



**Intergovernmental Oceanographic Commission**  
*Reports of Meetings of Experts and Equivalent Bodies*

## **IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS)**

**Third Session**  
Accra, Ghana  
13 – 15 April 1999

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IOC-WMO-UNEP-ICSU/C-GOOS-III/3

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## 1. OPENING

The third meeting of the Coastal GOOS (C-GOOS) Panel was opened at 0900 on 13 April, 1999 by Kwame Koranteng, Chairman of the Local Organizing Committee (LOC), who welcomed the Panel and invited participants (Annex I).

Tom Malone, Chairman of the C-GOOS Panel, thanked K. Koranteng and the LOC for their hard work in planning and arranging the meeting and the Science and Technology Policy Research Institute for hosting the meeting. T. Malone then thanked the panel members for coming and gave a special welcome to observers from Côte d'Ivoire, Ghana and Nigeria; to Frank van der Meulen representing the National Institute for Coastal and Marine Management of the Netherlands; to George Needler representing the Ocean Observations Panel for Climate; and to Thorkild Aarup, the new Technical Secretary for C-GOOS. Apologies were noted from Janet Campbell, Elisabeth Lipiatou, Carlos Duarte, Stephen Walker and Sinjae Yoo.

Thorkild Aarup welcomed participants on behalf of the Executive Secretary of the Intergovernmental Oceanographic Commission (IOC) and on behalf of the sponsors of GOOS: Intergovernmental Oceanographic Commission, World Meteorological Organization (WMO), United Nations Environmental Programme (UNEP), and International Council of Scientific Unions (ICSU).

This meeting was made possible by the IOC, the National Oceanic and Atmospheric Administration (NOAA) of the USA, and the Government of the Netherlands, and their generous support is gratefully acknowledged.

Tom Malone emphasized the primary objectives of this Panel meeting as follows:

- (i) review and evaluate the initiating design of C-GOOS global network with the goal of agreeing on a preliminary design strategy;
- (ii) review and evaluate pilot project proposals with the goal of identifying a short list of high priority projects that should go to the full proposal stage;
- (iii) discuss possible linkages with related programmes, in particular the Ocean Observations Panel for Climate (OOPC), the Global Sea Level Observing System (GLOSS), the Global Terrestrial Observing System (GTOS), and the Land Ocean Interactions in the Coastal Zone (LOICZ); and
- (iv) agree on the content and organization of the C-GOOS strategic design plan.

The Panel hopes to adhere to the following time table: complete a draft of the C-GOOS Strategic Design Plan in preparation for C-GOOS-IV (China, November, 1999); develop the outline for the C-GOOS Implementation Plan at C-GOOS-IV; draft the Implementation Plan during the intersession period before C-GOOS-V (Spring, 2000); and finalize the Implementation Plan at the C-GOOS-V meeting.

## 2. ADMINISTRATIVE ARRANGEMENTS

Edgardo Gomez was elected Rapporteur for the meeting. K. Koranteng explained logistics. T. Malone reviewed the agenda (Annex II) and emphasized the need to focus on C-GOOS Panel initiatives and critical linkages with other GOOS modules and related programmes. Most background documents were provided by the GOOS Project Office (GPO). Supplementary documents were circulated at the meeting.

### **3. REPORTS AND STATUS OF C-GOOS PLANNING**

#### **3.1 OVERVIEW**

As human populations and activities increase in the coastal zone, the combined effects of global climate change and human alterations of the environment are expected to be especially pronounced in coastal waters of the global ocean. It is here that the problems of sustaining living resources, protecting and restoring ecosystem health, mitigating natural disasters, and protecting public health will be most pronounced over the next 1-2 decades. In these regards, C-GOOS must address a broad spectrum of changes that are related to a complex interaction between natural perturbations and anthropogenic stresses (Table 1). These perturbations, stresses, and indicators of change are occurring on local to regional scales in coastal waters worldwide. They are globally ubiquitous; they indicate profound changes in the capacity of coastal ecosystems to support living resources; and they are making the coastal zone more susceptible to natural hazards, more costly to live in, and of less value to the economies of coastal nations. The purpose of C-GOOS is to (i) quantify perturbations and stresses to coastal ecosystems and to (ii) detect and predict their effects on people living in the coastal zone, on coastal ecosystems and living marine resources, and on coastal marine operations.

It is recognized that the fully integrated ocean observing system must encompass both oceanic and coastal systems as well as climate and terrestrial systems. Coastal waters are defined here to include the Exclusive Economic Zone (EEZ), seas, estuaries, bays, and sounds. Physical processes are of fundamental importance to the ocean-climate system and to the ecology of aquatic systems in general. Thus, the requirements for data on physical processes are similar for oceanic and coastal systems (i.e. temperature and salinity; fluxes of heat, water and momentum; wind stress, waves and circulation patterns) with the important exception that variability must be resolved on smaller temporal and spatial scales in coastal systems. The interdisciplinary importance of physical processes provides a framework for the fully integrated ocean observing system.

The oceanic component of the observing system, which is principally concerned with the role of the ocean in climate change, is much closer to being operational than is the coastal component. This reflects several important realities that underscore important differences between oceanic and coastal ecosystems:

- (i) Ecosystem goods and services are concentrated in the coastal zone where the combined effects of climate change and human activities are likely to be most pronounced.
- (ii) In contrast to the open ocean where air-sea interactions are the primary source of environmental variability and the coastal ocean is a boundary condition, coastal waters are a transition region where inputs of materials and energy from terrestrial, oceanic, atmospheric and anthropogenic sources converge.
- (iii) The coastal zone is a complex mosaic of interacting terrestrial and marine systems that include drainage basins with heterogeneous and changing land cover, tidal wetlands, estuaries, bays, sounds, and open waters of the EEZ.
- (iv) As a consequence of the diverse nature of external forcings, spatial heterogeneity, the proximity of the benthos to the air-sea interface, and the constraints of coastal geomorphology, coastal marine ecosystems are also characterized by a broad spectrum of temporal variability from the low frequencies of oceanic systems to the higher frequencies unique to coastal waters. Populations and processes in coastal ecosystems are more variable on smaller space and shorter time scales than is typical of either the open ocean or terrestrial ecosystems.
- (v) The spatial and temporal complexity of the coastal zone and the rapid increase in the number of people living, recreating and working in the coastal zone, have created a complex diversity of related environmental problems from the susceptibility of people to natural hazards and safe navigation to the sustainability of living resources and ecosystem health.



Thus, the spectrum of issues that must be addressed in coastal waters is more diverse in terms of the nature of environmental problems that must be addressed, the range of biological and chemical properties that must be measured, and the scales of variability that must be captured (Table 1). These realities suggest an approach to the design of a C-GOOS that is based on a backbone of environmental measurements common to both oceanic and coastal subsystems with each subsystem enhanced for particular purposes.

**Table 1.** Prominent natural perturbations and anthropogenic stresses and associated changes occurring in coastal marine ecosystems.

<p><b>Perturbations &amp; Stresses</b></p> <ul style="list-style-type: none"> <li>• Climate change</li> <li>• Exploitation of living resources</li> <li>• Physical restructuring of habitats</li> <li>• Introductions of non-indigenous species</li> <li>• Chemical contamination of air, soil &amp; water</li> <li>• Natural hazards &amp; variations in weather cycles</li> <li>• Nutrient mobilization &amp; enrichment of coastal waters</li> </ul>
<p><b>Indicators of Change</b></p> <p>Diseases and accumulations of chemical contaminants in marine organisms  Excessive accumulations of algal biomass &amp; harmful algal blooms  Increased frequency of mass mortalities of fish, birds, and mammals  Increased susceptibility to natural hazards, public health risks  Temperature increase, sea level rise, and salt intrusions  Habitat loss, erosion &amp; oxygen depletion  Loss of biodiversity &amp; living resources  Growth of non-indigenous species  Sea state &amp; sea ice</p>

### 3.1.1 The Initial Design

Although the list of indicators of environmental change in coastal waters is long, they are related in terms of ecosystem dynamics suggesting that there is a common set of key properties that, if measured with sufficient resolution, over long enough periods, and large enough areas, will serve many needs from forecasting changes in water depth and sea state on short time scales to predicting the environmental consequences of human activities and climate change on longer time scales. In this context, the implementation of C-GOOS is currently envisioned to occur through the parallel development of regional pilot projects nested in a global C-GOOS network. The global network should be designed to:

- quantify inputs of energy and materials from oceanic, terrestrial, atmospheric, and anthropogenic sources;
- assess the extent to which local indicators of environmental change are occurring on regional to global scales; and
- provide the larger scale perspectives required to predict local expressions of larger scale patterns of variability.

Regional pilot projects are expected to achieve one or more of the following:

- resolve patterns of variability relevant to local-regional problems of interest;
- provide a regional context for evaluating the results of local scale research projects;
- demonstrate the usefulness of the GOOS end-to-end, user driven approach (proof of concept); and
- develop networks of «index sites.»

Here, **regional** is defined as the next larger scale of observation required to understand local problems of interest. **Index sites** are selected sites of high intensity observations that incorporate research and development programmes required for monitoring and research programmes to become operational. Such sites are intended to quantify cause and effect relationships, develop indicators of environmental change, develop predictive models of environmental changes and their effects; and translate data into useful products.

### 3.1.2 Critical Design Criteria: Integrated, Sustained and Operational

The design and implementation of C-GOOS must address the three major impediments to the development of a predictive understanding of environmental variability in coastal ecosystems:

- (i) lack of programmatic integration;
- (ii) undersampling in both time and space; and
- (iii) long-time lags between data collection and analysis.

The system must be integrated from measurements to analysis. Historically, programmes have typically developed independently of each other on a case-by-case basis, by different groups for different purposes. As the multi-disciplinary, multi-dimensional, multi-scale nature of environmental issues has become apparent, efforts to collate and integrate data from many different sources have increased. Under current conditions, this is a time consuming and expensive process that inhibits timely analysis of data. C-GOOS must promote the development of (i) integrated measurement programmes that are multi-disciplinary (synoptic measurement of key physical, chemical and biological properties), multi-dimensional (e.g. integration of remote and *in situ* measurement made on different time and space scales), and multi-scale (local-regional-global in scope); and (ii) a system of integrated data management that enables the rapid exploitation of data sets from disparate sources to serve the needs of a variety of different user groups. The problem of integration is especially challenging for C-GOOS.

The problem of developing a predictive understanding of environmental variability in coastal ecosystems is exacerbated by the reality that, even for those regions where programmes have been in place for many years, the scarcity of observations of sufficient duration, spatial extent, and resolution and the lack of real-time data telemetry, assimilation and analysis severely limit the development of predictive capabilities. Thus, the observing system must be sustained to capture episodic events, low frequency variability, and long-term trends. To date, there are no programmes that are both integrated and sustained. For example, numerical weather predictions and sea-level measurements are sustained but narrow in scope. Programmes under the International Geosphere-Biosphere Programme (IGBP) such as the Joint Global Ocean Flux Study (JGOFS), LOICZ and the Global Ecosystem Experiment (GLOBEC) are integrated in that they are multi-disciplinary and multi-dimensional, but they are not sustained. Projects such as the Global Data Assimilation Experiment (GODAE) and the JGOFS time-series stations (index sites as defined above) represent emerging efforts that have the potential of being both.

In addition to being sustained and integrated, the observing system must be operational. That is,

- (i) it must be responsive to user needs and data must be transformed into useful products in a timely fashion;
- (ii) measurements must be routine with known precision and accuracy;
- (iii) sampling must be systematic to capture the desired scales of variability; and
- (iv) the entire system from measurements to products must be cost-effective.

### 3.1.3 Indicators and Indices

An **indicator** can be defined as a quantitative expression of the current or future state of a system. For the purposes of C-GOOS, indicators should be selected that measure status or vulnerability to change in response to a natural perturbation or an anthropogenic stress (Table 1). Three types of **indices** are envisioned which related to the risk of an event occurring, the vulnerability of a system or region to natural perturbations

or stress (hazards), or the health of the ecosystem. The development of indices in all three categories should be a goal of C-GOOS Pilot Projects.

Risk Index: Risk is the probability that a particular event will occur (e.g. a harmful algal bloom, storm surge, an oil spill) or have a certain impact (fish kill, flooding, mass mortalities). Risk may be calculated using statistical models for retrospective analysis of historical patterns which provide an estimate of potential risk based on past experience. Risk may also be calculated using numerical simulation or assimilation system models based on mechanistic (processes) or theoretical understanding of the structure and function of coastal ecosystems (e.g. weather forecasts).

Vulnerability Index: The vulnerability index measures the capacity of a nation or region to cope with and respond to natural and anthropogenic hazards. To what extent and with what certainty can hazardous event be forecasted? Have effective response plans for mitigation or restoration been developed and does the nation or region have the resources to implement these plans?

Ecosystem Health Index: This index measures the extent to which an ecosystem or region has been degraded or stressed by anthropogenic activities. The rapid increase in population density in the coastal zone is stressing coastal ecosystems in several different ways. These include (i) the physical restructuring of the environment through land-use practices, alteration of fresh water flow patterns, dredging etc.; (ii) nutrient mobilization and over enrichment of coastal waters with N and P; (iii) chemical contamination of air, soil and water; (iv) exploitation of living resources; and (v) introductions of exotic species. Indicators of stress that are candidates for an ecosystem health index include oxygen depletion, harmful algal blooms, chemical contamination of organisms, shellfish bed closures and fish kills, loss of habitats and biodiversity, and declines in living marine resources.

### **3.1.4 Global Inventory of Coastal Data and Programmes**

The Integrated Coastal Area Management (ICAM), the International Oceanographic Data and Information Exchange (IODE), LOICZ and the C-GOOS and the Living Marine Resources (LMR) modules of GOOS have indicated an immediate need for an inventory of existing national coastal monitoring systems that will provide the basis for (i) identifying candidate programmes for GOOS and (ii) determining deficiencies relative to minimal design criteria for the purposes of both GOOS and ICAM. The Executive Council of the IOC decided in November 1998 to hire an external expert to gather and compile this information. A candidate has been identified and it is expected that the consultant will start on August 1, 1999. In the mean time an IOC team is collecting relevant information on coastal monitoring systems so the consultant can start compiling this information immediately.

## **3.2 EFFECTING CRITICAL LINKAGES WITH USER GROUPS**

C-GOOS must be designed to meet the needs of a wide range of users including government agencies, industry, scientists, educators, and the general public. For C-GOOS to be successful there must be strong links with the end-users of C-GOOS products from design and implementation through subsequent evaluation and adaptation. The development of such linkages was discussed at C-GOOS-II (GOOS Report No. 63, 3.7 Developing Functional Linkages Among Scientists and User Groups) at which time an intersession committee was formed to provide «Recommendations for Activities that Will Promote Functional Linkages among Scientists and Other User Groups» and tune it to the needs of C-GOOS for the purposes of formulating design and implementation plans and identifying R&D needs for the full scale implementation of C-GOOS. The report of this committee (Annex III) recommends general approaches that should be used to develop effective linkages between C-GOOS and end-users and describes some issues that should be considered. These include identification of participants from data providers to users, clear and specific definition of goals, agreement on a process to insure continued interaction among participants to adapt to changing technologies and user needs,

and how the observing system will be funded. In these regards, the following are considered to be of critical importance: (i) communications as the means to develop and maintain a rapport among participants based on mutual respect and understanding of different perspectives and needs of the diverse groups involved in the observing system; and (ii) capacity building as the means to achieve a common level of knowledge, capability and expertise.

In response to the need for an enhanced the public awareness of GOOS and its benefits to potential participants from «data providers» to end-users, a GOOS Services and Products Bulletin (GSPB) has been proposed (Annex IV). The Bulletin would be formatted for easy access to information and structured to emphasize successful implementation of operational systems; critical and constructive feedback from user groups; current applications and impacts on national, regional (e.g. European Association for the GOOS [EuroGOOS], North East Asian GOOS [NEAR-GOOS]) and global scales (e.g. C-GOOS, Health of the Oceans [HOTO], LMR, OOPC); and progress in meeting R&D needs. It is envisioned that the Bulletin will be available on the Web and updated monthly. It would also be published bi-monthly in hard copy. The terms of reference for the GSPB would include the following:

- (i) inform user groups of GOOS state-of-the-art capabilities and impacts;
- (ii) describe typical operational oceanographic products;
- (iii) meet clearly stated quality assurance and documentation standards;
- (iv) meet GOOS criteria including, the free exchange of data;
- (v) invite contributions from GOOS stakeholder groups to describe applications, products, cost-benefits, and political and societal impacts; and
- (vi) the scope of the Bulletin will reflect the status and future of GOOS.

An editorial board shall be established to manage the bulletin and to review, accept and edit contributions. Initially, the board would be an *ad hoc* advisory panel consisting of representatives from the GOOS Steering Committee (GSC) and the Joint Commission for Oceanography and Marine Meteorology (JCOMM). A Web master shall also be appointed jointly by the GSC and JCOMM. As GOOS develops, the board will be re-organized to reflect the evolving capabilities of the observing system.

It was stressed that the Bulletin is to be of high quality and professional in delivery. The Bulletin is expected to provide timely information on progress in the design, implementation, and applications of GOOS on local, regional and global scales. Yves Tourre, who is responsible for the Electronic Products Bulletin of the Integrated Global Ocean Services System (IGOSS), has responded positively to this proposal. The panel supported this initiative and encouraged J. Guddal to continue the planning process.

### 3.3 CAPACITY BUILDING

#### 3.3.1 GOOS Principles

Capacity building involves, as a minimum, (i) developing and maintaining the basic scientific expertise and infrastructure required to participate in GOOS and (ii) educating the public and governments concerning the benefits of investing in GOOS. A draft document entitled «Principles of GOOS Capacity Building» was released on 1 April, 1999 (Annex V). The document, written by Jan Stel, Worth Nowlin and Colin Summerhayes, is intended as a guide to the design and implementation of the capacity building elements of GOOS and as a basis for seeking funds to support this important activity. The report emphasizes the following:

- (i) Coastal countries in the developing world often have the greatest need for data and information products but lack the capacity in expertise and technical infrastructure to participate in C-GOOS;
- (ii) Capacity building can be thought of as occurring in three stages beginning with an initial stage (research capability are quite limited), developing into a transitional stage, and concluding with a developed stage (research system and the research community are dynamic, well linked to society and the economy, and self-sustaining);

- (iii) Capacity building will involve a long-term commitment and partnership of governments, foundations, scientific and international organizations to training, technology transfer, and sustained international interactions among providers and user groups;
- (iv) GOOS capacity building should be built through the parallel development of nested observing systems at national, regional and global scales; and
- (v) The IOC should play a lead role through its programme on Training, Education and Mutual Assistance (TEMA) in implementing capacity building activities and raising the awareness of GOOS requirements, benefits, and costs.

It recommends that a GOOS Capacity Building Panel be formed with the following terms of reference:

- (i) initiate, plan and oversee the implementation of GOOS capacity building through the development of key demonstration projects using the GOOS implementation process;
- (ii) submit a plan to the ODA organizations to obtain funding;
- (iii) create an awareness of GOOS capacity building activities;
- (iv) develop standardized mechanisms and tools to be used in GOOS capacity building; and
- (v) initiate and assist in the development of multi-year regional plans for capacity building including partnerships with developed regional activities. This Panel has been formed with E. Marone as the C-GOOS representative.

### **3.3.2 C-GOOS Review of «Principles of GOOS Capacity Building»**

The C-GOOS Panel prefers an earlier version of the document which emphasized the need for onsite technical expertise and building on existing programmes. More specifically, the C-GOOS Panel recommends the following:

- (i) The names of specific countries should be avoided;
- (ii) Emphasize the large number of countries that fall under the category «initial stage» and that no countries fall in the category «developed stage»;
- (iii) While the Panel agrees that TEMA is the appropriate vehicle for GOOS capacity building, the roles of other programmes should be elucidated (e.g. the Global Change System for Analysis, Research and Training [START], Train-Sea-Coast, GLOSS training courses, UNESCO institutions) to give a more comprehensive perspective of capacity building activities and relative roles of the respective efforts; and
- (iv) Training must be recognized as an on-going need with a focus on «train-the-trainers» approaches that incorporate an appropriate mix of onsite and distance learning (e.g. through interactive video and CD-ROM) activities.

### **3.3.3 C-GOOS Principles**

Given the importance of capacity building to the successful implementation of C-GOOS, the Panel has decided to conduct its business in developing countries to the extent possible and to begin each panel meeting with a 1-day stakeholder's workshop. Recommendations for C-GOOS capacity building will follow the philosophy and principles of the parent body and will incorporate GLOSS capacity building as appropriate.

The realities of limited funding for capacity building and the complexity of issues to be addressed (e.g. Table 1) require a systematic setting of priorities. In this context, key demonstration projects should be identified which will have a significant impact on the implementation of C-GOOS, will show early signs of success, and be sustainable. Although the full development of the capacity building plan for C-GOOS must await the formulation of the strategic design plan for the global network and related pilot projects, one aspect of the preliminary plans for the global network (section 4) would appear to meet the above criteria. Capacity building to implement the proposal for coastal ocean watch may provide a cost-effective means of achieving an immediate and significant impact.

### 3.4 RESULTS OF THE STAKEHOLDERS MEETING

The meeting was opened by Dr. Koranteng, Chair of the LOC, who was introduced by Mr. Agbobli (Director, Water Resources Institute). Opening remarks were made by Dr. Odei (Chair, LOC), Mr. Kusi-Acheampong (Executive Secretary, Ghana National Commission, IOC), and Mr. Lefèvre (UNESCO Representative, Ghana). The keynote address was given by Professor Alhassan (Director General, CSIR). The stakeholders meetings consisted of 3 sessions: background, regional issues, and discussion. It was noted that the lack of funds limited the involvement of stakeholders and the GOOS-Africa Committee.

In addition to a brief presentation on the goals and status of C-GOOS, Mr. Awosika gave presentations on GOOS-Africa and the implications of sustainable management of the West African coastal ocean and Mr. Biney described the Gulf of Guinea Large Marine Ecosystem (LME). This was followed by presentations on fisheries (Dr. Koranteng), oil and gas exploration (Mr. Onwuzurike-Azu), and coastal hazards (Mr. Wellens-Mensah). The subsequent discussion yielded the following recommendations from stakeholders and the LOC:

- (i) Involve more stakeholders outside the scientific community, Non-Governmental Organizations (NGO) in particular, in the implementation of C-GOOS;
- (ii) Network nations and institutions in West Africa to collate and disseminate existing data relevant to the goals of C-GOOS, e.g. Sea Surface Temperature (SST) that can be used to predict rainfall patterns and shifts in species composition and abundance of fish;
- (iii) There are urgent needs for capacity building to collect and analyze basic data such as tides and temperature and to improve communications from access to the internet to access to data on regional to global scales, including satellite downlinks;
- (iv) Assist GOOS-Africa to harmonize and standardize measurements, quality assurance and data management for comparability;
- (v) Support and assistance is needed from the GOOS Project Office to ensure that GOOS-Africa is able to participate effectively and benefit from involvement in GOOS.

### 3.5 C-GOOS DESIGN PROCESS

Critical links between measurements and users in an «end-to-end, user driven system» include identification of user groups; precise definition of the attributes to be predicted or described; determination of acceptable time lags between observation, model outputs, and the delivery of products; determination of acceptable levels of accuracy and precision; identification of models that are to be used to link measurements to products; and the definition of model inputs and outputs. The procedure may be summarized as follows:

- (i) User groups - Identify the users of C-GOOS information and products and define their wants and needs.
- (ii) Final Prediction - Define the final form(s) of the prediction. It is recognized, for example, that coastal managers do not need predictions about the possible occurrence of a red tide in the form of a complex model output. A straightforward alert may suffice. On the other hand, a coastal engineer designing

flood defenses may need a precise confidence interval for the probability that a critical level will be exceeded or the captain of a container ship may need precise predictions of water depth in the Port of New York. **The term prediction is not used simply in the sense of forecasting the future, but also in the sense of estimating (interpolating, extrapolating) a quantity which is not observed directly,** e.g. inferring the present biodiversity of an ecosystem from measurements made at a small number of stations, estimating return times of extreme sea levels at a coastal site with no sea-level data from a tide gauge with a long record at another site.

- (iii) Lead Time - Lead time is the acceptable time lag between measurement and prediction. For cases involving straightforward spatial interpretation this may be zero (e.g. the probability of a specified sea-level being exceeded at a site without a tide gauge). On the other hand, useful storm surge forecasts are required hours to days ahead while land use management decisions might be based on GIS products that require days-months to produce.
- (iv) Models, Model Outputs, and Model Inputs - Identify the types of models to be used. This may range from conceptual models, Geographic Information System (GIS), and simple regression models (based on empirical relationships) to sophisticated, coupled ocean-atmosphere and hydrodynamic-ecosystem models based on theory and empirically derived parameters. Describe model outputs, i.e. the quantity (ies) predicted directly by the model. This might be, for example, time varying fields of currents or productivity, linear trends of sea level over recent decades, or ice distribution. In many instances this will differ from the final form of the prediction provided to users which will commonly be a highly reduced version of the raw model output. Describe model inputs. These are the measured variables required by models to make predictions, e.g. winds, air pressure, sea level, currents, sea surface temperature and salinity, concentrations of nutrients, chl-a, O<sub>2</sub>.
- (v) «Cost-benefit» Analysis - The feasibility of each measurement and its impact are ranked high, medium or low. Feasibility is assessed in terms of cost, difficulty of measurement, and/or the availability of acceptable technologies and techniques. Impact is assessed in terms of the importance of the measurement to decision making or the effect on model output if an input variable is not measured, is measured infrequently, has a large error associated with the estimate, is aggregated with other variables, etc. In an impact-feasibility matrix, properties may fall, for example, into the following categories: (i) the property is easily measured (routine) and has a high impact; (ii) the property has a low impact and is difficult to measure (not routine or the technology does not exist); and (iii) the property has a high impact and is difficult to measure. Properties that fall into category (iii) should be the subject of active R&D to move them to category (i).

It is expected that all C-GOOS programmes (global network, pilot projects, regional and national programmes) will follow this procedure. In those instances where the information for a particular step cannot be provided, a process shall be proposed or specified that describes a plan for how the appropriate information will be obtained.

## 4. THE GLOBAL COMPONENT

### 4.1 BACKGROUND

An important objective of C-GOOS is to foster the development of a predictive capability for the coastal ocean. To succeed, C-GOOS will need a global observing system that provides reliable data in a reasonable time frame and models with a proven ability to predict changes in the marine environment (Annex VI). Some of the elements required for the global system are emerging through remote sensing and the global network of tide gauges. The observing system of the future will build on and be constrained by existing infrastructure. However, to be effective, C-GOOS must also optimize the use of new observing technologies, advances in knowledge of coastal systems, and developments in computer modeling and data assimilation.

Three observing systems are in place that are clearly relevant to the design and implementation of the global backbone of C-GOOS: World Weather Watch (WWW), the initial observing system for the climate component of GOOS, and Global Sea Level Observing System (GLOSS). As discussed above, there are important differences in the development of systems such as these which have a singular purpose. For example, the *raison d'être* for the meteorological system is the provision of data to initialize atmospheric models for forecasting. The observing system is designed for a single purpose; the quantities to be forecast are clearly specified; and the physics underlying the models are clear. This is not the case for the coastal ocean where the issues to be addressed are more complex and diverse and the processes responsible for the observed variability are less well understood. In this regard, it should also be noted that the first attempt to organize an international observing network took place in the late 1700s and that the first permanent observing network (and the first national weather service) was established in France in the mid-1800s. The present day global meteorological observing system (WWW) is run by the WMO and has three major components:

- (i) The global observing system run by the national meteorological services (surface and radiosonde networks, aircraft and satellite systems);
- (ii) The global telecommunications system; and
- (iii) The global data processing system consisting of national and international meteorological centres for the collation, processing, archival and dissemination of observations in near real-time.

The initial observing system for the climate component of GOOS was designed by the Ocean Observing System Development Panel (OOSDP) in 1994. The plan recognizes the importance that data assimilation models are critically important to both the synthesis of data and prediction. The design is based on a ranking of subgoals for surface fields and fluxes, the upper ocean, and the interior of the ocean. The report devotes considerable space to an analysis of feasibility and impact which take into account scales of variability and sources of error.

In a sense, the initial observing system for the climate component of GOOS is the deep ocean counterpart of C-GOOS. The deep ocean and coastal components of GOOS should evolve into a single, integrated system with each subsystem benefiting from the other (e.g. the deep ocean subsystem provides boundary conditions for regional coastal models and the coastal system will allow coastal measurements such as sea level to be incorporated into basin scale models). Much of the initial observing system for the deep ocean is justified in terms of climate change. To make these predictions useful, they must be extrapolated to population centres along the coast. One way to achieve this is through the coupling of ocean and atmospheric models. Another is to couple ocean and shelf models that will allow predictions of bottom temperature and stratification in coastal systems that may be related, for example, to changes in local climate and fish abundance.

Finally, GLOSS is an international programme co-ordinated by the IOC for the establishment of high quality global to regional networks of sea level measurements. Measurements of sea level are critical to the prediction of coastal flooding and circulation. Sea-level is also useful as an indirect measure of such important processes as vertical movements of the earth's crust, global warming of the ocean, and melting of the polar ice caps. Thus, GLOSS is a component of GOOS and of central importance to the C-GOOS global network.

#### 4.2 THE BEGINNINGS OF A GLOBAL NETWORK

The design for the global component of the coastal observing system must follow the C-GOOS design process (section 3.5) and measurement made for the observing system will of necessity be a compromise between variables that are straightforward to model and predict in the short term and variables that ultimately will be the most useful. Physical variables tend to fall in the first category while biological and chemical variables tend to fall in the second category. For a more complete description of the first draft of a design for the global backbone of C-GOOS see Annex VI.



The Initial Global Network for C-GOOS is conceived as encompassing four key elements:

- (i) Remote sensing (satellites, aircraft, shore based systems such as high frequency radar) to capture the spatial and temporal dimensions of change in surface properties (e.g. dynamic height, winds, waves, currents, temperature, sea ice, ocean color and coral reef assessment).

Remote sensing is a critical tool for obtaining spatially synoptic measurements of the status of coastal marine systems. Examples include phytoplankton biomass and productivity from ocean color, sea surface temperature from infrared and microwave portions of the electromagnetic spectrum, currents and wave spectra from altimeters, sea surface winds from scatterometers, and sea ice from visible, infrared and microwave reflectance. The development, validation and calibration algorithms, the assimilation of remotely sensed data, integration of *in situ* time series and spatially articulated remote observations, and the continued improvement of coupled ocean-climate and ecological-physical models for transforming measurements into products are particularly important.

- (ii) In situ measurements (an enhanced GLOSS, enhanced arrays of instrumented moorings and fixed platforms, drifters, voluntary observing ships, research vessels, Autonomous Underwater Vehicles [AUVs], Remotely Operated Vehicles [ROVs]).

Sea level is arguably the single most important physical variable to measure along the coastline. C-GOOS must work closely with GLOSS to extend the present array of tide gauges and possibly add more instrumentation to GLOSS sites (to achieve the integrated aspect of the network). The present distribution of GLOSS stations is inadequate for many important applications, e.g. surge prediction.

Enhancing the array of instrumented moorings and fixed platforms (in term of both number of sample sites and diversity of sensors) will lead to better predictions of extreme marine weather; more accurate atmospheric forcing fields for hydrodynamic models; more accurate algorithms for remote sensing; and the development of ecosystem models for predicting the effects of anthropogenic stresses on water quality and the capacity of coastal ecosystems to support living marine resources.

Ferries (e.g. the Ferry Box Project of EuroGOOS) and other Voluntary Observing Ships (VOSs) provide an opportunity to measure core variables (and estimate fluxes) across critical shelf sections. This will also be useful for specifying open boundary conditions for numerical models.

- (iii) Coastal Ocean Watch Coastal laboratories, schools, and NGOs can be networked into Coastal Ocean Watch (COW) to monitor environmental conditions in the coastal zone. This will provide a cost-effective means of describing regional to global distributions of core properties in the near-shore environment of the coastal ocean and will provide data that can be used to validate remote sensing algorithms. This element also has the greatest potential for promoting public awareness and for engaging developing countries in C-GOOS.
- (iv) An effective data management system that accommodates a diversity of data types and data sources including real time telemetry, data assimilation, and integration of remote and *in situ* measurements for timely access to and applications of environmental data.

A preliminary list of the diversity of data types that may become part of the «backbone» of the global C-GOOS network is given in Table 2.

**Table 2.** Key properties and processes that should be considered for the measurement programme of C-GOOS

Property or Process	Time Scale	Platform
air: winds, pressure, temp <sup>1</sup> surface waves	Hourly	moored systems <sup>2</sup>
freshwater inputs	Continuous	fixed platforms
sea ice/icebergs	Continuous	ships, remote
ambient noise	Continuous	moored systems
atmospheric deposition <sup>3</sup>	daily – weekly	moored systems
water level	Continuous	fixed platforms, remote
bathymetry	decadal	ships
currents	continuous	moored systems, remote
temp & salinity	continuous	moored systems, AUVs, remote
color (phytoplankton biomass)	continuous - daily – monthly	moored systems, AUVs, remote, ships
nutrients <sup>4</sup>	hourly - weekly – monthly	moored systems, ships
suspended solids, turbidity	continuous - daily – monthly	moored systems, remote, ships
pCO <sub>2</sub> , O <sub>2</sub>	continuous – monthly	moored systems, ships
plankton species	weekly – monthly	ships
zooplankton biomass	continuous – monthly	moored systems, ships
benthic species, biomass	yearly	ships, AUVs
recruitment indices	seasonally	ships
stock assessment	seasonally	ships
chemical contaminants	annually	ships, mussel watch

<sup>1</sup> Measurements over water;

<sup>2</sup> Includes surface (buoys) and bottom mounted instrumentation;

<sup>3</sup> Wet and dry deposition of nitrate, nitrite, ammonium;

<sup>4</sup> Dissolved inorganic nitrate, ammonium, phosphate and silicate.

## 5. PILOT PROJECTS

### 5.1 PILOT PROJECT PROPOSAL FORMAT

As agreed to at C-GOOS-II, proposals for pilot projects (new, existing, enhancements of existing projects) are to follow the following format:

- I. ISSUES ADDRESSED AND THEIR SIGNIFICANCE
- II. USERS AND PRODUCTS OF THE OBSERVING SYSTEM
- III. RELATIONSHIP TO THE C-GOOS GLOBAL NETWORK
- IV. PROJECT DESIGN
  - A. Issues to be addressed (see Table 1, GOOS Report No. 63)
  - B. Final Prediction and Lead Time
  - C. Models to be Used, Model Variables and Outputs
  - D. Feasibility and Cost-Benefit Analysis
- V. R & D NEEDS (GIVEN THE ISSUE TO BE ADDRESSED, WHAT MUST BE DONE TO MAKE THE OBSERVING SYSTEM FULLY OPERATIONAL)
  - A. Measurements
  - B. Models
  - C. Products

- VI. DATA AND INFORMATION MANAGEMENT (CO-ORDINATE WITH GODAE, JOINT DATA AND INFORMATION MANAGEMENT PANEL [JDIMP])
  - A. Elements
  - B. Data Sharing Policy
- VII. CAPACITY BUILDING AND ENHANCEMENTS OF EXISTING PROGRAMMES
  - A. Needs and Priorities
  - B. Plans

## 5.2 PROPOSED PILOT PROJECTS

The pilot project proposal presented for consideration by the Panel is listed below. The written proposal submitted to the Panel is given in Annex VII.

Coastal Ocean Observing System in the Eastern South Pacific Ocean (Osvaldo Ulloa) - Design and implement a coastal network to provide data and develop models to forecast low frequency variability (10 - 70 day periods) in ocean circulation along the west coast of S. America from wind measurements over the equatorial Pacific (Tropical Atmosphere Ocean [TAO] array).

Remote Sensing Algorithm Development for Coastal Waters (Sinjae Yoo and Dale Kiefer) - Develop a global network of laboratories to provide *in situ* data required develop, validate and calibrate reflectance models for translating measurements of ocean color into concentrations of phytoplankton pigments.

Harmful Algal Blooms in the Indo-Pacific Region (Adriana Zingone) - Establish a regional observing system to detect and mitigate the effects of *Pyrodinium bahamense* blooms (which cause paralytic shellfish poisoning) in the Indo-Pacific.

The Phytoplankton Network (PhytoNet)(Adriana Zingone) - Establish a monitoring network to conduct retrospective analyses of changes in phytoplankton species and abundance (including harmful species), to "intercalibrate" methods, and to promote timely access to data. The goals are to document patterns of variability, detect trends (e.g., changes in biodiversity, frequency of harmful algal events), and determine the causes and consequences of such trends.

The Co-ordinated Adriatic Observing System (CAOS) (Tom Malone) - Establish a regional observing system in the Adriatic as part of the Mediterranean Forecasting System to determine the effects of nutrient inputs on the production and fate of phytoplankton in terms of changes in water quality and carrying capacity for fisheries.

Caribbean Coastal Marine Productivity (CARICOMP) (John Ogden) - CARICOMP is an observing system that was established in 1990 (28 sites, 19 countries) to monitor the productivity and associated physical parameters of coral reefs, sea grasses and mangroves to assess habitat loss in terms of such phenomena as coral bleaching, disease, and mass mortalities.

Global Network on Sea grass Science, Monitoring, Training and Information Exchange (Sea Net) (Carlos Duarte with Eva Maria Koch and Mike Fortes) - Design and implement an observing system to assess the status of sea grass ecosystems; detect trends in distributions and abundance of sea grass species; and determine the causes and consequences of sea grass habitat loss.

Southwest Atlantic (Eduardo Marone) - Establish a coastal network to forecast natural hazards and mitigate their effects on coastal communities of the east coast of S. America.

Coastal Hazards in the IOCEA Region (Larry Awosika) - Establish a coastal network to forecast natural hazards and mitigate their effects on coastal communities of western Africa.

Vietnam Coastal Disaster Warning System (Johannes Guddal) - Establish a coastal network to forecast storm surge flooding and mitigate its effects on coastal communities of the east coast of Vietnam.

Western Pacific Biodiversity (Yoshihisa Shirayama) - As part of the International Biodiversity Observation Year (IBOY), establish a network of coastal laboratories to monitor and detect trends in the biodiversity of western Pacific flora and fauna.

Of these, CARICOMP (implemented) and CAOS (design phase) are candidates to be incorporated into the design and implementation plans for C-GOOS. The remaining proposals for projects have yet to be fully developed, and, after due consideration of their status, significance and feasibility, the Panel agreed that full proposals should be developed for pilot projects in two categories: (i) biodiversity and habitat and (ii) coastal circulation and natural hazards.

## **6. CO-ORDINATION AND COLLABORATION**

### **6.1 THE GLOBAL COMPONENT OF C-GOOS**

Clearly, the design and implementation of the global network must build on and co-ordinate with research programmes and observing systems that are in place or planned. Not only must the coastal observing system build on existing programmes as appropriate, it must evolve through the incorporation of new knowledge and advances in technology (sensing and communicating environmental variability), data management, data assimilation and modeling. Existing programmes and activities relevant to the global component of C-GOOS include GLOSS, OOPC, JDIMP, GODAE, the Tsunami warning system, the Global Coral Reef Monitoring Network (GCRM), the Global Investigation of Pollution in the Marine Environment (GIPME), and ICAM. GIPME and ICAM were discussed during C-GOOS-II. GLOSS and OOPC are of central importance to the design and implementation of the global component of C-GOOS and are discussed below.

#### **6.1.1 OOPC**

The goals of the OOPC are to (i) monitor, describe and understand the physical and bio-geochemical processes that determine ocean circulation and its influence on the carbon cycle, and the effects of the ocean on seasonal to multi-decadal climate change; (ii) provide the observations needed for the prediction of climate variability and climate change; and (iii) develop GODAE.

Both C-GOOS and OOPC will benefit from co-ordination and collaboration. Programmes developed through the OOPC should provide the following information in support of C-GOOS: (i) sea surface temperature and wind data on the large scale for local use (coastal meteorological observations are already on the Global Telecommunications Network [GTN]); (ii) sea-level data in large scale geocentric network for local context; (iii) El Niño – Southern Oscillation [ENSO] tropical wave guide forcing of the Americas; and (iv) dynamic oceanic boundary conditions (forcing) of shelf systems (e.g. *via* GODAE). Programmes that become a part of C-GOOS should provide data on winds, sea surface temperature, and currents to improve the accuracy of global products, develop coastal models to link offshore sea level to tide gauges, and enable higher resolution climate observations in for instance the Arctic region for determination of poleward flowing eastern boundary currents, shelf transports, and west wind drift along the Arctic Archipelago.

It was noted that there now is a joint implementation mechanism, JCOMM, for all physical observations and it was suggested that this commission might need input from C-GOOS. Finally it was stressed that there is a need for consistency between the OOPC and the global C-GOOS.

#### **6.1.2 GLOSS**

GLOSS is of central importance to the global component of C-GOOS and to many C-GOOS pilot projects. An analysis of the current configuration of stations (Annex VI) suggests that the current network is

should be expanded with more automated stations to address problems of under sampling. E. Marone will represent C-GOOS at the GLOSS Panel meeting in Toulouse in May 1999. Two areas of collaboration are evident and will be introduced for discussion by Marone: (i) capacity building activities and the expansion of the GLOSS network for the purposes of both the global component and pilot projects. E. Marone will report on the results of this meeting at C-GOOS-IV.

## 6.2 HOTO AND LMR

Implementation of HOTO is taking place under the auspices of GIPME. The objectives of the HOTO Module are to provide a basis for the assessment of the state and trends in the marine environment regarding the effects of anthropogenic activities, including, *inter alia*, increased risk to human health, harm to marine resources, alterations of natural change and general ocean health. Central to the objectives and terms of reference of the HOTO Panel is a definition of the term "Health of the Ocean" and identification of the environmental health criteria, or biological indices, that can serve as early warning signs of change in the quality of marine environment. This is clearly an area for collaboration among the HOTO and C-GOOS Panels in the development of an integrated design and implementation plan for the coastal ocean.

The design of the LMR module is currently under development. The LMR panel's main focus is currently on developing its monitoring programme and specifying monitoring parameters, indices and utilization. Two programmes merit consideration for immediate incorporation in the initial observing system of GOOS: (i) the international bottom trawl survey (International Council for the Exploration of the Sea [ICES]) and (ii) the continuous plankton recorder survey.

Although in different stages of development (HOTO is in the implementation phase while C-GOOS and LMR are in the design phase), it is clear that there is considerable overlap between them. The C-GOOS Panel anticipates that the three modules will be merged once the design plans for C-GOOS and LMR are completed, and the GOOS Steering Committee has charged the chairs of the three panels to meet early in 2000 to develop plans to complete the merger before the end of 2000.

## 6.3 LOICZ

### 6.3.1 Background

C-GOOS recognizes the importance of establishing a linkage with the LOICZ programme to facilitate information exchange and development of joint projects. C. Crossland provided an overview of LOICZ and outlined areas where collaboration may be possible. LOICZ is an IGBP research programme, the purpose of which is to determine the fluxes of materials (e.g. C, N, and P compounds; sediments) into, through, and from coastal ecosystems. LOICZ activities are organized into four focus areas (Annex VIII, Annex IX):

- (i) The effects of changes in external forcings on coastal fluxes;
- (ii) Coastal biogeomorphology and global change;
- (iii) Carbon fluxes and trace gas emissions; and
- (iv) Economic and social impacts of global change in coastal systems.

Two major goals to be achieved by the end of this 10-year programme are global estimates of C, N and P budgets for the coastal ocean and an assessment of specific data and techniques needed to improve and track changes in these budgets in local ecosystems and on regional to global scales. C-GOOS will work to insure that this legacy of LOICZ becomes a reality.

Recognizing that LOICZ has a finite «life» (end of year 2002; subject to current discussions in IGBP), a process should be established to ensure that the data, knowledge, tools, and networks developed by LOICZ are embodied in C-GOOS as appropriate. It is expected that C-GOOS will encourage the development of sustained observing systems required to document and predict the consequences of changes in bio-geochemical cycles and fluxes to, within and from coastal ecosystems. C-GOOS will promote the use of new knowledge and technological advances (sensors, models, data management) generated by LOICZ for applied purposes and

provide the framework of observations required to extrapolate research results to coastal systems that have not been the subject of an in depth LOICZ study. Currently there are four areas where collaboration between C-GOOS and LOICZ could begin immediately: (i) data management; (ii) the development of a coastal typology; (iii) joint research projects on material flux modelling; and (iv) the formulation of design and implementation plans. To these ends, the existing Memorandum of Understanding between LOICZ and IOC should be updated to provide the framework for incorporating the legacy of LOICZ as a part of C-GOOS.

### **6.3.2 Data Management**

LOICZ is developing a global database on material fluxes, bio-geochemical processes, and socio-economic factors for a network of LOICZ projects, coastal zone researchers and agencies. The LOICZ databases are linked to coastal zone information services and the databases of government agencies concerned with environmental issues in the coastal zone. The database includes data from more than 250 projects and nearly 2400 scientists, and, although not comprehensive, provides wide global coverage. Data and metadata in the LOICZ database is public domain, and the Executive Committee is discussing mechanisms for creating access to the database which includes analyses of parameters of coastal typology, river discharge (GLORI), and bio-geochemical budgets for C, N and P in coastal seas and estuaries.

The data management component of the design and implementation plans for C-GOOS should consider the data management systems developed for LOICZ. In this regard, LOICZ is keen to link with the initiatives of C-GOOS for resolving its data and information transfer matters. Possible joint actions include the following:

- (i) Make the LOICZ researcher database accessible to C-GOOS through IOC, to assist in the development of a global inventory of researchers and to enhance networking and capacity building;
- (ii) Provide access to the LOICZ project database and information to assist in regional project development, increase awareness of regional capabilities and expertise, and enhance information transfer for the development of coastal zone management policies;
- (iii) Establish a mechanism for data and information exchange between C-GOOS and LOICZ data and metadata bases;
- (iv) Establish an ongoing dialogue (through joint workshops, meetings?) ensure co-ordination and collaboration among projects as appropriate;
- (v) Work collaboratively to establish and maintain a common database and information transfer system established under the aegis of C-GOOS within IOC (in the sense of JDIMP Plan).

### **6.3.3 Coastal Typology**

At an early stage of its development, LOICZ embarked on a coastal typology approach to address spatial scaling issues. In recent years, workshops and activities focused on building a database addressing the global coastal zone ( $\pm 50$  m elevation). By mid-1998, a database of physical, biological and socio-economic parameters (109 variables) was established at one-degree pixel scale which required about 9600 pixels to represent the global coastal zone. The database is rudimentary in terms of socio-economic parameters, scaling aggregation, and number of variables. Physical parameters are more extensive. In many locations, the database includes land, immediate coastal ocean, and coastline pixels.

There are no clear recipes for aggregating the pixels into a coastal classification. (It was noted that this is currently a «hot issue» in some research sectors). Trials showed that statistical correlative methods were not appropriate. A workshop in October 1998, brought together skills for cluster methodologies and evaluated the LOICZ database to minimize aggregation biases and to assess alternative indicator parameters. Work since then has refined the database and extended the methodological approach to yield typology images that are intuitively reasonable and representative. The further development of methods, databases and finer-scale resolution remain as priorities.

A small group of specialists is working on the development of tools for a global coastal typology. It is likely that more than one typological approach will be required to meet the LOICZ needs for «up-scaling» coastal flux information to regional and global scales. Current work includes: development of «cluster»

methodologies, tools for aggregating coastal descriptions, expanding and rationalizing indicator parameters in the database, ways of linking to existing global data models, and seeking ways to link coastal with catchment typologies (which are being developed in IGBP and elsewhere). Initial products are being posted to Web sites, mainly for group discussion and an intuitive assessment by regional experts. These include the following:

[www.ghsun1.kgs.ukans.edu:8002/Lohtml/Typhtml/typindex.html](http://www.ghsun1.kgs.ukans.edu:8002/Lohtml/Typhtml/typindex.html)  
[www.palantir.swarthmore.edu/~maxwell/loicz/](http://www.palantir.swarthmore.edu/~maxwell/loicz/)  
[www.kars.ukans.edu/mexico/coastal/hhgdx50coast.html](http://www.kars.ukans.edu/mexico/coastal/hhgdx50coast.html)

The Web sites are dynamic and have yet to be aggregated as summary products into the LOICZ Web page ([www.nioz.nl/loicz/](http://www.nioz.nl/loicz/)), which contains some preliminary text and an initial database.

#### **6.3.4 Material Flux Modelling**

Formulating quantitative bio-geochemical budgets (for C, N, and P) of coastal ecosystems is a core activity of LOICZ. To this end, LOICZ has sponsored workshops and training sessions in various regions of the world. The current status of this activity can be found on the LOICZ Web site. Hard copy and CD-ROM copy of budget workshops are available through the LOICZ International Project Office. Site descriptions for Europe, Central and North America, and Australia are well developed and expanding. Other regions are scheduled for workshops over the next 18 months. Support funding for this work and allied training is expected from UNEP-GEF.

A joint LOICZ-JGOFS group (CMTT) is working on C, N, P fluxes across margins of the continental shelf. Catchment models for horizontal flux of materials and the implication of the human dimension are a major activity. Currently efforts are focussed on Europe, but work progresses in other regions. A project in South East Asia is focusing on the development of an integrated modeling approach to the ecological, social, and economic aspects of alterations in bio-geochemical cycles. The project, supported by Netherlands Foundation for the Advancement of Tropical Research (WOTRO) and START, is completing Phase I and expected to continue. The model approach is being transferred for application in other regions.

Possible joint activities include (i) the use of data from the coastal observing system to test and verify LOICZ budgets and models; (ii) organizing regional workshops on bio-geochemical budgets, development of applications, and training; (iii) developing projects to identify and evaluate indicators of system function to monitor ecosystems status and provide guidance for coastal zone management; and (iv) developing procedures for applying ecosystem models for the purposes of managing coastal resources and protecting coastal environments.

#### **6.3.5 Regional Projects**

LOICZ organizes much of its activities on a regional scale. It depends on the work of national agencies and scientists, supplemented by funding and organization to bring together regional groups of experts to integrate relevant science and, where possible, to assist in capacity building. LOICZ has some history of working with IGBP-START and IOC in regional enterprise, and is actively seeking to expand these associations in carrying forward its work. Regional activities are summarized in Annex IX. Potential joint activities include capacity building and information transfer and the development of integrated research and monitoring activities.

### **6.4 REGIONAL GOOS PROGRAMMES**

The implementation of C-GOOS is likely to be carried out under the auspices of national and regional GOOS programmes. In addition to facilitating cross-fertilization among national and regional programmes, it is hoped that the C-GOOS design and implementation plans will provide useful guidance to the development of these more focused efforts.

#### 6.4.1 EuroGOOS

EuroGOOS is an informal association of national organizations (authorities, agencies, and institutes) whose members seek to foster European co-operation on the GOOS. Members include 30 organizations from 16 European countries. The major goals of EuroGOOS are as follows: (i) promote the development and communication of the best available scientific advice on the design and implementation of the ocean observing systems; (ii) ensure that requisite models are developed and tested; (iii) analyze limits to predictability and the associated role of data assimilation; (iv) alert EuroGOOS members to new scientifically-led opportunities and, conversely, to scientific shortcomings, and needs for research. In these regards, the goals of EuroGOOS and C-GOOS are similar. The Panel agreed at C-GOOS-II that «The Science Base for EuroGOOS» provides guidelines that will be useful in the formulation of the C-GOOS design and implementation plans. These include the following:

- (i) **Data management, assimilation and modelling** - The EuroGOOS report stresses the importance of access to quality controlled data in a common format in near real time. The development of the data management component of the design and implementation plans will especially challenging for C-GOOS because of the diversity of data types and sources and of the multiple applications these data will serve. Effective and efficient methods for real-time and near real-time data assimilation and analysis are of fundamental importance to an operational observing system and this must be a high priority for the implementation of C-GOOS. C-GOOS should review the data management strategy of EuroGOOS from quality control and assurance to model outputs, and incorporate appropriate approaches and elements into its design plan;
- (ii) **New technologies - Satellite remote sensing is identified as the most promising new technology for incorporation into EuroGOOS.** An important distinction between EuroGOOS and C-GOOS is the focus on physical environmental variables. EuroGOOS has focused on measurement systems that are currently operational. Biological monitoring and prediction systems will be incorporated as operational systems become available and as user demand warrants. In contrast, C-GOOS has taken a more integrated approach that involves both research and operational components that will, if successful, serve a broader spectrum of user groups from the beginning. This calls for a major R&D effort to develop technologies for measuring biological and chemical properties rapidly and with know precision and accuracy;
- (iii) **Sampling design** - Despite the reality that major investments have been made in remote and *in situ* sensing, the ability to predict change and its consequences in the oceans is severely limited by the problem of undersampling. Clearly, the observing system of the future must build on the existing infrastructure to improve its ability to accurately document patters of change over a broad range of scales. Data assimilation and modelling can be useful in the design of observing systems that involve both in situ and remote sensing for the purposes of operational forecasting. Observing system simulation experiments will be particularly useful in this regard.

Areas of collaboration and cooperation include the following:

- (i) **Physical environmental variables** - Physical and meteorological variables are of fundamental importance to the ocean-climate system and to the ecology of aquatic systems in general. Thus, the requirements for data on physical processes are similar for oceanic and coastal systems (e.g. temperature, salinity, wind stress, waves and currents) except that variability must be resolved on smaller temporal and spatial scales in coastal systems. Thus, while EuroGOOS focuses on physical and meteorological variables, C-GOOS may wish to incorporate aspects of the European observing system in its design and implementation plans so that national and regional GOOS efforts may benefit.
- (ii) **Biological and chemical variables** - The C-GOOS design will be integrated in that it will be multi-disciplinary, multi-scale, and multi-dimensional. In these regards, the development of an integrated system for EuroGOOS may be enhanced by the C-GOOS approach. Collaboration in this arena may be particularly important for the Baltic Project, Mediterranean Forecasting System Project, and the European North West Shelf Project.



- (iii) **Globalization of EuroGOOS** - Like all regional GOOS efforts, EuroGOOS must assimilate data on a global scale to predict local to regional expressions of large-scale changes. Each national and regional GOOS effort can benefit from the experiences of others in terms of the procedures by which this is accomplished and the products that are produced. C-GOOS can and should facilitate such cross-fertilization.
- (iv) **Assessment of social and economic benefits** - Assessment of the economic and social benefits from forecasting marine and coastal conditions and the marine contribution to climate forecasting has been identified as one of ten strategic sectors of EuroGOOS. This provided a means to prioritize steps in the development of EuroGOOS. The process by which this analysis was done and its results should prove useful to the design and implementation of the global C-GOOS observing system and to regional pilot projects.

#### 6.4.2 NEAR-GOOS

Under the auspices of the IOC Sub-commission for the Western Pacific (WESTPAC), China, Japan, the Republic of Korea and the Russian Federation are developing NEAR-GOOS as a regional pilot project of GOOS. The immediate priority of NEAR-GOOS is data management and the regional dissemination of data. Data management has been organized in two categories: (i) real-time database management and (ii) delayed mode database management (archival).

Since the last meeting of the C-GOOS Panel, NEAR-GOOS has facilitated the formation of National GOOS Co-ordinating Committees of each of its partner nations. A NEAR-GOOS brochure and manuals for NEAR-GOOS databases will be published in September 1999. A regional GOOS/NEAR-GOOS workshop is being planned, and a NEAR-GOOS training course will be given once a year. Further information on NEAR-GOOS can be obtained from the Web pages and contact persons listed below:

- Regional Real Time Data Base (RTDB), NEAR-GOOS in Tokyo (<http://goos.kishou.go.jp>): Contact Dr. Naoyuki Hasegawa ([naohase@naps.kishou.go.jp](mailto:naohase@naps.kishou.go.jp));
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- Russian Federation, RTDG and DMDB: Contact Dr. Victor A. Akuliev ([akulich@marine.fberas.ru](mailto:akulich@marine.fberas.ru)).

The NEAR-GOOS Co-ordinating Committee has expressed great interest in co-ordinating activities with C-GOOS. High priority areas for co-ordination and collaboration are as follows:

- (i) Indicators of Environmental Condition - The C-GOOS panel is in the process of formulating environmental indicators of ecosystem health that may be incorporated into the NEAR-GOOS design to (a) evaluate the status of coastal ecosystems in the NEAR-GOOS region; (b) enhance existing monitoring systems to provide data required to calculate indicators; and (c) replenish existing real-time and delayed mode databases.
- (ii) Data and Information Management - The NEAR-GOOS and C-GOOS strategies for data management must be consistent with GOOS data policies and enable the development of an integrated global data management system that is responsive to user needs on local, regional and global scales. The NEAR-GOOS data management system is based on the following: (a) free exchange of data; (b) real-time and delayed mode databases; (c) common standards of data quality assurance and control; and (d) access to data *via* the Internet. C-GOOS and NEAR-GOOS should collaborate in the development of a common strategy for data management.

- (iii) Networking Metadata - The NEAR-GOOS Co-ordinating Committee is drafting metadata standards and encourages all data providers to establish their own metadata based on these standards. C-GOOS should consider incorporating these standards into the C-GOOS design and implementation plans.
- (iv) Remote Sensing - The C-GOOS pilot project proposed by Sinjae Yoo (Algorithm Development for Coastal Waters) has been endorsed by the NEAR-GOOS Co-ordinating Committee. It provides an important opportunity for collaboration between C-GOOS and NEAR-GOOS. The Co-ordinating Committee has made the following recommendations: (a) establish a network of qualified laboratories in the NEAR-GOOS region to contribute to the development, validation and calibration of coastal algorithms; (b) work with participating nations to obtain financial support; (c) supply relevant *in situ* data; and (d) co-ordinate the use of data on ocean color from satellites launched by China, Korea and Taiwan.
- (v) East China Sea - The Three-gorge dam on the Yangtze River will affect water quality and living resources in the East China Sea. C-GOOS and NEAR-GOOS should work together to develop a pilot project to assess the environmental effects of changes in the discharge of the Yangtze on coastal ecosystems of the E. China Sea.

#### 6.4.3 GOOS-Africa

GOOS-Africa was conceived at the Pan-African Conference on Sustainable Integrated Coastal Management (PACSICOM) meeting in Maputo Mozambique in July 1998. The summary record of the main conclusions and specific recommendations from the PACSICOM meeting can be found at: <http://www.sdn.org.mz/entidade/pacsicom/conclus0.htm>

The GOOS-Africa initiative has the backing of the environment ministries in the region, and the Co-ordinating Committee strongly recommended the establishment of national GOOS Co-ordinating Committees.

Major impediments to the development of GOOS-Africa are the lack of national and regional data management and of the communications infrastructure to disseminate and analyze data. Capacity building is clearly the highest priority, the initial focus of which should be to establish a regional network of collaborating institutions and expertise to develop an integrated system of data management and a programme of data «rescue.» In addition to developing the initial regional database, this activity will lead to the identification of the types of data and information regional nations are capable of collecting and analyzing using their own resources. This in turn will provide the basis for determining regional priorities for building the measurement and communications infrastructure required to be a full player in GOOS.

The initial strategy is to build on existing regional programmes. Generic priorities agreed to at the PACSICOM Conference for future funding include:

- (i) Build an IODE network of National Ocean Data Centres;
- (ii) Enhance the network of tide gauges along the African coast;
- (iii) Enable timely access to remotely sensed data for the African continent and provide training in the analysis and applications of remote data; and
- (iv) Improve access to state of the art communication networks (e.g. Internet) to enable the timely dissemination, storage, and analysis of data.

If funded, the proposed «Ocean Data and Information Network for Africa» (ODINAFRICA-II) will be an important first step. The project, which is to be sponsored by IOC and the Government of Flanders, will establish and expand the number of national oceanographic data centres in several African countries, provide training in marine data management, and develop a Pan-African marine metadatabase.

Initially, funding for GOOS-Africa must be sought from countries outside the continent. The Global Environmental Facility (GEF) assisted LME projects such as the Gulf of Guinea LME may provide the nucleus for initiating GOOS-Africa. LOICZ (START/IOC/LOICZ Workshop on Climate Change and Coastal

Processes in West Africa) and GTOS (Southern Africa Project) also have related interests in the region and these efforts should be co-ordinated to leverage funding.

## 6.5 GLOBAL TERRESTRIAL OBSERVING SYSTEM (GTOS)

Since many of the environmental issues of concern to C-GOOS (Table 1) are of terrestrial and anthropogenic origin, there is a clear need for C-GOOS and GTOS to co-ordinate the formulation of design and implementation plans. The GTOS is to provide policy makers, resource managers and researchers with the data they need to detect, quantify, locate and understand changes (especially reductions) in the capacity of terrestrial ecosystems to support sustainable development. In these regards, GTOS has 5 focus areas of global concern:

- (i) change in land quality,
- (ii) availability of freshwater resources,
- (iii) loss of biodiversity,
- (iv) climate change, and
- (v) impacts of pollution and toxicity.

All of these issues directly or indirectly affect ecosystem health and living resources in coastal waters. The C-GOOS Panel has emphasized the importance of quantifying inputs of water and materials (e.g. sediments, nutrients, and contaminants) from land, and it was agreed that monitoring these inputs should be conducted under the auspices of GTOS and in close co-ordination with C-GOOS programmes. Initial links between GTOS and C-GOOS may be effected most efficiently *via* pilot projects. Examples include the following:

- (i) Co-ordination of projects related to primary production is a near-term possibility. The C-GOOS Pilot Project, "Algorithm Development for Coastal Waters" has been endorsed by the NEAR-GOOS Co-ordinating Committee which is also considering the possibility of developing a pilot project in the East China Sea to assess the effects of the Yangtze River dam. GTOS is planning a project that will employ remote sensing to estimate net primary productivity (NPP) of terrestrial ecosystems including the coastal zone. Both projects would benefit from co-ordination from planning through implementation.
- (ii) Marine and estuarine biodiversity is a priority concern of C-GOOS with a counterpart in GTOS. The Western Pacific Biodiversity pilot project is explicitly linked to the International Biodiversity Observation Year (IBOY). A parallel effort is being planned by GTOS to relate NPP to biodiversity as part of IBOY. Clearly, biodiversity is a shared concern, and collaborative efforts in the coastal zone should be explored.
- (iii) Land-use and the effects of land-use practices on living marine resources and the health of estuarine and coastal marine systems are important issues for both C-GOOS and GTOS. The proposed C-GOOS pilot project to assess the effects of nutrient loading on the Adriatic Sea would benefit greatly from simultaneous information on land-use, nutrient inputs, and dynamics of coastal lagoons. Collaboration would allow assessments of the relationships between land-use practices and changes in water quality and fisheries that would be invaluable in land-use planning and management.

C-GOOS and GTOS will co-ordinate the development of their design and implementation plans to optimize co-ordination and collaboration as appropriate.

## 6.6 DUTCH COASTAL ZONE MANAGEMENT PROGRAMME

An integrated coastal observing system is clearly important for the purposes of coastal zone management. As demonstrated by their Coastal Zone Management Programme. (J.H.M de Ruig & R. Hillen: Developments in Dutch coastline management: Conclusions from the second governmental coastal report, *Journal of Coastal Conservation* 3, 203-210, 1997.), the Dutch have made a major commitment to managing their coastlines. This reflects, among other things, the fact that 55% of the Netherlands lies within 75 km of the coast which support 65% of their GNP and a capital investment with an estimated value of \$2.1 trillion.

The Coastal Zone Management Programme was adopted in 1990 to stop a long-term landward retreat of the coastline. A policy of «dynamic preservation» was introduced at that time. This scheme was primarily aimed at safety against flooding and sustainable preservation. Preservation measures are taken in reference to a 1990 coast baseline map, and the main method used to counteract structural erosion is sand supply.

## **7. THE STRATEGIC PLAN**

The Panel agreed to the tentative outline of the Coastal GOOS Design Strategy (Toward the Implementation of C-GOOS) given below. The goal is to complete a first draft during C-GOOS-IV.

### **EXECUTIVE SUMMARY**

#### **I. GOALS**

#### **II. BACKGROUND**

- A. Coastal Issues & Rationale for a Global Coastal Strategy
- B. GOOS Design Principles for C-GOOS
- C. Benefits
- D. Relationship to Other GOOS Modules & Building on Existing Programmes

#### **III. THE CHALLENGE**

- A. Scales of Variability (spatial and temporal heterogeneity, land-sea interface)
- B. Detecting and Forecasting Change in the Coastal Zone (need for an integrated, global approach, e.g. international participation; integration of remote and *in situ* sensing, synoptic multidisciplinary measurements, timely access to and dissemination of data and information)
- C. Stressors, Indicators and Indices
- D. Operational Observing Systems for Coastal Waters
  - (i) Characteristics of Operational Programme
  - (ii) Operational Status of C-GOOS (the need for R&D)

#### **IV. DESIGN AND STATUS OF AN INTEGRATED COASTAL OBSERVING SYSTEM**

- A. Elements (Parallel development of regional scale pilot projects nested in a global C-GOOS Network)
  - (i) The Global Coastal Network (purpose, rationale)
    - a. document the global dimensions of local to regional patterns of change in coastal waters;
    - b. provide larger scale perspectives required to distinguish between locally generated patterns and those generated by regional-global scale changes;
    - c. the core measurements (properties to be measure, relationship to C-GOOS indicators of change, scales, platforms);
    - d. sampling guidelines.
  - (ii) Regional Pilot Projects (purpose, rationale, definition)
    - a. purpose of current exercise (systematic approach to thinking through the design process, identification of core variables, build the global network)
    - b. building the global network (demonstrate the usefulness of the end-to-end approach [proof of concept]; incorporate R&D needed for observing system to become operational [enabling research]; resolve patterns of variability on local-regional scales; make predictions on scales relevant to local-regional problems; provide larger scale context for research programmes for more robust interpretation of research results)
  - (iii) Soliciting New Pilot Projects (need and procedures for)
  - (iii) Incorporating Relevant Programmes (e.g. relationships to IGBP programmes and their legacies)

- B. Design Process
  - (i) Final Prediction
  - (ii) Lead Time
  - (iii) Models, Model Outputs and Inputs
  - (iv) Feasibility and Impact
- C. Data Management (protocols, dissemination, access, archival, QAQC)
  - (i) The Global Network
  - (ii) Pilot Projects
  - (iii) C-GOOS & J-DIMP
  - (iv) Products: Linking with the GOOS Services Module
- D. Capacity Building
  - (i) The Global Network
  - (ii) Pilot Projects

## V. NEXT STEPS

## VI. SUMMARY & CONCLUSIONS

### APPENDICES

- A. Pilot Projects Recommended for Implementation
- B. Listing (with brief description and status) of Existing Observing Networks

## 8. INTERSESSION ACTION PLAN III

Writing assignments in preparation for C-GOOS-IV are outlined below (subcommittee chairs are in bold) All Panel members were encouraged to initiate discussion and a C-GOOS Web site has been established for Panel members to collaborate in the preparation of their reports. Panel members were also asked to review «Toward a U.S. Plan for an Integrated, Sustained Ocean Observing System.» (<http://core.cast.msstate.edu/NOPPobsplan.html>).

### 8.1 THE GLOBAL NETWORK

- 8.1.1 Design** (Thompson, Hall, Kiefer, Malone, Marone, Needler, van der Meulen)
- 8.1.2 Benefits and Products** (Hall, Crossland, Ehler, Guddal, Pacyna, BR, van der Meulen)
- 8.1.3 Data Management** (Wang, Walker)
- 8.1.4 Capacity Building and Enhancements** (Marone, Awosika, Gomez, BR, Ulloa)
- 8.1.5 Existing Operational Programmes: Potential Building Blocks** (Aarup, Gomez)
- 8.1.6 Implementation Mechanisms** (Needler, Guddal)
- 8.1.7 Soliciting New Pilot Projects** (proposed or existing programmes) (Malone)

### 8.2 PILOT PROJECTS

- 8.2.1 Biodiversity and Habitat: Western and Indo-Pacific, PhytoNet** (Zingone, Duarte, Gomez, Kiefer, Ogden, Shirayama, Thompson)
- 8.2.2 Coastal Circulation and Natural Hazards: Eastern South Pacific, Western South Atlantic, West Africa, Vietnam** (Needler, Awosika, Guddal, Marone, BR, Ulloa, Walker)

### 8.3 COLLABORATIONS

- 8.3.1 LOICZ/C-GOOS Collaboration** (Crossland, Hall, Pacyna)
- 8.3.2 GTOS/C-GOOS Collaboration** (Christian, Malone, Marone, Shirayama)

8.4 MECHANISMS FOR SUSTAINING AND ENHANCING C-GOOS (Ehler, Hall, Guddal, Malone, Pacyna) life after the C-GOOS Panel

8.5 USER GROUPS/STAKEHOLDERS:

Identify individuals and institutions in government, private industry and science that should receive copies of the GOOS Services and Products Bulletin and the C-GOOS Strategic Plan (Panel).

## ANNEX I

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## **ANNEX II**

### **AGENDA**

Stakeholder-user group meeting on Monday, 12 April 1999

Panel Meeting, 13-15 April 1999

**1. OPENING** (Koranteng, Malone, Aarup)

**1. WORKING ARRANGEMENTS**

- 2.1 ADOPT AGENDA (Malone)
- 2.2 DESIGNATE RAPPORTEUR (Malone)
- 2.3 LOGISTICS & ADMINISTRATION (Koranteng, Aarup)

**2. GOALS AND BENEFITS OF C-GOOS**

- 3.1 OVERVIEW (Malone)
- 3.2 THE SCIENCE BASE FOR EuroGOOS (Pacyna)
- 3.3 LOICZ AND C-GOOS (Crossland)
- 3.4 C-GOOS AND OOPC (Needler)
- 3.5 INDICATORS (Malone)
- 3.6 THE SCIENCE BASE FOR C-GOOS (group)

**4. GLOBAL INVENTORY OF COASTAL DATA AND PROGRAMMES**

- 4.1 STATUS OF INVENTORY (Aarup)
- 4.2 COASTAL TYPOLOGY (Crossland)
- 4.3 KEY ISSUES FOR C-GOOS (group)

**5. C-GOOS PRODUCTS AND USER GROUPS**

- 5.1 RESULTS OF ACCRA STAKEHOLDERS MEETING (Awosika, Koranteng)
- 5.2 GOODS & SERVICES MODULE C-GOOS USER NEEDS AND THE SERVICES & PRODUCTS BULLETIN (Guddal)
- 5.3 EFFECTING CRITICAL LINKAGES WITH USER GROUPS (Hall)
- 5.4 KEY ISSUES FOR THE DESIGN OF C-GOOS (group)

**6. CAPACITY BUILDING**

- 6.1 GOOS CAPACITY BUILDING COMMITTEE (Marone)
- 6.2 PRINCIPLES OF CAPACITY BUILDING FOR C-GOOS (Gomez)
- 6.3 KEY ISSUES FOR THE DESIGN OF C-GOOS (group)

**7. THE GLOBAL NETWORK**

- 7.1 DESIGN (Thompson)
- 7.2 CORE MEASUREMENTS AND R&D NEEDS (Aarup, Guddal)
- 7.3 CAPACITY BUILDING (Marone, Gomez)
- 7.4 DISCUSSION AND NEXT STEPS: BUILDING ON EXISTING PROGRAMMES AND OTHER ISSUES (group)

## **8. PILOT PROJECT PROPOSALS**

### **8.1 DESCRIPTION**

- 8.1.1 Eastern South Pacific** (Ulloa)
- 8.1.2 Remote Sensing Algorithm Development For Coastal Waters** (Kiefer)
- 8.1.3 Harmful Algal Blooms** (Zingone)
- 8.1.4 PhytoNet** (Zingone)
- 8.1.5 Adriatic Sea** (Malone)
- 8.1.6 CARICOMP** (Malone for Ogden)
- 8.1.7 Seagrass Network (SEAGNET)** (Malone for Duarte)
- 8.1.8 Southwest Atlantic** (Marone)
- 8.1.9 Coastal Hazards in the IOCEA Region** (Awosika)
- 8.1.10 Vietnam Coastal Disaster Warning System** (Guddal)
- 8.1.11 Western Pacific Biodiversity** (Shirayama)

### **8.2 PROJECT BY PROJECT EVALUATION (group)**

## **9. JOINT PROJECTS AND CO-ORDINATION ISSUES**

- 9.1 GTOS (Bob Christian)
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## **10. INTERSESSION ACTION PLAN III**

- 10.1 DRAFT THE STRATEGIC PLAN FOR C-GOOS
- 10.2 DATA AND INFORMATION MANAGEMENT
- 10.3 VENUE AND PREPARATION FOR C-GOOS IV (Link with EuroGOOS?)
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## **11. OTHER BUSINESS**

- 11.1 INTEGRATING HOTO, LMR AND C-GOOS MODULES (Aarup)
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### ANNEX III

#### EFFECTING CRITICAL LINKAGES BETWEEN C-GOOS AND END-USERS

At the second C-GOOS meeting we were asked to draft a document outlining approaches for promoting functional linkages between C-GOOS and end-users for use in the design and implementation plans. For C-GOOS to be successful there must be strong links with the end-users of C-GOOS products and end-users must be involved in the design and implementation of C-GOOS.

A number of the design principles of GOOS highlight the need for effective two-way communication of ideas and information between C-GOOS and end-users.

- D1 The GOOS is based on a plan designed to meet defined objectives on the basis of user needs.* To achieve this design principle C-GOOS must have effective linkages with the end-users be they industry, resource managers or public interest so that end-user needs can be clearly identified and GOOS products made as useful and relevant as possible.
- D2 The design assumes that the contributions to GOOS are long term and systematic.* This highlights not only the need for effective linkages but also the need for some of these linkages to be maintained in the long term.
- D3 The design will be reviewed regularly.* This identifies the need for long-term ongoing interactions with the end-users of C-GOOS again reinforcing the need to ensure products are tailored to the end-users.
- D4 The design takes into account the existence of systems outside GOOS that can contribute to and/or benefit from GOOS.* To be able to take into account existing systems C-GOOS must be aware of existing systems that are currently used by the potential end-users of C-GOOS.

The above design goals highlight the need for effective two-way flow of information of ideas and information between C-GOOS and its end-users in both the short and long term. This is not always simple to achieve, as there are a number of barriers to effective communication between scientists (who are the primary planners of C-GOOS) and end-users. This document will outline some general approaches that could be used to develop effective linkages between C-GOOS and end-users and some of the issues that will need to be considered. These include defining the aim of the interaction, the participants in the interaction, the type of interaction that might be used, funding of the interaction, and barriers to effective interaction and ways of removing these barriers.

#### **Defining the aim of the interaction**

To initiate effective interaction between C-GOOS and end-users there must first be a clear definition of the aims of any particular interaction. This aim must be clear, well defined and worded in such a way that it is comprehensible to all of the potential participants. For example:

- Identify appropriate C-GOOS products for the aquaculture industry in a region;
- Identify and prioritise appropriate C-GOOS products for the shipping industry in a region.

All participating groups must also agree upon the aim.

#### **Participants**

The aim of the interaction will determine the groups that should be represented. For example there would be very different groups represented to address the aims outlined above.

The potential participants are likely to come from a number of groups. These include:

- Representatives of government agencies at all levels;
- Major economic interest groups, e.g. industry, agriculture, tourism;
- Environmental non-government agencies (NGOs);
- Public interest groups;
- Indigenous and/or subsistence user groups;
- Scientific community.

The aim will also determine the type of skills the participants will require. It is important the individual participants have the skills (including communication skills) to participate effectively. This will enable them to be effective representatives and participants.

### **Type of interaction**

There are numerous ways for people to interact effectively. The aim of the interaction and also the number and backgrounds of participants in the interaction will need to be considered before a type of interaction can be decided upon. There are numerous ways to achieve an aim and in many cases a range of different types of interaction may be required. For example;

- an initial workshop with speakers from each of the key groups may be needed to present information from the different groups before any discussion of the issues can be initiated;
- a group might be used as a «sounding board» for a proposal by a technical group and this might be achieved using email.

When developing linkages with a particular sector group it is important to identify networks of individuals or companies that could be utilised. This maybe particularly effective for ongoing long-term interactions.

The period of the interaction is also an important factor in considering the type of interactions that might be required. In some cases this may be as short as a one-day workshop in others there maybe a requirement for a long-term interaction over a number of years. For longer term ongoing interactions electronic methods of communication maybe a useful approach.

### **Funding of the interaction**

The requirement for funding of an interaction will also vary with the aim and the participants. It is often relatively simple for private sector groups to provide funding for representatives to participate. For example industry, consulting firms, industry groups can generally finance participation of their representatives and in some cases environmental and other NGO groups with full time staff can allocate resources to ensure ongoing participation. It is considerably more difficult for public interest groups to sustain participation particularly over an extended period of time. In some cases to achieve effective interactions C-GOOS will need to consider how these interaction can be funded.

### **Differences in approach and knowledge**

Differences in approaches and knowledge can be a critical barrier that needs to be overcome to achieve effective interactions between C-GOOS and the end-users or between end-users. These differences can lead to misunderstandings, misuse of products and result in conflict and competition rather than co-operation. For example the following table highlights some of the differences in approach between scientists and some potential end-users.

Behaviours and Points of View Typically Associated with the Cultures of Science and Users

Factor	Science	Users
Valued action	Research, scholarship	Decisions, results
Time frame	Whatever needed to gather evidence	Immediate, short-term
Goal	Increase understanding	Manage immediate problems
Basis for decisions	Scientific evidence	Science, values, public opinion, economics
Expectations	Understanding is never complete	Expect clear answers from science
Grain	Focus on details, contradictions	Focus on broad outline
Worldview	Primacy of biological, physical, chemical mechanisms	Primacy of political, social, interpersonal, economic mechanisms

Source: 1995, National Research Council, Science, Policy, and the Coast: Improving Decision-making, 85 p.

To overcome differences between groups it is important to:

- develop an understanding between groups and individuals that is based on mutual respect and understanding of the different perspectives the groups represent. This does not mean admiration or agreement but a simple acceptance that another party has a legitimate status and role in the process;
- communicate at a level that enables all participants to understand the issues and other groups' point of view. To achieve this there may need to be capacity building that brings all the participants to a similar level of knowledge before an effective interaction can take place.





## ANNEX IV

### GOOS SERVICES AND PRODUCTS BULLETIN

*Submitted by Johannes Guddal, president of CMM*

#### SUMMARY

It is proposed to establish a **GOOS Services and Products Bulletin (GSPB)**. This document describes the background for the proposal and the tentative structure for the proposed bulletin, and suggests, correspondingly, terms of reference in the final section.

#### MOTIVATION

There is an obvious need to enhance the awareness of GOOS and its benefits, in particular among its various stakeholders. Further, a broader, publicly oriented information is considered helpful to stimulate attention among more high-level decision-makers, such as within maritime authorities and industry. Strong needs have been identified among stakeholders and users to learn more from services/products already operationally available, their quality, cost/benefits, and impacts. Further, steps should be taken to ensure and protect high quality professionally in the organization and making of GOOS services and products. The Bulletin, governed and advised upon by exclusively qualified experts, must take on this responsibility. Even further, there will be a need to monitor GOOS progress on the global level, as well as to make regions able to compare each other achievements.

#### RECIPIENTS

Although the GOOS Bulletin information must be open, it is in principle aimed for the stakeholders and end-users, such as:

- policy makers (such as implementers of SOLAS and follow-ups of Agenda 21);
- managers and planners within ocean related authorities and industry;
- operators within the same sectors;
- the public, the media, etc.

#### FORMAT AND FUNCTIONALITY

The Bulletin must have an easy-to-read format and a logical structure corresponding to GOOS modularization and regionalization. Regional progresses and scenarios must also be projected into a global scenario. Strong emphasis is put on the presentation of user feedback. The Bulletin shall be available on the Web, updated monthly, and on paper with 6 monthly editions.

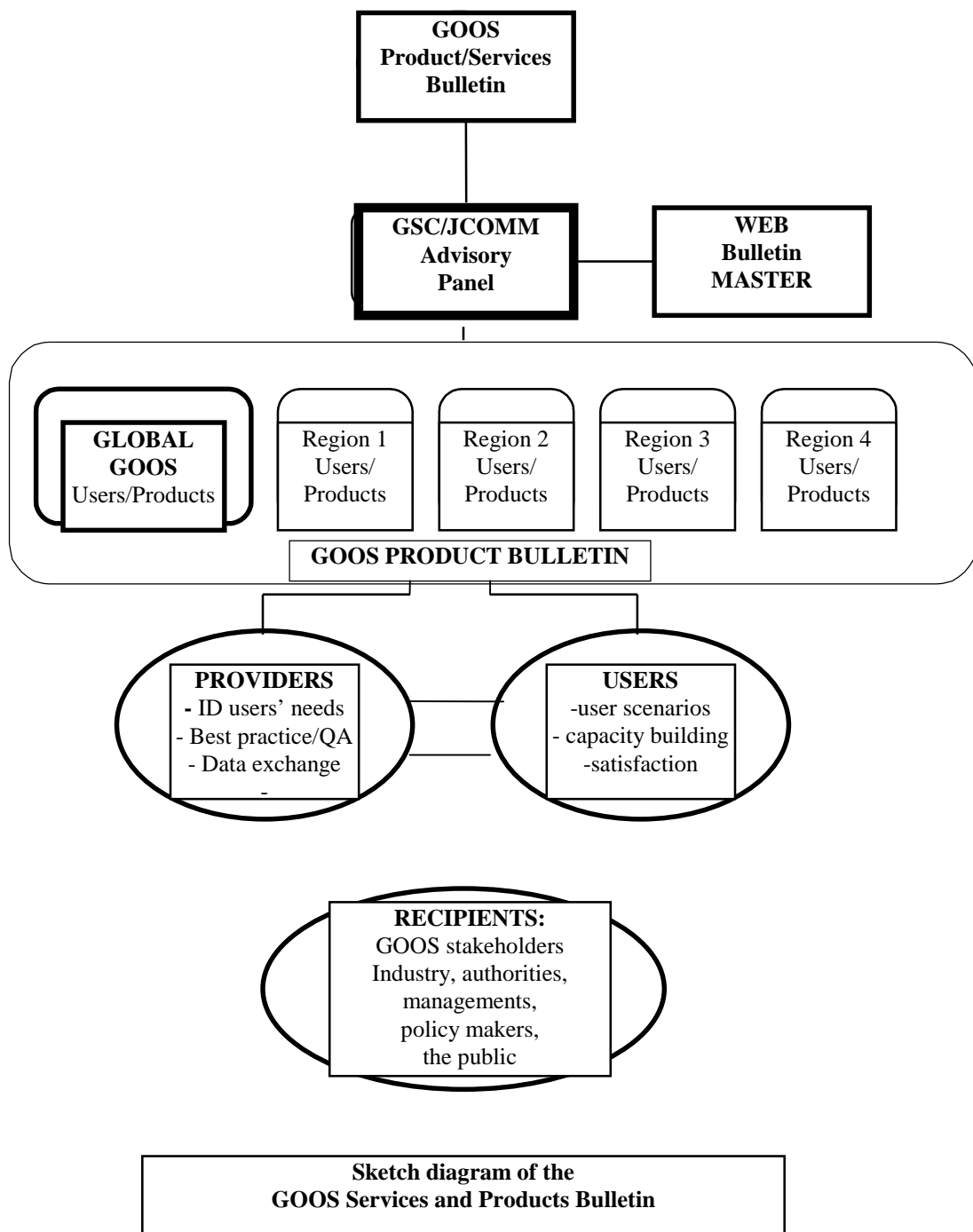
#### CONTRIBUTIONS, QUALIFICATION AND CRITERIA

Contributions must be accepted by an Editor Board, in the first implementation phase an *ad hoc* Advisory Panel composed from GSC and JCOMM. General quality criteria will be defined on the basis of 'best practice' considerations and documented scientific/technological qualification. Representatives from different stakeholders and users will be invited to contribute within GOOS product applications within their respective sectors, their satisfaction with the products, and the socio-economic impacts. The term 'operationality' shall imply that the production process is well documented, so that QA audits are possible, and that there is an active end-user community responding to the usefulness of the products.

#### ORGANIZATION

At GSC-I, it was recommended to seek capitalization on the IGOSS Electronic Bulletin. This recommendation was followed up, and positive responses were obtained from Dr. Yves Tourre, who is

responsible for the IEB. The IEB is already on the Web with a comprehensive set of ocean information products. The following sketch diagram illustrates one possible structure and organization of the Bulletin.



## **TYPICAL CONTENTS**

The contents of the GSP Bulletin would be those of the already existing IEB, enhanced with a range of additional contributions from different sources, such as:

- typical existing CMM member (and also private agencies) operational products, for example: wave, surge, current, sea ice nowcast/forecast/hindcast;
- «new GOOS» products within the full range of physical/chemical/biological oceanography; including both models and instrumentation products;
- «user satisfaction» articles represented from outstanding users or users constituencies;
- «GOOS stakeholders» feedbacks, such as environmental policy-makers.

## **USER SCENARIOS**

A set of user scenarios will be included, intended to guide potential users in the sense of judging potential candidates for production, and to assess the potential significance and impact within their domains of responsibility. User scenarios will also help to educate policy makers on their need for decision support, particularly in cases when more high level educational services are requested.

## **TERMS OF REFERENCE**

The GSPB shall have the following terms of reference:

- (i) The Bulletin shall facilitate GOOS state-of-art and progress information to GOOS stake-holders, users within industry and authorities, and to the public;
- (ii) The contents of the Bulletin shall describe typical operational oceanographical products from the IGOS domain, qualified CMM members and private agency products, and new GOOS operational products as they appear through the progress of GOOS at the national, regional and global scale;
- (iii) Contributions shall obey to clearly stated criteria of quality assurance and documentation standards. In particular, the issues of free data exchange and product availability shall be emphasized;
- (iv) Contributions shall be invited from GOOS stakeholders and outstanding users, in order to present the end user application of products, their quality, their compliance with QA requirements, user satisfaction, cost/benefit, and, if possible, socio-economic impacts;
- (v) The Bulletin shall in its first phase be conducted by an ad hoc Advisory Panel appointed by IGOS and JCOMM. As new GOOS products appear, the panel must be reorganized in order to reflect the roles of the other sectors of operational oceanography; the chemical and the biological;
- (vi) The web part of the Bulletin shall have a GSC/JCOMM appointed web master. Web updates will be required monthly;
- (vii) The Bulletin shall be published in paper on a 6 monthly basis. Responsible candidate organizations are to be found.
- (viii) The funding of the Bulletin must be discussed; possibly funding must be obtained by subscription;
- (ix) The scope of the Bulletin may be revised at a later stage. Possibly, at some stage, the Bulletin could advertise Capacity Building services in parallel to 'conventional' nowcast/forecast/hindcast/climatological products.

### **The GOOS Services and Products Bulletin. Addendum 1**

Submitted to the JCOMM transition meeting, St. Petersburg, 19 - 23 July 1999

This addendum is written in order to include issues or events that have occurred during and after the submission of the proposed GOOS Bulletin document to the GSC in Beijing in April 1999. Even before the GSC meeting it was also presented to C-GOOS III in Accra early in May 1999, and received positive support from the CGOOS members. Further, EuroGOOS has established its own working group on EuroGOOS Products and Services, with, as part of its terms of references, to contribute directly to the proposed bulletin. (In the following we should include the formal GSC report text when it becomes available).

GSC supported the Bulletin proposal, with some remarks regarding the availability of Internet in some developing countries. A hard copy version will have to be included. A transition period is foreseen where most of the work will be done on a voluntary contribution basis, building on the existing IGOSS Electronic Bulletin. An editorial board (or advisory panel) of 10 - 15 persons will be established.

Some emphasis must be put on recruiting contributors from the user communities, such as from offshore oil industry, coastal management, environmental policy makers, etc. Implicitly, this can be achieved by attending conferences in users' *fora*, and to invite them by personal communication.

## ANNEX V

### PRINCIPLES OF GOOS CAPACITY BUILDING (1 April 1999)

#### CAPACITY BUILDING: THE SETTING

Through dedicated research efforts our understanding of the ocean system has increased greatly during recent decades. Ocean science is still largely observational in nature, though modelling and forecasting are playing rapidly increasing roles. Society, however, is not yet fully benefiting from the results of ocean science. In view of the major issues currently facing society it is imperative that use be made of scientific and technological breakthroughs. Science plays a key role in development as demonstrated in the World Science Reports of UNESCO and many recent studies of the World Bank. However, solving society's needs requires not only capacity for making observations, forecasts and other products but also the capacity to communicate these results to the public and policy makers.

All too often, the coastal countries in the developing world with the lowest capacity for marine research and production of needed marine products are also the ones most vulnerable to potential effects of climate change such as rising sea levels, to the consequences of coastal disasters and marine pollution, etc. Sound advice from local experts is essential for policy makers in such countries. To develop the local expertise requires a series of conditions, including well-developed science education, marine science training, a sound scientific research base, and well-equipped national oceanographic services that are fully integrated into a global network. Thus, marine capacity building is a challenging assignment.

The United Nations Convention on the Law of the Sea (UNCLOS), in defining the Exclusive Economic Zone, gave coastal states the right to use and the obligation to protect and manage their resources within at least 200 miles of their coasts. The United Nations Conference on Environment and Development (UNCED), through the conventions on biodiversity and climate change and through the publication of Agenda 21, committed countries to sustainable use of the environment and the development of a global monitoring system. More recently, the awareness of policy-makers and the public was raised further through the United Nations International Year of the Ocean (1998) and the report in that year of the Independent World Commission on the Oceans, which called for a new model of global governance. One element of this model must be an ocean observing system, along with the building of capacity throughout the world needed to make it work.

#### CAPACITY BUILDING: THE PROCESS

Developing and strengthening marine research and observational capacity involves human resources, the necessary institutions, and environments that support and sustain observational activities. These components must be integrated to form a single observing system. Procedures for integrating these components are not clear-cut.

There are large differences between individual countries with respect to the level of existent capability for an observing system. Three different stages can be identified. In the *initial stage*, research capacities are quite limited. This is often the case in poorer countries (e.g. Mozambique, Madagascar). In the *transitional stage*, research capacity is developing. Although a research community may be available, its development may be uneven due to lack of sustaining funding, planning, and national research policy. The capabilities in Kenya, Nigeria, Tanzania, and Pakistan are examples of this situation. In the *developed stage*, the research system and the research community are dynamic, well linked to society and the economy, and are self-sustaining. This is the case in most industrialized and industrializing countries, such as Brazil, India, Indonesia and Thailand. Because of such differences between countries, GOOS capacity building activities must be tailor-made to the specific needs of a country or a region.

A number of overall conclusions can be drawn about marine capacity building. It is a long-term process. The involvement of the government is crucial. Approaches should be tailored to specific country or regional needs. For building an indigenous capacity, the active involvement of the community in the developing

countries is necessary. Partners in these countries are the most effective and persistent advocates for marine science and technology. Capacity building activities can vary from a training course to the implementation of a complete environmental monitoring system. The best instruments for capacity building are activities in which scientists, technicians, and users work closely together (learning by doing, teaching the teachers) in the execution of projects, programmes, and partnerships. Governments, scientific and international organizations, the private sector, and donors should join forces in capacity building. In this regard, substantial capacity building also is needed between the science foundations and donor organizations (even in industrialized countries) because most donor organizations are unsure of marine issues. Finally, all participants must recognize the need to maintain capacity once it has been built. Creation of awareness in the minds of the public and policy makers is essential for raising national and international support.

## **CAPACITY BUILDING: THE ROLE OF THE IOC**

The IOC has a leading role to play in supporting the creation and strengthening of national mechanisms. To do so it has established several regional subsidiary bodies. Although all the IOC subject area programmes underpin the required actions, it is the IOC/TEMA (Training, Education and Mutual Assistance in marine sciences) Capacity Building Programme that acts as a catalyst, with advisory, co-ordinating, and facilitating roles. It should also act as a link with potential donor agencies able to provide financial resources for implementation. A programmatic approach to TEMA, as within GOOS for instance, is desirable to help ensure that the capacity building process is linked to existing and planned national and regional programmes, thereby enhancing the success rate of capacity building.

The IOC's regional intergovernmental subsidiary bodies provide mechanisms to stimulate capacity building for GOOS and other IOC programmes, as appropriate, with analogous mechanisms of sister organizations such as WMO, UNEP, UNDP, ICSU. The IOC regional bodies formulate and agree on co-operative regional projects built on national actions and addressing identified national and regional needs and priorities. They aim at regional pooling of resources and joint capacity building, and draw upon the global programmes of the IOC, for expertise, results, and advice. Together, the IOC, nations, and appropriate donors (including the private sector) must provide financial support for these projects.

The IOC/GOOS is developing principles and a programme to develop national capabilities in marine sciences and services. This programme for the building of capacity involves a wide range of activities, depending on the starting capacity (level of ability) of the nation concerned. The activities fall under the general headings of training, education, and mutual assistance; within the IOC they are managed through the TEMA Capacity Building Programme. The first steps in building capacity are raising awareness of the activities involved, the benefits that may accrue from participation, and the likely costs. The building of capacity of all countries to participate in and benefit from GOOS on a continuing basis is regarded as essential for the effective development of a continuing global ocean observing system. Donor countries stand to benefit from their investment in the capacity of developing countries because it will lead to fuller development of GOOS, from which donor countries will benefit—as will developing ones. (The goals of IOC capacity building are given in Appendix A.)

## **GOOS CAPACITY BUILDING OBJECTIVES**

Capacity building in relation to GOOS is carried out by three partners: (i) recipients or local, national or regional beneficiaries of the activities; (ii) national or international donor agencies, the private sector or countries; and (iii) the GOOS organization with its sponsors.

In the OECD (Organization for Economic Co-operation and Development) countries, the existing infrastructure will underpin many of GOOS activities. This is not true of many countries, where the necessary infrastructure is only partly or poorly developed. Where such infrastructure does not exist, strategies should be implemented to meet the following needs of nations:

- The need to develop and maintain a minimum scientific capability to support and participate in GOOS-related activities, including among others coastal zone and fishery resource management;

- The need to raise understanding of the value of *in situ* and space-based observations of the ocean to solving socio-economic problems. Efforts must be made to educate the public and politicians regarding the benefits to be obtained from investing in developing, maintaining, and utilizing ocean observation systems;
- The need for ocean data, including satellite measurements and *in situ* measurements necessary for their calibration, validation, and augmentation. (Special efforts should be made to create and sustain baseline networks in the coastal waters and EEZ of high quality surface-based stations or sections in a wide range of climates. Many of these are likely to be in countries requiring assistance);
- The need to raise the ability of countries to contribute to and benefit from global observing systems. There must be a long-term investment in facilities for receiving, processing, and interpreting data from ocean and space-based sources to be accompanied by training in the use of such facilities and in the provision of services and products. (Services and products are likely to relate to seasonal predictions, drought and severe storm monitoring, sea-level rise, regional climate change, coastal zone and fisheries management, coastal protection, coastal pollution, harmful algal blooms, coral reef disturbance and recovery and the like).

Examples of actions required to meet these objectives are included in Appendix B.

## **GOOS CAPACITY BUILDING: APPROACHES**

Effective GOOS capacity building is a long-term process which starts with the potential users and their needs. An important instrument is partnerships between countries with a more and a less advanced marine capacity. These partnerships may involve bi-lateral or multi-lateral relationships. Yet, the underlying objective is that the interests and commitments of all partners must be considered prior to taking actions. GOOS capacity building activities should be harmonized to the extent possible with those of other entities, including organizations and states interested in the region. A major part of the financial support must come from agencies/states located or interested in the region.

It should be remembered that many capacity building activities are undertaken on behalf of the Global Climate Observing System or the Global Terrestrial Observing System as well as GOOS. Thus, it is imperative to retain close connections between the global observing systems when planning new capacity building initiatives.

### ***National***

To facilitate an active involvement in GOOS capacity building, countries should consider the creation of National GOOS Steering Committees in which all of the key stakeholders (government departments, private sectors, and academic institutions) are brought together to define the user needs and find ways of meeting them. The chairman of this committee should act as a national focal point. This committee also acts as a national focus for GOOS capacity building. The National GOOS Steering Committees might be expected to:

- Define user needs and specify data and products required to satisfy those needs;
- Identify and suggest improvements to existing national capabilities;
- Identify gaps in those capabilities and suggest corrections, including training and practical assistance as well as gap filling;
- Promote communication among marine scientists, environmentalists, and coastal zone managers;
- Encourage design and implementation of regional strategies for data acquisition, communication, synthesis, and dissemination of needed products;
- Encourage pilot projects to demonstrate the usefulness of the GOOS approach;
- Evaluate costs and benefits as a basis for persuading governments, donor agencies, and the private sector to support GOOS initiatives;
- Actively search for partners to initiate the GOOS capacity building process.

### ***Regional***

Capacity building often is most effective when the region is entrained as a partner. The capacity building needs are formulated jointly by partners from industrialized and the relevant developing countries (here the national GOOS Steering Committees should play a pro-active role). Potential funding agencies (donors, private-sector) should participate in this endeavour in an early stage. If possible, regional offices or officers based at an existing regional office, should be staffed or augmented with individuals from the region. It is important to circumscribe the area of responsibility for a regional office/officer to avoid over commitment and false expectations. It is important to network with regional institutions (such as the regional IOC offices) and pertinent operational agencies.

GOOS will continue to evolve. Regional offices will help to sustain the capacity building activity by assisting with continuing upgrades of new communications, models, sampling technology, products, and other needs. Regional organizations (e.g. the South Pacific Applied Geoscience Commission [SOPAC]) already having operational responsibilities should be fully utilized by the GOOS system because it is imperative to have access to staff, support systems, communications, data facilities, and other infrastructure, particularly in regions lacking such capabilities.

Needed are multi-year GOOS development plans (which can include a number of partnerships) that identify the needs of the users in the region, the requirements for GOOS implementation in the region, the capacity building needs related to that implementation, and sources of funding support. Regional representatives must be involved in developing all elements of this plan. Finally, it is important to keep a keen eye on how these activities will support the implementation of the global GOOS. Regional activities just as national ones, are parts of the global jig-saw puzzle leading to a truly effective Global Ocean Observing System.

### ***Global***

Building a global GOOS is a challenge. At present, GOOS development is progressing most in industrialized countries with well-developed marine science capability and a keen interest in and need for marine operational activities. This is expected, but unfortunately GOOS capacity building activities are often given low priority in these countries, partly for economic reasons. Another obstacle to be overcome is that many donor agencies do not understand the potential benefits for both the donor and recipient countries. Even so, change from short-term project funding to long-term, focussed programmatic funding is happening in some donor organizations. The consequence of the present difficulty and delay in obtaining support for capacity building is that developing countries often feel disappointed because follow-up activities take long times to materialize.

## **GOOS CAPACITY BUILDING: ORGANIZATIONAL**

### ***Composition of the Panel***

A strong and continuing link must be maintained between the GOOS Steering Committee and GOOS capacity building activities. The GOOS Capacity Building Panel should be constituted as a resource and steering committee reporting to the GOOS Steering Committee and through that committee to the I-GOOS.

The Panel should have one representative from each GOOS module panel and representation from the GOOS Steering Committee (including representation of countries needing assistance). The Panel chair should be independent of the GOOS organizational structure.

GOOS is intended to serve the needs of users. The Capacity Building Panel is one link between users and developers of GOOS. Thus, it is important to include in the membership of the Panel representatives of private sector users to provide guidance to the Steering Committee regarding user needs and to communicate GOOS plans and common requirements to users.



To promote understanding and strengthen support of GOOS Capacity building, representatives of GOOS sponsoring agencies and potential donor agencies should be invited as affiliates to the Panel meetings.

*Ex officio* membership on the Panel should include that person at the IOC/GOOS Office with overall responsibility for GOOS capacity building and a representative of TEMA (who may be the same person representing the Office).

### ***Terms of reference***

The terms of reference for the GOOS Capacity Building Panel are to:

- (i) initiate, plan, and oversee the implementation on GOOS capacity building through the development of key demonstration projects carried out within the GOOS implementation process. (Required is a series projects closely related to development activities. As an example, the GODAE offers opportunities for projects to strengthen data and information capabilities in developing countries. Demonstration projects might also be formulated by major research programmes such as those of the World Climate Research Programme [WCRP] or IGBP);
- (ii) develop a plan to be submitted to ODA organizations to obtain funding for GOOS related capacity building activities (The IOC lacks funding adequate for all needed activities);
- (iii) create awareness of GOOS capacity building (The uses of products and information from the oceans must begin with awareness at all levels in society of their value);
- (iv) develop standardized mechanisms and tools to be applied in GOOS capacity building activities;
- (v) initiate and assist in the development of multi-year regional plans for GOOS capacity building, including partnerships with developed regional activities. (As examples of partnerships, EuroGOOS might offer opportunities for Africa and Eastern Europe; ENSO research partners could join together and initiate related activities in the Pacific).

## **APPENDIX A: DEFINITION OF IOC CAPACITY BUILDING**

Recognizing that many coastal states lack the capabilities in marine science required for them to fully participate in, contribute to, or benefit from the four main themes of the IOC:

- (i) To develop, promote and facilitate international oceanographic research programmes to improve our understanding of critical global and regional ocean processes and their relationship to the sustainable development and the stewardship of ocean resources;
- (ii) To ensure effective planning, establishment and co-ordination of an operational global ocean observing system to provide the information needed for oceanic and atmospheric forecasting, for ocean and coastal zone management by coastal nations and for global environmental change research;
- (iii) To provide the international leadership for education and training programmes and technical assistance essential to systematic observations of the global ocean and its coastal zone and related research;
- (iv) To ensure that ocean data and information obtained through research, observation, and monitoring are efficiently handled and made widely available;

The IOC has developed a cross-cutting theme focussed on the development of national capabilities in marine sciences and services. The IOC Programme for this building of capacity involves a wide range of activities, depending on the starting capacity (or level of ability) of the country concerned. The activities fall

under the general headings of Training, Education, and Mutual Assistance, and are managed through the TEMA Programme, which includes technology transfer. A first step in building capacity is raising awareness of the activities involved, the benefits that may accrue from participation, and the likely costs.

## **APPENDIX B: EXAMPLES OF CAPACITY BUILDING ACTIONS REQUIRED**

Given the need for initial baseline networks of stations and sections as part of an integrated global observing system, priority should be given to creating, strengthening, and/or rehabilitating reference stations or sections in the waters around nations requiring assistance.

Equally high priority should be given to establishing or improving data receiving, distribution, and processing centres in nations requiring assistance ensure full data acquisition and use. (In the context of GOOS, there are a number of data centres managed by the IOC's Committee on International Oceanographic Data and Information Exchange. Many need upgrading to incorporate the full range of multi-disciplinary data. Special centres should be created in a few places to handle advanced processing and assimilation of oceanographic data into regional ocean and climate models. Such is proposed by the Southeast Asian Centre for Atmospheric and Marine Prediction (SECAMP) project serving the needs of Southeast Asia from Singapore.)

It also is important to ensure that nations are capable of benefiting from and involved in environmental monitoring. This requires that:

- such countries have access to data and products along with the capacity to produce and utilize high-level products and data sets consisting of both satellite and *in situ* data;
- the introduction of new facilities be matched by training and supporting their use, particularly focussed on the generation of advisory services and products;
- scientists from nations needing assistance be able to participate fully in the work of major national and international centres engaged in advanced data processing, as for seasonal and climate scale predictions; and
- full use be made of existing capacity building programmes, such as IOC's Training Education and Mutual Assistance (TEMA) programme in the GOOS context, and START (the Global Change System for Analysis Research and Training) in the IGBP context.

## ANNEX VI

### DRAFT DESIGN FOR THE INITIAL OBSERVING SYSTEM OF COASTAL GOOS

*Keith Thompson (Chair), Julie Hall, Eduardo Marone, George Needler,  
Jozef Pacyna, Steven Walker and Adriana Zingone.*

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At the second C-GOOS meeting a group of us was asked to draft a design plan for the Global C-GOOS observing network. In Section 1 we review the goals of C-GOOS and the need for a global observing system. This section also contains a summary of the development of the global meteorological observing system and the draft plan for the initial observing system for the climate component of GOOS. In Section 2 we outline our approach to the design of the network and compare it to the approaches used to develop the meteorological and deep ocean observing systems. The elements of the global observing system for the coastal ocean are described in Section 3. Implementation and development of the global network are discussed in Section 4. Capacity building is discussed briefly in Appendix 2.

#### 1. BACKGROUND

The coastal ocean is presenting mankind with a number of pressing and complex problems (Table 1). Examples include eutrophication, loss of coral reefs and increased frequency of flooding associated with sea level rise. It is clear from these examples that solutions will be hard to find and will require a multidisciplinary approach.

An important objective for C-GOOS is to foster the development of a predictive capability for the coastal ocean. Potential users are policy and decision-makers in government, agencies responsible for regulating and managing the coastal zone, private industry, non-governmental organizations, scientists and the general public. To succeed C-GOOS will need a global observing system that can provide reliable data in a reasonable time frame, and models with a proven ability to predict changes in the marine environment. This document outlines a draft plan for the initial global observing system for the coastal ocean. Designing the system proved difficult for two main reasons. First the diversity and complexity of the problems is formidable. They are generally defined by non-scientists and require immediate answers (Table 1). The second reason is that relatively little is known about the scales of variability of the coastal ocean and the processes that cause them. Clearly one of the tasks for the observing system will be to gather data to optimise future system design and also deepen our understanding of the causes of change in the marine environment. Both steps are necessary in the development of a predictive capability.

How does one design a coastal observing network? Clearly a significant investment has already been made in observing systems. For example satellites are providing vast amounts of data on the surface properties of the coastal ocean. Another example is the global distribution of tide gauges, some of which have records stretching back two centuries. The observing system of the future will have to take advantage of, and will therefore be constrained by, the infrastructure already in place. However to be effective C-GOOS will also have to optimize its use of new observing technologies, recent advances in our understanding of the coastal ocean, and developments in computer modeling and data assimilation.

**Table 1: Some important problems affecting the coastal ocean**

<b>PRESERVE HEALTHY COASTAL ENVIRONMENTS (1)</b>
• Habitat loss and modification (e.g., Wetlands, SAV, coral reefs)
• Nutrient over-enrichment (eutrophication, anoxia)
• Toxic contaminants and oil spills
• Diseases in marine organisms
• Harmful algal blooms
• Non-indigenous species
• Bio diversity
<b>PROMOTE SUSTAINABLE USE OF COASTAL RESOURCES (2)</b>
• Exploitation of living resources
• Mariculture (pond and open water)
• Saltwater intrusion
<b>MITIGATE COASTAL HAZARDS (3)</b>
• Flooding
• Tsunamis
• Erosion
• Tropical storms and storm surges
• Sea-level change
<b>SAFE AND EFFICIENT MARINE OPERATIONS (4)</b>
• Safe navigation and efficient maritime commerce
• Exploitation of non-living resources
• Spills of hazardous materials (oil, chemicals)
• Ballast water (e.g., Transport and release of non-indigenous species)

*The numbers associated with the four categories are used in Section 3 in the definition of the variables to be measured by the global observing system.*

To provide a context for our design for a global observing system we summarize below the history of the development of the global meteorological observing system. Meteorologists have had to face many of the problems that now confront C-GOOS and much can be learned from their experience. We also review of the

work of the Ocean Observing System Design Panel (OOSDP)<sup>1</sup> in designing an initial observing system for the climate component of GOOS. In a sense this is the deep ocean component of the coastal observing system.

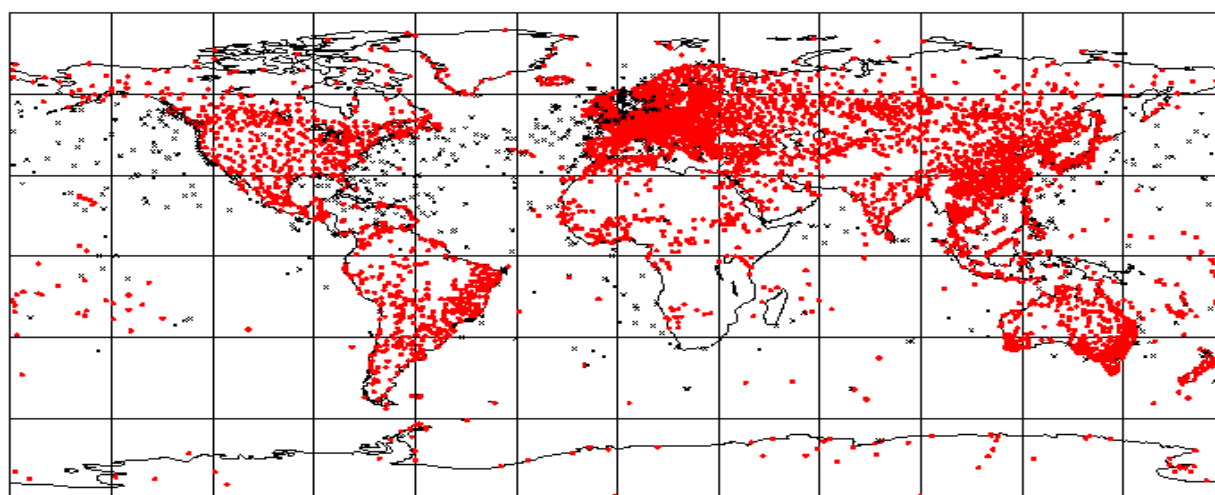
### 1.1 Development of the global meteorological observing system<sup>2</sup>

The roots of the present day global meteorological observing system stretch back over 300 years. Meteorological observatories started to make regular observations in the 1600s. The first attempt to organize an international observing network was undertaken by the Palatine Academy of Sciences and Letters in the late 1700s. The first permanent observing network, and the first national weather service, was established in France in the mid 1800s following a severe storm in 1854 that destroyed the French fleet in the Black Sea. The International Meteorological Conference of Vienna in 1873 established a permanent international committee to help standardize meteorological observations. As Daley notes this was not a trivial task: English speaking meteorologists took 75 years to adopt metric units.

By the beginning of the 1900s a real-time global observing system was in place. It was primarily a land-based, surface network with an uneven spatial distribution of observing stations. An upper air network was established in the mid 1900s. It employed balloon-borne radiosondes which provided vertical profiles of the atmosphere. In the late 1960s satellite-borne radiometers started to provide uniform global coverage, including the oceans which to that point had been poorly sampled.

The present day global meteorological observing system is known as the World Weather Watch and is run by the World Meteorological Organization. It has three components:

- The Global Observing System: The basic surface and radiosonde networks, aircraft and satellite systems run by the national meteorological services.
- The Global Telecommunications System: The infrastructure used to transmit and process observations.
- The Global Data Processing System: National and international meteorological centers that collect, process, archive and disseminate observations in near real-time. A complete set of global observations is usually available several hours after the time of observation.



**Figure 1: Positions of 1321 Voluntary Observing Ships providing data for assimilation into the ECMWF forecast model for 28 March, 1999.**

<sup>1</sup> The Ocean Observing System Development Panel, 1995. *Scientific Design for the Common Module of the Global Ocean Observing System and the Global Climate Observing System: An Ocean Observing System for Climate*, Texas A & M, College Station, 265 pp.

<sup>2</sup> This section is based primarily on Daley, R. 1991. *Atmospheric Data Analysis*. Cambridge University Press, Cambridge, NY, 457pp.

The above figure is an example of the data available for assimilation into the European Center for Medium Range Weather Forecasting (ECMWF) model. The gray crosses show the position of Voluntary Observing Ships contributing to the Global Observing and Telecommunications Systems.

Daley makes a number of points with regard to the global meteorological observing system that are relevant to the development of a coastal ocean observing system:

- The global meteorological observing system is a multipurpose network that requires international cooperation.
- Rapid communications are of the utmost importance.
- The system is based on many types of instruments and is controlled by many nations. This leads to great variation in coverage and data quality.
- The observations suffer from two types of error. First there is the straightforward instrument error which is a function of the instrument and ambient conditions. Then there is the error of representativeness which occurs when the scale of the phenomenon being observed is smaller than the spacing between the observing locations. This error can lead to the well-known problem of aliasing. To assess the magnitude of this error one needs an idea of the spatio-temporal scales of the phenomena being measured.
- Formal network design plays a relatively small role in the development of the international global observing network. It is important however for observing networks set up for the scientific study of specific phenomena.
- The future will see increased use of space-based instruments including lidars that measure Doppler shift in backscatter from aerosols to estimate wind velocity; radars to measure precipitation; radiometers to measure trace gases, land properties and ocean variables.

Similar problems must be faced in developing observing systems for the atmosphere and coastal ocean: irregularly spaced observing stations, many established for non scientific purposes and without regard for the scales of variability of the phenomena being observed; observations in different units and of different quality; the need for rapid data collection, quality control and dissemination; the provision of predictions in a form useful to the end user. There are also similar opportunities with the emergence of new observing technologies, particularly satellite borne sensors, and improved numerical models and data assimilation techniques. Based on the above historical summary, we conclude that the developmental stage of the coastal ocean observing system is similar in several respects to that of the global meteorological observing system of the 1960s.

There are also important differences in the development of global observing systems for the atmosphere and coastal ocean. The *raison d'être* for the meteorological system is the provision of data to initialize atmospheric forecast models; the observing system is designed for a single purpose and the quantities to be forecast, and the physics underlying the models, are clear. This is not the case for the coastal ocean. Here the observing system must provide data to address a far wider range of issues. In many cases the processes causing the observed variability are poorly known and statistical models are often the only way of making predictions. To further complicate the issue, predictions required for the coastal ocean are not be limited to forecasts with lead times of hours to days. They may be a simple spatial interpolation (e.g. what can be said about the loss of coral reefs globally given measurements at a few locations) or a prediction of coastal sea level in the next century.

## 1.2 The initial observing system for the climate component of GOOS

The initial observing system for the climate component of GOOS was designed by the Ocean Observing System Development Panel as detailed in its 1994 report *Scientific Design for the Common Module of the Global Ocean Observing System and the Global Climate Observing System: An Ocean Observing System for Climate*. This is a lengthy document, supported by 8 background papers. It describes a systematic approach to the design of a deep ocean observing system. The design is supposed to satisfy the needs of GCOS and the climate component of GOOS. Most of the goals for the climate component of GOOS are motivated by the need to understand and predict climate change (Table 2). The OOSDP recognized from the outset that data assimilative models will play a critical role in synthesizing observations and making predictions.

To design the observing system the OOSDP ranked sub-goals (see column 2, Table 2) and then assigned a level of importance to each of the observational elements required to attain each sub-goal. The report devotes considerable space to the feasibility and impact of the different observational elements, taking into account scales of variability and both types of observation error mentioned above. The main elements of the proposed deep ocean component of GOOS, along with some enhancements proposed for the Climate Variability and Predictability (CLIVAR), are summarized in Table 3. This table is not supposed to be definitive. Rather it gives an idea of the measurements that will be made by the climate component of GOOS and the level of detail that will eventually be required of C-GOOS as it finalizes the design of the global observing system for the coastal ocean.

**Table 2: Goals of the initial observing system for the climate component of GOOS**

Goal Rank		
<b>Surface fields and surface fluxes</b>		
<b>1a</b>	1	Provide <i>in situ</i> measurements of SST that, when combined with satellite measurements, are adequate for defining SST variability on monthly, seasonal, inter annual, and longer time scales. Where it can be determined with sufficient accuracy, sea surface salinity and its variability should be measured.
<b>1b</b>	1	To assist in providing data at the sea surface and in marine boundary layer needed to estimate global distributions of wind stress on monthly, seasonal, inter annual, and decadal time scales.
<b>1c</b>	2	To assist in providing surface data needed to estimate global distributions of the surface fluxes of heat and fresh water on monthly to decadal time scales.
<b>1d</b>	2	To provide the physical, chemical, and biological data required to describe the global distribution of sources and sinks for atmospheric carbon dioxide and the carbon exchanges within the interior of the ocean.
<b>1e</b>	2	To provide data to describe the extent, concentration, volume, and motion of sea ice on monthly and longer time scales.
<b>The upper ocean</b>		
<b>2a</b>	2	To provide global data for monitoring, understanding, and analyzing monthly to inter annual upper ocean temperature and salinity variations.
<b>2b</b>	1	To provide upper ocean data in the tropical Pacific for the initialization and verification of models for ENSO prediction.
<b>2c</b>	4	To provide upper ocean data outside the tropical Pacific for the understanding and description of ocean variability and for the initialization and development of present and future models aimed at climate prediction on seasonal to interannual time scales.
<b>The interior ocean</b>		
<b>3a</b>	3	To provide data to determine the changes in oceanic inventories of heat, fresh water, and carbon on large space and long time scales.
<b>3b</b>	4	To describe changes in the large-scale ocean circulation and its transport of heat, fresh water, and carbon on long time scales through the collection of data and their assimilation in models.
<b>3c</b>	1	To provide measurements of the long-term change in sea level due to climate change; in particular that arising from greenhouse gas warming.

The similarities in designing deep ocean and coastal systems are primarily in the variables to be observed e.g. sea level, temperature and salinity. The differences however are quite profound. Much of the observational database for the deep ocean has resulted from research programmes in which considerable attention was paid to the formulation of clear questions and sampling strategies. This is not the case for the coastal ocean. The deep ocean observing system will measure primarily physical variables and models will play an important role in interpreting and synthesizing the observations and making predictions. Again the situation for the coastal ocean is quite different. The number of variables to be monitored is far greater and more diverse, and for all but a few physical variables predictive models do not yet exist.

In a sense the initial observing system for the climate component of GOOS is the deep ocean counterpart of C-GOOS. The deep ocean and coastal components of GOOS may eventually evolve into a single, integrated observing system. Each system could benefit from the other in a direct way. For example the deep ocean component can provide open boundary conditions for limited area coastal models, on time scales ranging from hours to decades. Applications could include forecasting storm surges, hydrographic variability along the west coast of South America generated in the tropical Pacific, warm core rings entraining fish larva into the deep ocean from their spawning sites on the outer shelf. Conversely the coastal system will be useful to the deep ocean system in that it will allow coastal measurements (e.g. sea level) to be corrected for shelf effects before assimilation into models of the deep ocean. Much of the initial observing system for the deep ocean is justified in terms of climate change. To make these predictions useful to the general public they have to be extrapolated to populated regions. One way this will be achieved will be through coupling of the ocean models to atmospheric models. Another way will be by coupling ocean to shelf models. This will allow predictions of bottom temperature and stratification to be made in coastal waters where they may be related, for example, to changes in fish abundance and local climate.



**Table 3: Initial Observing System for the Climate Component of GOOS.**

Observations	Basic System	Additional Elements	Sampling Strategy, Accuracy and Comments
<b>Sea Surface Temperature</b>	<ul style="list-style-type: none"> <li>Global AVHRR</li> <li>Existing mooring and drifter SST</li> <li>Existing VOS SST</li> </ul>	<ul style="list-style-type: none"> <li>Hull contact sensors on VOS subset</li> <li>Additional drifting buoy SST in regions lacking VOS</li> <li>Use of other satellite systems (e.g. ATSR and GOES) to improve SST</li> </ul>	<p>Strategy is to use satellite data calibrated and blended with <i>in situ</i> data.</p> <p>Requirement for NWP flux estimates is 0.2-0.5°C on 100 km squares x 3 days; for ENSO prediction, 0.2-0.3°C on 200 km x 30-100 km areas x 5 days; and for climate change detection 0.1°C x 2-500 km squares x 1 month.</p>
<b>Surface Wind</b>	<ul style="list-style-type: none"> <li>NWP surface analyses</li> <li>Met observations from VOS</li> <li>SSP and wind observations from meteorological buoys</li> </ul>	<ul style="list-style-type: none"> <li>Enhanced use of satellite winds</li> <li>Winds from TAO-type moorings</li> <li>Increased drifting buoy SSP and winds</li> <li>Improvement of VOS wind data</li> </ul>	<p>Benchmark accuracy is 2° x 2° x 1-2 days x 0.5-1.0 m/sec in both components.</p> <p><i>In situ</i> observations are needed to tie down NWP analyses especially in the tropics (e.g. using TAO)</p>
<b>Surface Heat and Fresh Water Flux</b>	<ul style="list-style-type: none"> <li>Surface analyses from NWP models assimilating atmospheric data</li> <li>Marine data from VOS, and drifting and moored buoys</li> </ul>	<ul style="list-style-type: none"> <li>Satellite systems for estimating radiation, precipitation and evaporation</li> <li>Improvements of VOS coverage and accuracy</li> <li>Flux measurement packages on VOS and buoys</li> <li>Budgets either from <i>in situ</i> data or assimilation products</li> <li>Implementation of several reference sites</li> </ul>	<p>Basic strategy is to use flux estimates from NWP/re-analysis projects using sampling requirements of WWW</p> <p>Improvements to be sought from implementation of listed additional elements required by CLIVAR</p>
<b>Upper Ocean Temperature</b>	<ul style="list-style-type: none"> <li>The NW Pacific upper ocean monitoring presently being carried out by Japan</li> <li>Parts of low density monitoring XBT programmes of WOCE and TOGA</li> </ul>	<ul style="list-style-type: none"> <li>Moored arrays such as TAO in Pacific and internationalization of the arrays</li> <li>Indirect estimates from precision altimeters and tide gauges</li> <li>T profiles from profiling floats and frequently repeated XBT lines</li> <li>Development and enhancement of assimilation systems to optimize <i>in situ</i> and satellite observations</li> </ul>	<p>Strategy is to maintain low density WOCE/TOGA XBT lines with priority to lines with good records and scientific significance, maintain TAO array in Pacific, seek enhanced sampling in polar regions, and in the longer term seek truly global coverage using profiling floats.</p> <p>Requirement is for 2-500 km bimonthly global maps of heat content, climatologies at 1° resolution and 0.5°C accuracy, 1° x 5° x 10 day x 500m and 0.2-0.5°C accuracy for ENSO prediction, and larger scale 0.1°C accuracy for climate change detection</p>



Observations	Basic System	Additional Elements	Sampling Strategy, Accuracy and Comments
<b>Ocean Circulation (Currents)</b>	<ul style="list-style-type: none"> <li>reface current estimates from operational drifter programmes</li> </ul>	<ul style="list-style-type: none"> <li>Measurements from moored arrays such as TAO</li> <li>Precision altimeter derived surface geostrophic currents</li> <li>Systematic acoustic Doppler currents from VOS and research vessels</li> <li>Currents from floats and surface currents from drifters</li> </ul>	Strategies for current observations are not well defined. Accuracies of order 5 cm/s for the tropical upper ocean is considered a benchmark. For the global surface drifter programme the benchmark is one measurement per month per 600 km square giving accuracies of about 10% of eddy variability
<b>Surface and Subsurface Salinity</b>	<ul style="list-style-type: none"> <li>Basically nil</li> </ul>	<ul style="list-style-type: none"> <li>Introduction of more quality salinographs into the VOS programme and maintenance of those currently in operation</li> <li>Subset of moored arrays and surface drifters.</li> <li>Salinity profiles from profiling floats</li> <li>Research cruise XCTDs and CTDs</li> <li>Measurements from time series stations</li> </ul>	Tropical western Pacific, Indian Ocean and high latitudes. The benchmark for the surface is 1 observation per 200 km square per 10 days at an accuracy of 0.1 and for the subsurface 4 profiles per 3° box at an accuracy of 0.02
<b>Heat and Water Transport and Budgets</b>	<ul style="list-style-type: none"> <li>Monitoring of river discharges</li> </ul>	<ul style="list-style-type: none"> <li>Transocean hydrographic sections at key locations.</li> <li>Repeat hydrographic sections for water mass formation estimates</li> <li>Selected time series stations</li> </ul>	For estimates of the variability of meridional heat fluxes at mid to low latitudes, station spacing of 25-100 km is required to resolve mesoscale. For measurement of water mass formation, sections are required to resolve interannual variability at a station spacing sufficient to sample the region
<b>Sea Level</b>	<ul style="list-style-type: none"> <li>Selected tide gauges from the GLOSS network</li> <li>Small set of tide gauges geodetically positioned for altimeter calibration</li> </ul>	<ul style="list-style-type: none"> <li>High precision global precision altimeter missions (e.g. Topex/Poseidon, Jason, ERS)</li> <li>Enhanced <i>in situ</i> sampling in selected regions</li> </ul>	Preferred strategy is approximately 10 day global precision altimeter maps supported by ~ 30 in situ gauges for removing temporal drift, additional gauges at continental coasts and a programme of geodetic positioning. An alternate strategy in the absence of a precision altimeter would be a globally distributed network of in situ measurements (such as the GLOSS LTT set) supported by geodetic positioning. Meso-scale variability is only assessable from multiple altimeters with at least one, but preferably 2, of T/P class
<b>Sea Ice</b>	<ul style="list-style-type: none"> <li>Monitoring extent and concentration of ice using passive and active microwave sensors globally and SAR locally</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance and optimization of Arctic and Antarctic drifting buoys in co-operation with ACSYS</li> <li>Enhancement of research networks measuring ice thickness and declassification of submarine observations</li> </ul> <p>Improved dynamical use models to estimate ice velocity, ice concentration and transport using forcing fields and available observations</p>	Desired characteristics are sea ice extent daily to 10-30 km resolution, ice concentration daily to 2-5 % accuracy, and sea ice thickness monthly at a resolution of 2-500 km <sup>2</sup> and an accuracy of order 0.2 m.

*This is a slightly modified version of a table that was provided by George Needler.*



## 2. APPROACH

Designing an observing system for the coastal ocean is an exercise in compromise. For example the end users need immediate answers to pressing, practical problems. Scientists on the other hand often argue for the collection of more data and more research before they can provide predictive models. The easiest variables to predict at this time are physical (e.g. sea level) yet many of the problems are best classified as biological or chemical. Thus when selecting variables one must make a compromise between what is straightforward to model and predict in the short term, and what will ultimately be the most useful. Much of the data for the coastal ocean is collected for non-scientific purposes and yet is extremely useful to the developers of the predictive models. The future observing system will involve a compromise between the investments already made in observing infrastructure and the new instrumentation that will likely revolutionize the way we see, understand and model the coastal ocean. Finally many of the problems affecting the coastal ocean are in a sense local yet they occur globally. Balancing the global and local aspects of coastal problems is difficult to incorporate in the design of an observing system.

To establish a framework for the design of an observing system for the coastal ocean we review in Section 2.1 some of the GOOS design principles. We then identify the users needs, and the observations required to address them, in Section 2.2.

### 2.1 GOOS design principles

The full set of design principles, and their published explanations, are listed in Appendix 1.

#### **D1. GOOS is based on a plan designed to meet defined objectives on the basis of user needs.**

Our approach to the design of the network is based directly on the needs of the users. However it is also important to note that scientists are also users. We do not understand fully all the problems in the coastal ocean or even how to solve the ones we do know about. Our knowledge about scales of variability is inadequate with the exception of a few simple variables like coastal sea level. In some cases we have a predictive capability (e.g. storm surges) but for many we do not (e.g. loss of coral reefs). The best we can do at this stage is monitor and compile a database that will eventually lead to understanding and a predictive capability. We anticipate that the research community will make a major contribution to the design of C-GOOS through Pilot Projects.

#### **D2. The design assumes that contributions to GOOS are long term.**

Where possible the observing network will build on useful stations that have been operating for some time. Tide gauges sited on open coasts and with long records extending back several decades would be good candidates for inclusion in the initial observing system.

#### **D3. The design will be reviewed regularly.**

It is important that users have a voice in the ongoing design and operation of the system. It is unclear at this point how this will be done. The national level is perhaps the most appropriate.

#### **D4. The design allows for flexibility of technique.**

We have identified variables to be measured with a specified accuracy and precision. We have not however specified the method or instrument. We have also tried to ensure that all countries can contribute to C-GOOS in a meaningful way by developing the idea of a Coastal Ocean Watch as outlined below.

#### **D5. GOOS is directed towards global problems and/or those ubiquitous problems benefiting from global observing systems.**

The coastal ocean has a number of truly global problems. (e. g. sea level rises loss of coral reefs and mangroves). One could argue that pollution, dredging or pumping of ballast water and introduction of non-indigenous species in a particular harbor are not global problems and therefore not of primary concern to C-GOOS. However if enough harbors are affected the result is a problem of global concern even though its solution will be achieved through local actions. (We use ubiquitous to describe such problems.)

In designing the array we have tried to take into account of the more important ubiquitous problems. We argue that global observations are relevant to ubiquitous problems because they will give, at the very least, an indication of the severity of the problem. It will also help define spatial scales and hence a more effective monitoring array. Finally it will give a clean separation of what is local and what is regional or global in scale.

**D7. The management, processing and distribution of data will follow a specified data policy.**

Although this principle is not considered in this document we highlight it as one of the most difficult and important problems that C-GOOS has to tackle.

**D8. The design takes into account the existence of systems outside GOOS that can contribute to and/or benefit from GOOS.**

This is an important part of our philosophy of system design. As noted above, the observing system must take advantage of the investment already been made in the development of instrumentation and deployment of observing systems (e.g. satellite remote sensing). We must also be cognizant of the developments of new observing technologies, recent advances in our understanding of the coastal ocean, and developments in computer modeling and data assimilation. Some relevant programmes are:

- GLOSS
- Tsunami warning system
- GCRMN
- HOTO Pilot Projects
- ICAM (Integrated Coastal Area Management )
- GIPME
- CARICOMP

The above list is not exhaustive but does give an indication of the level of interaction that will be required by C-GOOS.

**D9. The design takes into account quality assurance procedures.**

As for **D7** this principle is not considered in this document but we highlight it as of great importance.

## 2.2 Users' Needs

We have used the following two-stage approach to link environmental measurements to user needs in the design of the initial coastal observing system. First there is the definition of an appropriate operational category and issue (Table 1), the identification of user groups, definition of the attribute(s) to be predicted, determination of acceptable lag times between the present and the time of the prediction, selection of models to be used, and finally the listing of inputs required by the model(s). A key aspect of this stage is the explicit relationship between the design of a measurement programme and the requirements of models to be used in data synthesis and prediction. The second stage is more difficult and subjective (and only partially completed for our design). It is an attempt to assess the feasibility versus impact of the measurements. Beginning with the list of variables to be measured, the required scales of measurement (resolution, duration, spatial extent) are determined and assessments made of the importance of the variable, the feasibility of measurement, and the availability of proven techniques and technologies. A key aspect of this stage is the identification of those variables that are most important to achieving the desired results and are the easiest to measure in terms of cost and available technology. By systematically working through these two steps, cost-effective observing systems can be designed and implemented that meet the needs of user groups.

As an aside note that we use a general definition of the term prediction in that we have not restricted it to predicting the future, i.e. forecasting. We take prediction to include, for example, inferring the present biodiversity of an ecosystem from measurements made at a small number of observing stations. Prediction also includes the spatial extrapolation of return times of extreme sea levels from a tide gauge with a long record to a coastal site with little or no sea-level data. In other words we take prediction to mean quite generally the

estimation of a quantity which is not observed directly. Prediction therefore includes, as special cases, forecasting and spatial interpolation.

We have constructed separate tables for physical/geological issues (Table 3) and biological issues (Table 4). The reason is that physical variables are not usually affected by biological variables but biological variables are often affected strongly by physical processes. A description of the columns of the tables is as follows:

<b>Issue:</b>	The number refers to the four operational categories defined in Table 1.
<b>Final Prediction:</b>	Final prediction. Coastal managers do not want predictions about possible occurrence of a Harmful Algal Bloom (HAB) in the form of complex model output. A straightforward "Alert" may suffice.
<b>Lead Time:</b>	Storm surge forecasts need lead times of hours to days. The symbols <b>m, h, d, w, s, y</b> , refer to minutes, hours, days, weeks, seasons, years and longer. No entry implies a nowcast.
<b>Model:</b>	Type of model used to make the prediction. Models can range from simple statistical models to sophisticated coupled atmosphere-ocean models based on first principles.
<b>Model Inputs:</b>	Observations needed by the model to make predictions.
<b>Feasibility:</b>	We have used a relative ranking of high (H), medium (M) and low (L).





**Table 4: Physical Issues**

Issue	Final Prediction	Lead	Model	Model Inputs	Feas
Storm surges (3)	Alert	H d	Mesoscale storm, hydrodynamic, wave and inundation models	Air pressure, storm intensity and track, precipitation, sea-levels and currents (to specify open boundary conditions), bathymetry	H
Tsunamis (3)	Alert	M h	Statistical and shallow-water wave model	Seismic activity and origin, sea-level, bathymetry	H
Marine search and rescue (4)	Trajectories with error bars	H d	Hydrodynamic model, wind-drag model	Winds, air pressures, sea-levels and currents (to specify open boundary conditions), waves	H
Surface navigation hazards (e.g. icebergs) and pollutant spills (e.g. oil) (4)	Trajectories with error bars	H d	Hydrodynamic model, wind-drag model, spill properties-behaviour model	Winds, air pressures, sea-levels and currents (for open boundary conditions), surface roughness (e.g. RADARSAT) and ocean color from satellites	H
Safe design of coastal and offshore structures (4)	Frequency of extreme currents, waves or sea-level; scour, erosion, maximum loads on structures	H d y	Hydrodynamic, wave, sediment transport models	Geomorphology, historical meteorological statistics, extreme events, statistics from likely future climate scenarios	H
Extreme marine weather (3, 4)	Alert of extreme marine conditions (winds, waves, precipitation, freezing rain, fog)	H d	Limited-area meteorological forecast model, wave model.	Output from global forecast model with assimilation of local meteorological observations	M
Mariculture kills by extreme water temperature (2)	Alert	D s	Limited-area hydrodynamic model with evolving T and S, statistical	Coastal sea level, runoff, currents, hydrography, and atmospheric forcing from high-resolution forecast model, remote sensing. For ENSO will need open boundary conditions from global model.	M
Sea-Level Rise (3)	Present rate of coastal sea-level rise		Statistical (regression and interpolation)	Tide gauge records, typically longer than 20 years, local meteorological data, accurate survey data	H
	Future sea-level rise (3)	Y d c	Coupled ocean-atmosphere-crustal model	Global temperature and salinity for initial state, projections of global CO <sub>2</sub> over next century, factors affecting local subsidence (e.g. water extraction)	L
Efficient navigation in ice-infested waters (4)	Optimal shipping route	H d s	Statistical-hydrodynamic	Satellite images (e.g RADARSAT), aircraft reconnaissance, ship observations, currents, winds and heat content	M
Coastal erosion (4)	Planning criteria for coastal development, beach nourishment rates	S y d	morphodynamic and statistical	geological factors (e.g. grain size, sediment type), wave climate, sea level and winds, sedimentation rates	L
Salt water intrusions (2)	Salt/freshwater interface position	Y d	Hydrological model	Sea-level rise, ground-water extraction rates, borehole observations.	M

A model input not listed above, but is of critical importance to hydrodynamic and wave modeling studies, is accurate bathymetry. For many parts of the world the available bathymetric data are inadequate for models with a resolution of order 10km.

**Table 5: Biochemical Issues**

Issue	Final Prediction	Lead	Model	Model Inputs	Feas
Occurrence of Harmful algal blooms (1)	Assessment of mean risk of occurrence for specific area	dwsy	Statistical, neural network	Nutrient [ ], temperature, algal species present, PAR, history of occurrence, sediment type, land run off nutrients Physical model of stratification,	M
Intensity of Harmful algal blooms (1&2)	Forecast time and intensity of HAB for specific location	dw	Statistical	Nutrient [ ], temperature, algal species present, PAR, history of occurrence, sediment type, land run off of nutrients Physical model of stratification, and water movement	M
Movement of Harmful algae blooms (2)	Forecast movement of HAB for specific location	dw	Statistical	Nutrient [ ], temperature, algal species present, PAR, history of occurrence, sediment type, land runoff of nutrients Physical model of stratification, and hydrodynamic model of area	H
Nutrient overenrichment (1)	Probability of eutrophication	y	Statistical, hydrodynamic water quality	Nutrient [ ], benthic fluxes nutrients, dissolved oxygen, land runoff of nutrients Hydrodynamic model of area	
Habitat loss (e.g. coral reefs, mangroves) (1)	Alert of potential loss	yD	Statistical	temperature, sea-level, meteorology, sedimentation rates, nutrients	
Habitat diversity (1)	Alert of potential loss	yD			
Mariculture shellfish carrying capacity, natural food (2)	Maximum sustainable stocking density	yD	Coupled hydrodynamic-biological	chlorophyll a, nutrients, SPM, primary production, algal species composition Hydrodynamic model of area	M
Mariculture carrying capacity of fish	Maximum sustainable stocking density	yD	Coupled hydrodynamic – biological	Dissolved oxygen, sediment type, nutrient [ ], chlorophyll a Hydrodynamic model of area	M
Non-indigenous species (1)	?? not sure of what we want to predict here. We could go for introductions via ballast water and hull fouling	years	????	?????	
Diseases in marine organisms (1)	?? need help here I do not have a handle on this one		??????	??????	



### 3. THE INITIAL COASTAL GOOS

Based on the users' needs, and the feasibility and impact of the observations needed to satisfy them, we propose the following observational elements of an initial observing system for the coastal ocean.

#### 3.1 Satellite Remote Sensing

Remote Sensing is revolutionizing the way we see the coastal ocean. It is also starting to provide quantitative information that can be used to predict changes (e.g. winds from scatterometers, sea surface height from altimeters, surface temperature from AVHRR sensors and ocean color). It is unique in its provision of large-scale views of biologically important quantities like ocean color.

The following table lists the main types of sensor, their applications and the number of missions in operation or planned.

**Table 6: Main types of satellite sensor, applications and number of satellites.**

Sensor	Application	1997-98	1999-2000
Altimeter	Surface height, ocean circulation, climate variability	2	4
Scatterometer	Vector winds, air-sea interaction	2	2
Ocean color	Ocean productivity, coastal pollution	4	9
Synthetic Aperture Radar (SAR)	Sea ice, wind-wave-current interaction	3	4
Passive Microwave Sensors	Sea ice, scalar winds, atmospheric moisture	2	2
Visible/Infrared (500-1000km)	Surface temperature, sea ice	5	8
Visible/Infrared (5-80km)	Coastal and coral reef assessments	15	5
Visible/Infrared (1-10km)	Coastal and coral reef assessments	15	5

*The information in this table was kindly provided by Dr W. Patzert.*

It is clear that C-GOOS must take advantage of remote sensing. Ocean color may provide estimates of algal phytoplankton abundance, primary production, suspended solids, circulation features from ocean color. From infrared sensors we may obtain estimates of sea surface temperature and the location of fronts. SAR allows all weather monitoring of the distribution of sea ice and scatterometers allows vectors wind fields to be mapped over the world's ocean. There are also some exciting new missions planned. For example GRACE is a joint US German gravity mission approved for launch in 2001. It will measure the small variation earth's gravity field by tracking two satellites in a low earth orbit connected by a microwave link. This should lead to better estimates of the geoid and hence absolute tilts of sea level and better estimates of currents.

Before satellite remote sensing reaches its full potential much must be done in sensor development, calibration and validation. For example there is no simple relationship between ocean color and HABs. Although some types of HAB can be detected by remote sensing (e.g. *cyanobacteria* in the Baltic Sea or *G.*

*breve* along the US coast), many species are harmful at low concentrations and many blooms concentrate in subsurface layers and cannot therefore be remotely sensed at present.

Another problem is the mismatch in time scales of many coastal processes and the repeat time of the satellites. For example aliasing of the tides is a serious problem for altimetric measurements of sea surface height in coastal waters.

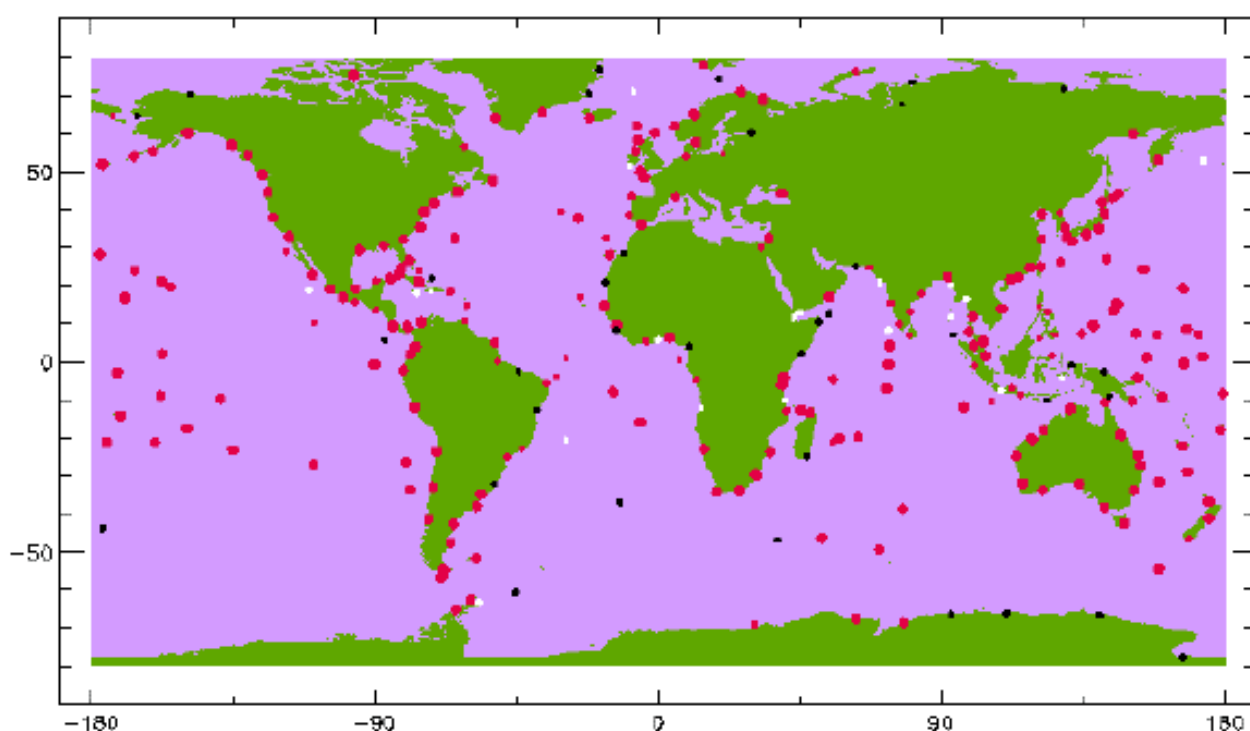
Finally clouds are a major problem, especially for color and thermal sensors, in many areas. Simply masking out the clouded areas can lead to serious bias in the sampling.

### 3.2 Tide Gauge Observing Array

Sea level is a variable of great interest to C-GOOS. For example it relates directly to the issue of coastal flooding. The geoid is an equipotential surface everywhere normal to gravity and is the reference level used by oceanographers to measure sea level tilts and calculate geostrophic currents. The geoid is defined in terms of global mean sea level. Sea level is also a useful indirect measure of, for example, vertical crustal movement, global warming of the world's ocean, melting of Antarctic ice sheets and finally ocean and shelf circulation. It is therefore not surprising that a network of coastal tide gauges be proposed as an essential observing element.

The Global Sea Level Observing System (GLOSS) is an international programme co-ordinated by the Intergovernmental Oceanographic Commission (IOC) for the establishment of high quality global and regional sea level networks. The programme is known as GLOSS as it provides data for defining the 'Global Level of the Sea Surface'. GLOSS is considered a component of GOOS and is expected to be a major contributor to its climate and coastal modules.

The main component of GLOSS is the 'Global Core Network' (GCN) used for long term climate change and oceanographic sea level monitoring. Another component is the GLOSS Long-Term Trends (LTT) set of gauge sites (some of which are in the GCN) for monitoring long term trends in global sea level. These will be priority sites for Global Positioning System (GPS) receiver installations to monitor vertical land movements.



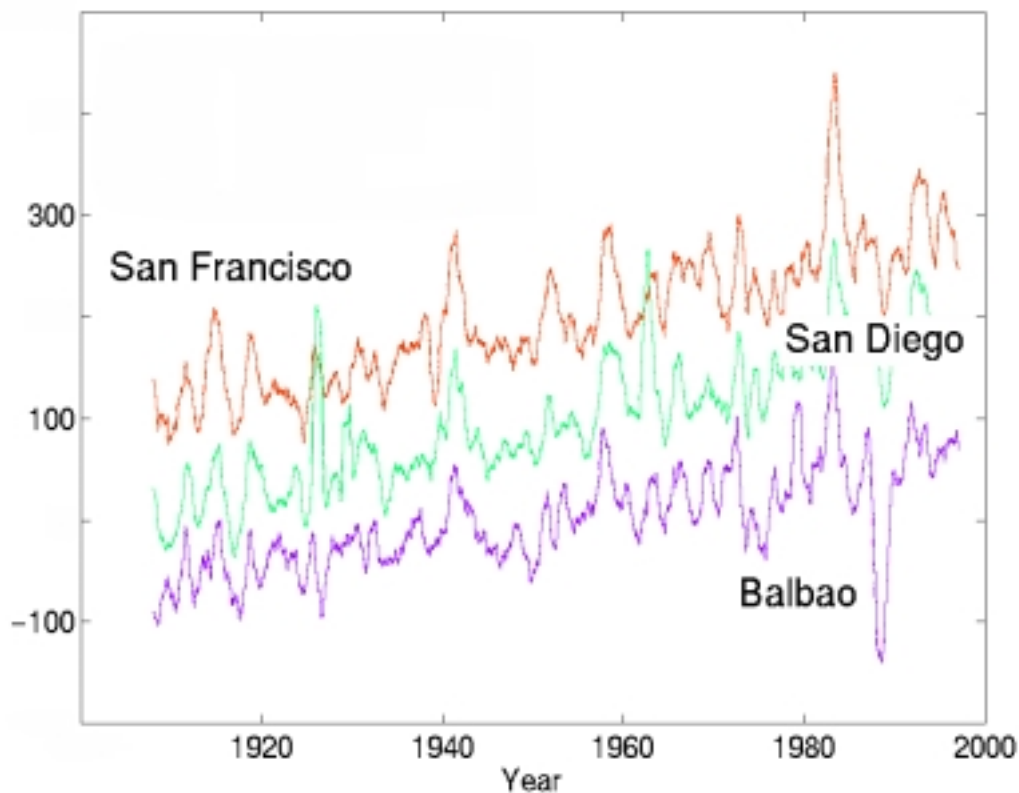
**Figure 2: GLOSS observing array as of October 1998**

GLOSS had 287 stations in 1998 (Figure 2). The network was designed to have an approximately even distribution of stations. Many GLOSS stations are on islands and it could be argued that they are not relevant to C-GOOS. Note however that sea level from island stations will feed into the deep ocean GOOS observing system and could therefore be useful in providing boundary conditions for coastal models.

How many tide gauges does C-GOOS need? This is a difficult question even for a relatively simple variable like sea level. We will explore the question in some detail because it will highlight some of the problems C-GOOS will have to face as it becomes more explicit about the specification of its observing elements. We will examine daily sea level from the following 3 gauges on the west coast of the US and Central America:

<i><b>Location</b></i>	<i><b>Country</b></i>	<i><b>Period</b></i>	<i><b>Latitude (N)</b></i>	<i><b>Longitude (W)</b></i>
San Francisco	United States	1901-1996	37.48	122.28
San Diego	United States	1906-1996	32.43	117.10
Balbao	Panama	1907-1996	8.58	79.34

The linear trends of sea level are almost identical at San Francisco and San Diego (2.1 mm/y) and slightly lower at Balbao (1.4mm/y).



**Figure 3: Annual mean sea level (in mm) at San Francisco, San Diego and Balbao.**

The variations from year are also quite similar at San Francisco and San Diego. Their correlation is 0.7 as shown in the table below.

<i><b>&gt; 1 y (2-10 days)</b></i>	<i><b>San Francisco</b></i>	<i><b>San Diego</b></i>	<i><b>Balboa</b></i>
San Francisco	1		
San Diego	0.7 (0.5)	1	
Balbao	0.6 (0.1)	0.5 (0.1)	1

However the correlation between annual means at Balbao and San Diego is only 0.45. This means that about 20% of the variance in annual means at Balbao can be predicted using annual using San Diego. Turning to higher frequencies we calculated average coherences in the 2-10 day band. The coherence between Balbao and the two northerly gauges is now only about 0.1 (see values in parentheses in the above table). Although this is significantly different from zero at the 1% level, it is not of much practical significance. A C-GOOS observing system would clearly require finer spatial resolution than that possible with these 3 tide-gauges.

As the tide gauge array for C-GOOS evolves it is essential that a close working relationship develop between C-GOOS and GLOSS. The same is true of the groups proposing pilot projects that will extend and add instrumentation to the existing tide gauge array. The addition of tide gauges either side of straits could lead to an effective and cheap way of monitoring variations in the surface flow and possibly transport. In addition to GLOSS there are a number of other groups undertaking work on sea level that is relevant to C-GOOS. Two examples are given below. They illustrate the level of activity in sea level research and point to the co-ordination that will be required to make C-GOOS a success.

**The University of Hawaii Sea Level Center (UHSLC)** collects, processes and distributes sea level data in support of multi-national field programmes and for climate research. UHSLC played a major role in the development of GLOSS. Its functions include (1) Maintenance of 42 tide gauges, most with satellite data telemetry, in the Indian and Pacific Oceans; (2) Collection of sea level data from various contributors worldwide for distribution in near-real time. The provision of data in near real time is particularly relevant to C-GOOS and cooperation with UHSLC should be explored.

**The International GPS Service for Geodynamics (IGS)** is working with oceanographers to begin adding continuous GPS to tens of tide gauges around the world. One goal is to define the absolute vertical position of the tide gauges to within a few cm in order to calibrate and validate measurements of sea level by satellite-borne altimeters. Another goal is to measure the vertical velocity of the tide-gauges on time scales of decades. If accuracies of better than 1mm/year over a 10-year period could be achieved it may be possible to separate the effects of vertical crustal movement from oceanic effects and allow for better predictions of sea level rise.

### 3.3 Enhanced network of offshore buoys and fixed platforms

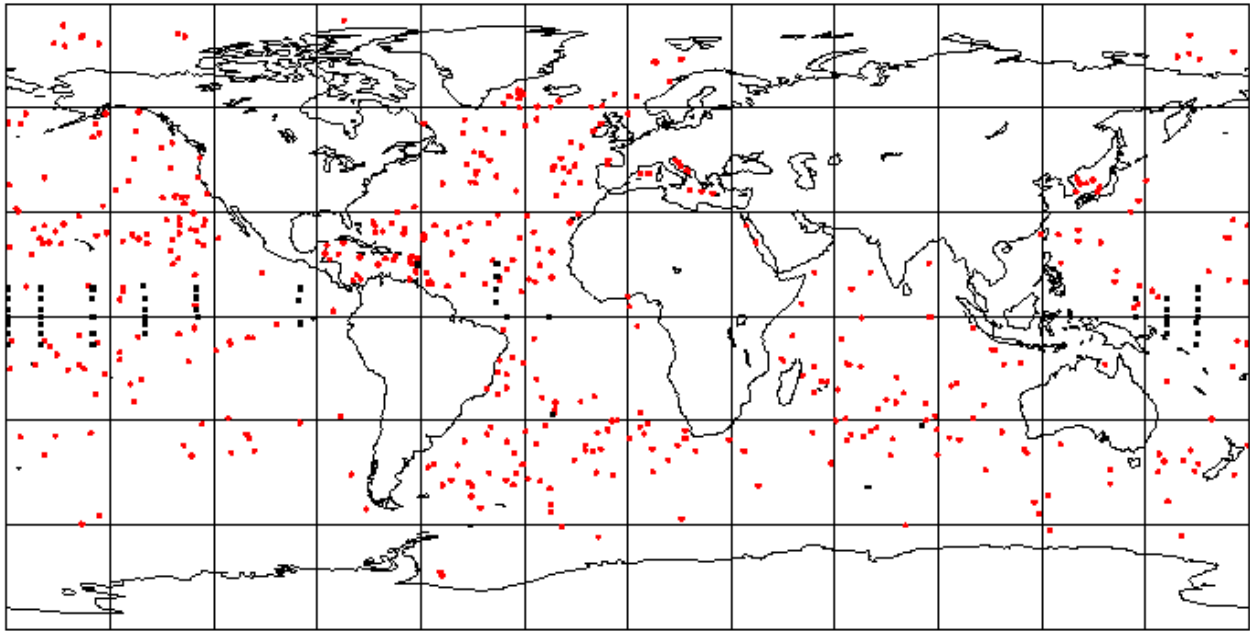
Accurate fields of winds stress and air pressure are essential for storm surge modeling. Moored buoys add valuable data to the global atmospheric observing system. For example Figure 3 shows all the drifting and moored buoys that provided input to the global analysis and forecast system of the ECMWF for 18UTC 28 March, 1999. It is clear that some regions are poorly sampled.

Over the last 10 years there have been significant developments in instrumentation for measuring water properties from offshore platforms. Measurements can now be made of vertical profiles of current, temperature, salinity, fluorescence, transmittance, position using GPS, radiance and irradiance at wavelengths sensed by satellites with spectroradiometers. Many of these sensors are commercially available. New sensors on the scene include nitrate and CO<sub>2</sub> analyzers.

These instruments can be deployed on moored and drifting buoys. The resulting data could be used to assess variability, calibrate satellite imagery and, in some cases, be assimilated into predictive models. Recent development in telemetry allow users to communicate with remote platforms to download data and possibly change sampling strategy (e.g. Chavez *et al.*<sup>3</sup>, 1999). Range is on the order of 100km and so such technology is well suited to shelf applications.

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<sup>3</sup> Chavez F. P., J. T. Pennington, R. Herlien, H. Jannasch, G. Thurmond and G. E. Friederich. 1999. Moorings and drifters for real-time interdisciplinary oceanography, Monterey Bay Aquarium Research Institute, Moss Landing.



**Figure 4: Locations of 1866 ocean platforms providing weather data for assimilation into the ECMWF forecast model for 28 March, 1999.**

We therefore propose to enhance the present array of moored buoys to measure wind and air pressure in regions requiring more accurate meteorological forcing fields. We also propose to add some of additional sensors described above. The most likely platforms would be a subset of the moored meteorological buoys used by the World Weather Watch to monitor atmospheric variability over the ocean. (See also Figure 5.)

Another set of possible offshore platforms would be rigs used for hydrocarbon exploitation. SeaNet is a European organization concerned with monitoring networks on fixed structures in the North Sea region. Its objective is to realize a North Sea monitoring system based as a contribution to an integrated European marine monitoring and forecasting system. It is undertaking the following activities (taken from the *Science base for EuroGOOS* report):

- Establishment of a homogenous distribution of fixed monitoring sites.
- Online data exchange between fixed monitoring networks.
- Standardization of data collection, processing methods and validation techniques.
- Co-operation in new measuring techniques and sensors.
- Sharing experience in data communication and collection, particularly on fixed structures.

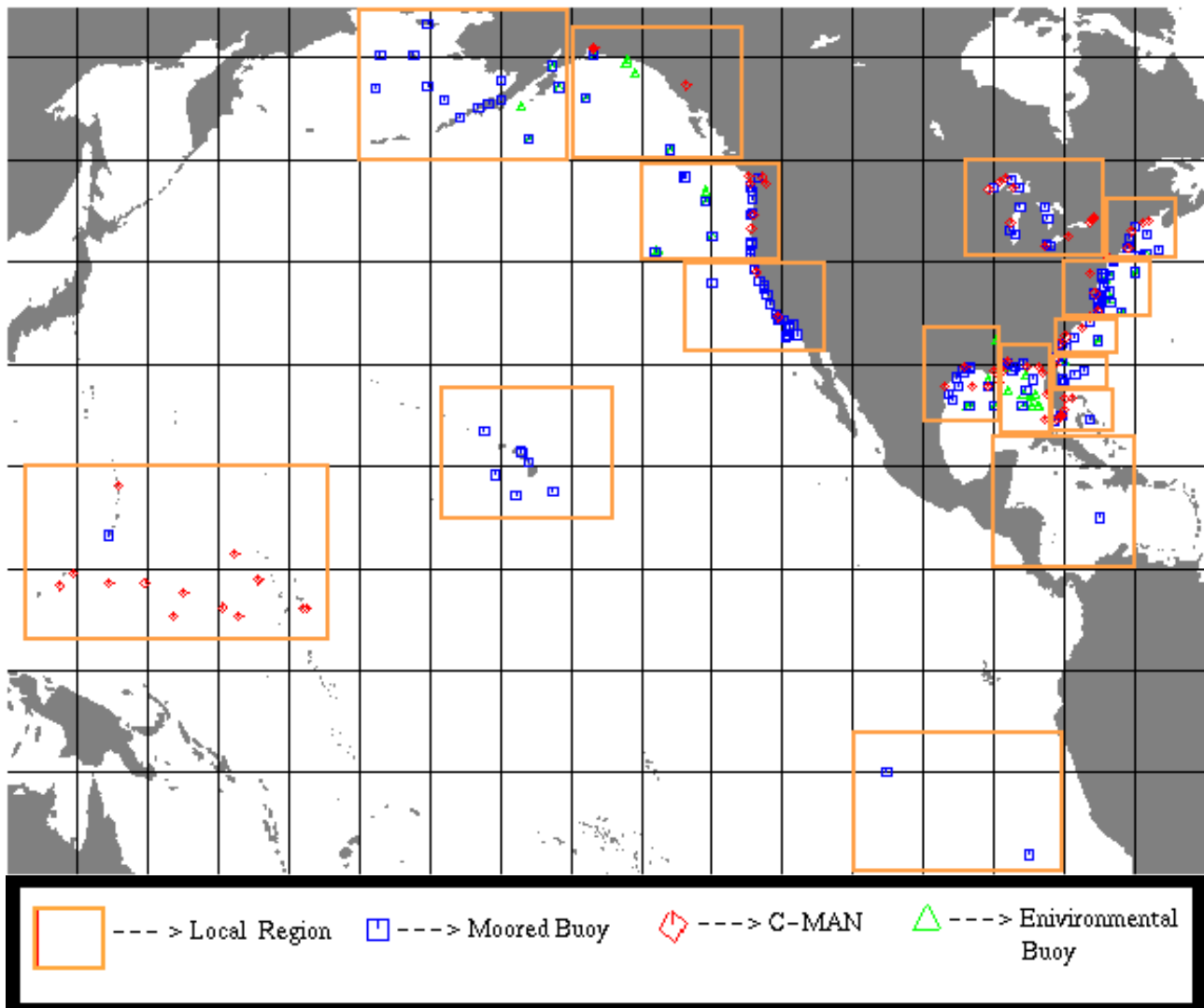
There are several benefits of enhancing the distribution and instrumentation of offshore moored buoys and fixed platforms:

- Better predictions of extreme weather.
- Improved nowcasts and forecasts of wind and air pressure fields that can be used to drive hydrodynamic models.
- Calibration and validation of satellite remote sensing (e.g. winds, surface temperature, currents, sea level, ocean productivity).
- Expanded database of ocean variability which will deepen our understanding of how the coastal ocean works and lead to the development and validation of predictive models.

Choosing the optimal locations of additional offshore buoys will be difficult. For wind and air pressure the atmospheric forecast models will be useful in evaluating the benefits of data from new locations. For the oceanographic variables it will be much more difficult because we only have a crude idea of scales of



variability. Clearly to reduce spatial aliasing it would be sensible to avoid regions with strong gradients (e.g. fronts).



**Figure 5: Positions of National Data Buoy Center (NDBC) moored buoys and Coastal-Marine Automated Network stations located on piers, offshore towers, lighthouses, and beaches.**

### 3.4 Monitoring Critical Sections

The Science Base for EuroGOOS describes an interesting project to monitor conditions on critical sections using regular ferries.

The following is an abbreviated project description taken from the EuroGOOS report:

#### **Ferry Box Project:**

There are more than 800 ferryboats routinely operating in the coastal waters of Europe with frequencies varying between once a week to several times a day. By developing and installing an operational autonomous ship-borne instrument package («Ferry Box» in analogy to the «black box» of a commercial airliner) the following set of variables could be measured *en route* with no additional platform costs: sea surface temperature, salinity, oxygen, nitrate, sound velocity, fluorescence, light attenuation and light scattering.

This project could be usefully extended to other parts of the coastal ocean and thereby provide section measurements that would nicely complement the measurements from fixed and moored platforms discussed in Section 3.3 and the Coastal Ocean Watch (see Section 3.6). One particularly attractive feature of this type of measurement is that it may provide estimates of integral fluxes of quantities like mass and nutrients along the shelves. Such measurements could be most usefully in providing boundary conditions for limited area models of the shelf.

An ongoing programme that is relevant to the establishment of a global Ferry Box programme, and perhaps one that may be extended to include more instrumentation, is the Shipboard Environmental Data Acquisition System (SEAS) programme of the National Oceanic and Atmospheric Administration. It provides meteorological and oceanographic data in real time from ships at sea. Meteorological observations made onboard merchant vessels of the NOAA voluntary observing ships (VOS) programme make an important contribution to the World Weather Watch and hence weather forecasting. SEAS equipped vessels provide as many as 80,000 observations per year. Most of NOAA's ships submit at least one SEAS report a day and some submit up to eight reports a day (one every three hours).

Many Research Institute monitor hydrographic sections. These data would also be usefully included in this section.

### 3.5 In situ coastal measurements of basic water properties

We propose a large scale, flexible observing network that will make basic *in situ* measurements in the nearshore zone. We envisage a variety of groups taking part, ranging from schools (Level 1), though environmental groups and oil companies (Level 2) to research laboratories (Level 3). The basic idea is to monitor basic properties of the near shore zone with a global distribution of observing stations. In a sense we are proposing an early form of the World Weather Watch for the coastal ocean: a Coastal Ocean Watch (COW - the acronym has to change!). We are advocating here the bottom up approach discussed in Curitiba in that we are attempting to include in C-GOOS some of the data already collected, much of it for non scientific purposes. Our goal is not to make the Coastal Ocean Watch an all encompassing observing network for the coastal ocean. Rather it would make *in situ* measurements at stations at, or close to, the shore.

There are four main reasons for proposing the Coastal Ocean Watch:

- (i) It will provide an overall indicator of the state of the global nearshore environment. Such information would be useful to policy makers and of interest to the general public. For example the public could use the Coastal Ocean Watch to answer the following type of question: Is the increasing pollution in my harbor a local phenomenon? Or is it part of a regional, or possibly global, variation? To be most effective data should be processed, quality controlled and made available as soon as possible. For simple measurements like water temperature the time-to-display may be a day. For measures of pollution time-to-display might be weeks.
- (ii) Public awareness and capacity building potential are considerable. Data could be made available in graphical form on the WEB, with the possibility of overlays of recent satellite images to fit the data into a global perspective. This may well catch the imagination of the general public and attract young people to environmental science. It is also important to note that the WEB cannot be accessed easily by all groups wishing to participate. Alternative forms of communication will have to be developed, at least for the short term.
- (iii) All countries can contribute. One of the difficulties faced in designing a global observing system for the coastal ocean is allowing all interested parties to participate. The Coastal Ocean Watch is one solution to this problem.
- (iv) Calibration and validation of satellite imagery. The Coastal Ocean Watch could collect a tremendous amount of data in a critical part of the coastal ocean: the nearshore zone. It was noted above that satellite

remote sensing has great potential but still needs to undergo systematic calibration and validation. A global distribution of stations in nearshore regions could be a most valuable resource in this regard.

We now outline possible *in situ* measurements by the Coastal Ocean Watch. We do not go into detail about accuracy and quality control or give recommendations on instrumentation. Our choice of measurements is a compromise between relevance and feasibility. To obtain global coverage and participation the instrumentation cannot be too complicated. It also has to be affordable. However measurements have to be relevant locally otherwise it will difficult for national agencies to justify their additional expenditures. Based on a discussion of issues like relevance, availability, robustness, cost, accuracy and maintenance of sensors we propose the following list of basic ocean measurements:

Temperature	Salinity (conductivity)
Secchi depth	SPM
Nitrate	phosphate
Chlorophyll a	Variables defined by HOTO

The water samples will have to be analyzed by a local laboratory with the users/operators acting simply as collectors. Sampling time intervals could range from daily to monthly.

We now outline how individuals and organizations could contribute to the Coastal Ocean Watch. It proved convenient to define three levels of participation.

**Level 1:** Environmentally aware citizens, environmental groups, high schools and universities. This level will require the most help from C-GOOS in obtaining instrumentation and developing the correct measuring methodologies. We suggest that it may be useful to design an ocean observing kit to measure the basic variables. It would be an extension of the user kits proposed by the GOTO panel of C-GOOS. It may also be necessary to provide a set of written guidelines. We expect the kits to cost on the order of \$2000.

The advantages of Level 1 participation are raising public awareness, allowing all countries to participate in GOOS in a meaningful way, capacity building (see Appendix 2) and excellent spatial coverage of stations.

**Level 2:** Harbor and water authorities, oil companies and non-scientific operational agencies. Contributors at this level will generally have their own equipment and will be familiar with making some of the basic measurements. C-GOOS may consider producing a set of guidelines on accuracy and quality control. C-GOOS may also consider designing a kit for the Level 2 contributors. These contributors will provide more frequently sampled measurements than Level 1. It would be expected that these contributors would be conducting additional measurements to address local, regional or sector-based issues identified by the end-users.

**Level 3:** Scientific research institutes and laboratories, scientific operational projects and agencies. In most cases the experts in data collection and analysis will reside in these institutes and agencies and C-GOOS will have to lean on them to provide advice on choice of instrument and guidelines for Level 1 and 2. Without the support of Level 3, it is unlikely that the Coastal Ocean Watch will work. Level 3 organizations could provide laboratory support for Level 1.

Level 3 will add to the Coastal Ocean Watch in two important ways. First contributors will usually have collected a considerable amount of data and will therefore be in a position to provide an historical context for the observations made at Levels 1 and 2. Second the measurements will usually be of the highest quality and they will act as a yardstick against which to compare the measurements from the other levels. It would be expected that Level 3 contributors would be conducting additional measurements to address local/regional or sector based issues identified by the end-users.

Data dissemination and archival will need to be discussed at an early stage in the development of the Coastal Ocean Watch. Accuracy and quality control can probably be deferred for now.

C-GOOS may consider designing a kit of standard instruments with homogeneous accuracy and quality control procedures, specifically for the GLOSS stations. Most of the GLOSS tide gauges are run by Level 2 contributors and the gauges have a truly global distribution. The GLOSS stations could become an important part of the Coastal Ocean Watch.

The idea of ocean observing kits could also be extended to other IOC programmes such as:

- Global coral reef monitoring network (GCRMN);
- Tsunami warning system in the Pacific;
- HOTO coastal pilot projects;
- Integrated Coastal Area Management (ICAM);
- Marine pollution and monitoring (GIPME).

Another issue not addressed above is the inclusion of basic meteorological instrumentation in the COW. There are now commercially available reliable, accurate, operational, low cost (about \$800) coastal meteorological stations. This would require co-ordination with the enhancement of the offshore network and discussion with WMO to assess the value of such measurements in terms of nowcasting and forecasting weather. It would clearly be best if such data were assimilated into atmospheric forecast models so that the point measurements can be turned into time varying wind fields over the coastal ocean. Not this would extend the Coastal Ocean Watch from just *in situ* ocean measurements.

### 3.6 Network of Marine Observation and Institutes

As noted above many of the important problems in coastal waters are related to biological issues (Table 1) and require integrated, multidisciplinary observation systems. There are two major impediments to the development of a multi-disciplinary, integrated observation system:

- The technical development for biological and chemical sensors and automatic detection devices is still at quite an early stage. Only a relatively small number of biological variables can be measured autonomously and automatically, and problems still remain with calibration and instrument maintenance. It will take some years before automatic detection systems will be able to provide the data needed to solve the issues identified in Table 1.
- The science base required for the design of an optimal observing system, as well as the transformation of data into products is lacking. Mechanisms underlying biological processes and their scales of variability are poorly understood, especially for coastal waters and the pelagic system.

A useful steps to take at this stage are:

- Build on existing monitoring systems for biological variables. Currently, scientific activity in several marine laboratories around the world are based on *in situ* observations of biological systems which could be exploited by establishing networks of institutions and experts. On-going observation systems are generally very diverse in terms of aims, co-ordination and inter calibration with similar monitoring activities, data-quality, and data availability. Networking of monitoring agencies should be planned in order to obtain, as a final product, high-quality data-sets which respond to the GOOS concept and needs. This strategy responds to a frequently stated objective of GOOS that is to benefit from on-going and planned monitoring activities and to avoid duplication of effort.
- Foster scientific research addressing critical questions relevant to optimal monitoring strategies and interpretation of field-data. This also stresses the role of scientists as end-users: once a global network has been established, its products will constitute an invaluable resource for the development of scientific knowledge and a predictive capability for biological systems at both the local and global scale. Timely

information on, for example, coastal circulation and small scale meteorological variability are essential to understanding mechanisms underlying biological variability.

Two different kinds of networks can be identified:

- (i) **Mono-thematic networks:** they will focus on a single parameter, allowing inter-calibration of methodologies and data outputs. Due to the high level of specialization, these networks should be start as uni-disciplinary. (e.g. phytoplankton, zooplankton, sea grasses).
- (ii) **Multi-dimension, inter-disciplinary networks:** these can be built either by connecting existing uni-disciplinary networks, or started as inter-disciplinary effort to address specific problems. An example of the latter is MARS, the network of European marine stations addressing the problem of biodiversity, from genetic to ecosystem level and including planktonic and benthic systems. An array of different techniques and expertise in several fields scientific knowledge is required for this kind of network.

The benefits of networking are:

- The process can be started immediately;
- It exploits existing resources and, through their co-ordination, avoids duplication of effort;
- We can involve the whole scientific community;
- The network could measure all of the basic variables of the Coastal Ocean Watch and provide a theoretical and observational background for their interpretation.

#### 4. SUMMARY AND DISCUSSION

Designing an observing system for the coastal ocean requires many compromises. We recognize that C-GOOS cannot propose a research-based observing system: the problems are immediate and require solutions now. Nor can C-GOOS ignore the fact that our knowledge of how the coastal ocean works is rudimentary and, for many variables, not at a level that would support operational models.

After assessing the needs of users and scientists, and balancing the observational infrastructure in place and that planned for the next few years, we propose an initial observing system that has six observing elements. They are listed below along with some comments that supplement the fuller descriptions in the body of the text:

- (i) **Satellite remote sensing:** this technology holds great promise as a way of monitoring the coastal ocean. Calibration and validation would benefit from the data collected by the observing elements described below. We note with interest the possibility of Pilot Projects that will examine calibration and validation of remote sensing of the coastal ocean.
- (ii) **Global distribution of tide gauges:** sea level is arguably the single most important physical variable to measure in the coastal ocean. C-GOOS will need to work closely with GLOSS and Pilot Projects to extend the present array of tide gauges and possibly add more instrumentation to GLOSS sites. The present distribution of GLOSS stations is inadequate for many important applications (e.g. surge prediction).
- (iii) **Enhanced array of instrumented offshore moored buoys and fixed platforms:** this will lead to better predictions of extreme marine weather and more accurate atmospheric forcing fields for hydrodynamic models. It will also provide continuous measurements of core oceanographic variables that will be useful for calibrating satellite imagery. The SeaNet project described in the EuroGOOS science plan is a good example of this approach.
- (iv) **Ferries and research vessels monitoring basic variables and fluxes across critical shelf sections:** this will be useful as a way of monitoring the changes in integral properties of the coastal ocean. It will also provide useful data for specifying open boundary conditions for numerical models. The Ferry Box project described in the EuroGOOS science plan is a good example of this approach.

- (v) **A coastal Ocean Watch to monitor oceanographic, and possibly meteorological conditions, in the near shore region:** this will provide global scale distributions of basic properties of the near-shore zone of the coastal ocean. The data will be of interest in their own right and will be useful for calibration and validation of satellite imagery. This element has the greatest capacity and awareness building potential. It will allow all countries to make a useful contribution to C-GOOS. The call for basic measurements on a global scale could induce the ocean instruments industry to produce, in the near future, sensors that are more reliable. In addition, it may allow GOOS and C-GOOS to influence R&D policies, not only in the private sector, but also at research laboratories and institutes.
- (vi) **A network of research laboratories and institutes and to share data and modelling approaches related to a number of the critical issues facing the coastal ocean:** this is an element that could start up very soon. The sharing of methods and modelling approaches will be most valuable. It would be particularly helpful if it could encourage visits of individuals to other institutes of the network.

The initial observing systems for the climate and coastal components of GOOS may evolve into a single, integrated observing system. In a sense the climate component is the deep ocean counterpart to the coastal system and could be considered an observing element. Both systems stand to benefit from each other in a direct way. For example the deep ocean system can provide off shore boundary conditions for the coastal models, and the coastal system will allow coastal measurements to be corrected for shelf effects before assimilation onto the deep ocean models. A simple example is that of sea level, i.e. correcting for wind and hydrographic effects generated on the shelf can be dominate the variability on annual time-scales and longer. The coastal observing system will also allow the predictions of the deep ocean system to be extrapolated to coastal regions and hence made much more useful to the public, policy makers, fisheries researchers and so on. It is too early to be specific about the requirements of C-GOOS for the deep ocean observing system. However we note with interest the development of GODAE which will start to provide information on some of the important time and space scales for C-GOOS.

In drafting the design it became clear that there are a number of issues that C-GOOS should consider urgently if a global observing system is to become a reality.

**Links to Other Programmes:** One programme has already been identified as being of particular interest to C-GOOS. LOICZ has research projects on the assessment of material fluxes and their environmental effects in the coastal zone. The projects will study the dynamics and kinetics of changes in these fluxes and the biological, physical, chemical, and hydrological mechanisms of interactions between the ocean and other ecosystems. The emphasis is on carbon, nitrogen and phosphorus. Assessment (through modeling) of horizontal fluxes of these compounds from catchment basins to coastal seas to continental margins is a primary thrust of LOICZ. Catchment studies and the influence of human activities on processes of change are companion initiatives with coastal seas budget development. A vast spectrum of measurements, observations, models, documents, and other types of data at a variety of scales are needed for LOICZ to meet its goals. These data have been collected from more than 250 contributing projects and stored in the LOICZ database. An important issue is to provide C-GOOS with access to the LOICZ data base and information in order to assist in regional project development within C-GOOS. This could be one of the first C-GOOS - LOICZ join actions helping in the finalization of the C-GOOS observing system design.

LOICZ is not the only programme. The last IOC executive council meeting agreed to hire an external advisor to gather and compile information on existing coastal monitoring systems. It is essential that after this list is compiled and made available to C-GOOS as soon as possible.

**Data communication, quality control and integration:** This is an extremely important problem that will require guidelines on how to organize data flow, particularly when preparing an assessment of the data from the network. ICES is a good example of a data center which could perhaps serve C-GOOS. Perhaps C-GOOS should contact the World Weather Watch to gain from their experience.

**Making the GOOS fly:** Drafting the design for the initial observing system was difficult; making it a reality will be more challenging. Table 2 shows the detail provided by the OOSDP in specifying the deep ocean

component. Specifying the coastal observing system will be problematic. To illustrate we asked in Section 3.2 "How many tide gauges does C-GOOS need?" The answer was "It depends". The root of the problem is that the spatial scale of sea level variations is a function of frequency. It is also a function of direction: generally speaking sea level varies more slowly along shore than across shore. One can expect even greater difficulty when attempting to specify a sampling strategy for variables like harmful algal blooms or even sea surface temperature. When the C-GOOS panel has agreed on the observing elements, it will have to quickly establish working groups to examine many of the important details that have not been considered here. It will be necessary for many working groups to co-opt specialists from off the C-GOOS panel along with members of EuroGOOS, NEAR-GOOS and so on.

## **APPENDIX 1: GOOS DESIGN PRINCIPLES**

### **Principle D1. GOOS is based on a plan designed to meet defined objectives on the basis of user needs**

This principle states foremost that GOOS from its conception, is a planned system for the acquisition and value-added application of a specific subset of observations gathered according to a designed strategy. It is not an opportunistic assembly of whatever ocean observations are offered for contribution by participating countries. The plan will therefore state (or at least outline) the observations that are required for each particular objective, and should where possible define how they would be applied to the needs of users. Applications should include the 'public good' where there is a defined socio-economic basis. Observations that qualify for inclusion as contributions to GOOS will, by definition, be of a kind and quality applicable to the defined objectives and end-use.

### **Principle D2. The design assumes that contributions to GOOS are long term**

GOOS is founded on the concept of an observing system that is ongoing or of an indefinite lifetime, in the same sense as the system of global meteorological observations. Although it will inevitably include observations gathered and sponsored for a limited duration and for differing purposes, the design will assume that such observations will be selected and contributed as part of a continuum that assembles to create a long-term, systematically structured and quality-controlled data set.

### **Principle D3. The design will be reviewed regularly**

GOOS will evolve as plans consolidate, alliances form, commitments are made, needs become better defined and prioritized and technology improves. In addition, an essential element of the observing system must be the continual evaluation of the system design through the analysis of its products. Thus, to ensure that implementation proceeds continuously and effectively, the system design will require frequent review and adaptation.

### **Principle D4. The design allows for flexibility of technique**

GOOS is aimed at the assembly of a data set of specific oceanic variables. Depending on the capability of the participating observing agencies and the advance of technology, the method of observation of these variables will differ. The design should not unnecessarily restrict the technique used for observation provided its standard is adequate for the purpose.

### **Principle D5. GOOS is directed towards global problems and/or those ubiquitous problems benefiting from global observing systems**

Among the range of needs for systematic observation of the marine environment on all scales, there is a subset of needs that can be most effectively addressed through cooperation within GOOS. Some depend on a scheme of related observations; such as are required for the changing climate of the large-scale ocean or for a pollutant stressing the capacity of large parts of the ocean. Others are generic, common or dependent and can

be facilitated and in some cases only made possible by a globally co-ordinated or globally designed and facilitated system of observations. Even needs that are dependent only on local observations, as is the case for many coastal applications, may benefit greatly from data products that are generated as part of a globally co-ordinated system. The thrust of the GOOS design should be to service this subset of needs without prejudice to existing systems operating outside of the GOOS framework.

**Principle D6. The design covers the range from data capture to end products and services**

The end-to-end concept implies a known or definable pathway of connections between a basic observational element and the end use or purpose to which the observation (or information derived from it) is applied. Typically, each type of ocean observation has a range of potential applications, and most applications have the need for more than one observation type. In designing a system to serve a given range of end-uses, it is important to know how the observation would be used, processed and combined with other observations to deliver an observational 'product' of value to the end user. The GOOS design must therefore be concerned not only with how observations should be made but the steps and operational and scientific products (e.g. technology and models) required for their end use.

**Principle D7. The management, processing and distribution of data will follow a specified data policy**

In concert with the policies of IODE, IGOSS and GCOS, and following the data management plan for the World Weather Watch of the WMO, commitment is required by GOOS participants to establishing, maintaining, validating, making accessible, and distributing high quality, long-term data meeting internationally agreed standards. Preservation of GOOS data is required in suitable archives following appropriate procedures and criteria for data acquisition and retention, and should include information about data holdings. Data should be processed to a level which is generally suitable for the generation of operational products and for research, and described in internationally accessible on-line computerized directories that can also be made available by other means. GOOS contributors are responsible for full, open and timely sharing and exchange of GOOS-relevant data and products for non-commercial activities. Exchange implies that donation by individual nations gains access to data from others as well as to products derived using all available data, such that the benefit of cooperation exceeds the cost.

**Principle D8. The design takes into account the existence of systems outside GOOS that can contribute to and/or benefit from GOOS**

A cornerstone of GOOS development is that it will be built to the greatest extent upon existing systems of observation and data management, national, regional and global. This requirement is vitally important for the most effective use of global resources. By the same token, these systems have their own defined purposes and goals outside GOOS and these goals cannot necessarily be deflected to the delivery of GOOS. GOOS must therefore be designed to 'co-exist' and interact cooperatively and to mutual benefit with the other systems. As a particular example, to the present time, most interior ocean physical observations have been made through individual research projects or in connection with global research programmes like TOGA and WOCE. These provide valuable data sets to GOOS and could in turn benefit from GOOS observations, although in many respects they are inappropriate for incorporation into a GOOS implementation framework. Systems like IGOSS, GLOSS and IODE are presently structured as central points for the management of specific data types collected by national agencies for reasons that will often be outside the scope of GOOS. Their operations could be adapted and/or expanded to the management of a subset of data that contributes to GOOS.

**Principle D9. The design takes into account quality assurance procedures**

The incorporation of quality assurance (QA) procedures as an integral part of the GOOS plan represents a departure from the practice of existing observing systems, which in some cases apply QA processes but not as part of the observation design and acceptance strategy. Without quality assurance procedures, the great promise of global data sets to address specified problems will certainly not be met. Several of the principles stated above, for example D2, D3 and D4, address the need for strong oversight of the observing system and



its continued review with an eye to assessing and improving its effectiveness. Quality assurance is a fundamental part of that effort.

## **APPENDIX 2: CAPACITY BUILDING AND THE COASTAL OCEAN WATCH**

*This appendix was contributed by Eduardo Marone*

The direct operational characteristics of the COW will need to be closely managed through regular training courses directed to its operators. These courses could follow the format of the GLOSS regular training courses for mean sea level observation, processing and analysis. They will need to be grouped by region, with a biannual frequency at least, and presented by a minimum of four specialists indicated by the GPO and after proposal of the C-GOOS panel. These regular training courses, in addition to giving the basic guidelines for the operation of COW stations, will serve as the right place to establish the accuracy and quality control protocols and standards.

The production of a Manual, such as the one produced for mean sea level under GLOSS, will need to be initiated as soon as the first COW stations become operational, as well as the core of C-GOOS Pilot Projects.

Under the most general capacity building issues of GOOS, a strong component on COW training activities must be accomplished. The TEMA programme should include specific training for COW stations operators, not only general GOOS/C-GOOS training. Other UNESCO institutions and programmes (like the International Centre for Theoretical Physics or the TrainSeaCoast programme, among so many others) need to be instructed to introduce into their regular training and capacity building activities on marine sciences, specific courses for COW stations operators. Strong pressure from the C-GOOS and GPO on that sense needs to be exerted on those programmes and institutions, all under the UNESCO and/or IOC umbrella, to accept these activities as regular activities under their responsibility.

The necessary homogeneity, quality control and accuracy standards will be quickly established and enhanced within the regular training activities following C-GOOS guidance. This activity has the secondary advantage of spreading the COW concept if the inclusion of potential new "operators" is granted in each course. For that reason a (region specific) percentage of the course participants need to be reserved for new potential COW operators.

As the joint GLOSS/C-GOOS activities, one simple first approach could be to ask GLOSS to accept during the next few years, to share with C-GOOS just a little part of their regular training courses, just to illustrate the COW idea and other C-GOOS issues in order to give a very basic training on that.



## **ANNEX VII**

### **PILOT PROJECT PROPOSALS**

The following proposals are in development and can be found on the C-GOOS Intranet Web site (*tortoise.hpl.umces.edu*):

Coastal Ocean Observing System in the Eastern South Pacific Ocean (Osvaldo Ulloa)

Remote Sensing Algorithm Development for Coastal Waters (Sinjae Yoo and Dale Kiefer)

Harmful Algal Blooms in the Indo-Pacific Region (Adriana Zingone)

The Phytoplankton Network (PhytoNet)(Adriana Zingone)

The Co-ordinated Adriatic Observing System (CAOS) (Tom Malone)

Caribbean Coastal Marine Productivity (CARICOMP) (John Ogden)

Global Network on Seagrass Science, Monitoring, Training and Information Exchange (SeagNet) (Carlos Duarte with Eva Maria Koch and Mike Fortes)

Southwest Atlantic (Eduardo Marone) <http://www.cem.ufpr.br/fisica/quijote.htm>

Coastal Hazards in the IOCEA Region (Larry Awosika)

Vietnam Coastal Disaster Warning System (Johannes Guddal)

Western Pacific Biodiversity (Yoshihisa Shirayama)



## ANNEX VIII

### LOICZ

*(This section was provided by Chris Crossland)*

LOICZ has a number of activities that have potential to link with and support the C-GOOS development and actions. Key elements are considered below:

#### DATABASES

##### LOICZ activities

LOICZ maintains global databases for a network of coastal zone researchers and agencies, databases for LOICZ projects and links to coastal zone information and networks in other agencies, and data and scientific information addressing material fluxes, bio-geochemical processes, and human dimension aspects in the coastal zone.

The database of nearly 2400 coastal zone researchers is not comprehensive, but does provide a wide global coverage of active people in maritime nations. LOICZ has discussed access to this database with IOC (Dr Colin Summerhayes).

LOICZ has more than 250 contributing projects listed and active in different parts of the work. The projects encompass physico-chemical, biological, and socio-economic research in the coastal zone, ranging from local to regional and global scale enterprises. The database is currently being updated for amended listing on the LOICZ Web site. An archive of completed projects is held. Detailed project descriptions are being incorporated into the electronic database.

Data and scientific information within LOICZ is public domain. LOICZ databases include electronic (websites) and hard-copy publications for coastal typology variables, river discharge (GLORI), and bio-geochemical budgets for C, N and P in coastal seas and estuaries. Recently published scientific reports and newsletters from LOICZ are also listed on the LOICZ Web site.

##### Background

Early discussions in LOICZ addressed data issues and culminated in a Data and Information Plan (1996). However, the evolving structure of LOICZ and the rapid advances in electronic information systems has made obsolete much of the Plan. LOICZ has worked with IGBP-DIS to a limited extent in recent times to seek best advice on how to progress with data inventories. IGBP-DIS is currently being re-structured and IGBP is looking to new ways of dealing with the data/information issue. LOICZ has had some discussion with IOC-IODE regarding metadata issues.

LOICZ is keen to link with the initiatives of another agency (with longevity) for resolving its data and information transfer matters, and views IOC as a potential key agency particularly through the GOOS programme.

##### Potential joint action

- (i) Make LOICZ researcher database accessible to C-GOOS through IOC, to assist in the development of a global inventory of researchers and to enhance networking and capacity building.
- (ii) Provide access to the LOICZ project database and information, to assist in regional project development and information/skills awareness within regions, and to assist in information transfer into czm and policy areas, especially at national and regional levels.
- (iii) Establish a mechanism to transfer results of the C-GOOS projects to the LOICZ database.

- (iv) Establish a dialogue mechanism to ensure joint knowledge about the development of new projects in each programme, and seek to collaborate in research initiatives of mutual interest.
- (v) Work collaboratively to establish and maintain a common database and information transfer system established under the aegis of C-GOOS within IOC (in the sense of JDIMP Plan).

## **MATERIAL FLUX MODELING**

### LOICZ activities

The determination of local and regional bio-geochemical systems budget models (for C, N, P) is a core activity in LOICZ. Major effort is being put into workshops and training in various regions of the world. Current status of work is contained in the LOICZ Web site, with hard copy and CD-ROM copy of budget workshops available through LOICZ IPO. Site descriptions for Europe, Central and North America, and Australasia are well developed and expanding; other regions are scheduled for workshops over the next 18 months. Support funding for this work and allied training is expected from UNEP-GEF.

A joint LOICZ-JGOFS group (CMTT) continues to work on C, N, P fluxes across margins of the continental shelf.

Catchment models for horizontal flux of materials and the implication of the human dimension is a major activity; currently efforts are focussed on Europe, but work progresses in other regions.

A project in South East Asia has been addressing the people/coastal bio-geochemical processes issues, developing an integrative modeling approach. The project, funded by WOTRO and supported by START, is completing Phase I and expected to continue. The model approach is being transferred for application in other regions.

### Background

Bio-geochemical budgets for coastal systems are a linch-pin of LOICZ and the aim is to have about 200 systems described by end of the year 2000. Assessment of horizontal material fluxes from catchment basins-to-coastal seas-to-continental margins is a primary thrust of LOICZ. Catchment studies and the influence of human activities on processes of change are companion initiatives with the development of coastal seas budgets.

### Potential joint action

- (i) Establish collaborative activities (joint badging, at least) whereby LOICZ budgets and models developed by LOICZ are then tested and verified at regional and local scales by GOOS actions.
- (ii) Promote and effect regional bio-geochemical budgets workshops as joint venture activities, including the allied training components.
- (iii) Develop collaborative project (s) which identify and evaluate indicator parameters of system function for use in monitoring and czm.
- (iv) Jointly develop a mechanism and communication structure for transfer of models and tools to regions and end-users.

## **REGIONAL PROJECTS**

LOICZ, like other agencies with a global dimension, organizes much of its work activities through a regional focus. It depends on the work of national agencies and scientists, supplemented by funding and organization to bring together regional groups of experts to integrate relevant science and, where possible, to assist in capacity building. LOICZ has some history of working with IGBP-START and IOC in regional enterprise, and is actively seeking to expand these associations in carrying forward its work. Currently,

LOICZ is working with other «capacity building» agencies (IAI, APN, UNEP) to increase the collaborative actions and to minimize duplication when pursuing common agendas.

An outline of regional activities, current and projected, is listed:

## **REGIONAL LOICZ**

### **(i) Current:**

Southeast Asia	Joint SARCS-WOTRO-LOICZ research project (Primary funding from Netherlands WOTRO) - Phase 1 (96-99); Phase 2 planning in progress;
Oceania	Workshop and projects development with START in 1998; links with IOC; national and regional projects; and workshop/networks addressing Australasia/Papua New Guinea (PNG), plus sea level workshop in 1999;
West Africa	Workshops, project proposals with START and IOC in 1998; national and regional projects; engagement with region since 1996, response has been patchy and now strengthening;
Europe	Strong links and regional project activities developed in 1998 with ELOISE (EU programme); LOIS (UK);
Mexico and	Workshops on core projects, and national projects continuing, from Central America 1997 start up;
Med-North Africa	Core and regional projects exist (from 1997-8); looking to combine with European activities and link with IOC Med-GOOS (planned expansion in 1999, strengthening in 2000).

### **(ii) In progress:**

South Asia	Engaging the region through aegis of START (1999); core project activities planned in 1999-2000;
South America	Engaging with the broader Latin America region, intending to link with Caribbean, Mexico and Central America initiatives and activities 1999 (IOC and GOOS, IAI as potential partners); national projects, and LOICZ OSM in 1999;
Caribbean	Building a regional project (1998-9); positive indications of links with IAI, IOC, and European collaborative activities;
East Asia	Developing regional project now (START, IOC links expected); national research projects.

### **(iii) In development:**

East Africa	Work to do; proposed linking with START initiatives (initial development 1999, leading to activities in 2000);
Arctic	(Russia LOIRA regional project proposal in-preparation; linking with Permafrost group);
North America	Involves individual institutions and researchers.

**(iv) Potential joint action:**

- Establish a mechanism to discuss and develop joint regional actions which benefit both LOICZ and C-GOOS.
- Collaborate on the implementation of regional projects of mutual benefit, including training and information transfer.
- Jointly investigate the possibilities for funding of the C-GOOS and LOICZ projects (e.g. within the EU 5<sup>th</sup> Framework programme).

**ADDITIONAL ISSUES**

Recognizing that LOICZ has a finite «life» (end of year 2002; subject to current discussions in IGBP), a process should be established to ensure that the scientific information, capacities and networks are transferred for on-going use and support of C-GOOS.

An MOU exists between LOICZ and IOC; this could be updated and provides an initial framework for formal association and action.



## ANNEX IX

### C-GOOS and LOICZ

*(This section was provided by Chris Crossland)*

#### **Towards joint projects and formal linkages**

**The following commentary and identification of potential joint actions builds on discussion of the C-GOOS Panel meeting in Curitiba, Brazil (29 October – 1 November 1998).**

The complementary nature of global LOICZ and the Coastal GOOS programme is clear. LOICZ has scientific activities in progress that could be of significant benefit to the structure and operation of the evolving C-GOOS programme. These include developments in coastal typology, databases, and bio-geochemical and human dimension modeling. In addition LOICZ has an increasing regional focus for its global project activities and an expanding network of coastal researchers and agencies at national and regional scales. The development of a mechanism for close cooperation has potential for mutual advantage in the short and long term.

A brief outline of LOICZ approach to Typology issues is provided below and an outline of the broader purpose and directions of LOICZ.

#### **Coastal Typologies**

##### LOICZ activities

A small networked group of specialists is working on the development of tools for a global coastal typology. It is likely that more than one typological approach will be required to meet the LOICZ needs for up-scaling coastal flux information to regional and global scales. Current work includes: development of «cluster» methodologies, tools for aggregating coastal descriptions, expanding and rationalizing indicator parameters in the database, ways of linking to existing global data models, and seeking ways to link coastal with catchment typologies (which are being developed in IGBP and elsewhere).

Initial products are being posted to Web sites, mainly for group discussion and at least intuitive assessment by regional experts (e.g. [www.ghsun1.kgs.ukans.edu:8002/Lohtml/Typhtml/typindex.html](http://www.ghsun1.kgs.ukans.edu:8002/Lohtml/Typhtml/typindex.html); [www.kars.ukans.edu/mexico/coastal/hhgscx50coast.htm](http://www.kars.ukans.edu/mexico/coastal/hhgscx50coast.htm)). The Web sites are dynamic and have yet to be aggregated as summary products into the LOICZ web page ( ), which contains some preliminary text and an initial database.

##### Background

At an early stage of its development, LOICZ embarked on a coastal typology approach to address spatial scaling issues. In recent years, workshops and activities focussed on building a database addressing the global coastal zone ( $\pm 50$  m elevation). By mid-1998, a database of physical, biological and socio-economic parameters (109 variables) was established at one degree pixel scale, and required about 9600 pixels to represent the global coastal zone. The database is rudimentary in socio-economic parameters, often in scaling aggregation and number of variables. Physical parameters are more extensive. The database includes in many places land, immediate coastal ocean, and coast line pixels.

There are no clear recipes for aggregating the pixels into a coastal classification – indeed, this is currently a «hot issue» in some research sectors. Trials showed that statistical correlative methods were not appropriate. A workshop in October 1999, brought together skills for cluster methodologies and evaluated the LOICZ database to minimize aggregation bias and to assess alternative indicator parameters. Work since then has refined the database and extended the methodological approach to yield typology images that are intuitively reasonably representational. The further development of methods, databases and finer-scale resolution remain as priorities.

#### Potential joint action

- Maintain a watching brief on LOICZ developments and associated initiatives being taken within IGBP and EU (such as ELOISE), using LOICZ as a link agency.
- Jointly review the on-going typology approach and products in LOICZ and adopt the methods where appropriate for C-GOOS, drawing down on the LOICZ research network and posing questions for resolution.
- Establish a mechanism with LOICZ for dialogue, transfer of information and transfer of capacity/skills, as appropriate.
- Regional activities of C-GOOS could provide data and information to assist the LOICZ developments.

#### **An outline of LOICZ – Purpose and Directions**

For more than a decade, the International Geosphere-Biosphere Programme (IGBP) has been harnessing scientific skills throughout the world to address Global Change. The global programme aims to quantitatively understand the biophysical processes that regulate the Earth's surface and its capacity to support life. Land-Oceans Interaction in the Coastal Zone (LOICZ) is one of the eight core projects of IGBP, and is providing science information to answer the generic question: «How will changes in land use, sea level and climate alter coastal ecosystems, and what are the wider consequences?» (see IGBP Web site, <http://www.igbp.kva.se/>).

Fundamental to answering this question is the need to recognize that the area of the Earth's surface where land, sea and atmosphere meet and interact - the coastal zone - is not a line boundary of interaction but a global compartment (Figure 1). It is of special significance, not only for bio-geochemical cycling and processes but also increasingly for human habitation.

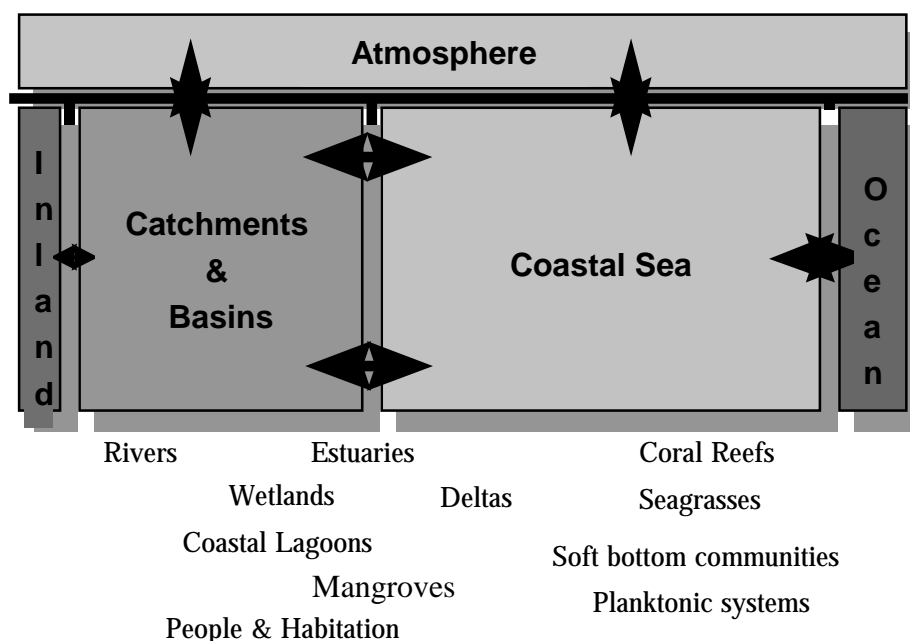


Figure 1. The coastal zone is not a line boundary but a vital global compartment with many boundaries and fluxes involving interacting biophysical, geochemical, and socioeconomic processes.

The vital nature of the coastal zone and its importance to global change considerations and the Earth's peoples is now generally acknowledged by scientific and political forums. In comparison with the

relatively uniform environment of the sunlight zone of the open ocean, or the rapidly mixing environment of the atmosphere, the spatial and temporal heterogeneity of the world's coastal zone is considerable. Consequently, considerable methodological problems are associated with developing global perspectives of the role of this compartment in the functioning of the total Earth's system.

Practical knowledge of the heterogeneous coastal zone depends on harnessing an array of research from natural and social sciences and recognizing both anthropocentric and geocentric driving forces of change. The LOICZ programme is designed to encompass these elements in providing science information to the global community and which should prove vital for use by global decision-makers and coastal zone management.

### LOICZ Purpose

LOICZ is trying to generate more accurate estimates of the fluxes of materials into, through, and from the world's coastal zone (LOICZ Implementation Plan 1995). Major questions that LOICZ addresses on a global scale are:

- ❑ Is the coastal zone a sink or source of CO<sub>2</sub>?
- ❑ What are the mass balances of carbon, nitrogen and phosphorus in the coastal zone?
- ❑ How are humans altering these mass balances, and what are the consequences?
- ❑ How do changes in land use, climate and sea level alter the fluxes and retention of water and particulate matter in the coastal zone, and affect coastal morphodynamics?
- ❑ What is the role of the coastal zone in trace gas (e.g. DMS, NO<sub>x</sub>) emissions?
- ❑ How can knowledge of the processes and impacts of biogeochemical and socio-economic changes be applied to improve integrated management of the coastal environment?

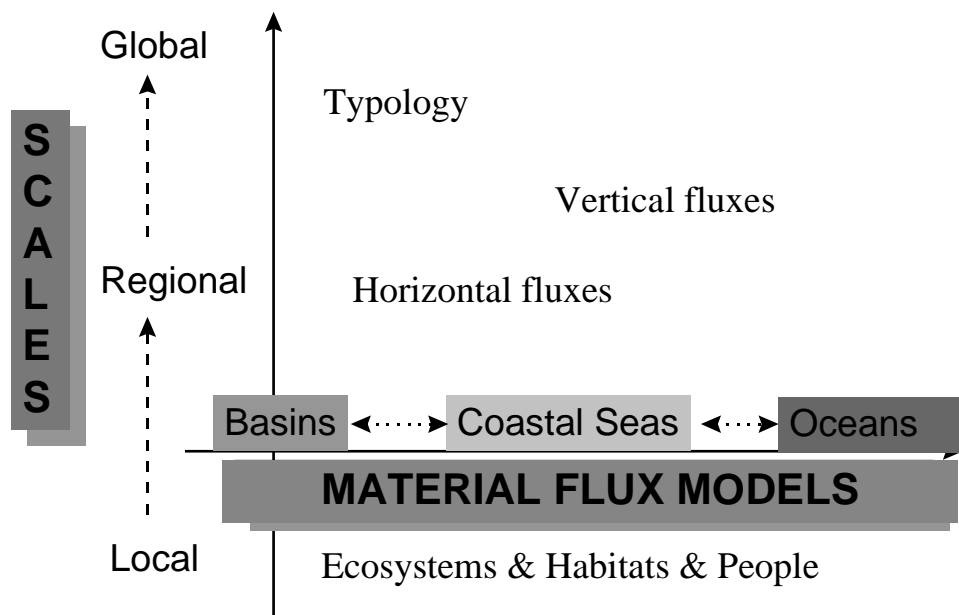


Figure 2. Representation of the two major dimensions of the LOICZ approach.

### LOICZ Approach

The LOICZ programme has two major thrusts (Figure 2). First, the development of horizontal and, to a lesser extent, vertical material flux models (or budgets) from continental basins through regional seas to continental ocean margins, based on our understanding of biogeochemical processes for coastal ecosystems and habitats, and the human dimension. Here, the influence of human activities on these changes and the impact of flux changes on human welfare are vital areas of enterprise. The second thrust is addressing the scaling of the material flux models at spatial scales from local to global levels and to a lesser extent across temporal scales.

### LOICZ Activities

The LOICZ activities are organized through four working areas, or Foci:

- ❑ Focus 1: The effects of changes in external forcing or boundary conditions on coastal fluxes;
- ❑ Focus 2: Coastal biogeomorphology and global change;
- ❑ Focus 3: Carbon fluxes and trace gas emissions;
- ❑ Focus 4: Economic and social impacts of global change in coastal systems.

The Foci bring together an integrated programme of research and assessment addressing material fluxes into and between coastal basins and coastal seas, and describing forcing functions and boundary fluxes with atmosphere and continental slopes. The emphasis is on C, N, P (especially CO<sub>2</sub>, with consideration of trace gases) and dissolved and particulate states and forms of matter. The socioeconomic dimension is important to LOICZ: the effect of people activities on the material fluxes and how the subsequent changes in the coastal zone may influence the human dimension of the coastal zone. Our modeling approaches will use the «currencies» of bio-geochemistry (especially carbon and energy) and will include considerations of the monetary and societal values in expressing changes and influences.

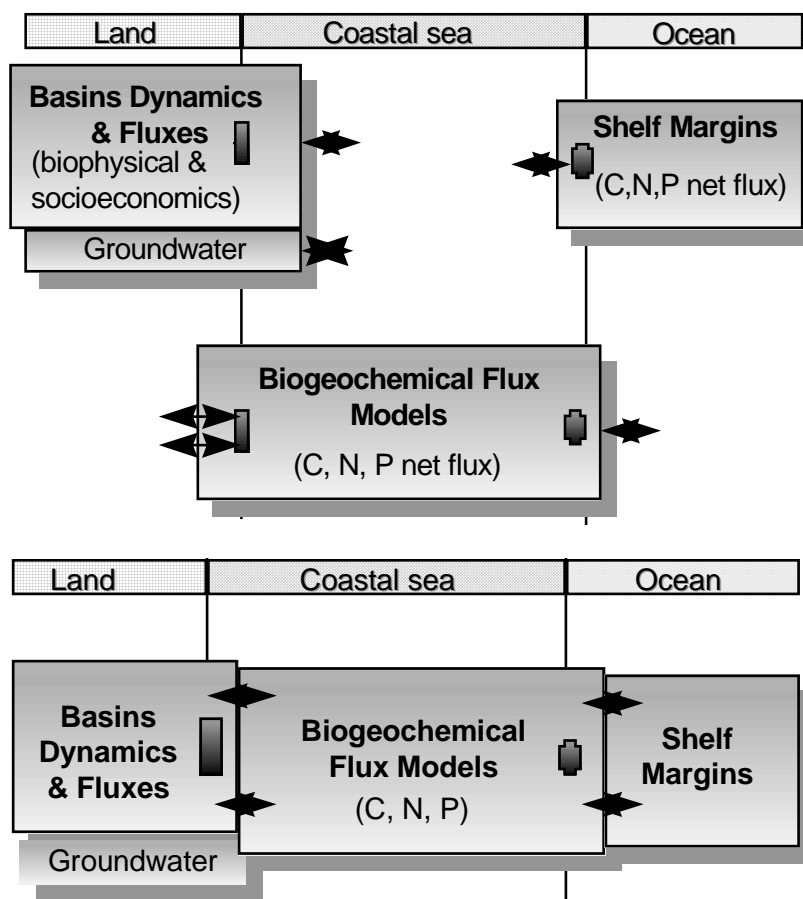


Figure 3. LOICZ approach to horizontal flow: Key elements (top) and their alignment (bottom) which describes material flow and the human dimension in the coastal zone for a site or region.

The development of carbon, nitrogen and phosphorus budgets at local and regional scales for coastal seas, including flux boundary conditions at landward estuarine environments and at continental margins environments, is a core element of LOICZ (Figure 7). Allied river basin work is to elucidate the material input conditions and processes, including the socioeconomic effects and conditions, influencing and modifying riverine and ground water discharges.

LOICZ aims to develop a suite of horizontal material fluxes models (continental basin to continental shelf margin) from case studies in different regions of the world, which take account of the range of linking and forcing variables.

To meet this challenge of better describing and understanding the dynamics of the land sea interface, a number of topical core projects are to be implemented. These will include capture and integration of research outcomes from the array of existing and contributed studies and other relevant research (particularly at local scales) which address the fundamental questions of ecosystem function, diversity and ecology, and the developing information base on the socioeconomic dimensions.

In addition to the bio-geochemical and socioeconomic dimensions and assessments of horizontal material fluxes (including groundwater), the scaling issues and necessary methodological developments are crucial to LOICZ. We have a strong involvement by researchers to develop typological approaches, tools and methods. This work is trying to find a coherent approach and tool kit to resolve the up-scaling issue. The development of further databases, identification of key indicator variables for monitoring (particularly at local and regional scales) and abilities to pursue scenario building («what if...») are planned activities.

Collaboration and partnerships are vital for LOICZ. While new projects are established to meet goals and fill gaps, LOICZ depends on existing data and information. The LOICZ programme is organized around a structure of major projects (including commissioned tasks and contributed relevant research projects) and activities which synthesis the global science knowledge, involving both original research activities and integration of our global science knowledge about the coastal zone. Major projects include:

- ❑ Foci-related, addressing key LOICZ elements and developing new tools; and
- ❑ Regional, addressing specific issues and enhancing skills, case studies and intuitively different - climatic, biophysical/socioeconomic impacts - global areas, integration of local-regional scales, models and needs of science for application to globally representative coastal zone management issues.

A network of global researchers continues to make available data and science findings from topical and local scale projects. Synthesis of scientific information and uncertainties is approached by a co-ordinated framework and integration processes to bring together the expertise and scientific information about the coastal zone through commissioned reviews, expert working groups and task teams, workshops and open science meetings for peer-review and tools assessments.

LOICZ aims to facilitate the necessary research activities by encouraging national support for key projects. Where possible, LOICZ looks to provide appropriate seed funding and particularly seeks avenues of funding from international and regional agencies and organizations to support targeted research, data assessment and capacity building and training. LOICZ funds are mainly directed to the processes of integration and synthesis of science information, facilitating networking and researcher collaboration, and communication and transfer of information, tools and skilled inputs to the global agencies (Intergovernmental Organizations [IGOs] and NGOs) and the wider community.

LOICZ started its first phase in 1993, and has developed comprehensive science and implementation plans and establishing a global network of some 2000 researchers. Engaging and involving IGO and NGO «client» organizations in the LOICZ work of research, integration and product delivery is important to ensure the transfer of our science knowledge for application by decision makers and other global interests in coastal zone management (Figure 4).

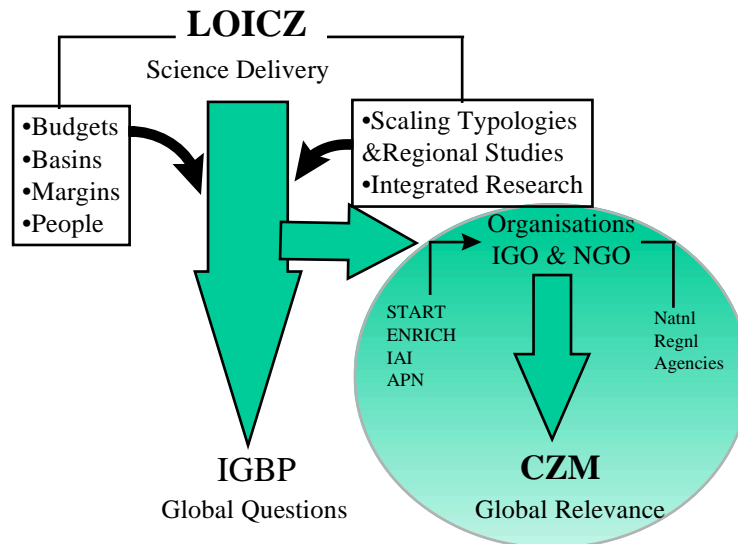


Figure 4. Representation of the major directions for use of LOICZ science: a) by IGBP programme and b) by global organizations (IGOs and NGOs), regional programmes and national agencies.

LOICZ began its second 5-year phase in 1998 and we are putting increased effort both into consolidating our partnerships and into developing new regional projects in Africa, Australia, Latin America and Europe. However, commitment of people and their regionally and nationally supported research is fundamental to our success.

### Timeframes and Projected outcomes

The intended outcomes to be achieved within the 10-year lifetime of the original LOICZ proposal (i.e. by 2002) include not only an initial globalized estimate of coastal zone bio-geochemical functions, but also an assessment of specific data and techniques needed both to refine the estimates at all scales. This improved understanding of sensitivity and interactions at various scales will ultimately be the major legacy of LOICZ to coastal zone science and management, as the estimates of bio-geochemical fluxes and functions will be the contribution to overall goals of IGBP in understanding the total Earth system.

LOICZ aims to have within three years, a collection of coastal bio-geochemical budgets that is an adequate basis for globalization (more than 150), a compendium of information on coastal basin dynamics, and a system of typologies that can be used for a first-cut global synthesis. It is expected that the system will involve multiple typologies - groundwater and surface water fluxes, for example, may be considered separately and compared. Similarly, we envisage several stages of superimposing the human dimension on the natural environment, mainly through case study evaluations for different regions and at different spatial scales. The overall synthesis of the LOICZ information to achieve a global statement against our goals will occupy a large number of scientists globally in the first years of the new millennium.

## ANNEX X

### LIST OF ACRONYMS

AUV	Autonomous Underwater Vehicle
C-GOOS	Coastal Panel of GOOS
CAOS	Co-ordinated Adriatic Observing System
CARICOMP	Caribbean Coastal Marine Productivity Programme
CDOM	Coloured Dissolved Organic Matter
CHL	Chlorophyll
CLIVAR	Climate Variability and Predictability
CMM	Commission for Marine Meteorology (of WMO)
COW	Coastal Ocean Watch
DMDB	Regional Delayed Mode Base
ECMWF	European Center for Medium Range Weather Forecasting
EEZ	Exclusive Economic Zone
ELOISE	European Land-Ocean Interaction Studies
ENSO	El Niño – Southern Oscillation
EuroGOOS	European GOOS
GCN	Global Core Network
GCOS	Global Climate Observing System
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environmental Facility
GIPME	Global Investigation of Pollution in the Marine Environment
GIS	Geographic Information System
GLOBEC	Global Ecosystem Experiment
GLOSS	Global Sea-Level Observing System
GODAE	Global Ocean Data Assimilation Experiment
GPO	GOOS Project Office
GPS	Global Positioning System
GSC	GOOS Steering Committee
GSPB	GOOS Services and Products Bulletin
GTN	Global Telecommunications Network
GTOS	Global Terrestrial Observing System
HAB	Harmful Algal Bloom
HOTO	Health of the Oceans
IAI	Inter-American Institute for Global Change Research
IBOY	International Biodiversity Observation Year
ICAM	Integrated Coastal Area Management
ICES	International Council for the Exploitation of the Sea
ICSU	International Council for Science
IGBP	International Geosphere - Biosphere Programme
IGO	Intergovernmental Organization
IGOSS	Integrated Global Ocean Services System
IGS	International GPS Service for Geodynamics
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IODE	International Ocean Data and Information Exchange programme
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
JDIMP	Joint Data and Information Management Panel
JGOFS	Joint Global Ocean Flux Study
LME	Large Marine Ecosystem
LMR	Living Marine Resources
LOC	Local Organizing Committee
LOICZ	Land-Ocean Interactions in the Coastal Zone
LOIRA	Land-Ocean Interactions in the Russian Arctic

LOIS	Land Ocean Interaction Study
LTT	Long Term Trend
NDBC	National Data Buoy Centre
NEAR-GOOS	North East Asian GOOS
NGOs	Non-governmental Organizations
NOAA	National Oceanic and Atmospheric Administration (USA)
NPP	Net primary productivity
ODINAFRICA	Ocean Data and Information Network for Africa
OECD	Organization for Economic Co-operation and Development
OOPC	Ocean Observations Panel for Climate
OOSDP	Ocean Observing System Development Panel
PACSICOM	Pan-African Conference on Sustainable Integrated Coastal Management
PNG	Papua New Guinea
ROV	Remotely Operated Vehicle
RTDB	Regional Real Time Data Base
SAR	Synthetic Aperture Radar
SEAS	Shipboard Environmental Data Acquisition System
SEACAMP	Southeast Asian Centre for Atmospheric and Marine Prediction
SeagNET	Seagrass Network
SOPAC	South Pacific Applied Geoscience Commission
SST	Sea Surface Temperature
START	Global Change System for Analysis, Research and Training
TAO	Tropical Atmosphere Ocean (buoy array)
TEMA	Training, Education and Mutual Assistance (IOC)
UHSLC	University of Hawaii Sea Level Center
UNCED	The United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational, Cultural and Scientific Organization
UNEP	United Nations Environment Programme
WCRP	World Climate Research Programme
WESTPAC	IOC Sub-Commission for the Western Pacific
WMO	World Meteorological Organization
WOTRO	Netherlands Foundation for the Advancement of Tropical Research
WWW	World Weather Watch