK	Deining	North Sea / Southern North Sea / Belgian coast	50 km 10 km 500 m	Op.	2nd generation

[1] Op. = operational, Pre-op. = pre-operational, Semi-op. = semi-operational, Scient. = scientific

Table 3.3 Storm Surge and Circulation Models (after de Vries et al., 1995, Proctor, 1995)

Country	Institution	Model Name	Model Area	Resolution	Type[1]	Characteristics
NL	KNMI in co-operation with RIKZ	WAQUA in SIMONA	Greater North Sea (Dutch coastal Shelf Model	8 km	Op.	2D Storm Surge Model with Data Assimilation (Kalman Filter)
D	BSH	BSHsmod BSHcmod	North Sea North Sea / Baltic Sea	6 nm 6 - 1nm 14 z levels	Op Op	2D Operational Storm Surge Model 3D Baroclinic Circulation Model
	IfM	HANSOM	North Sea / Baltic Sea	12' x 20" 14 z levels	Scient.	3D Baroclinic Circulation Model
DK	DMI	MIKE 21	North Sea / Baltic Sea	9 - 3 - 1nm	Op.	2D Storm Surge Model
	DHI	MIKE 3	North Sea / Baltic Sea	9 - 3 - 1nm z levels	Pre-op	3D Operational Baroclinic Circulation Model
N	DNMI	MI-POM	Greater North West European Shelf Nordic Seas, Norwegian Shelf	20 km 20 - 4 km	Op. Op.	2D Storm Surge Model 3D Baroclinic Circulation Model
	IMR	NORWECOM	Greater North West European Shelf		Op.	3D Baroclinic Circulation Model with SPM and Ecosystem Model
	NERSC	DIADEM TOPAZ NSEA NWAG	North Atlantic and Nordic Seas Nordic Seas Atlantic Margin and Faroes	10-20 km North Sea 7 km 2 km	Pre-op. Pre-op. Pre-op. Pre-op.	3D isopycnic layered OGCM 3D hybrid OGCM 3D hybrid OGCM 3D hybrid OGCM
UK	UKMO	POL CS3 POL "model B" Shelf Model	North West European Shelf 48N to 63N 12W to 13E	1/9° lat by 1/6° long. 15 σ levels	Op. Op. from June 2000	2D Storm Surge Model 3D Baroclinic Circulation Model. Surface forcing from mesoscale NWP. Deep ocean BCs from 1/3° FOAM climatology.
B	MUMM / AWK	OPTOS-CSM	North Sea	2.5' x 2.5'	Op.	2D Storm Surge and Circulation Model
	Univ. of Liege	PCNOE	North Sea	10' x 10' 15 σ levels	Scient.	3D Baroclinic Circulation Model with SPM and Ecosystem Model
B / UK	MUMM / NUE / POL / BODC	COHERENS	North Sea	6' x 4' 20 levels	Scient.	Coupled 3D Baroclinic Hydrodynamic-Ecological Model
F	IFREMER	SAM-2D SAM-3D	Northern Brittany Bay of Seine Seine estuary	900m 1,5-5 km 200m-1km	Semi-op Semi-op Semi-op	2D or 3D baroclinic circulation model

[1] Op. = operational, Pre-op. = pre-operational, Semi-op. = semi-operational, Scient. = scientific

Table 3.4 Dispersion Models (after ASMO, 1997 and 1998)

Country	Institution	Model Name	Model Area	Type[1]	Characteristics
NL	RIKZ	MARS DEMWAQ	North Sea	Op. Op.	PC-based Oil Spill Model 3D Model for Different Chemicals
	RIKZ / Delft Hyd.	SCREMOTOX ZeeBos SAWES NZB	North Sea North Sea West. Scheldt Estuary Greater North Sea / Dutch Coastal Zone	Semi-Op. Semi-Op. Semi-Op.	Screening Model for Toxic Substances Water Quality Model Estuarine Water Quality Model Water Quality and Ecosystem Model
	Delft Hyd.	RAMFOS	North Sea	Semi-Op.	Oil Spill Model
	DNZ	OILSPILL		Semi-Op.	PC-based Oil Spill Model
	TNO	EFFECTS		Op.	PC-based Model for Different Chemicals
D	BSH	BSHdmod.E BSHdmod.L	North Sea / Baltic Sea	Op. Op.	Water Quality Model Particle Trajectory and Oil Spill Model
DK	DMI DHI	MIKE 21 SAW MIKE 21 PA MIKE 21 SAW	North Sea North Sea / Baltic Sea	Semi-op Semi-Op. Semi-Op.	Oil Spill model Different Chemicals and Sediment Oil Spill Model
N	DNMI	NOROIL NORTRA	Greater North West European Shelf	Semi-Op. Semi-Op.	Oil Spill Model Particle Trajectory Model
	SINTEF	PROVANN	North Sea	Semi-Op.	Fate and Effects of Pollutants and Oil
	IMR	NORWECOM	Greater North Sea	Semi-Op.	Water Quality
UK	NETCEN	EUROSPILL and OSIS	North West European Shelf	Semi-Op.	PC Models for Fate of Chemicals and Oil Spills
	POL	RP/DP			
	SOC	NOSTRADAMUS	Southern North Sea	Scientific	Water Quality Model
F	Cedre & Lab. d'Hydraulique de France	CHIMER		Op.	PC-based Model for Different Chemicals
	IFREMER	ELISE SAM	Seine Estuary and Bay	Scient	Bioaccumulation of PCB in sea bass food-web. Sediment transport and cadmium fate
	EDF	TELEMAC/ SUBIEF	Channel/Bay of Seine	Semi-Op.	Radionuclides
B	MUMM	MU-SLICK	North Sea	Op.	Oil Spill Model

[1] Op. = operational, Pre-op. = pre-operational, Semi-op. = semi-operational, Scient. = scientific

Table 3.5 Ecological and Ecosystem Models (after ASMO, 1996)

Country	Institution	Model Name	Model Area	Type[1]	Characteristics
NL and D	NIOZ / IfM	ERSEM	Greater North Sea	Scient.	Ecosystem Model
D	IfM	ECOHAM1	Greater North Sea	Scient.	Ecological Model
UK	SOC	DYMONNS	Southern North Sea	Scient.	Ecosystem Model
	POL	RP			
	PML	JIA			
F	IFREMER	ELISE	Coastal (Engl Channel) Bay of Seine, Northern Brittany	Scient. Scient.	Ecological Model Box Model and coupled 3D Baroclinic Hydrodynamic-Ecological Model
N	IMR / DNMI	NORWECOM	Greater North Sea	Op.	Water Quality and Ecological Model
B	Univ. Bruxelles	MIRO	Coastal	Scient.	Ecosystem Model
B / UK	MUMM / NUE / POL / BODC	COHERENS	North Sea	Scient.	Coupled 3D Baroclinic Hydrodynamic-Ecological Model

[1] Op. = operational, Pre-op. = pre-operational, Semi-op. = semi-operational, Scient. = scientific

4 Relations with European and other international organisations

The role of NOOS is to create a design for a fully integrated observing and forecasting system for the North Western part of the EuroGOOS area. This system has to meet the needs of a large number of user groups in a cost-effective way. Moreover it should be designed in such a way that all countries bordering the North West Shelf area will be involved in the development and implementation of NOOS. At present a large number of public (scientific, governmental) and private organisations is focused on certain, mostly sectoral, activities in the NOOS region. For NOOS most of these organisations will be potential clients or as is mostly the case for governmental bodies, users of NOOS data and information.

In this section the activities and needs of key environmental, governmental, scientific and industrial grouping are discussed. Moreover a list is given of the relevant European and national organisations which all might be potential users of NOOS-data. The European satellite organisations ESA and Eumetsat, but also NASA and NOAA, are not discussed in this section.

The exchange of information through Internet has opened new opportunities for virtual networks where national networks, research vessels, cruises etc are being connected.

4.1 IOC/GOOS

The intergovernmental Oceanographic Commission (IOC) was the lead UN agency in establishing the Global Ocean Observing System (GOOS) between 1990 and 1993, when a Memorandum of Understanding was signed with the World Meteorological Organisation (WMO) and the International Council of Scientific Unions (ICSU). Later MoUs included the United Nations Environment Programme (UNEP) and the Food and Agriculture Organisation (FAO) as sponsors of components of GOOS.

GOOS is managed through a GOOS Steering Committee (GSC) and an Intergovernmental GOOS Committee (I-GOOS). The GOOS Project Office (GPO) is at the IOC headquarters of UNESCO in Paris. GOOS provides extremely comprehensive web connections through its homepages, and operates a portal to hundreds of other web sites. For further information visit the OceanPortal on http://oceanportal.org.

GOOS activities are described broadly in the GOOS Prospectus (IOC 1998) and the regular publications of the Ocean Observing Panel for Climate (OOPC) and the Coastal Ocean Observing Panel (COOP). Most documents are available on the GOOS Home-page.

GOOS supports regional components such as the North East Asian Region (NEAR-GOOS) and Mediterranean GOOS (MedGOOS) as well as EuroGOOS. There are about ten regional groups in GOOS, and representatives of these bodies will meet every two years in the GOOS Regional Forum. Each GOOS Region contains subsidiary projects, and, in some cases, sub-regions, such as the EuroGOOS North West Shelf Task Team.

EuroGOOS is formally recognised as the representative body for GOOS in Europe, and as such, works with other bodies such as ICES in projects such as the North Sea Ecosystem Monitoring Component. Representatives of the GOOS Project Office attend EuroGOOS meetings, especially the Annual Meeting. All EuroGOOS documents are copied to GPO, and EuroGOOS reports formally to I-GOOS.

NOOS activities need to interface with other European-scale organisations, and with those activities of IOC and GOOS which apply to the Atlantic and European scales.

4.2 European Union, European Commission

The European Commission Directorate General XII (Research) Programme of Marine Science and Technology (MAST) ran from 1988 to 1999, through the European Framework Programmes 2, 3 and 4. During these years the collaboration between European oceanographers and marine scientists and technologists was enormously strengthened. Numerous research projects were conducted in the North Sea and on the North West Shelf margins relevant to NOOS.

Under Framework 5 the MAST Programme was not continued, but substantial funding was available for marine research and operational oceanography under the headings of the Energy, Environment and Sustainable Development Programme. There was a major emphasis on identifying users for research products, and involving the users in the planning of the project. With Framework 6 due to start in 2002, the structure of project funding will change again, and the emphasis is likely to be more on the value added at the European level, investment in infrastructure, and integration of projects into larger programmes.

Other EC Directorates relevant to NOOS objectives are the Directorates for Transport, Fisheries, and the Environment.

Projects supported by the Commission have consisted of Research and Technology Development projects (RTD) where up to 50% of working costs can be covered; Concerted Action of Thematic Network projects where costs are provided for communications and meetings but without any new research; and Supporting Initiatives or Accompanying Measures, which provide background data and analysis of general benefit to marine research.

4.3 European Environment Agency

The European Union has established the European Environment Agency (EEA) in 1990. It is independent from the Commission and has its headquarter in Copenhagen, Denmark where it began to work in 1992. The mission of the EEA is: "to deliver timely, targeted, relevant and reliable information to policy-makers and the public for the development and implementation of sound environmental policies in the European Union and other EEA member countries". For the implementation of its mission the EEA uses the capacities of a network of environmental bodies and institutions active in the member countries. This is the European Environment Information and Observation Network (EIONET).

A series of environmental assessment reports are the main products of the EEA. As a consequence there is a very strong need for reliable and consistent data which can be analysed rapidly. NOOS will be able to provide most of these data. EEA was a co-sponsor of the Bio-Ecology Workshop in 2000 (Fischer et al., 2000).

4.4 OSPAR

The Oslo Commission was established to administer the Oslo Convention, which entered into force in 1974. Its task was to regulate and control the dumping at sea of industrial wastes, sewage sludge and dredged material and the incineration at sea of liquid industrial wastes. The Paris Commission was established to administer the Paris Convention, which entered into force in 1978. It regulated and controlled inputs of substances and energy to the sea from land-based sources (via the atmosphere, rivers, or direct discharges) and also from offshore platforms. In 1992 the Paris and Oslo Conventions were modernised and merged into a new Convention for the Protection of the Marine Environment of the North East Atlantic (the "OSPAR Convention"), which entered into force in 1998. OSPAR a) requires the application of the precautionary principle; the polluter pays principle; best available techniques (BAT) and best environmental practice (BEP), including clean technology; b) provides for the Commission established by the OSPAR Convention to adopt binding decisions; c) provides for the participation of observers, including non-governmental organisations, in the work of the Commission; and d) establishes rights of access to information about the maritime area of the Convention. The Secretariat is based in London, United Kingdom.

The future work of the OSPAR is directed to the following four main areas:

- Protection and conservation of ecosystems and biological diversity.
- Hazardous substances.
- Radioactive substances.
- Eutrophication.

OSPAR works within a strict legal and managerial framework to provide data and advice to the signatories. The objectives of OSPAR are totally consistent with the ones of NOOS. Data gathered in relation with the activities of OSPAR might be incorporated in NOOS models, while the outputs and predictions of the NOOS models may assist OSPAR to meet its objectives.

4.5 ICES

The International Council for the Exploration of the Sea (ICES) is the oldest intergovernmental organisation in the world concerned with marine and fisheries science. Since its establishment in 1902, ICES has been a leading scientific forum for the exchange of information and ideas on the sea and its living resources, and for the promotion and co-ordination of marine research by scientists within its member countries. The Secretariat is based in Copenhagen, Denmark.

ICES 2000 mission statement is to: " lead the way by mobilising scientific assets to advance the capacity to understand and advise on the effects of human activity and natural change on marine ecosystems". This statement includes:

- Focusing on the North Atlantic and adjacent seas, with due consideration for global concerns.
- Investing in both short- and long-term interdisciplinary research, including physical, chemical, biological, and social sciences.
- Establishing partnerships with other organisations that share a common interest.
- Being responsive to emerging issues.
- Creating effective arrangements to provide scientific advice.
- Informing the public objectively and effectively about marine ecosystem issues.

For its advisory role ICES needs more reliable data of the marine environment of the North Atlantic and adjacent seas. EuroGOOS and especially its subregional systems for the North West Shelf (NOOS) and Baltic Sea (BOOS) can improve the delivery of this information to ICES.

ICES co-sponsored with EuroGOOS the Bio-Ecology Workshop (Fischer et al., 2000) and the Workshop on a North Sea Ecosystem component held in Bergen in September 2001.

4.6 OGP

The International Association of Oil and Gas Producers (OGP) is a world-wide association of oil and gas companies involved in exploration and production. Membership is open to all companies involved in exploration and production (E&P) activities, national associations of OGP companies, and institutes with E&P interests.

OGP represents its members before international regulatory bodies, and has observer status as a non-governmental organisation with global and regional regulatory bodies who have an interest in marine environment protection.

OGP works closely with other United Nations Agencies such as the United Nations Environment Programme (UNEP), and with environment/conservation bodies such as the World Conservation Union (IUCN).

OGP has a committee for Meteorology and Oceanography (Metocean) which was formed in 1974 and an Environmental Quality Committee (EQC) which was formed in 1977.

NOOS data and information is relevant for offshore exploration and exploitation activities and for design criteria of offshore structures for which OGP also has a special committee.

4.7 SeaNet, fixed monitoring network

The objective of SeaNet is to establish more co-operation, mutual tuning and exchange of data and expertise between the monitoring agencies. The ultimate goal on a time scale of approximately 10 years was to accomplish an integrated marine monitoring and forecasting system for the North Sea region, to the benefit of both users and providers of monitoring and forecasting data in the region:

- Users will benefit from increased data availability and harmonisation in data offerings with respect to quality and presentation;
- Monitoring agencies will increase the efficiency of their operations by exchange of data and expertise, joint research & development efforts and more focus to user demands.

To investigate the feasibility of an integrated system based on national networks and to get more detailed insight into the terms of reference and a feasible work plan for development and implementation two inventories were made.

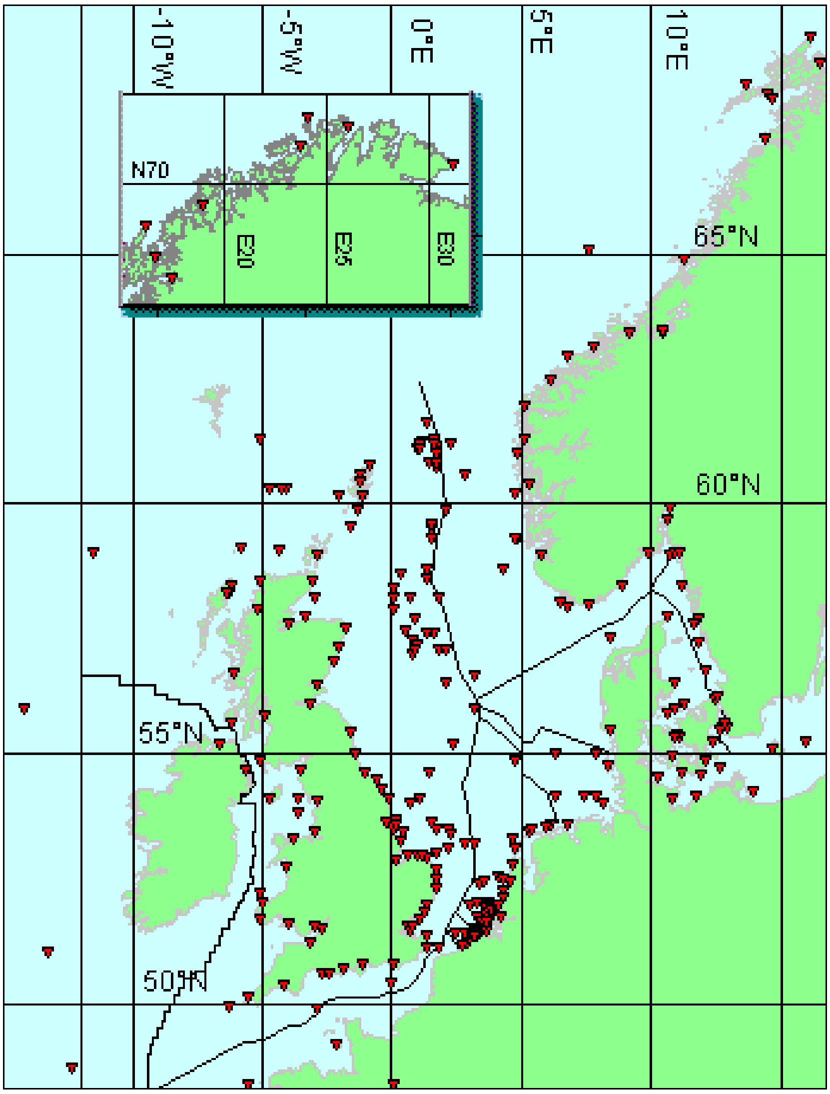


Figure 4.1 Map of the present fixed monitoring networks in the North Sea countries linked to data base with details on e.g. stations, parameters, operators, instruments, frequencies and distribution schemes. See SeaNet web site for details: http://www.seanet.co.uk.

4.8 NODC (National Oceanographic Data Committees/Centres)

National Oceanographic Data Centres are national bodies recognised by the International Oceanographic Data and Information Exchange Committee of IOC, (IODE), as the official body for gathering and archiving oceanographic research data, and for transmitting those data to the World Data Centres for Oceanography, as part of the ICSU WDC system.

Most European countries operate NODCs, and the holdings are catalogued in documents such as the European Directory of Marine Environmental Data (EDMED). NODC's tend to concentrate on gathering data which have been obtained through non-routine scientific research cruises, emphasising quality control and thorough documentation of the data sets for archival preservation, and accurate use by third parties. During recent years the distinction between delayed mode and real time data has become less sharp, and Data Centres are becoming involved in providing directories and portals to real time data systems

The NODCs in the NOOS Region are an essential asset since they provide the ultimate standards of data quality control, and they hold the long-term archives and time series which are needed to establish climatology.

5 NOOS strategic principles

5.1 Introduction

So far this report has defined the goals of NOOS, analysed the user benefits from the application of operational oceanographic information products, reviewed the existing observing systems already in place, and considered the mechanisms for working closely with existing European Agencies and institutions.

We have established that an operational oceanographic service to the marine industries and governmental authorities in the NOOS area will contribute to the efficiency of marine operations, reduce the risk of accidents and public health hazards, optimise the monitoring and management of the marine environment, improve climate research and prediction of climate variability and climate change, improve recreational use of the sea, and improve the regulation and management of marine activities. These benefits can be developed and optimised within the context of national regulation and European Directives.

It is now possible to define a set of Strategic Principles which will direct the development of NOOS, and which will provide the guidance needed to set out the Implementation Plan (see Chapter 6).

In setting out the Strategic Principles we must bear in mind that NOOS is being built on existing systems and will be implemented mainly through the commitments from participating agencies. At present there already exist most of the components needed for an operational system within national and international programmes. The main task of NOOS is therefore to co-ordinate activities, develop operational routines, improve the technical components by exploiting new technology and science, and to harmonise products based on user requirements. Each of these activities is itself composite and highly technical.

5.2 Strategic principles

We identify 5 major Strategic Principles, which will serve as headings for more detailed break-down.

a) Make formal agreements and commitments between participating agencies to create networks of existing systems and services, delivering operational ocean data products.

b) NOOS must plan and innovate so as to fill the gaps in existing systems, creating new structures, and introducing new technology, new hardware, and exploiting new scientific developments.

c) NOOS will be developed in the context of GOOS, EuroGOOS, Coastal Ocean GOOS, and the GOOS Regional Policy and the GOOS Regional Forum.

d) NOOS will maintain and strengthen working relations with other European agencies and bodies concerned with the North West European Shelf seas.

e) Consult user communities on a routine basis to improve products and services, and introduce new components into the observing system.

Under each of the Strategic Principles listed above, we identify subsidiary points as follows:

a) Make formal agreements and commitments between participating agencies to create networks of existing systems and services, delivering operational ocean data products

i) NOOS will consider a formal Memo-randum of Understanding between its members setting out the principles of commitment and collaboration.

ii) NOOS will emphasise the importance of participating agencies maximising the scope of their Data Catalogues submitted under the principles of the EuroGOOS Data Policy Agreement.

iii) NOOS will seek to establish methods for sharing model software and protocols through bilateral or multi-lateral arrangements.

iv) NOOS members will develop formal agreements to collaborate in generating specific products and services.

b) NOOS must plan and innovate so as to fill the gaps in existing systems, creating new structures, and introducing new technology, new hardware, and exploiting new scientific developments

i) Design and implementation of NOOS will take into account the scientific basis established in the Report of the Science Advisory Working Group of EuroGOOS. (Prandle and Flemming, 1997).

ii) Operational model design is of high priority, including the operational management of models.

iii) There is an urgent need to standardise technological systems and improve compatibility and communications.

iv) The introduction of new science and technology into NOOS should take into account the developments within the planned Large Integrated Programme of the European Commission within Framework 6.

v) New space technology and new operational ocean observing missions will be of major importance, especially in regard to salinity measurements and ocean colour.

vi) Urgent development is needed in respect of bio-ecological sensors and bio-monitoring instrumentation.

vii) NOOS will maintain working relations with the marine technology suppliers.

viii) A well-functioning operational ocean observing system in the NOOS area will require an optimal observation system that can provide:

- A data analysis system
- Access to meteorological forcing
- Operational forecasting models
- A presentation and information system

ix) NOOS should review the range of gaps in science, technology, and systems, including such matters as sensor design, OSSE, communications systems, sampling design strategy, interfacing between models, and the competence of existing procedures for data assimilation into coastal models.

c) NOOS will be developed in the context of GOOS, EuroGOOS, Coastal Ocean GOOS, and the GOOS Regional Policy and the GOOS Regional Forum

i) Collaborate with the GOOS Coastal Ocean Observing Panel to establish or expand the list of core variables which are to be exchanged or made available on a global scale.

ii) Utilise the Regional Policy of GOOS and the GOOS Regional Forum to exchange information and experience which will held the development of NOOS, or be helpful to other Regions.

iii) Promote workshops on specific topics and data types or technology, leading towards formal agreements between NOOS participants.

iv) Link NOOS where appropriate to neighbouring EuroGOOS sub-regions, that is the Arctic, Atlantic, and Baltic regions.

v) Link NOOS activities to large scale international and global programmes such as GODAE, Argo, and GYROSCOPE.

d) NOOS will maintain and strengthen working relations with other European agencies and bodies concerned with the North West European Shelf seas

i) NOOS will collaborate closely with, and seek to provide added value products for, other European and NWS bodies, including the European Commission, OSPAR, ICES, ESA, EUMETSAT, ECMWF, etc....

ii) Encourage and promote public awareness of operational oceanography and bio-ecological information products, using the Internet.

iii) NOOS, in collaboration with other members of EuroGOOS and bodies such as ICES, OSPAR, HELCOM, etc., should influence national governments and agencies in Europe towards a greater acceptance of co-ordinated international marine monitoring, and real time use of marine data.

iii) NOOS should participate in activities to promote recognition of the importance of operational oceanography in promoting Global Monitoring for the Environment and Security. (GMES).

iv) Stress the importance of GOOS, EuroGOOS and NOOS in fulfilling the objectives of the Independent World Commission on the oceans.

e) Consult user communities on a routine basis to improve products and services, and introduce new components into the observing system

i) User involvement in the sampling strategy must be given high priority. Users of operational oceanographic products are: the scientific community; environmental and public health agencies; offshore oil and gas producers; service industries; coastal managers and decision makers; the public in general; fisheries and aquaculture business; shipping and tourist industry; and the navy.

ii) EuroGOOS should initiate an additional user requirement survey directed at customers of biological operational products and assess their specific data needs and possible contributions to sampling and monitoring.

iii) An improvement of interaction between marine scientists/operational agencies and politicians/public can be achieved through the following steps:

- Elaboration of a summary report that includes all marine bio-ecological variables and indicators suggested for operational use by groups of scientists should be made available for discussion with end users by GOOS, EuroGOOS and ICES
- Education of users of bio-ecological products as well as politicians and the public in general is important to help with strategic funding and the creation of useful and popular products.
- EuroGOOS, ICES, and international conventions (OSPAR, HELCOM) should influence national governments and agencies towards greater acceptance of co-ordinated international monitoring. This includes preparation of material (possibly from projects such as FerryBox and SeaFlux) showing the value of an approach that uses harmonised measurements throughout a region.

iv) NOOS must develop its customer relations within a comprehensive data management and information plan.

6 Implementation of NOOS: The next steps 2002-2006

6.1 Introduction

The Strategic Principles set out in the previous Chapter give a sense of direction and objectives to NOOS, and must be followed by a detailed Implementation Plan. Since we have already shown that EuroGOOS Member Agencies and many other bodies are already substantially engaged in operational oceanographic services, and many national and multi-national research projects are under way in the region, it follows that developments will take place while the Plan is prepared and published. The Plan will be constructed in such a way that it interfaces directly with the existing on-going systems, and introduces the new elements and inter-connections in a logical and step-wise way.

This Chapter describes the key elements, or necessary steps, which will be included in the preparation of a detailed Implementation Plan for NOOS. The full Implementation Plan will be prepared in a separate document, and updated at regular intervals.

6.2 Actions required: next steps

6.2.1 Memorandum of Understanding, commitments

The EuroGOOS Agreement provides a general framework and set of objectives for operational oceanography in the European areas of interest, and it has to be supplemented by more detailed and binding documents and agreements where Members commit themselves to delivering services or resources on a regular basis. This principle has been applied in the case of the EuroGOOS Data Policy, and the BOOS Agreement. Similarly, for the North West Shelf region, a Memorandum of Understanding has been prepared, setting out the practical methods of collaboration, and the types of commitment which are needed to develop and run collaborative operational systems.

The action required is for the MoU to be agreed and signed by all EuroGOOS Member Agencies in the NWS region.

6.2.2 Level of representation

Member Agencies wishing to be represented in NOOS should ensure that appropriate staff are briefed to attend meetings regularly, or nominate alternates, so that there is a continuity of representation at a suitable level of seniority and technical information.

6.2.3 Review of declared GOOS commitments

In 1999 most delegates from European countries to the GOOS Commitments Meeting in Paris provided lists of data types and observation systems which they would provide. These commitments constitute part of the GOOS Initial Observing System. These commitments should be reviewed within the NOOS Region, and itemised as a possible basis for a structure and planned observing system.

6.2.4 Membership of NOOS

The core Membership of NOOS consists of the EuroGOOS Member Agencies in the NWS Region. EuroGOOS Rules limit the Membership to a maximum of 3 Government Agencies per country. There are many other Government Agencies, specialised laboratories and research organisations, non-governmental bodies, regulatory authorities, river and port authorities, commercial survey companies, etc., who could contribute valuable skills and data to NOOS, or provide value added to the data. The Rules of EuroGOOS permit non-members to be participants in subsidiary bodies, working groups, and expert panels. The Regional Task Teams include representation from non-members.

The action required is for the EuroGOOS Members in NOOS to consider the appropriateness of recognising non-members as full participants in NOOS, provided that they sign the NOOS MoU and the EuroGOOS Data Policy.

6.2.5 Implementation of NOOS Projects

In order to achieve the goals of NOOS, Members of NOOS will collaborate on agreed Projects. A Project may be defined as the installation of a set of observing stations; development of a communication system; management of a conference; research to improve an instrument or sensor; or the management of a secretariat; or any other agreed requirement within the defined goals of NOOS and the Strategic Principles. Groups of Members of NOOS, but not necessarily all Members of NOOS, shall agree from time to time on their commitment to particular Projects.

6.2.6 Management of NOOS

The NOOS MoU will define the management structure. The management board will co-ordinate, develop, and approve the Implementation Plan for NOOS, taking into account the recommendations of this document.

6.2.7 Project management

Projects shall be managed in each case by a co-ordination group approved by the Management Board of NOOS.

6.2.8 Headline projects and actions

Projects which may be developed and supported by NOOS could include agreed headline or priority actions. Reviewing present activities by EuroGOOS Members in the NWS region, possible priority projects might include: ESODAE, Support for Coastal Zone Management; Modelling the interface with the open Atlantic; Gridded Bathymetry; Ferry Box; Predicting the regional effects of Global Climate Change; Optimising the design of the observing system, OSSE; Techniques of model interfacing and nesting.

6.2.9 Co-ordination with adjacent EuroGOOS regions

Activities in the NOOS region should be co-ordinated so far as possible with the adjacent EuroGOOS Regions, especially the Arctic, Baltic, and Atlantic Regions.

6.2.10 Collaboration with ICES

NOOS will collaborate with ICES to improve delivery of data products which are of value to fisheries management and ecosystems management, and will arrange for the earliest possible sharing of fisheries oceanographic data for operational use in models.

6.2.11 Collaboration with other European organisations

NOOS will collaborate with other European or regional bodies with objectives consistent with the objectives of NOOS in the NWS region.

6.2.12 NOOS data and information management

NOOS will establish a Data Management Team to develop a data management plan, within the EuroGOOS Data Policy, which emphasises operational real time data delivery, and may include a NOOS Data Portal, and a web-master, and which establishes the conditions for co-production of data products.

6.2.13 Consistency with agreed policies and recommendations of EuroGOOS

The drafting of the NOOS Implementation Plan should include reference to previously published EuroGOOS documents, reviews, and analyses, taking into account the recommendations of those publications.

6.2.14 Action on water quality and ecological modelling

Water quality modelling, marine chemistry modelling, and ecosystem modelling have been the subject of a major research effort for more than a decade. There are enormous advantages on the European scale if such modelling techniques can be made reliably operational so that water quality, health hazards, and ecological factors can be modelled and managed on an operational basis, with forecasts of likely outcomes. The following actions are recommended to progress this component of NOOS:

a. Different transport and ecosystem models should be compared with each other and standardised before using them on an operational basis. They could be tested using data from projects such as FerryBox and SeaFlux

b. The efforts of EuroGOOS in bringing together European modelling expertise are greatly appreciated and the importance of a continuation and broadening of the co-operation among modellers from different institutions and regions must be emphasised. Development of shared bio-ecological operational models that could become components of a European Ocean Observing System is only possible through the sharing of data and joint validation of models

c. High-frequency data are needed for the validation and calibration of ecosystem models:

- Flux data for the aquatic carbon cycle
- Chlorophyll
- Oxygen
- Turbidity
- Nutrients

d. The development of new ecosystem models should be based on identified user requirements, e.g. in consultation with EuroGOOS and using EuroGOOS and GOOS documentation

e. Nesting of models on different scales (mega - micro) is encouraged

f. Benthic processes and benthic-pelagic interaction deserves further efforts in understanding ecosystem dynamics and modelling

6.2.15 Routine consultation with users

NOOS will define routine procedures for consultation with user communities, industries, services, and other agencies in the NWS area, so as to up-date and improve NOOS services and products.

Annexe 1

Physical Background

The NW European Shelf is a dynamically active regime dominated by strong tides and frequent passages of mid-latitude synoptic weather systems. The waters are mostly shallow (depth < 150 m) in the region, with the exception being the Norwegian Trench where water depths significantly exceed 200 m (Figure 1). At the shelf edge west and northwest of the UK, a shelf slope current consisting of Atlantic water is steered by the bathymetry, at a depth of around 500m. The shelf edge is at the end of the North Atlantic Drift, receiving the warmer Atlantic waters. Deep water eddies can also approach the shelf edge from time to time.

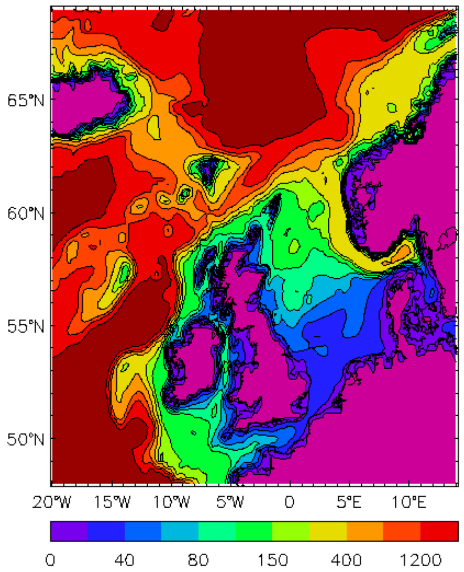


Figure 1 *Bathymetry of the NE Atlantic, Norwegian Sea and NW European shelf*

Tides and sea level

As tides from the deep Atlantic Ocean enter the NW European shelf, they propagate around the coast in the form of long gravity waves. Conservation of energy flux requires an increase in tidal height and current amplitude as water depths decrease. The increase in tidal currents gives rise to strong bottom friction and generation of intense turbulence, dissipating a large amount of energy and mixing the water column. It has been estimated that the NW European shelf accounts for about 10% of the global shallow water tidal dissipation.

The combined effects of Coriolis and frictional forces and the geometry of the NW European shelf result in complex tidal patterns in this region. In the semi-enclosed North Sea, for example, the tide originating from the North Atlantic enters from the north as a progressive Kelvin wave, travelling southward along the eastern side of the UK coast. Much of the tidal energy is dissipated in the Southern Bight, but a portion is reflected as a damped wave, propagating northward along the continental coast. When the incoming and reflected Kelvin waves are superimposed together, three amphidromic systems are established in the North Sea. The one in the Southern Bight lies about halfway between East Anglia and the Netherlands. The two further north are displaced progressively eastward from the mid-distance as the reflected wave is damped gradually when travelling northward. (Figure 2)

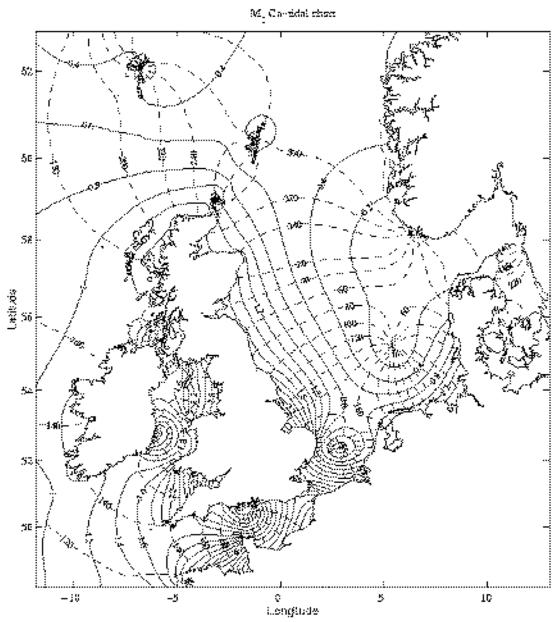


Figure 2 *M2 co-tidal plot for North-west European shelf seas*

The actual observed tides are in fact more complex than this, when tidal constituents other than M2 are considered. Superposition of semidiurnal M2 and S2 tides for example gives rise to a spring/neap cycle that has a period of about 14 days. In addition, when water becomes shallower, higher harmonics of astronomical constituents are generated by bottom friction and non-linear effects. These higher harmonics are referred to as shallow water constituents.

Figure 3 shows the distribution of modelled maximum tidal range across the NW shelf seas. Particular areas with large tidal range are on the west coast of the United Kingdom, for example the Bristol Channel, and off the coast of Brittany and Normandy. By contrast the tidal range on the continental coast of the north sea is much smaller, rendering the impact of a storm surge that much greater.

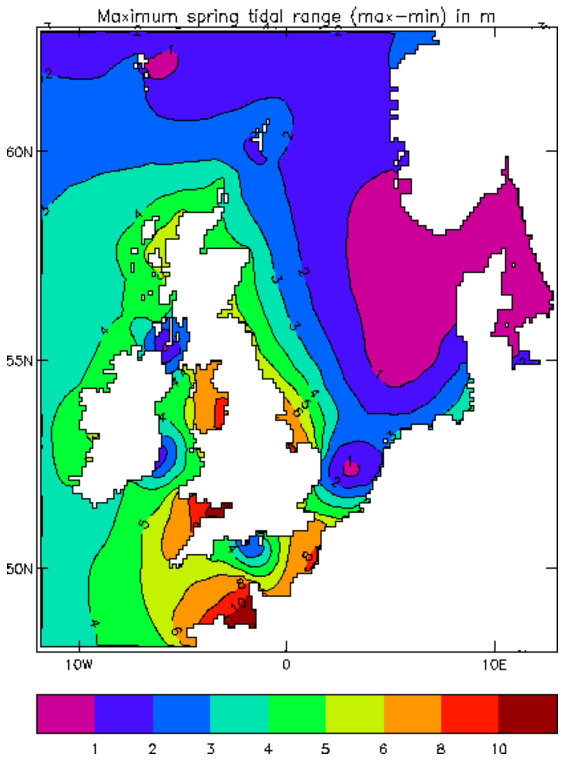


Figure 3 *Showing the maximum modelled tidal range (m) at spring tide (in a 12km resolution tidal model)*

Though changes in sea-level are predominately due to tides in the NW European shelf, winds and variations in the atmospheric pressure can raise or lower sea level by up to several meters, producing a storm surge. A wind-driven current can cause a rise in the sea level by piling up water against the coast. Changes in atmospheric pressure on the other hand give rise to an 'inverted barometer' effect: a fall in pressure by 1 mb resulting in a 1 cm rise in sea-level. Therefore, if a positive peak surge (higher water level) occurs at the time of high tide, flooding may result along the coastal areas. The much-publicised North Sea storm surge in 1953 occurred when the high spring tide interacted with a deep depression which first travelled eastward to the north of British Isles and then south-eastward into the North Sea. In this surge event, the east coast of British Isles and the Netherlands were severely flooded, and about 2000 people lost their lives. Figure 4 shows an intercomparison of 3 model representations of a storm surge on the south coast of England, taken from a routine data exchange agreement developed under the ESODAE1 concerted action.

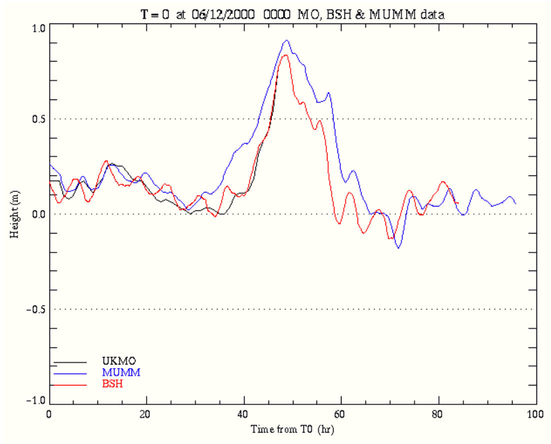


Figure 4 *Storm Surge model timeseries output showing a 48 hour prediction from 00z 6 December 2000 of a large storm surge at Weymouth, on the south coast of England (Met Office surge model to t+48, MUMM and BSH models to t+120)*

Seasonal stratification

Seasonal stratification and tidal-mixing fronts are two important thermally-related features in the NW European shelf seas. The stratification develops in late spring/early summer as a result of increasing solar input at the sea surface. In the deeper regions tidal currents and associated bottom vertical turbulence mixing are relatively weak. A thermocline of sharp temperature gradient is therefore formed, separating the (warmer) wind-mixed surface layer from the tidally-mixed bottom layer. In the shallower regions, on the other hand, stronger tidal mixing is vigorous enough to overcome the surface buoyancy input, making water well-mixed throughout the depth of the water column. Consequently, in summer, a transitional zone of sharp horizontal gradient in temperature, known as a tidal mixing front, occurs between the deeper, stratified, waters and the vertically mixed waters of shallow regions (Figure 5).

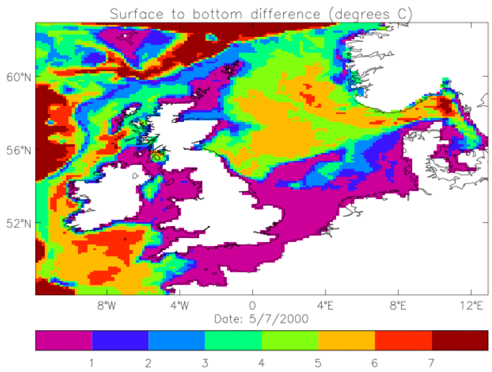


Figure 5 *Modelled surface to bed temperature difference, May 2000, showing the boundary between well mixed and stratified water.*

Though tidal mixing fronts are semi-permanent features during the summer months, their locations are subject to the modulation of spring-neap tides and actual meteorological forcing at the surface (i.e. surface winds and heat fluxes.)

In autumn, the stratification and tidal mixing fronts weaken on the shelf due to increased surface winds and net heat loss from the sea surface. They are destroyed by convective overturning in early winter when the whole shelf becomes vertically well-mixed. Stratification redevelops again in deeper regions during the following late spring/early summer soon after the start of the annual heating cycle. A timeseries of modelled and observed daily averaged sea surface temperature (and modelled sea bed temperature) for a site in the northern North Sea is shown in Figure 6, illustrating the seasonal onset and decay of stratification.

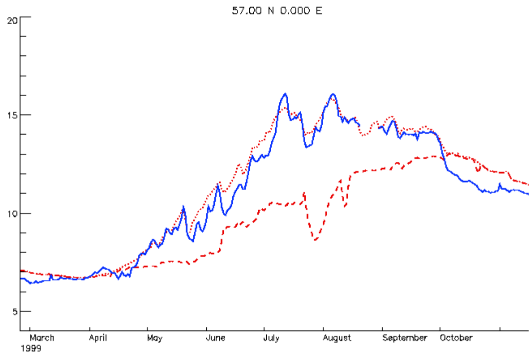


Figure 6 *Timeseries of daily averaged temperature in the northern North Sea at 57°N 0°E, March 1999 to November 1999. Observed SST solid, model SST dotted, model bed temperature dashed.*

Figure 6 also shows the evolution of bed temperature in the model. After a gradual increase in temperature during spring and early summer, a pool of colder water from offshore deeper waters moves across the site in July. Unfortunately there are no observations available for comparison.

Temperature and salinity

Conditions in the shelf seas, which are inter-connected with those in the adjacent ocean, may not be considered in isolation. As described earlier, strong tides and tidal currents in the NW European shelf are first generated in the deep Atlantic Ocean. Similarly, on the east side of the North Atlantic, the North Atlantic Current, an extension of the Gulf Stream, brings oceanic water of high salinity ($S > 35$ psu) northward along the shelf break. This saline (and warmer in winter) water then enters the northern North Sea in two branches: an inflow through the Fair Isle channel off the north of Scotland, and a more significant inflow along the western slope of the Norwegian Trench. This branch also supplies saline water for the deep inflow through the Skagerrak into the Baltic Sea. The Norwegian Coastal Current, a density-driven current off the west coast of Norway, forms an outflow along the eastern side of the Trench, carrying less saline (and cold in winter) surface water from fjords and rivers northward. (Figure 8).

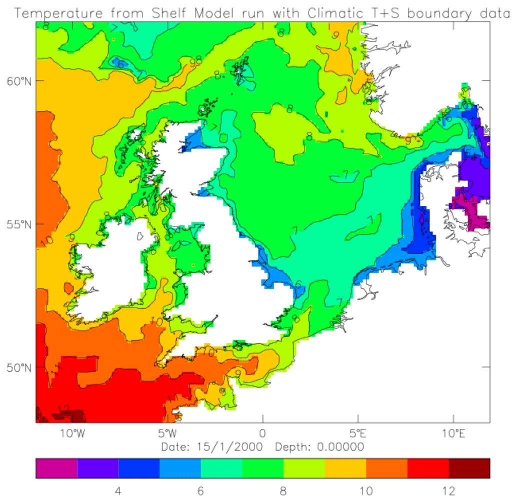


Figure 7 *Shelf Seas model SST January*

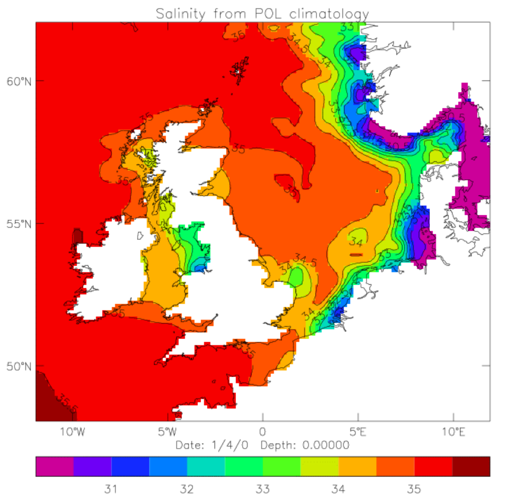


Figure 8 *Salinity Climatology for April*

In addition to the oceanic inflow to the northern North Sea, the saline water of Atlantic origin also penetrates into the southern North Sea through the Dover Straits as a branch of the North Atlantic Current turns eastwards into the English Channel.

River inflow is also important in the NW shelf system. Figure 8 shows the lower salinity of the Baltic outflow and Norwegian coastal current. Also evident are the Rhine outflow, along with the Elbe and Weser on the German North Sea Coast, and the UK rivers such as the Thames, Mersey and Humber.

Currents

Currents in the shelf seas are predominantly due to tidal forcing. Figure 9 shows a typical distribution of modelled maximum tidal currents at the time of Spring Tides. Wind driven surge residual currents, particularly in winter months, are additional to these tidal currents. At the shelf edge, internal tides can be generated, through the interaction of tidal flow with the thermocline in deeper water. These are periodic in nature. Non-periodic internal waves can also be generated on the thermocline at the shelf edge. These small scale features can locally produce strong currents, however they are not resolved by the typical 12km grid of the operational and pre-operational models in use today.

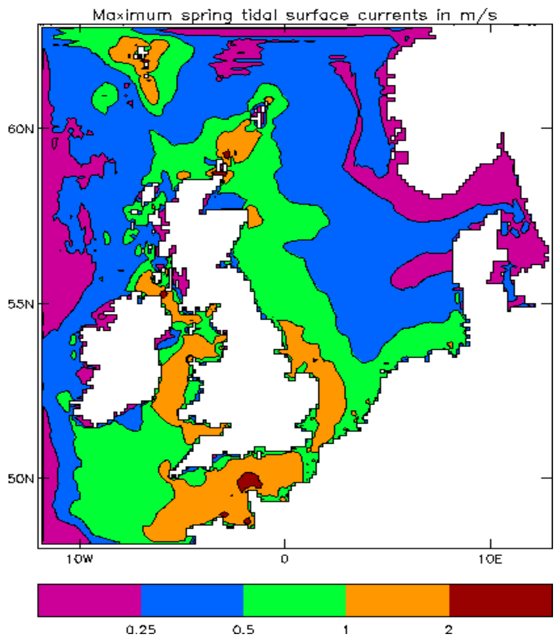


Figure 9 *Maximum tidal currents at Spring Tides (m/s)*

Seasonal coastal currents are associated with the onset of tidal mixing fronts, for example the Irish southern coastal current, from the front in the Celtic Sea (Figure 10). A similar current system develops with the Flamborough front in the North Sea. These residual currents are persistent features, in addition to the periodic tidal flow. Modelled peak residual currents of up to $0.1 ms^{-1}$ can be a significant fraction of the total current speed.

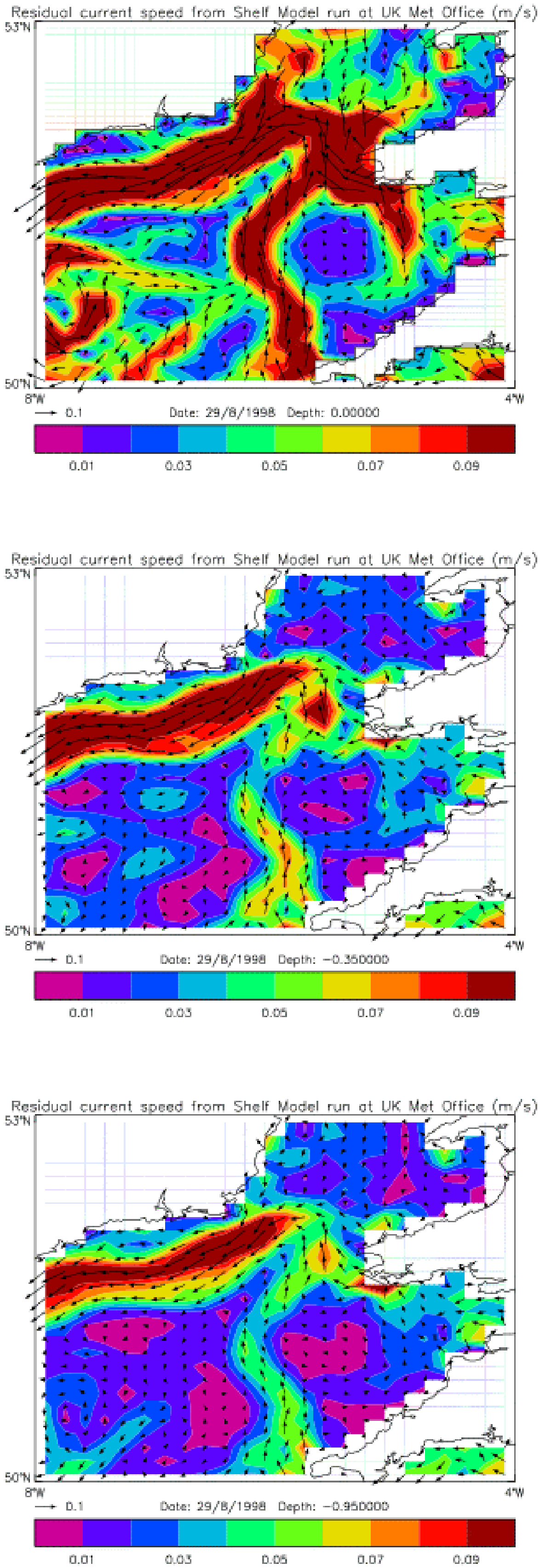


Figure 10 *Residual currents at the Celtic Sea tidal mixing front. Surface, mid level and bottom.*

Annexe 2

Water Quality

Contents

- Drivers for improved information systems for water quality
- What determines water quality
- Chemical aspects of Water Quality
- “Indicators” of demonstrable effects of pollution
- A NOOS approach to water quality issues
- Sampling Strategies
- Chemical Background Information
- Biological Background Information

Drivers for improved information systems for water quality

If water quality is degraded it has a detrimental effect on the biodiversity of the immediate ecosystem and can affect human health directly or through the accumulation of toxins in the food chain. Other consequences such as deterioration in amenity value can also result. The water quality of the North Sea area can be considered to be in state of “incipient degradation," as defined by Argent & O’Riordan (1995). It is an area where current demands on the resource base do not yet but could within the foreseeable future cause serious deterioration. Importantly the North Sea is an area where management opportunities exist to prevent irreversible degradation. Successful management of the system requires a combination of - *political will* (backed by informed and supportive public opinion, to embark on a defined course of action). - *information* (comprehensive data on pertinent conditions) - *prediction* (assimilation of the data into reliable prognostic models which can guide preventive and remedial actions).

In a statement issued by the Intermediate Ministerial Meeting on the North Sea in Bergen in March 1997 on “The Integration of Fisheries and Environmental Issues” the ministers adopted several guiding principle (EU1998). One of these was that “further integration of fisheries and environmental protection conservation and management measures shall draw upon the development and application of an eco-system approach”. The North Sea because of the work that has and is being carried out is an obvious candidate for developing such an integrated eco-system approach to its management. This requires integrated monitoring and data assimilation into data evaluation and management models.

What determines water quality

The water quality of a sea is determined by:- (i) the type of material reaching the sea from human activity and (ii) the capacity of the sea to tolerate these inputs by effectively dispersing and absorbing them. Human wastes and by-products arrive from diffuse and point source inputs along coast lines such as rivers and sewage works, from point source inputs in the sea mainly oil and gas extraction work and from the transfer of atmospheric pollution to the sea.

Water quality is degraded by the input of :-

- Toxic elements and compounds which may be naturally present in the system at low levels such as heavy metals or be man made compounds such as PCB which do not have natural analogues.
- Pathogenic organisms (bacteria and viruses) from human and animal wastes.
- Excess inputs of naturally occurring compounds such as nitrate and phosphate which can cause stress by fertilising the system and cause shifts in the eco-systems. (In certain cases similar shifts may result from human activity reducing inputs e.g. dam building).
- Eco-system shifts can in turn result in the enhanced occurrence of toxic material by favouring the development of toxic algae.
- Direct effects on eco-systems by the introduction of foreign organisms e.g. in discharges of ships' ballast water or escapes for mari-cultural operations.

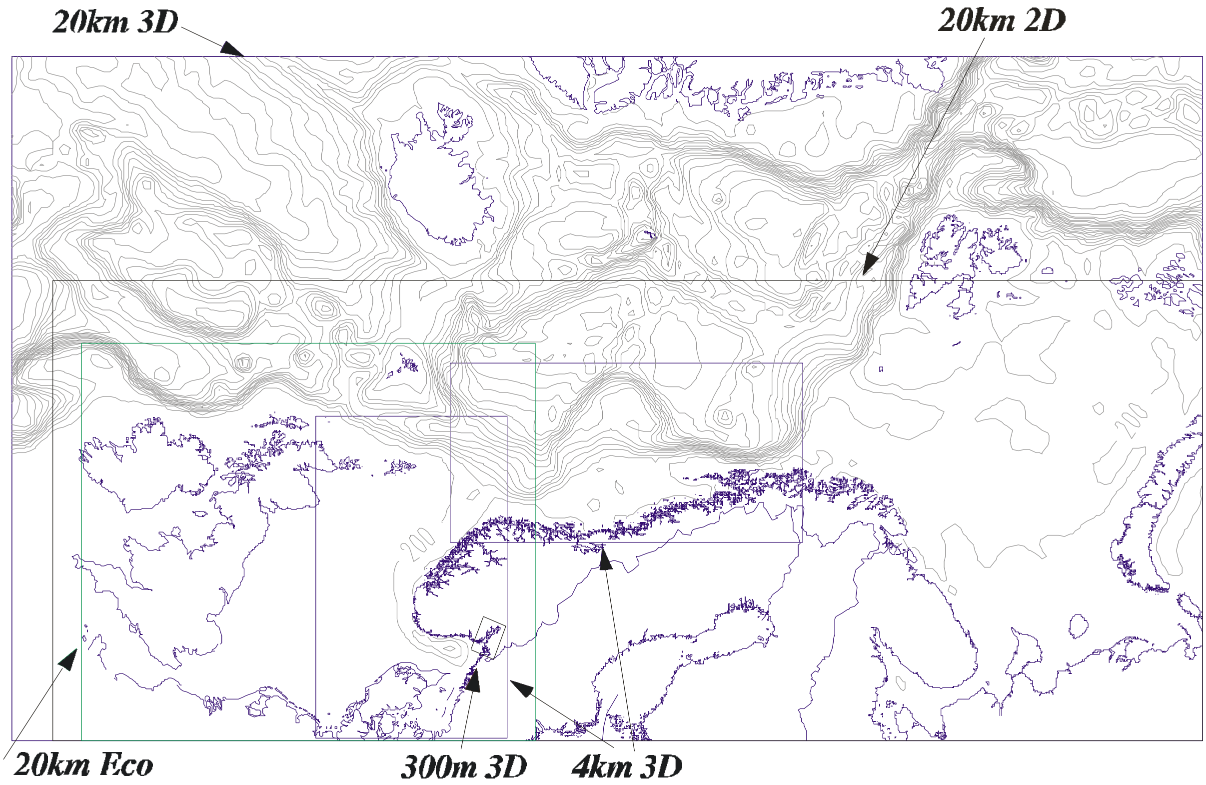


Figure 1 *DNMI's operational ocean model domains. MI-POM model code is run on all domains. The 3D domains are nested 20km - 4km - 300m. Operational ecology model is run in cooperation with the Institute of Marine Research, Bergen. 20 km models are run twice daily, other models daily.*

The capacity of the marine eco-system to tolerate contamination is determined by:-

- Hydrographic processes (discussed in Appendix 1) determine the rate of dispersion and dilution.
- Geology and geomorphology influence hydrographic and bio-geochemical processes. The types of sediments present determine the degree of absorption of contaminants. In turn the hydrography and current speeds determine where different sediments may accumulate. The different mixtures of muds, sands and gravels at different water depths have associated with them different populations of bottom dwelling organisms.
- Biology and the structure of the different eco-systems can determine the routes of pollution back to man through accumulation of toxins in potential food stuffs. Some processes can ameliorate the effects of some discharges (e.g. the conversion of nitrate to nitrogen gas by denitrifying bacteria, Hydes et al 1999).

Chemical aspects of water quality

The chemical aspects of water quality in the North Sea have been considered in the Quality Status Reports (QSRs) that have been prepared by OSPARCOM and ICES for the intergovernmental Ministerial Conference on the Protection of the North Sea. A QSR 2000 is recently available. Prior to that report an intergovernmental Monitoring Master Plan was prepared to provide information on the on the present condition of the North Sea and to provide a future basis for the assessment of temporal trends in chemical and biological parameters. Monitoring stations were selected to cover open waters and coastal areas and included some measurements of estuarine gradients. In addition to the simple tabulation of measurement of chemical concentrations the plan promoted the development of biological effects monitoring. Several techniques are considered to be sufficiently tested to permit their use for the monitoring of biological effects. These included the study of benthic invertebrates, fish diseases and two experimental methods - “EROD” measurement of the induction of detoxification enzyme in flatfish liver and “scope for growth” a water quality assay using oyster embryos. At present the usefulness of these studies is limited by:- (1) Doubts about the inter-comparability of different measurement procedures. (2) The number of points sampled in different areas and at different times of year is often insufficient to provide statistically reliable data for the comparison of trends and relationships between different areas and sources.

Relatively the assessment of inorganic chemical compounds is straightforward in that the number of chemicals involved is small. The problems to be tackled are monitoring the most appropriate waters and sediments and linking chemical causes to biological effects. In contrast monitoring the potential effects of the more than 150,000 synthetic organic compounds now produced by man is an altogether different problem as the effort expended to increase the number of new compounds far outstrips the effort available to detect and monitor them as they enter the environment.

“Indicators” of demonstrable effects of pollution

The European Environment Agency defines an “indicator” as the output of mathematical function operating on a combination of measurements of different components of the system that provide an indication of the sustainability of that system. As part of the task of developing “expert systems” for aids to management, impact “indicators” need to be derived for use in monitoring of pollution and eutrophication of coastal waters. Measurements of a single parameter may not be a reliable sign of a change in or threat to an eco-system. Expert knowledge is required to find those single parameters or groups of measurements that are reliable “indicators” of impact. In data analysis when a level or event occurs where a defined “indicator” value is exceeded then management action will be triggered. In most cases at present the skill level is lacking to define these “indicators”. For their development common definition of the significant biological or ecological parameters is necessary in order to standardise “indicators” and harmonise assessment in different areas. For the time being, impact indicators can only be used in parallel to a human expert examining the raw data. EuroGOOS and EEA should co-operate with other organisations (OSPAR, Helsinki and Barcelona Conventions) to determine the types and distribution of measurements that could be developed to derive successful “indicators”.

Chemical Pollution Indicators

A specific sub-set of indicators are required to deal with monitoring the potential effects of the more than 150,000 organic compounds that are now produced by man. At present our knowledge and abilities to track and determine the impact of these compounds in national and international monitoring programs extends to the less than 100 compounds that are included on “black and grey lists”. There is a scientific challenge to develop “pollution indicators” that move the debate from simple determination of concentrations to achieving quality objectives. This requires that for different classes of compounds we know the limiting concentration at which effects occur. This in turn requires improved bioassays, rapid screening assays and toxicity identification evaluation methods developed and applied. Internationally co-ordinated, optimised, and standardised monitoring of inputs (from rivers, the atmosphere, and adjacent seas) and effects (on organisms and ecosystems) of chemical compounds (natural and xenobiotic) to the marine environment are required.

A NOOS approach to water quality issues

The NOOS plan is to promote an operational monitoring and information system for the North West European Shelf sea region. This will encompass work that already runs in a fully operational mode at a national level. A fully operational system may be defined as one where:- Monitoring observations are made in routine standardised ways. The measurements made are automatically and immediately transmitted to a data centre for archiving. At the data centre the data is immediately checked and passed on to a modelling centre where it is assimilated into a prognostic model (e.g. weather or storm surge forecast numerical model). The output from that model is then transmitted to end users who will act in response to the forecast. In general the scale time from the original measurement being made to the prediction based on the measurement being acted on will be less than a day.

Numerical models used to generate weather and storm surge forecasts are based on relatively well understood physical processes. The linkages between the appropriate physical laws of nature are again relatively well understood. When we want to move on to the operational study of water quality and eco-systems the situation changes. The underlying natural laws and how they interact are much less well known. Therefore as operational oceanography is developed to provide better management of the North Sea eco-system the development will include work to improve scientific understanding.

As operational oceanography is expanded to cover water quality and eco-system changes, the time span between the collection of a sample and the data from measurements on that sample being used in a model will expand. This is because unlike physical measurements many chemical and biological measurements cannot be made instantly. In addition an operational framework for data gathering for water quality and ecosystems studies will have to take into account the ranges of time scale that encompass both: i) *acute* effects such as oil spills which may require study over periods of days, and ii) *chronic* effects such as those associated with anthropogenic inputs from rivers and eco-systems shifts related to climatic variations with time scales of decades.

Sampling Strategies

Any part of a NOOS programme should be based on and developed from an integration of existing sampling and assessment programmes. Both at a national level as well as an international level within Europe better use can be made of existing operations by improved co-ordination of existing sampling programmes (Portmann, 2000).

The aim of NOOS is to implement the use of bio-ecological models in an operational framework. We are already in a position to be able to use these models to define and plan the spatio-temporal resolution of measurements required for monitoring to be done most efficiently (c.f. Moll & Radach 2001). Sampling programmes are expected to evolve and improve with time. The monitoring of many biological and chemical variables is time consuming and costly. Frequency and accuracy of such measurements have to be carefully balanced against user requirements. To reduce these costs where possible the use of responsive sampling strategy should be investigated, i.e. increase the frequency and/or precision of measurements when experience, model output other indicators determine the need. Part of the NOOS development must be in the development of “expert systems” that will define the optimum ratio between accuracy and spatio-temporal sampling. In part these systems can be developed by extracting the necessary information from existing databases.

Considerable potential now exists in the form of new instrumentation and platforms (such as “smart” moorings or “ferry box” (Tziavos & Flemming, 1998) that can provide the high-frequency monitoring required order to improve model (forecast) precision. Where networks using such approaches are established the key element making the operation effective will be the standardisation of methods and establishment of minimum quality requirements.

To be able to determine long term change it is essential that any evolution of the date collecting process aimed at short term improvements in capability does not damage our ability to compare observations back through time.

TOTAL SUSPENDED MATTER [mg/l]

Sensor: SeaWiFS **Image:** S1998045125841 **Geographical area:** Southern North Sea	**Date:** 14 February 1998 **Time:** 12 H 58 MIN 41 S UTC **Processed by:** MUMM

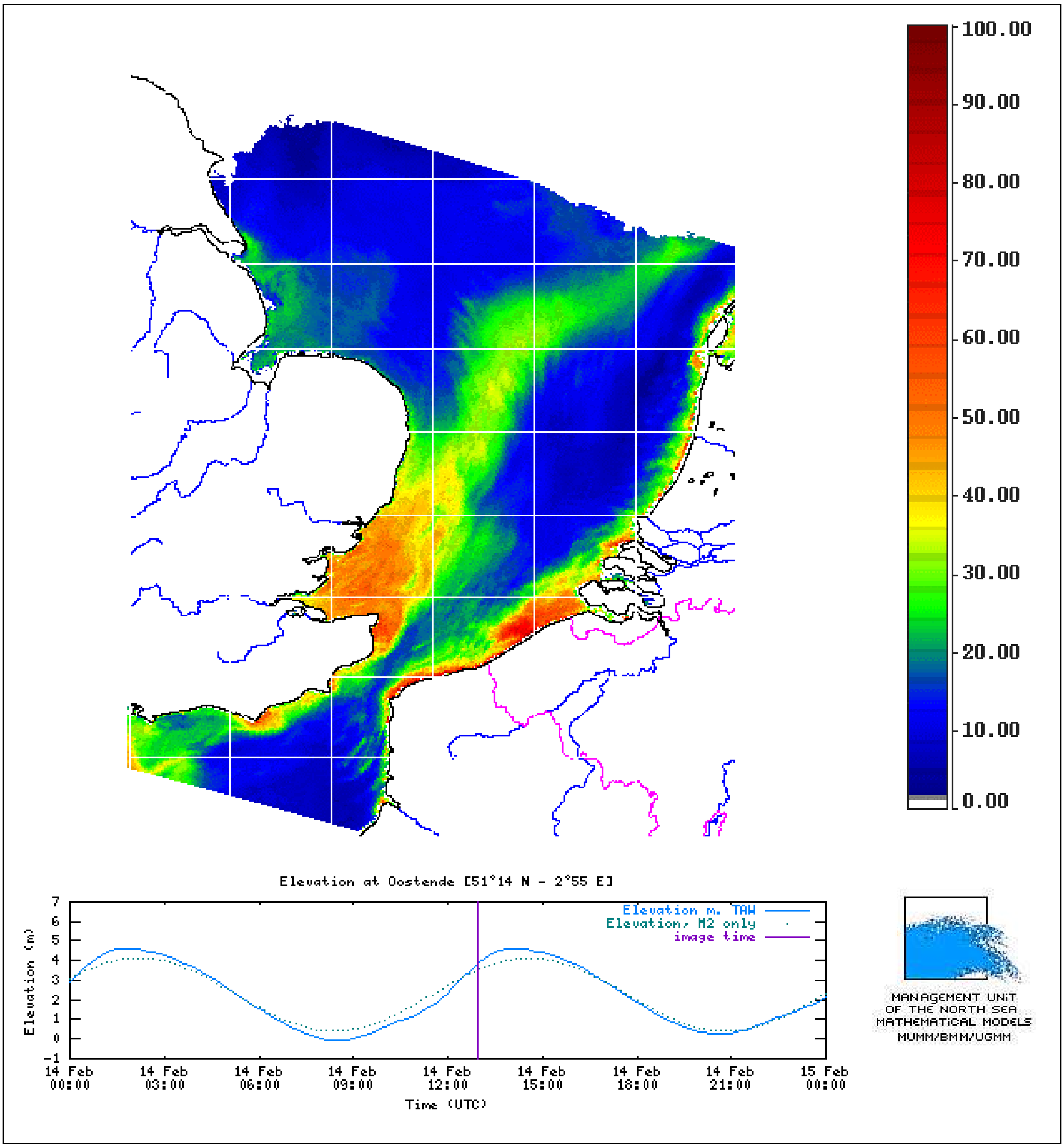


Figure 2 *Management Unit of the North Sea Mathematical Models (http://www.mumm.ac.be/OceanColour/)*

Chemical Background Information

Eutrophication

The elements nitrogen and phosphorus are essential for the growth of photosynthetic organisms. In aquatic environments they tend to be the first to be depleted from the water by the production of biomass so their lack prevents the further development of organisms. As a consequence they are termed the “limiting nutrients”. Also included in this term is dissolved silicon which tends to limit the growth of diatomaceous algae. As result of increased application of agricultural fertilisers containing N and P and the more systemic collection of sewage, inputs of N and P to surface waters have increased several fold above natural levels in recent decades. In Europe the rate of increase has been slowed in the last decade as a result of ministerial decisions taken in the light of concern about the potential damaging effects of inputs of excess N and P. Elsewhere in the world such as around the rivers and coasts of China and India the rates of input are beginning to accelerate.

Gray (1992) suggested that eutrophication could be seen as five stage process. An “enrichment phase” in which algal biomass increases. A fraction of this increase reaches the sea floor and in turn causes an increase of benthic biomass. The effects at this stage are benign and may lead to an increase in harvestable fish stocks. In the following “initial phase” changes in biological species composition occurs. The excess of N and P relative to Si will favour the development of smaller celled flagellates after an initial bloom of diatoms which will be limited by the availability of Si. Blooms of rapidly growing nuisance algae such as phaeocystis may occur. In the “secondary phase” the production of biomass is increased to such an extent that the depth of light penetration is reduced and the growth of bottom dwelling plants is inhibited. The increased rates of organic material falling into poorly ventilated lower waters and decaying there can lead to low oxygen conditions in the water which can drive out or in more severe cases kill fish. In the “extreme phase” the deposition of organic matter to the sediments is sufficient that they become anoxic and the presence of hydrogen sulphide causes extensive mortalities of organisms. In the “ultimate phase” anoxic events recur repeatedly preventing the re-colonisation of the area by the native species.

The extreme phase is regularly reached in number of environments. These are mostly areas where the water exchange is severely restricted such as Danish fjords. Areas in which excess macro-algal weed growth is apparent or blooms of nuisance organisms or harmful algae occur are more common. There are difficulties in determining how wide-spread eutrophication effects are. Away from estuaries and fjords the limited information available at the moment prevents the unambiguous attribution of changes to eutrophication.

Oil

Some 80-200k tonnes of oil are estimated to enter the North Sea each year. The largest source being from river and land run off, from oil and gas production and from accidental and illegal discharges from shipping. The effect on the eco-system depends on the type of oil and how it enters the system e.g. attached to sediment particles, dissolved or dispersed in the water or as surface slicks. Oil is also an important source of toxic polycyclic aromatic hydrocarbons (PAHs). Oil in sediments is a problem around oil rigs due contaminated drill cuttings and 8000 km^2 (1%) of the bed of the North Sea is estimated to be affected.

Oil concentrations in water are elevated in estuaries and close to oil platforms. Phyto-plankton and fish eggs and larvae begin to be affected at concentrations around 5µg oil/l. Concentration of this level can be expected 1000m down-stream of platform discharges.

Oil slicks are monitored by surveys carried out under the Bonn Agreement. In the North Sea area most slicks are observed in the shipping corridor between the Strait of Dover and the German Bight. The majority of slicks are ships' bilge oil. Birds are the most obvious victims of oil slicks but mammals can also be fouled. Oil slicks are observed coming from ships and offshore installations.

Toxic Organic Compounds

PAHs are present in the environment from natural sources such as oil seeps and forest fires, but have been enhanced by human activity. Information is scarce for most of the possible PAH compounds and the large array of synthetic compounds which are now entering the environment. Monitoring efforts are swamped by the range of compounds to which new ones are constantly being added. Also by the difficulties of measuring concentrations of these compounds at the low levels at which they are present but still may be capable of having toxic effects. PAHs are known to be wide-spread in the North Sea. In the main they are associated with areas of fine grained sediments such as the Dogger Bank and the Oyster Ground. In the German Bight a variety of effects have been found including pre-neoplastic lesions and elevated EROD activity that correlate with contaminant concentration gradients. Many halogenated organic compounds have been detected in the North Sea, including DDTs, PCBs. Of these PCBs generally occur in the highest concentrations. In spite of efforts to reduce inputs there are few indications of reducing trends in the data from monitoring.

Metals

In the case of metals, detectable concentrations of metals (with the exception of certain radionuclides) are naturally present and ubiquitous in the environment, and many of them such as iron and zinc are essential to many biochemical processes. Metal inputs have risen as a consequence of industrialisation and increased weathering. Estimating loads of metals reaching the sea or the bio-availability of metals has to take into account reactions that can take place in estuaries. The extent of such reactions depends on the factors that can be regionally different such as salinity, turbidity and composition of the suspended and bottom sediments.

The clearest evidence for the a distinct effect on organisms is available from the effects of tributyl tin derived predominantly from anti-fouling paint. Females of dogwelks and pacific oysters develop male sexual characteristics, which lead to sterility and destructive effects on the populations.

In the case of other metals the evidence for effects is less strong. The potential hazard of heavy metals such as mercury and cadmium stems from direct effects and accumulation through the food chain. Concentrations of both these metals above laboratory determined “lowest observed effect concentrations” have been observed in some areas but the true eco-toxicological significance is unclear.

Releases from Mariculture

Pesticides and antibiotics are used extensively to protect farmed fish. Most of the antibiotics are persistent in the environment and can spread from the farms and accumulate in sediments. Residues of oxolinic acid have been found in surrounding wild populations. In some cases the accumulations can be to levels higher than accepted for human consumption.

Microbiological Water Quality and algal toxins

Two direct effects on human health are the microbiological contamination of water (principally bathing waters) and the contamination of shell fish by algal toxins and pathogenic organisms. Bathing water quality is now monitored under the EU Waters Directive. The nature of contamination by bacteria tends to be specific to local areas and is heavily dependent on the size of the local population and the degree of sewage treatment that is employed. In addition, diffuse discharges from agriculture and run-off from storm waters may play a significant role. In some areas excrement from sea birds can make a measurable contribution to the contamination. The persistence of contamination is affected by light, temperature and local conditions which determine dispersion.

Biological Background Information

Bacterioplankton

In the last 20 years it has come to be recognised that micro-organisms (bacteria, yeasts and viruses) play a significant role in the marine food web. Some 60% of the photosynthetically produced biomass in the sea may be recycled into inorganic material through the microbial community.

Phytoplankton

The North West European Shelf is an area of relatively high primary biological production (the proliferation of algal cells that reproduce by photosynthesis). This growth requires nutrients and is limited by the supply of N, P and Si from the north-east Atlantic, and rivers (and the atmosphere). At the latitude of the North Sea sufficient sunlight is available in spring and summer to support production in most waters near the surface of the sea. Sediment suspended in the water reduces the amount of light available to organisms and consequently can reduce the amount of production in some areas. The high productivity of the North Sea in summer is maintained by the rapid turn over of nutrients between solution-plankton-detritus back to solution. This cycle may occur up to six times in areas which are relatively clear and shallow such as the German Bight (Hydes et al 1999). The size structure of the phytoplankton community is important in determining the efficiency of the transfer of energy through the food chain to commercial species. A population composed of larger cells such as diatoms tend to be grazed more effectively by higher organisms than small cells such as cyanobacteria and flagellates. Shifts in population appear to have occurred in association with changes in nutrient inputs.

Most phytoplankton have rapid doubling times of the order of 1-3 days, so that when conditions are favourable population densities can increase rapidly. This leads to "blooms" of algae. These are a regular occurrence in the spring when they are triggered by the increasing light levels. They can occur in other circumstances and certain species of algae may dominate the population which have "noxious" or actually harmful characteristics. This may be water discoloration (e.g. Noctiluca spp.), foam production (e.g. Phaeocystis spp.) fish and invertebrate mortality (e.g. Chrysochromulina spp) or toxicity to humans (e.g. Alexandrium spp.).

The plankton populations have been studied in the North Sea in an operational way for some time through the Continuous Plankton Recorder Survey (CPRS), which has recorded spatial and temporal occurrence and variation since 1958. Data from the continuous survey indicate significant long-term changes. Changes are thought to relate to the position of the Gulf stream and to climatic change (Radach 1982; Reid et al., 1998). Changes in the phytoplankton were accompanied by a general decline in zooplankton.

Zooplankton

Zooplankton are small animals living in the water column and transported by water movement. They range in size from unicellular organisms (microzooplankton, 0.2mm) to krill, jellyfish and fish larvae (macrozooplankton >2mm). 70-80% of the zooplankton biomass in the North Sea are the mesozooplankton (0.2-2mm). These are mostly herbivorous copepods and they are the main link between phytoplankton and fish larvae. Some species, the holoplankton (e.g. Copepods and Euphausids) remain zooplankton throughout their life. Others (meroplankton) have a zooplanktonic stage in their early life. These include eggs and larvae of most bony fish and many sea bed animals (e.g. sea urchins, polychaete worms and shrimps etc.). In the North Sea these early developmental stages coincide with the period of highest primary production. A general feature of the meroplankton is that large numbers of eggs and larvae are produced which suffer high mortality rates during their period as plankton.

Grazing by zooplankton is one of the major factors controlling the populations of phytoplankton. Knowledge of the distribution of zooplankton throughout the North Sea is limited to few extensive surveys and the Continuous Plankton Recorder Surveys. Zooplankton abundance varies between areas due to differences in production predation and transport. Transport is an important determinant of populations of meso-zooplankton in the North Sea. Large scale water movements extending across the whole basin of the North Atlantic Basin are involved. CPR data suggests that the biomass of both phytoplankton and meso-zooplankton in the North Sea declined during the 1960s and 1970s and then increased again. These changes are poorly understood but it has been suggested that they may be related to small climatic shifts and the circulation change associated with the North Atlantic Oscillation (Reid et al., 1998).

Benthos

Biota living on, near or in the seabed are collectively called the benthos. Bottom dwelling commercially important molluscs and crustaceans are called shell fish. Plants are phytobenthos. Animals are zoobenthos. The phytobenthos range in size from unicellular algae such as diatoms and flagellates to large sea grasses. The zoobenthos may live in the sediment (infauna) and include polyceate worms, crustaceans bivalves, gastropods and many other animal groups. Commercially important are cockles and lug worms. Surface living animals (epifauna) include a wide range of commercially important species including lobsters, oysters and scallops. Meiofauna (<1mm) feed on benthic bacteria and microphytobentos (<50µm). Macrofauna (>1mm) feed on organic particles and bacteria in the sediment (deposit feeders) or on suspended matter in near bottom water (filter feeding). The activity of both benthic bacteria and animals determines the rate at which organic matter depositing on the sea bed is either recycled or buried in the sediment.

Both phytobenthos and zoobenthos are used in many monitoring programmes because they live permanently in or on a substrate and therefore integrate the effects of changing conditions at that site (c.f. Frid et al., 1999).

Annexe 3
Examples of User Requirements

Examples of user requirements for some kinds of public interests or economic activities

This table demonstrates that explicit information is needed on specific defined as well as unpredictable locations.

User	Parameter Variable	Location	Real time	Forecast Time scale	Statistic
Shipping of all kinds	Current Waves	NWS	Y	1 week	Y
Navigation shallow areas and harbour entrance	Water depth, Current, Waves, Swell	Shallow area Harbour entrance	Y	1 day	N
Rescue operations	Waves, Wind, Drift	NWS	Y	1 day - 1 week	N
Storm surge warning	Water level	Coastal area	Y	1 - 3 days	N
Flood protection	Water level & Waves Climate change	Coastal area NWS	Y Y	1 week n/a	Y Y
Coastal protection	Water level, Waves, Transport of sediment, Currents Climate change	Coastal area NWS	Y Y	n/a n/a	Y Y
Transport calculations of water, substances and biological material, e.g. algae and fish eggs	River outflow, Discharge, Bio ecological parameters SST	Rivers Channel, NWS	N	n/a	Y
Coastal Engineering	Water level, Waves, Current, Meteo, Water depth	Coastal areas	Y	1 day - 1 month	Y
Hydrographical survey	Water level Waves	NWS	N Y	**Hind cast** 1 day - 1 week	Y N
Ecosystem assessment	Bio ecological parameters	NWS	N	n/a	Y
Fisheries	Physical and environmental parameters	NWS	N	n/a	Y

User	Parameter Variable	Location	Real time	Forecast Time scale	Statistic
Off-shore oil industry	Waves, Currents, Wind, Water level, Air pressure, Air temperature, Temperature bottom layer	Local on NWS	Y	1 day - 1 week	Y
Mineral extraction (no energy)	Waves Bottom structure Current	Local NWS Local NWS Local NWS	Y n/a Y	1 day - 1 week n/a Y	Y n/a Y
Recreation	Waves Water depth Wind SST	NWS Coastal area NWS Coastal areas	Y Y Y N	1 day - 1 week 1 day - 1 week 1 hour - 1 day	Y N N Y

NWS North West European Shelf
N/a Not appropriate
Statistics Trends, variability, frequency of occurrence, etc.

Annexe 4

Geographical areas of Interest

Spatial and Temporal Resolution of products required in different geographical areas, and the availability of observations to meet the requirements

For each variable, and for each sea area, the resolution requirements are considered in terms of space and time, and then the upper line in each box indicates the resolution available, while the lower line shows the resolution required. If the data are not available, or available resolution is not certain, the upper line in the box is left blank. This table refers to the resolution of observations.

		AREAS of INTEREST					
Parameter	**Resolution**	**Atlantic**	**Shelf edge**	**Shelf**	**Coastal**	**Estuaries**	**River & Harbours**
Temperature Surface	Space	100 km 10 km	10 km 1 km	1 km 1 km	1 km 1 km	1 km 100 m	50 m
	Time	1 day 1 day	1 day 6 hrs	1 day 6 hrs	1 day 6 hrs	1 day 1 h	1 h 1 h
Temperature Profile	Space			300 km 100 km	100 km 50 km	300 km 100 km	50 m
	Time			1 h 1h	1 h 1h	1 h 30 min	10 min
Salinity Surface	Space		1 km	1 km	1 km	100 m	50 m
	Time		1 day	1 day	1 day	1 h	1 h
Salinity Profile	Space			100 km	50 km	100 km	50 m
	Time			1 h 1h	1 h 1h	1 h 30 min	10 min
Sealevel	Space	50 km 20 km	50 km 10 km	50 km 10 km	30 km 10 km	10 km 1 km	50 m
	Time		1 day 6 hrs	6 hrs 3 hrs	10 min 10 min	1 min 5 min	1 min 1 min
Currents Surface	Space		10 km	5 km	(1 km) 1 km	1 km	50 m
	Time		1 h	1 h	(1 h) 1 h	10 min	10 min
Currents Profile	Space						
	Time		1 h	1 h	1h 1 h	10 min	10 min
Currents Trajectory	Space						
	Time		1 h	1 h	30 min	10 min	1 min
FLUX Transport Concentration Fresh water	Space			50 km 20 km	20 km 5 km	5 km 1 km	
	Time			1 year 1 month	6 months 10 days	1 month 1 day	
Bathymetry	Space		5 km 1 km	5 km 1 km	2 km 300 m	50 m 50 m	10 m 10 m
	Time			10 yrs	1 yr	1 yr	

(green)	Matching of requirements
(yellow)	May be used
(blue)	Should be available
(red)	Must, really needed
Upper line	Available
Lower line	Required

Annexe 5

Useful Internet addresses

Association of International Shipping Agents	www.A-I-S-A.com
Associations of National Organisations of Fishing Enterprises in the EC (EUROPECHE)	www.marinfo.net/Mar_data/Organisations/stubs/126_stub.html
Bureau Veritas, France:	www.bureauveritas.com
Central Dredging Association (CEDA)	www.dredging.org
Det Norske Veritas , Norway	www.dnv.no
European Aquaculture Society (EAS)	www.easonline.org/
European Association of Fish Producer Organisations (AEOP)	www.marinfo.net/Mar_data/Organisations/stubs/48_stub.html
European Centre for Medium Range Weather Forecast	www.ecmwf.int
Economic Commission for Europe, ECE of UN	www.unece.org
EUMETSAT	www eumetsat.de
European Dredging Association (EUDA)	www.marinfo.net/Mar_data/Organisations/stubs/122_stub.html
European Environment Agency	www.eea.dk
European Federation of Inland Ports (EFIP)	www.marinfo.net/Mar_data/Organisations/stubs/113_stub.html
European Sea Ports Organisation (ESPO)	www.espo.be
European Space Agency (ESA)	www.esrin.esa.it/
European Union	www.europa.eu.int
Federation of European Private Port Operators (FEPORT)	www.marinfo.net/Mar_data/Organisations/stubs/128_stub.html
Food and Agriculture Organization, FAO	www.fao.org
Germanischer Lloyd	www.germanlloyd.org
HELSINKI COMMISSION Baltic Marine Environment Protection Commission	www.helcom.fi/
Hydrographic Society Worldwide website	www.hydrosoc.demon.co.uk/index.htm
International Association of Cities and Ports	www.aivp.com
International Association of Dredging Companies(IADC)	www.iadc-dredging.com/
International Association of Ports and Harbours (IAPH)	www.iaph.or.jp/
International Chamber of Commerce (ICC)	www.iccwbo.org/
International Chamber of Shipping (ICS)	www.marisec.org
International Council for the Exploration of the Sea	www.ices.dk
International Hydrographic Organization (IHO)	www.iho.shom.fr/
Intergovernmental Oceanographic Commission (IOC)	ioc.unesco.org
International Salvage Union (ISU)	www.marine-salvage.com
International Union of Marine Insurance	www.iumi.com
Lloyd's Register of Shipping, UK	www.lr.org/home.html
London Convention 1972 Website	www.londonconvention.org/
The Website for Defence Industries - navy	www.naval-technology.com/
The Website for the Oil and Gas Industry	www.offshore-technology.com/
World Health Organization	www.who.ch
World Meteorological Organization, WMO	www.wmo.ch/
World Trade Organization, WTO	www.wto.org

Annexe 6

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Annexe 7

Addresses

- Bundesamt fur Seeschiffahrt und Hydrographie, Bernhard Nocht Strasse 78, P.O. Boks 301220, 20359 Hamburg, Germany
- CERFACS, 42 Avenue Gustave Corioilis, 31057 Toulouse, France
- Danish Meteorological Institute, Lyngbyvej 100, 2100 Copenhagen Ø, Denmark
- Environment Agency, National Centre, Rivers House, Lower Bristol Road, Bath, Avon, BA2 9ES
- Institut Français de Recherche pour l’ Exploitation de la Mer, IFREMER, PO Box 70, 29280 Plouzané, France
- Institute of Marine Research, PO Box 1870 Nordnes, N-5024, Bergen, Norway
- Management Unit of the North Sea Mathematical Models (MUMM), Belgian Royal Institute of Natural Sciences, Gulledelle 100, B-1200 Bruxelles, Belgium
- Marine Institute, 80 Harcourt Street, Dublin 2, Ireland
- Meteo-France, 42 Avenue Gustave Corioilis, 31057 Toulouse, France
- Met Office, London Road, Bracknell, Berkshire RG12 2SZ, United Kingdom
- Nansen Environmental & Remote Sensing Centre, Edvard Griegsvei 3a, N-5037 Solheimsviken, Bergen, Norway.
- National Institute for Coastal and Marine Management/RIKZ, PO Box 20907, 2500 EX, The Hague, The Netherlands
- Norwegian Meteorological Institute (DNMI), PO Box 43, Blindern, N-0313 Oslo, Norway
- NWO Earth and Life Sciences Council, PO Box 93120, 2509AC The Hague, The Netherlands
- Proudman Oceanographic Laboratory (POL), Bidston Observatory, Bidston, Birkenhead, Merseyside L43 7RA, United Kingdom
- Royal Danish Administration of Navigation and Hydrography, Overgaden o. Vandet 62B, 1023 Copenhagen K, Denmark
- Royal Netherlands Meteorological Institute (KNMI), PO Box 201, 3730 AE De Bilt The Netherlands
- Southampton Oceanography Centre, Empress Dock, European Way, Southampton SO14 3ZH, United Kingdom
- Swedish Meteorological and Hydrological Institute (SMHI), 60176 Norrköping, Sweden

Annexe 8

Acronyms

ADCP	Acoustic Doppler Current Profiler
ADSL	Asymmetrical Digital Subscriber Line
Argo	Array for Real-time Geostrophic Oceanography
ASMO	Environmental Assessment and Monitoring Committee (OSPAR Commission)
AVHRR	Advanced Very High Resolution Radiometer
BEP	Best environmental practice
BODC	British Oceanographic Data Centre
CDS	Catalogue of Data Sources
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
COHERENS	Coupled Hydrodynamic Ecosystem for Regional Seas
CPRS	Continuous Plankton Recorder Survey
CTD	Conductivity Temperature Depth
DDT	Dichloro diphenyl trichloro ethane
DIADEM	Operational data assimilation system for the North Atlantic and the Nordic Seas
ECDIS	Electronic Chart Display System
ECMWF	European Centre for Medium Term Weather Forecasting
EDIOS	European Directory of the Initial Ocean-observing System
EDMED	European Directory of Marine Environmental Data
EEA	European Environment Agency
EIONET	European Environment Information and Observation Network
EQC	Environmental Quality Committee
EROD	7-ethoxyresorufin-O-deethlyase - Highly sensitive indicator of contaminant uptake in fish
ERS	European Remote Sensing Satellite
ERSEM	European Regional Seas Ecosystem Model
ESEAS	European Sea-Level Service
ESODAE	European Shelf Seas Ocean Data Assimilation and Forecast Experiment
EU	European Union
EUMETSAT	European Meteorological Satellite organisation
EuroGOOS	European Global Ocean Observing System
EuroROSE	European Radar Ocean Sensing
FAO	Food and Agriculture Organisation
FCCC	UN Framework Convention on Climate Change
FOAM	Forecasting Ocean Atmosphere Model
FP5	EU Fifth Framework Programme
FTP	File Transfer Protocol
GDP	Gross Domestic Product
GMES	Global Monitoring for the Environment and Security
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GTS	Global Telecommunication System
GYROSCOPE	EU project linked to Argo to provide up to 100 profiling floats in the Atlantic
HELCOM	Helsinki Commission (Baltic Marine Environment Protection Commission)
HF	High Frequency
IACMST	Inter-Agency Committee on Marine Science and Technology (UK)
ICES	International Council for Exploration of the Sea

IHO	International Hydrographic Organisation
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
IUCN	World Conservation Union
MAST	EU Programme on Marine Sciences and Technologies
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration (USA)
NOAA	National Oceanographic and Atmospheric Administration (USA)
NODC	National Oceanographic Data Centre (IODE)
NOMADS	North Sea Model Advection-Dispersion Study
NOOS	North West Shelf Operational Oceanographic System
NWP	Numerical Weather Prediction
NWS	North West Shelf
NWSTT	North West European Shelf Task Team
OCCAM	Ocean Circulation and Climate Advanced Modelling
OECD	Organisation for Economic Co-operation and Development
OGCM	Ocean General Circulation Model
OGP	International Association of Oil and Gas Producers
OSPAR	Convention for the Protection of the Marine Environment of the North East Atlantic
OSPARCOM	Oslo and Paris Commission
OSSE	Observing System Simulation Experiments
PAHs	Polycyclic Aromatic Hydrocarbons
PROFILE	Processes in Regions of Freshwater Influence
QSR	Quality Status Report
ROSCOP	Report of Observations/Samples collected by Oceanographic Programmes
SAWG	Science Advisory Working Group (of EuroGOOS)
SeaNet	Data interface group
SNDI	SeaNet Data Interface
TEUs	Twenty-Foot Equivalent Units
THC	Thermohaline Circulation
TPWG	Technology Plan Working Group (of EuroGOOS)
UNCED	UN Convention on Environment and Development
UNCLOS	UN Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
WMO	World Meteorological Organization
XBT	Expendable Bathythermograph
XML	Extensible Markup Language

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