The GMES Marine Forum

and associated EuroGOOS Conference, Athens, Greece, 2-6 December 2002.

Some relevant findings and conclusions are summarised below.

1. Policy Framework

A considerable number of global and regional marine Conventions place monitoring and reporting requirements on EU Member States.

a) The Global Ocean Observing System (GOOS), for example, obtained its UN mandate through Agenda 21 at the United Nations Conference on Environment and Development (UNCED) that was held in Rio de Janeiro in 1992. This mandate was reconfirmed at the 2002 World Summit on Sustainable Development, in Johannesburg.

b) In November 1994 the United Nations Convention on the Law of the Sea (UNCLOS) came into force. Under UNCLOS, i.e. under international law, some 40% of ocean space was placed under national jurisdiction. UNCLOS allows States to exploit the resources in its Exclusive Economic Zone (EEZ). Further, under UNCLOS, States are obliged to use these resources in a sustainable way and to preserve the marine environment. Moreover, transfer of technology and know-how forms an intrinsic part of UNCLOS. UNCLOS also requires States to make data freely available where matters of human security are concerned.

c) Since UNCED, an increasing number of international conventions address problems related with the use of the oceans. Examples of these are: the Bio-diversity Convention, the Framework Convention on Climate Change, the Global Plan of Action for the Protection of the Marine Environment from Land-Based Activities and the Agreement on Highly Migratory and Straddling Fish Stocks. To allow the international community, including the European Union Member States, to comply with the requirements of these conventions (all calling for an effective management of the ocean and a sustainable use of its resources), there is a need for an ocean space information system.

It is currently foreseen that GOOS will fulfil the role of a global ocean space information system. GMES could clearly provide the European contribution to GOOS. But equally, GOOS could contribute an important part of the global element of GMES.

d) Many regional Conventions are in operation: OSPAR, Helsinki and BARCELONA, and the Bonn agreement being good examples in the marine domain.

These and the many other treaties, conventions and protocols in existence already place significant obligations on EU Member States with respect to monitoring and reporting requirements. This is also true for other areas relevant to GMES such as access to data – see for example UNCLOS and the World Meteorological Organization (WMO) Resolution 40 (Cg-XII).

There is an urgent need, therefore, to take account of the "legal and policy" framework that is already in place when setting out the future proposals for GMES.

2. Reporting Requirements

Valuable contributions were made to the GMES Marine Forum regarding the very different reporting requirements that GMES could be called upon to meet.

Indicators

The very first talk of the Conference emphasised the need for high quality indicators of environmental change, based upon good science, and their use in educating the public. The presentation from the European Environmental Agency (EEA) demonstrated the data that the EEA needs for indicator based reporting. Many of the conventions referred to above also layout specific reporting requirements that require indicators. Indicators are, therefore, very important, especially in the context of the provision of information for policy makers.

Conversely, a substantial number of those working in the operational oceanographic community have little experience of indicators, be it in providing suitable data or in deriving relevant indicators. Within the marine domain, there is, therefore, a considerable gap in many areas between the "suppliers" and the "customers" when considering indicators.

Seasonal to Inter-annual Predictions

Most people are familiar with the need for seasonal to longer range climate – predictions. However, the Intergovernmental Oceanographic Commission of UNESCO (IOC) reported on work that is underway to

demonstrate that such forecasts can not only inform policy and contribute to environmental research and impact assessments, but may also help to guide commercial market decisions. Trials with industry are underway to evaluate the effects on commercial decision making of environmental information services, especially those derived from seasonal to inter-annual predictions. If such studies demonstrate that sufficient skill can be achieved to deliver significant commercial benefits for the industrial sector, then this will provide an additional "push" for the provision of such information and to improve its skill, in addition to the climate change studies needs.

Operational Forecasts

The recent loss of the *Prestige* oil tanker and the subsequent environmental damage suffered in the Iberian Peninsula clearly demonstrated the need for high quality reliable and routine nowcasts and short-range forecasts to help prevent, or at worst mitigate against such disasters. There also is a need for a decision support system and a line of command for the use of marine information in cases such as the *Prestige*. If GMES comes into being, member States will certainly look to it to provide immediate "answers" in the event of similar such accidents occurring in the future.

The topic of how such very diverse reporting requirements can be effectively included in GMES has therefore to be addressed.

3. Ecosystem Management

Brief mention must be made regarding the topic of active ecosystem management, that is 'the integrated management of human activities based on knowledge of ecosystem dynamics to achieve the sustainable use of ecosystem goods and services, and the maintenance of ecosystem integrity'. Given the many challenges that must be overcome in order to implement complete and fully operational active ecosystem management, present work is very much at the research and development stage. Nonetheless, it remains the main long-term objective of the operational oceanographic community to implement active ecosystem management.

The long-term plans for GMES should take account of such a noble aim and seek to reinforce and support such work wherever possible.

4. Socio-economic Issues

Whilst there are numerous socio-economic issues of importance for GMES, a number of points are worth highlighting from the GMES Marine Forum.

a) The Global Ocean Observing System (GOOS) is at the threshold of implementation at many levels, but predominantly in developed countries. A concerted action towards developing countries is still lacking and could be a challenge in the future GMES framework. Without such a concerted action, it may be difficult to realise the "global" element of GMES.

b) There also is no integrated European policy for the sustainable use of the European EEZ. Most European actions are focused on sectors such as maritime safety, pollution and the transport of hazardous cargo, as in the case of the Prestige. There is a need for a nested integrated policy and legislation for the sustainable use of all stocks and resources of ocean space within European coastal Member States.

c) Although many end-users can be defined, a participatory process to involve stakeholders has not yet truly occurred. Yet there is a strong need to involve stakeholders at the European, regional and national level. Through this awareness can be raised and a communication process could start. The real involvement of "end-users" remains, therefore, one of the major challenges.

5. Current Scientific and Technological Capabilities

Findings concerning relevant scientific and technological capabilities available at present include:

a) There are modelling and observing programmes in place and providing operational services globally, for the North Atlantic and in all the European regional seas and shelf areas, including the Black Sea.

b) Models are beginning to be eddy-resolving and capable of better representation of the thermocline. Increased computer power, variable grids and nesting were much in evidence to achieve these improvements. Sea ice models are in use where appropriate.

c) There will be a capable satellite based observing system in place for environmental monitoring purposes during the GMES build up phase, on the assumption that the Jason-2 and other relevant programmes announced by the space agencies go ahead as planned. ENVISAT will be a key

component. The overall system should be able to provide data at a useful accuracy to monitor SST, SSH, ice cover and height, ocean colour, sea state, internal waves, wind speed and direction, shallow water bathymetry, oil slicks and ship location.

d) A few examples of prototype services based on single (remote sensing) technologies are being promoted but the vast majority of operational services are based on multiple data streams assimilated (in one form or another) into predictive models.

e) The overwhelming majority of operational services are focussed upon the physical environment and on processes and parameters that obtain their predictability from astronomical effects (tides) or atmospheric coupling (waves, sea level surges, currents, sea ice cover). It follows that the limits on atmospheric predictability also limit most of the latter services.

f) There is a rich range of technology available to make the physical, **near-surface** ocean and atmospheric observations that are required, based on remote sensing from satellites and coastal radars, and in situ observations from moorings, floats and instrumented ships of opportunity. Effective technologies exist (XBTs from ships of opportunity, ADCPs on moorings and landers) and are also emerging to monitor **sub-surface** physical properties, based on profiling floats, fixed and profiling moorings, and AUVs (including gliders). Their actual operational use is very limited at present, seriously limiting the prediction of deep currents for example.

g) The technology available to make needed marine biogeochemical measurements is more limited and still remains largely in the RTD domain. Data were reported from ocean colour measurements from space and a few ongoing transects employing 'Ferry Box' technology or towed vehicles, typically carrying the SAHFOS Continuous Plankton Recorder (CPR) or derivatives. Recent progress in equipping buoys and landers for routine physical and biogeochemical monitoring is encouraging and a few ships of opportunity are being equipped to make pCO2 measurements. The experimental use of airborne fluorescence lidar was reported. However, large uncertainties continue to exist in the interpretation of the ocean colour measurements. Biofouling remains a problem when (some physical and biogeochemical) sensors are exposed for long periods in the photic zone; calibration techniques for reducing the impact of this were reported. AUVs can be equipped to carry a wide range of sensors, but are not yet in regular use. The point was made during the conference that the business case for the deployment of AUVs for environmental monitoring purposes remains to be constructed.

h) Little progress was reported in the development and validation of ecosystem models, although many groups avowed their intention to nest such models within their physical ocean models.

i) Very few papers concerning the middle and higher trophic levels of marine life were posted; none was presented.

j) There is continuing interest in the development and validation of novel monitoring techniques (e.g. based on GNSS reflections, remote sensing of salinity and acoustic detection of precipitation).

k) Risk-based sampling strategies (i.e. in vigorous or environmentally/economically sensitive locations) are practiced. The importance of feature (eddy, ecosystem or event) resolving observation and modelling was emphasised, particularly in such regimes. In this context, the construction of well-equipped coastal observatories to carry out marine research at sensitive locations, perhaps possessing simple topography and/or well-behaved boundary conditions, is an interesting development, as is the use of adaptive sampling techniques.

6. Gaps in Knowledge, technology and tools.

Specific findings were identified as follows:

a) Although good progress has been made in implementing operational oceanography, there is a lack of knowledge that is preventing implementation of the ecosystem approach. We are still far away from being able to model fish behaviour, which is necessary for stock prediction.

b) Marine ecosystem models are still in an early stage of development, particularly with respect to benthic processes. A 4D view needs to be taken.

c) Ocean colour from satellites and monitoring from vessels equipped with the Ferry Box or undulating towed vehicles will provide useful near surface data. But it is far from clear how the sub surface data required for verification and routine operation of ecosystem models is to be captured. – *Landers, buoys and AUVs/gilder instrumented for sub-surface biogeochemical measurements are candidates for this.*

d) Measurements of chlorophyll-α from space still have large error bars. There is need for standardisation of techniques.

e) There are large gaps in our knowledge of currents at depths below a few hundred metres and concern that high resolution sampling will be necessary to resolve this, particularly in areas of complex topography. – *Landers, buoys and AUVs/gliders carrying ADCP provide possible technical solutions.*

f) There is a need for improved knowledge about inflow from the major rivers, e.g. of the inflow of fresh water, temperature, sediment and nutrient loading. – *Monitoring to meet the requirements of the WFD should help with this.*

g) Much of the suspended sediment is lifted or generated by erosion in episodic (storm) events. There are large implications of this for monitoring.

h) The document 'Towards a strategy to protect and conserve the marine environment' – COM(2002) 539 final – identifies a number of knowledge gaps. These are important drivers for the FP6 research programme that is serving the GMES.

i) There are unresolved issues for the GMES concerning the handling of uncertainty in policy making. Uncertainty in the science makes it difficult to construct and enforce effective compliance and liability legislation.

7. Adequacy of monitoring networks and data quality

Specific findings were identified as follows:

a) Spatial resolution and representativeness are almost always a problem in the marine environment, where important eddy structures have dimensions ~ 5 to 10km and strong topographically induced, unstable flows are common. There are dangers of aliasing signals and biasing statistics. Targeted, adaptive sampling may be the only solution for subsurface measurements.

b) Measurement error statistics are almost as important as the measurements themselves.

c) Many of the environmental science and change detection problems require long time series of data. It is unrealistic to expect research activities to provide these.

d) Reliable scientific conclusions about the behaviour of the marine environment demand at least a minimum set of standards and effective quality control.

e) 'Variable or inadequate data quality' is often the first challenge by vested interests to findings and policies based them; the second is 'inconsistency'.

f) Specific gaps in data are identified in COM(2002) 539.

g) Gaps in knowledge, data and information are intimately connected. The transformation of data into useful products and services based upon them is usually a substantial task, which tends to be underestimated.

h) There is much to be done to enable existing databases to be accessed in near real-time (for modelling purposes) and in delayed mode. The systems for this are not in place. In particular biogeochemical data are highly dispersed and generally without quality control. Concerted actions and networking will be necessary to insure the widest and fastest access to comprehensive, coherent and compatible data sets by the operational and scientific communities. Only a professional, semi-distributed, multidisciplinary data management infrastructure will be able to give an appropriate access to the national data holdings, merge them with new data collected in real time and delayed mode and prepare the best timely integrated data products, that the scientific, technical and economic studies require.

i) Attention was drawn to a new Strategic OSPAR Plan for Joint Assessment and Monitoring, which should be signed off in June 2003. It is likely to be useful in the planning of the GMES.