THE GLOBAL OCEAN OBSERVING SYSTEM (GOOS): NEW DEVELOPMENTS

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Abstract

GOOS will provide information about the present and future states of seas and oceans and their living resources, and on the role of the oceans in climate change. Among other things, it will include monitoring the extent to which the sea is polluted, and applying models enabling the behaviour of polluted environments to be forecast given a variety of forcing conditions including anthropogenic and natural changes. Implementation has begun through integration of previously separate existing observing systems into a GOOS Initial Observing System, and through the development of Pilot Projects, most notably in the coastal seas of Europe and North-east Asia. Although the present emphasis is on the measurement of physical properties, plans are underway for increasing the observation of chemical and biological parameters. The main biological thrust at present comes through the Global Coral Reef Monitoring Network (GCRMN). Consideration needs to be given to incorporation into the GOOS Initial Observing System of present national, international and global chemical and biological monitoring systems, and the development and implementation of new chemical and biological monitoring subsystems, especially in coastal seas for monitoring the health of those environments. GOOS will offer marine scientists and other users a scheme of continuing measurements on a scale larger in time and space than can be accomplished by individuals for their own applications, and a vastly improved store of basic marine environmental data for a multitude of purposes. For GOOS news see the GOOS Homepage at http://ioc.unesco.org/GOOS/.

1. INTRODUCTION

The vision guiding the development of GOOS is one of a world where the information needed by governments, industry, science and the public to deal with marine related issues, including the effects of the ocean on climate, is supported by a unified global network that will systematically acquire, integrate and distribute ocean observations, and generate analyses, forecasts and other useful products [1,2]. In response to this vision, GOOS will provide information about the present and future states of seas and oceans and their living resources, and on the role of the oceans in climate change. It will include monitoring the extent to which the sea is polluted, and applying models enabling the behaviour of polluted environments to be forecast given a variety of forcing conditions including anthropogenic and natural changes [3, 4, 5, 6].

2. THE COASTAL DIMENSION

A global observing system is clearly needed to monitor climate change and the effects of pollution by excess greenhouse gases. But why have a global observing system for coastal problems, like those caused by runoff from land? While coastal seas and their ecosystems are not in themselves global, the achievement of a predictive understanding of coastal ecosystems depends on the development of regional to global networks that link observation and analysis in more effective and timely ways [2, 7]. GOOS is thus promoting integration of the fragmented coastal environmental research community and its linkage to the community at large, especially user groups like policy makers, environmental and resource managers, Non-Governmental Organisations (NGOs), the business community, and the public in general, to enable them to get the scientific information they need to make informed decisions in a timely fashion.

GOOS is also promoting a broad-scale view of coastal ecosystems that takes into account the large scale forcing of the coastal system and which leads to reliable mechanisms for predicting environmental changes and their ecological consequences. The ultimate goal of the coastal GOOS program is to encourage and support the development and application of now-casting, forecasting and predictive capabilities as a means of preserving healthy coastal environments, promoting sustainable uses of coastal resources, mitigating coastal hazards, and ensuring safe and efficient marine operations [7].

In another sense, we need a global observing system, even for monitoring pollution, because ocean processes know no national boundaries and the ubiquitous nature of many of the problems to be solved means that it is often prudent to implement even local and regional operational or research programmes co-operatively and in a co-ordinated way. Such co-ordination needs to be carried out so as to achieve economy of scale and mutual support, and to enable future global extension.

Fifty percent of the world's population lives within 200 km of the coast, and 2/3 within 400 km [8]. The proportion is increasing, and over the next 50 years perhaps 2/3 of the world's population will live within 200 km of sea coasts and estuaries. Expected absolute and relative growth in coastal population, with the attendant pressure on natural resources, suggests that the pressure on the coastal environment will increase in pace with demands for its (preferably sustainable) use. Wetland and other shoreline areas are extremely important breeding and spawning areas for many species of fish and other organisms and yet, globally, over 50% of such areas have already undergone severe environmental degradation. Safe and efficient management of the marine environment under such conditions demands an increase in information about it, of the kind that can only be provided satisfactorily by a carefully designed monitoring system integrating various disciplines (physics, chemistry biology, geology) and data streams (ships, floats, buoys, aircraft, submersibles, radar's, satellites). To meet this requirement the United Nations Conference on Environment and Development in Rio in 1992 called in its Agenda for the 21st Century (Agenda 21) for creation of a Global Ocean Observing System (GOOS).

3. BENEFITS AND BENEFICIARIES

Calculations of costs and benefits suggest that the implementation of GOOS is likely to repay investment at a ratio of 10:1 or more [2, 9]. Beneficiaries of GOOS products will include managers and users of coastal defences, ports and harbours, fishing and fish farming, shipping, offshore industry, waste disposal and recreation, as well as Governments seeking to implement Agenda 21; the Global Plan of Action for the Protection of the Marine Environment from Land-Based Activities; and related instruments [2, 9, 10]. GOOS will offer marine scientists and other users a scheme of continuing measurements on a scale larger in time and space than can be accomplished by individuals for their own applications, and a vastly improved store of basic marine environmental data for a multitude of purposes [11].

4. IMPLEMENTATION

Implementation of GOOS, which is sponsored by the IOC, the WMO (World Meteorological Organisation), UNEP (United Nations Environment Program), and ICSU (International Council for Science) has begun, based on the integration of previously separate existing observing systems, and the development of Pilot Projects [2]. GOOS will develop to full global scale over the next 10-15 years as new monitoring systems are integrated into it, including the chemical and biological ones pertaining to the management of sustainable healthy coasts [7].

4.1 The GOOS Initial Observing System

The GOOS Initial Observing System integrates earlier observing systems [2]. It currently includes mostly open ocean physical observations in support of climate studies, which also provide data about the forcing of coastal seas. It includes some coastal elements, such as the tide gauge data from the Global Sea

Level Observing System (GLOSS), and the Global Coral Reef Monitoring Network (GCRMN). Other elements are:

- upper ocean measurements of the Ship of Opportunity Programme (SOOP)
- meteorological observations of the Voluntary Observing Ship programme (VOS)
- data from the fixed and drifting buoys of the Data Buoy Cooperation Panel (DBCP)
- data from the buoys of the Tropical Atmosphere Ocean (TAO) array set up to monitor El Niño
- data from the Global Temperature and Salinity Profile Programme (GTSPP)
- marine meteorological and ocean data from NOAA operational satellites
- communication through the Global Telecommunication System (GTS) of WMO.

These elements of GOOS are already of proven value to the communities that started and support them. For instance, there is no disputing the value of El Niño forecasts based on data collected by the TAO array.

4.2 GOOS Regional Pilot Projects

Most of the Pilot Projects developed so far are centred on the coastal seas of Europe (the EuroGOOS Pilot Project [12]) and North-east Asia (the NEAR-GOOS Pilot Project [13]). Initially they too focus on the physical data, not least because those data happen to be the most abundant and there is a well developed user community requiring them. However, chemical (nutrient) and biological (plankton) parameters also feature prominently in the EuroGOOS programme, and NEAR-GOOS is now moving to embrace such parameters. The initial focus in these and other Pilot Projects tends to be on data exchange, with a move eventually towards development of a numerical modelling and forecasting capability. Different Projects are moving in this direction at different rates.

Other Pilot Projects are now being developed in the Mediterranean Sea (MedGOOS)[14] and the Pacific islands (PacficGOOS)[15].

4.3 The Future

GOOS organisers recognise that more effort now has to be put into developing monitoring systems covering chemical and biological information and their integration with physical data [1, 2, 3, 6, 7]. This is especially true for coastal seas where most living marine resources exist. The monitoring requirements for these environments are now actively being considered by three GOOS Advisory Panels: (i) the Coastal GOOS (C-GOOS) Panel; (ii) the Health of the Oceans (HOTO) Panel, which is concerned with contamination and pollution of coastal seas and with marine responses to anthropogenic inputs; and (iii) the Living Marine Resources (LMR) Panel, taking into consideration the needs of resource managers and other users.

Examples of existing global biological and chemical observing systems currently under consideration for inclusion in the GOOS Initial Observing System include the Harmful Algal Bloom (HAB) programme of the IOC; the international Mussel Watch program; the Marine Pollution and Monitoring Program (MARPOLMON); and the Continuous Plankton Recorder (CPR) programme.

In due course, GOOS will incorporate not only existing international monitoring systems but also existing national monitoring systems provided they agree with the published GOOS Principles [1].

The (HOTO) Panel is developing plans for pollution-related Pilot Projects in marginal seas that appear to be most at risk, including east Asian seas, the Black Sea, the Red Sea and the Arctic [6]. Together with C-GOOS, the HOTO Panel will also be considering the development of Pilot Projects in the Adriatic and Caribbean. The HOTO-driven Pilot Projects will be developed in the context of a Strategic Plan that has been drafted for pollution monitoring within GOOS [3,4,5].

The HOTO Panel is also beginning to consider (i) how to develop indicators of the sustainability of marine environments, as a guide to coastal seas management, and (ii) the development of numerical models to aid in forecasting, to assist in assessing the sustainable development of ecosystems [6].

Forecasting using sophisticated physical-biogeochemical ecosystem models that incorporate living and non-living components of the system may prove useful, for instance, as the basis for a variety of early warning systems, eg for eutrophication (which may lead to increased algal blooms, anoxia, massive fish deaths and major alterations in biological communities). Simpler models coupled with dynamic models of regional circulation can be used to predict the dispersion of passive tracers such as oil spills, and accidental releases of contaminants, radioactive tracers and sediment load. Water quality modelling can assist in the development and possibly predict the effectiveness of measures to prevent pollution and contamination in the water column. Numerical models may also add value to data by enabling interpolation between data points, and enabling estimation of some of model parameters from a limited number of observations under certain constraints, thereby complementing data obtained by the HOTO observing system.

The list of variables that could be monitored under the HOTO Strategic Plan includes: (i) physical measurements (solid litter and plastic; and suspended particulate matter; (ii) chemical measurements (synthetic organics; polycyclic aromatic hydrocarbons; trace metals; petroleum (oil); herbicides and pesticides; dissolved oxygen; artificial radionuclides; and pharmaceuticals); and (iii) biological measurements (phytoplankton pigments and community structure; human pathogens; nutrients; and algal toxins), which can be used to provide indications of biological distress that may be useful in determining the sustainability or otherwise of marine ecosystems [3,4,5,6]. However, what is actually measured in any one region under the HOTO programme will depend on the design of the monitoring programme and will flow from its goals and objectives.

Aside from the design of different facets of the observing system, GOOS organisers are also involved in formulating plans for a data and information management system and service [2]. Initially, by default, it comprises the data and information management components of the elements of the GOOS Initial Observing System and of the GOOS Pilot Projects.

5. TRAINING AND CAPACITY BUILDING

For GOOS to be fully global demands that all coastal countries are able to contribute to and benefit from it. For its realisation, this dream requires a considerable rise in the capabilities of many developing countries so that at the very least they can gather, process and interpret data, exchange data with neighbours and other GOOS partners, and provide products valued by the local or regional user community. This requires; (i) the building of appropriate institutional infrastructure, (ii) the training of more scientists to appropriate levels, and (iii) provision of or access to appropriate equipment [1, 2]. Developed nations and aid agencies will need to take these requirements on board if they are to obtain the benefits of a fully global GOOS.

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