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An Implementation Strategy for the Coastal Module of the Global Ocean Observing System

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UNESCO

Intergovernmental Oceanographic Commission (IOC)

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Layout and design by Eric Loddé.

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Preface

Some could say that the Open Ocean Module of the Global Ocean Observing System (GOOS), benefited from the well known "science-technology push". This is not surprising, since most technological applications that finally make their way into our everyday life, are in their origins developed in this way. Market forces and demand undoubtedly play a role, but technological and knowledge vectors of development, do still maintain a salutary independence and autonomy.

What is more surprising is that one can assert that the Coastal Module of GOOS has been relentlessly pulled by obvious societal needs accompanied by a dedicated group of scientists, a distinct minority. These scientists strongly believe that improving the availability of data and information on a variety of oceanic and costal processes can effectively provide a series of useful services that can eventually stop and reverse the accelerated degradation of our coastal resources. I strongly share their vision.

There is also another interesting contrast. In the Open Ocean Module of GOOS, we are mostly addressing a single-issue challenge: the role of the Ocean in climate variability and climate change. To say that this is a single issue, is of course a simplification, but in contrast to the coastal domain it is certainly much simpler and better focused. This goes hand in hand with the fact that for studying climate through understanding the variability and distribution of heat and momentum in the ocean at different scales, we have the needed science more or less at hand. A well delimited, round scientific ambit, with a good backbone theory and powerful tools of application. Nobody should be taken by surprise that much of the Open Ocean Module of GOOS has been able to secure funding through a variety of national science and technology budgets. It is mainstream science.

None of that applies to the coastal module. The coastal module is multi-purpose and addresses many issues. It deals with the physics of the ocean where it is usually most difficult, at the limit or boundary layer, but it also deals with chemistry, biology, biogeochemistry and socio-economics. In terms of processes they are complex and with many second and third order interactions. The science involved is far from simple and much of it yet needs to be done. I firmly believe that this module of GOOS will develop driven mostly by its applications, driven by the demand not by the supply of knowledge. Applications of science are possible at any given time of its development, if sufficient creativity and ingenuity are applied to provide the solutions.

A case in point is the development of the tsunami warning system in the Pacific Ocean. The system depends on one of the core networks that is part of the Coastal Module of GOOS, the global sea-level network GLOSS. It was not a major breakthrough in the geosciences that moved the IOC to design the system. It was a clear case of need. The system does not forecast tsunamis. Its purpose is more humble. It is designed to use what we can do, that is detect tsunamis in the ocean after they have been generated, and to warn distant places of its presence. Since only a minority of strong, shallow earthquakes generates tsunamis, tsunami warnings cannot be based on seismic information alone. When a strong shallow earthquake occurs, the tsunami warning system issues an "information bulletin" transmitting the seismic information available and enters automatically in a mode of "watch". Travel times and arrival times of the possible tsunami are calculated and sent to all participating centers and the observing network is alerted. As soon as the estimated arrival time to the first detection station has been surpassed and the instrument has detected or not a tsunami, a tsunami warning can be issued or the watch period can be cancelled. The system goes on and off many times in a given year, triggered by strong earthquakes, but only very few times issues a true tsunami warning.

Others things happen as well, sophisticated numerical modeling to find the direction of propagation, focal seismic modeling, etc., but the hard core depends on this "procedure", that is based on ingenuity, common sense and the full exploitation of what knowledge and technologies are at hand. The tsunami warning system in the Pacific Ocean has evolved with technology. Communications links today are different than when the system was established, and today in addition to digital tide-gauges connected through satellites, we have deep ocean pressure sensors that can improve the design of the observing network and shorten the response time of the system as a whole.

The Coastal Module of GOOS is designed to improve capabilities to mitigate the effects of natural hazards. As in the case of the tsunami warning system, the Coastal Module of GOOS will be based and driven by applications, finding the way to use available knowledge and technologies to provide an important answer to a group of users. After the Tsunami catastrophe on 26 December 2004 in the Indian Ocean, the IOC has been called to lead the effort to establish a Tsunami Warning System for the Indian Ocean. In doing so and in the emergency to act immediately we resorted to one of the observing networks in the Coastal Module of GOOS and started to upgrade tide gauges in the GLOSS network to make them capable to detect tsunamis. With the cooperation of many, we will put a system in place that will prevent a similar catastrophic event to again create such a huge loss of human life with its sequels of trauma and pain. It is only appropriate that we dedicate this publication to the memory of the victims of the December Tsunami.

Patricio A. Bernal
Executive Secretary of IOC
Assistant Director General of UNESCO

Executive Summary

Coastal nations worldwide are experiencing changes in their coastal marine and estuarine systems that jeopardize sustainable development, human health and safety, and the capacity of marine ecosystems to support products and services valued by society. Changes of concern include increases in the susceptibility of coastal populations to flooding, tsunamis, erosion and disease, habitat loss, declines in living resources, harmful algal blooms, and mass mortalities of marine mammals and birds. Such trends reflect the combined effects of both natural processes and human uses.

Because these changes, their causes and their effects often transcend national borders, numerous international treaties and conventions have been agreed to that require sustained, routine and reliable observations of oceanic, coastal, terrestrial and atmospheric systems on local, regional and global scales. Implementation of the coastal module of the Global Ocean Observing System (GOOS) will provide the required data and information on coastal marine and estuarine systems worldwide. As such, coastal GOOS is an important contribution to the Integrated Global Observing Strategy (IGOS) and the Global Earth Observing System of Systems (GEOSS).

The coastal module of GOOS is intended to develop an integrated and holistic approach to addressing six goals for the public good:

- improve the capacity to detect and predict the effects of global climate change on coastal ecosystems;
- improve the safety and efficiency of marine operations;
- control and mitigate the effects of natural hazards more effectively;
- reduce public health risks;
- protect and restore healthy ecosystems more effectively; and
- restore and sustain living marine resources more effectively.

Routine, continuous provision of reliable data and information required to address these goals will make possible rapid and repeated assessments of the condition of coastal marine and estuarine systems; timely predictions of the effects of extreme weather, climate change and human activities; and the development ecosystem-based approaches to managing and mitigating the effects of human activities and natural variability on socio-economic systems that underpin the health and well-being of human populations.

The Integrated Design Plan for the Coastal Module of GOOS (IOC, 2003) calls for establishing regional coastal ocean observing systems (RCOOSs) worldwide and, through this process, the development of a Global Coastal Network (GCN). The former has begun and coordinated development of these regional observing systems is needed to create a GCN that (i) measures, manages and analyzes common variables needed by all or most coastal nations and regions; (ii) establishes sentinel and reference stations; and (iii) implements internationally accepted standards and protocols for measurements, data telemetry, data management and modelling. The provisional common variables include geophysical variables (temperature, salinity, currents, waves, sea level, shoreline position, bathymetry, sediment grain size), chemical variables (dissolved inorganic nutrients, dissolved oxygen, sediment organic content), biological variables (faecal indicators, phytoplankton biomass, benthic biomass), and biophysical variables (optical properties).

Implementation of the coastal module is justified in terms of socioeconomic benefits, environmental conservation, sustainable development, and national commitments articulated in international agreements and treaties. This report proposes the actions needed to implement the Design Plan. It includes organizational and administrative proposals for governance and presents practical recommendations for phased development of the GCN through the establishment and networking of GOOS Regional Alliances (GRAs), National GOOS programmes, and existing global programmes.

Recommended Actions

With the completion of both Strategic Design and Implementation Plans for the Coastal Module of GOOS, the COOP makes the following recommendation:

- Dissolve COOP and request the GSSC to take on the responsibility for the provision of science and technical guidance for implementing the coastal module of GOOS. The GSSC must be expanded to include the required areas of coastal expertise and given the authority to include experts as needed. In collaboration with the GRAs, the GSSC is to prepare, and update as needed, an action plan for implementing actions recommended herein and to periodically assess progress toward achieving the goals and objectives set forth therein. The action plan should include recommendations for pilot projects needed to build capacity globally.

Governance

The GCN will be implemented by nations, by GRAs and by other international bodies supported by nations. Needed are mechanisms to ensure the development of a network of national and regional observing systems that are locally relevant and globally coordinated. Such mechanisms must (1) promote the development of regional coastal ocean observing systems and services worldwide; (2) promote the development of a GCN through coordinated regional development; (3) engage groups that use, depend on, manage or study marine systems (collectively referred as "user groups") in the design, operation and improvement of a coastal GOOS that meets their data and information needs on local to global scales; and (4) effectively interface with the existing planning, oversight and implementation bodies of GOOS, JCOMM, GTOS and GCOS.A mechanism is needed to ensure that GRAs and national GOOS programmes as a group will guide development of the GCN to enable coordinated development of GRAs for interoperability, and to facilitate data and information exchange, technology transfer, and capacity building.

Recommended Actions

- Each GRA and national GOOS programme should establish a Users' Forum to engage user groups in the design, operation and improvement of regional coastal ocean observing systems and the development of the GCN. The forum should involve groups that use, depend on, manage and study marine systems from all partnering countries in the region to identify high priority products and services and to use them to guide the development of a regional coastal ocean observing system.
- Establish a mechanism to ensure that GRAs as a group can function, with technical guidance from the GSSC and in collaboration with JCOMM, as the international coordination, regulation and management mechanism for developing coastal systems of observations, data management, and analysis that includes the full spectrum of required geophysical, biophysical, chemical and biological variables. The initial priority should be rapid implementation of proven technologies and procedures in regions that will benefit most, e.g. the establishment of a tsunami warning system in the Indian Ocean modeled after the Pacific Tsunami Warning System.
- Establish an ad hoc joint JCOMM-GSSC Task Team (JCOMM-Management Committee) to work in collaboration with the GRAs to establish requirements and mechanisms for GCN implementation. This is a high, immediate priority. Among those issues that should be considered is the establishment by the grouping of GRAs of four working groups of experts in the following areas: measurements (MWG), data management (DMWG), modelling and analysis (MAWG), and capacity building (CPWG). These WGs would facilitate exchanges of data, information, knowledge and technologies among regions; coordinate regional development globally; and engage international research programmes (e.g. LOICZ, GLOBEC, IMBER, GEOHAB), relevant regional programmes (Regional bodies of the Tropical Cyclone Programme, Large Marine Ecosystem Programmes, Regional Seas Conventions, Regional Fishery Bodies, etc.) and operational agencies (e.g. coastguards, port authorities, regulatory bodies) as appropriate with the objective of ensuring timely de-

velopment of operational capabilities for an end-to-end system from measurements to applications that encompasses geophysical, biophysical, chemical and biological variables as needed.

Implementing the Measurement Subsystem

Both in situ and remote platforms will be used to measure the common variables as part of the GCN. In situ measurement will be made at a sparse network of in situ reference and sentinel sites and by existing global programmes such as the global network of tide gauges (GLOSS) and the global coral reef monitoring network (GCRMN). A GCN that measures the common variables and manages the resulting data streams will be established through two parallel processes: (i) the incorporation and extension of existing global programmes for coastal needs; and (ii) regional development of techniques that are scaled up for incorporation into the GCN. The Measurement Working Group (MWG) is expected to work with GSSC, GRAs, JCOMM and other organizations as appropriate to coordinate the development of both regional and global scale measurement (observing) subsystems of the coastal module.

Recommended Actions for Regional Development

• The MWG should:

(1) compile and maintain a data base on variables being monitored in each region, the responsible organization(s), length and spatial extent of observations, temporal and spatial resolution of the measurements, methods used and their precision, developmental stage (research, pilot project, pre-operational, operational), products and end users of the data, and funding sources and levels (Much of this information has been collated in some regions such as Europe and North America);
(2) formulate a web-based version of the toolkit used to select variables with an accompanying guidebook for its use that can be downloaded from the web;
(3) lead an effort to ensure broad and effective coordination among GRAs to harmonize the adoption, development and use of common standards and protocols for measurements, data telemetry, and quality control globally; and
(4) develop procedures and the means to (i) implement proven technologies and procedures in regions where they are needed (e.g. ocean basin scale tsunami warning systems), (ii) identify research priorities for developing operational capabilities in all regions, (iii) ensure conformance to internationally accepted standards and protocols, and (iv) enable efficient use of new knowledge and technologies to improve operational capabilities.

Currently, operational capabilities are most advanced for products and services that require observations of geophysical variables (marine weather forecasts, early warnings of coastal flooding, maritime services, search and rescue, etc.). Implementing these elements of GOOS in regions lacking such capabilities should be a high and immediate priority.

Recommended Actions for Development of the Global Coastal Network of Observations:

• In collaboration with GSSC, the IGOS Coastal Theme Team, and JCOMM, the MWG should:

(1) Review the common variables to determine if variables should be added or dropped based on (i) the number of GRAs that require and use data on them; (ii) their significance as indicators of global changes or as indicators of socio-economic impacts of changes in coastal systems; and (iii) the technical feasibility of incorporating them into the GCN as an operational element of GOOS;
(2) Consistent with JCOMM procedures, adopt (or establish as needed) and facilitate the implementation of international standards and protocols for measuring the common variables and establish requirements for their accuracy and time-space resolution;

• The GSSC should:

(1) Collaborate with the GRAs to prepare and periodically update a global listing of national and regional monitoring programs that are candidates for the GCN;
(2) Identify those programmes or elements thereof that should be networked and incorporated into the GCN, and recommend them to the JCOMM or the GRAs as appropriate;
(3) Collaborate with the IGOS Coastal Theme Team and the JCOMM Satellite Requirements

Task Team to (i) compile assessments of techniques, sensors, algorithms and data management activities specifically for coastal waters and prepare them if they are not available; (ii) regularly review the quality and utility of coastal satellite products (in terms of required time, space and spectral resolution) and make clear recommendations for enhancements, including improvements to algorithms, deployment of new sensors and priorities for research and development; (iii) formulate and recommend standard procedures for calibration and validation of satellite products that are comparable across regions; (iv) promote the development of operational remote sensing capabilities for ocean colour in coastal waters; and (v) formulate criteria for determining optimal locations for calibrating remotely sensed data and validating satellite products; recommend locations and requirements for measurements (time-space resolution, accuracy) at each; and encourage their establishment or continuation as a critical component of the GCN.

(4) Collaborate with the GRAs and the IGOS Coastal Theme Team to formulate criteria for determining optimal locations for sentinel stations, surveys and transects; recommend locations and requirements for measurements (time-space resolution, accuracy) at each, and encourage their establishment or continuation as a critical component of the GCN.

(5) Assess requirements for data telemetry regionally and globally and (i) document existing data telemetry infrastructure; (ii) recommend simple, cost-effective and robust technologies that can be implemented immediately; (iii) promote the development and deployment of new telecommunications systems as needed; (iv) develop standards and protocols for telemetry technologies used for GOOS in order to facilitate dissemination of the data for research and operational purposes; and (v) promote implementation of technical support programs for telecommunications systems utilized for GOOS.

Implementing the Data Management Subsystem

The Data Management Subsystem (DMS) for the coastal GOOS should have the following capabilities: (1) process and archive data on the common variables according to scientifically sound and well-documented standards and formats; (2) distribute data on the common variables (observations and model outputs) in real time and in "delayed" modes depending on the needs of user groups and their technical capabilities (automatic dissemination as well as "on demand"); and (3) enable efficient access to data on the common variables and derived products (including forecasts, alerts and warnings) by users who have a broad range of capabilities.

Most data will enter the DMS and be processed initially by national data centers or existing operational agencies where the delivery of data and products can be tuned to the needs of local users. In many areas, regional clusters of national centers and operational agencies will provide efficiencies of scale and allow each GRA to take advantage of the diverse capabilities provided by countries in the region. In addition, where national centers do not exist, the development of multi-national, regional data centers may be the most cost-effective means of managing data. National centers and regional clusters will manage data from both regional coastal ocean observing systems and the GCN. Global clusters will provide a final level of aggregation for the common variables where well tested global data communication, processing and management tools can be brought to bear.

Operational agencies such as coastguards, pollution control agencies, fisheries departments, flood warning agencies, and regulatory bodies responsible for safety at sea and on offshore oil and gas platforms often have efficient but limited data management and data telemetry networks already in place. These should be included in regional data management subsystems both for acquisition of data, and the distribution of data products.

The development of a DMS for the GCN and for regional coastal ocean observing systems will be facilitated by the formation of the Data Management Working Group (DMWG). The DMS will develop most efficiently through open software design. In carrying out the actions recommended below, existing protocols and standards should be used whenever possible in preference to developing new solutions.

Recommended Actions

- GSSC should work with the I-GOOS and the GRAs to promote conformance to the IOC Data Policy (http://ioc.unesco.org/goos/GOOSdm_final.pdf) and the establishment and execution of international agreements for timely data exchange among GRAs and participating nations.
- In collaboration with national ocean data centers and the IODE, the DMWG should promote the establishment of regional and global data management clusters as needed. The data management components of operational agencies should be included.
- The DMWG should monitor the development of OBIS and the U.S. DMAC subsystem for lessons learned, to integrate OBIS into the DMS infrastructure, and to determine which aspects of the U.S. effort can be scaled up to help build the global infrastructure for the DMS of the coastal module of GOOS.
- The DMWG, in collaboration with national GOOS Programmes and ocean data centers, the JCOMM-IODE Expert Team on Data Management Practices, the Terrestrial Environmental Monitoring Sites (TEMS) of GTOS, and international research programmes (e.g. IGBP and SCOR), should

(1) Determine metadata content and specify (or adopt existing) metadata format standards; facilitate their implementation for both historical data and data streams generated by the GCN and regional coastal ocean observing systems.
(2) Determine what search and browse capabilities are needed and establish a standard machine-to-machine interface (the data location service) that enables the seamless transition from data discovery to access.
(3) Develop web services standards and a comprehensive data model for data transport between server and client.
(4) Establish archival services.
(5) Explore the ability of the JCOMM-IODE infrastructure to oversee the implementation of the DMS for the coastal common variables of the GCN. If needed, establish an oversight mechanism for developing an integrating DMS that builds on existing capabilities, includes non-physical variables, and enables interoperability among GRAs, with the global ocean-climate observing system (GOOS/GCOS) and the Global Terrestrial Observing System (GTOS), and with ocean research programmes (e.g. those sponsored by the IGBP and SCOR).

Implementing the Modelling and Analysis Subsystem

The purpose of a modelling subsystem is to assimilate data generated from the measurement network (in situ and remotely sensed observations) to (1) produce more accurate estimates of the variables, their distributions, and associated errors; (2) develop, test and validate models, and (3) initialize and update models for improved predictions. Model outputs include comprehensive and integrated spatial representations of past (hindcasts), present (nowcasts) and future (forecasts) states of the coastal ocean.

Achieving these capabilities, or improving them, should begin by engaging user groups to define data and information needs (products and services) and developing and updating inventories of modelling capabilities and activities that satisfy these needs. This will provide the basis for selecting, developing and/or improving models through community-based modelling networks.

Recommended Actions

- The MAWG, in collaboration with GRAs, research programmes, Large Marine Ecosystem Programmes, and other bodies as appropriate, should

(1) Encourage and guide the development of Community Modelling Networks focused on regional needs, technical problems and products.

(2) Develop and maintain an up-to-date inventory of proven coastal models (organized by application); make them available on the world wide web; and recommend measures of model skill and operational status.
(3) Define a set of external metrics for quality control and assurance and for user- satisfaction with coastal model products.

• The MAWG should:

(1) Work with community modelling networks to promote access to (through a web-based inventory) and development of freely available, well-documented models and software for data assimilation and visualization.
(2) Promote pilot projects that will accelerate the development of community models and metrics related to ecosystem forecasting, including ecosystem-based management of fisheries and water quality.
(3) Prepare and maintain an up-to-date inventory of the data and observing requirements for coastal models.
(4) Building on the experience gained by other groups who have already developed similar measures for other types of models (e.g. OOPC/GODAE for deep ocean models), work with community modelling networks to define internal metrics that can be used to assess the quality, internal consistency and skill of the main classes of coastal models.

Developing and Improving Capacity

A fully integrated GOOS that addresses all six societal goals can be achieved only by improving coastal observing and reporting capabilities globally. Capacity building is needed on two related fronts: (1) enabling nations and GRAs in different stages of economic development to establish coastal ocean observing systems and to benefit from data and information provided by GOOS and (2) developing new technologies and models through research that can be used to improve the operational capabilities of regional coastal ocean observing systems and the GCN. Both can be achieved most effectively by initiating cooperative projects with GRAs that have focused, attainable objectives and will leave a legacy of sustained observations, data management, and analysis.

Recommended Actions

- With the assistance of GSSC and the GOOS-JCOMM Capacity Building Programme, GRAs and National GOOS Programmes should identify priority products and services that require development of or improvements in regional coastal ocean observing systems.
- The GOOS-JCOMM Capacity Building Programme should establish centres of technical support at existing institutions that will provide advice and send technicians to recipient countries or GRAs to facilitate the deployment, use and maintenance of new instruments and existing infrastructure.
- GSSC, in collaboration with the global body of GRAs and the GOOS-JCOMM Capacity Building Programme, should:

(1) Inventory and review existing capacity building efforts relevant to coastal GOOS development and recommend procedures for making more effective use of their collective resources to achieve common goals. This should include aid and training activities currently conducted by operational agencies and their world organizations (e.g. the WMO for meteorology, the International Maritime Organization (IMO) for shipping and ship management, and equivalent bodies for ports and harbors, coastguards, etc.) that may be improved in developing countries through additional funding, training, and infrastructure development.
(2) Persuade international donors (including the GEF) to fund partnerships between developing and developed nations to establish infrastructure for GOOS through LME Programmes and other programmes as appropriate.

- The CBWG should:

(1) Identify, develop and make available toolkits for building capacity for all three subsystems (observations, data management and modelling).
(2) Advise the GOOS-JCOMM Capacity Building programme on the establishment of procedures for nations and GRAs to implement, operate and improve regional coastal ocean observing systems based on their own priorities.
(3) Work with the GRAs to design and implement pilot projects that will enable the establishment of sustained coastal ocean observing systems worldwide, especially in regions that lack the resources to develop such systems.

Pilot Projects

Pilot projects are an important mechanism for developing operational capabilities regionally and globally. To these ends, two categories of pilot projects are recommended: (i) those that build capacity in regions that lack the resources needed to contribute to and benefit from coastal GOOS and (2) those that are needed to accelerate the development of operational capabilities through advances in science and technology.

Recommendations

- GSSC should review pilot projects recommended herein; assess those that have been funded to determine their potential for incorporation into the GCN (or adopted by other regions); identify those that should be promoted for funding as coastal GOOS pilot projects; and promote the development of new pilot projects as needed.
- GSSC should work with the GRAs to identify regional problems and requirements where solutions could be obtained by implementing proven technologies and procedures for developing regional coastal ocean observing systems and promote investments in Pilot Projects (including training) that will lead in time to permanent operational systems.

Performance Evaluation

Systematic, rigorous and periodic assessments of performance in terms of socio-economic benefits of data and information provided by GOOS are critical to its sustained development of observing systems. Performance should be measured in terms of both how well the system functions and the benefits it provides. System function should be measured in terms of (i) interoperability among GRAs and the GCN; (ii) the continuity, quality, diversity and integration of data streams; and (iii) improvements in operational capabilities. Benefits should be measured in terms of (i) the number of new or improved products traceable to the coastal module; (ii) the number of groups that use these products; (iii) the use of data and information provided by the system to meet the requirements and conditions of international conventions and agreements; and (iv) cost/benefit analyses – measure the cost of the system against socio-economic benefits.

Recommended Actions

- GSSC should:

(1) Promote implementation of the IGOS Coastal Theme.
(2) Collaborate with the IGOS Coastal Theme Team and the JCOMM Satellite Task Team to regularly prepare an adequacy report on satellite-remote sensing (sea surface temperature, altimetry, scatterometry, SAR and ocean colour for coastal waters), airborne remote sensing (e.g. LIght Detection and Ranging instruments or LIDAR and Compact Airborne Spectrometry Instrument or CASI), and land-based remote sensing (e.g. High Frequency radar); recommend procedures for improving them (including algorithms) and developing new satellite-based remote sensing capabilities.
(3) Collaborate with the GRAs to develop procedures for conducting product-specific, impact-feasibility procedures for assessing current operational capabilities of the observing system and identify research priorities for improving them.
(4) Establish procedures for periodically assessing and updating the common variables and sampling programs for the GCN, and for identifying priority research activities needed to improve operational observing capabilities.

- The MWG should:

(1) Promote and coordinate intercalibration activities (e.g. workshops, comparison of results from measurements of reference material among laboratories globally) among GRAs and national and global programmes to improve and evaluate measurements of the common variables.
(2) Identify existing standards and protocols, and develop ones as needed, for measuring the common variables recommended for use by data providers.
(3) Track progress in the development of new operational capabilities, standards and protocols for measuring the common variables and promote their incorporation into operational observing systems (GCN, regional coastal ocean observing systems).

- The DMWG should develop and promote the use of performance indicators to assess timeliness and continuity of data delivery, interoperability (development and use of common standards and protocols) and data exchange among regions and nations (bi-lateral and multi-lateral agreements for data exchange and their implementation).
- The CBWG should develop performance indicators for four key, cross-cutting activities that are critical

to establishing an end-to-end, user driven global observing system for the coastal ocean: (i) international coordination and collaboration in implementing the GCN (interoperability); (ii) capacity building in terms of the effectiveness with which regional and national priorities for developing all three subsystems are identified and addressed; (iii) development of operational capacity by the GRAs as a group; and (iv) development and use of socio-economic indicators that measure the effectiveness of more rapid detection and timely predictions of the phenomena of interest in terms of sustainable uses of the oceans and resources they support.

Résumé Analytique

Tous les pays côtiers du monde voient leurs systèmes côtiers marins et estuariens subir des modifications qui menacent le développement durable, la santé et la sécurité humaines ainsi que la capacité des écosystèmes marins de fournir des produits et services intéressant la société. Il est en particulier préoccupant d'observer que les populations des zones côtières sont de plus en plus exposées aux inondations, aux tsunamis, à l'érosion, aux maladies, à la perte de leur habitat, à la diminution des ressources biologiques, aux efflorescences algales et nuisibles, à la mortalité massive des mammifères et des oiseaux marins, tendances qui reflètent les effets conjugués de processus naturels et d'activités humaines.
Parce que ces changements, ainsi que leurs causes et leurs effets, dépassent souvent les frontières nationales, de nombreux traités et conventions qui exigent l'observation prolongée, régulière et fiable des systèmes océaniques, côtiers, terrestres et atmosphériques à l'échelle locale, régionale et mondiale, ont été conclus. La mise en œuvre du module côtier du Système mondial d'observation de l'océan (GOOS) fournira les données et informations nécessaires sur les systèmes côtiers marins et estuariens du monde entier. En tant que tel, ce module du GOOS constitue une importante contribution à la Stratégie d'observation mondiale intégrée (IGOS) et au Système mondial des systèmes d'observation de la Terre (GEOSS).

Il vise à élaborer une approche intégrée et holistique de la réalisation des six objectifs d'intérêt public ci-après :

- améliorer la capacité de détecter et prévoir l'incidence des changements climatiques mondiaux sur les écosystèmes côtiers ;
- améliorer la sécurité et l'efficacité des opérations en mer ;
- mieux lutter contre les effets des catastrophes naturelles et les atténuer plus efficacement ;
- réduire les risques pour la santé publique ;
- protéger ou restaurer plus efficacement la santé des écosystèmes ; et
- régénérer les ressources marines vivantes et en assurer la pérennité plus efficacement.

La fourniture systématique et en continu des données et informations fiables nécessaires pour atteindre ces objectifs permettra d'évaluer rapidement et de façon répétée l'état des systèmes côtiers marins et estuariens ; de prévoir en temps voulu l'incidence des conditions météorologiques extrêmes, des changements climatiques et des activités humaines ; et d'élaborer des approches écosystémiques de la gestion et de l'atténuation des répercussions des activités humaines et de la variabilité naturelle sur les systèmes socioéconomiques qui sous-tendent la santé et le bien-être des populations humaines.

Le Plan conceptuel intégré pour le module côtier du GOOS (COI, 2003) prône l'établissement dans le monde entier de systèmes régionaux d'observation des océans côtiers (RCOOS) et, par ce biais, la création d'un Réseau côtier mondial (GCN). La première opération a démarré et ces systèmes régionaux d'observation doivent être développés de manière coordonnée de façon à créer un GCN qui (i) mesure, gère et analyse des variables communes nécessaires à toutes les nations et régions côtières, ou à la plupart d'entre elles ; (ii) mette en place des stations sentinelles et de référence ; et (iii) applique des normes et protocoles internationalement admis de mesure, de télémétrie, de gestion et de modélisation des données. Les variables communes provisoirement retenues comprennent des variables géophysiques (température, salinité, courants, vagues, niveau de la mer, évolution de la ligne de rivage, bathymétrie, granulométrie des sédiments), des variables chimiques (nutriments inorganiques dissous, oxygène dissous, contenu organique des sédiments), des variables biologiques (indicateurs fécaux, biomasse phytoplanctonique, biomasse

benthique), et des variables biophysiques (propriétés optiques).

La mise en place du module côtier est justifiée par les avantages socioéconomiques qui en découlent, la conservation de l'environnement, le développement durable et les engagements nationaux énoncés dans des accords et traités internationaux. Le présent rapport propose les mesures nécessaires pour mettre en œuvre le Plan conceptuel.

Il comprend des propositions d'ordre administratif et organisationnel aux fins de la gouvernance et présente des recommandations pratiques en vue de la mise en place progressive du GCN par le biais de la création et de la mise en réseau d'Alliances régionales pour le GOOS (GRA), de programmes nationaux pour le GOOS et de programmes mondiaux existants.

Actions recommandées

Le plan conceptuel stratégique et le plan de mise en œuvre pour le module côtier du GOOS étant achevés, le COOP recommande ce qui suit :

- Dissoudre le COOP et demander au GSSC de se charger de fournir des conseils scientifiques et techniques pour la mise en œuvre du module côtier du GOOS. Le GSSC doit être élargi aux domaines nécessaires de compétence concernant les zones côtières et être habilité à faire appel à des experts si besoin est. Il doit, en collaboration avec les GRA, élaborer et mettre à jour, s'il y a lieu, un plan d'action visant à mettre en œuvre les mesures recommandées ci-incluses et évaluer périodiquement les progrès accomplis dans la réalisation des buts et objectifs qui y figureront. Le plan d'action devrait notamment faire des recommandations sur les projets pilotes nécessaires pour renforcer les capacités à l'échelle planétaire.

Gouvernance

Le GCN sera mis en place par les pays, les GRA et d'autres organismes internationaux soutenus par des pays. Des mécanismes sont nécessaires pour assurer le développement d'un réseau de systèmes nationaux et régionaux d'observation qui soit pertinent à l'échelle locale et coordonné à l'échelle mondiale. De tels mécanismes doivent (i) promouvoir l'établissement dans le monde entier de systèmes et services régionaux d'observation des océans côtiers ; (ii) promouvoir la création d'un GCN par le biais d'un développement régional coordonné ; (iii) faire participer des groupes qui utilisent des systèmes marins, en sont tributaires, les gèrent ou les étudient (collectivement dénommés « groupes d'utilisateurs ») à la conception, au fonctionnement et à l'amélioration d'un module côtier du GOOS qui réponde à leurs besoins en données et en information, depuis l'échelle locale jusqu'à l'échelle mondiale ; et (iv) entretenir de véritables relations avec les organismes existants de planification, de surveillance et de mise en œuvre du GOOS, de la JCOMM, du GTOS et du SMOC. Un mécanisme est nécessaire pour veiller à ce que les GRA et les programmes nationaux pour le GOOS orientent, en tant que groupe, le développement du GCN de façon à permettre une mise en place coordonnée des Alliances régionales assurant leur interopérabilité et à faciliter l'échange de données et d'information, le transfert de technologies et le renforcement des capacités.

Actions recommandées

- Chaque GRA et programme national pour le GOOS devrait créer un Forum des utilisateurs afin de faire participer ces derniers à la conception, au fonctionnement et à l'amélioration des systèmes régionaux d'observation des océans côtiers et à la mise en place du GCN. Le Forum devrait faire intervenir des groupes qui exploitent des systèmes marins, en sont tributaires, les gèrent et les étudient, dans tous les pays partenaires de la région, afin de définir des produits et services hautement prioritaires et faire appel à eux pour orienter le développement d'un système régional d'observation des océans côtiers.
- Créer un mécanisme pour veiller à ce que les GRA puissent, en tant que groupe, et avec le concours technique du GSSC et la collaboration de la JCOMM, faire office de mécanisme international de coordination, de régulation et de gestion de la mise en place de systèmes côtiers d'observation, de gestion des données et d'analyse comprenant tout l'éventail nécessaire de variables géophysiques, biophysiques, chimiques et biologiques. La priorité initiale devrait être accordée à l'application rapide de technologies et de procédures éprouvées dans des régions qui en tireront le meilleur parti, par exemple à la mise en place d'un système d'alerte aux tsunamis dans l'océan Indien sur le modèle du Système d'alerte aux tsunamis dans le Pacifique.

- Créer une équipe spéciale ad hoc mixte JCOMM-GSSC (JCOMM-Comité de gestion) chargée de travailler en collaboration avec les GRA afin de recenser les besoins et les mécanismes nécessaires à la mise en place du GCN. Cette activité hautement prioritaire doit être entreprise immédiatement. Entre autres questions, il conviendrait d'étudier la création de quatre groupes d'experts s'occupant des domaines ci-après : mesures (MWG, gestion des données (DMWG), modélisation et analyse (MAWG) et renforcement des capacités (CBWG)). Ils faciliteraient les échanges de données, d'information, de connaissances et de technologies entre les régions ; coordonneraient le développement régional à l'échelle mondiale ; et feraient appel à la participation de programmes internationaux de recherche (LOICZ, GLOBEC, IMBER, GEOHAB par exemple), de programmes régionaux pertinents (organes régionaux du programme sur les cyclones tropicaux, programmes relatifs aux grands écosystèmes marins, Conventions sur les mers régionales, organes régionaux des pêches, etc.) et à des organismes opérationnels (par exemple gardes-côtes, autorités portuaires et organismes réglementaires) s'il y a lieu afin d'assurer le développement en temps voulu des capacités opérationnelles nécessaires à la mise en place d'un système « de bout en bout » qui aille des mesures jusqu'aux applications et comprennent, selon les besoins, des variables géophysiques, biophysiques, chimiques et biologiques.

Mise en oeuvre du sous-système de mesure

Des plates-formes in situ et des plates-formes éloignées seront utilisées pour mesurer les variables communes dans le cadre du GCN. Les mesures in situ seront effectuées par un réseau clairsemé de sites sentinelles et de références in situ et par des programmes mondiaux existants comme le Réseau mondial de marégraphe du GLOSS (Système mondial d'observation du niveau de la mer) et le Réseau mondial de surveillance continue des récifs coralliens (GCRMN). Un GCN mesurant les variables communes et gérant les flux de données qui en résultent sera mise en place en associant deux processus parallèles : (i) l'intégration et l'extension des programmes mondiaux existants pour les besoins côtiers ; et (ii) le développement régional de techniques extrapolées à plus grande échelle en vue de leur intégration au GCN. Le Groupe de travail sur les mesures (MWG) devrait travailler de concert avec le GSSC, les GRA, la JCOMM et d'autres organisations, si besoin est, afin de coordonner le développement de sous-systèmes (d'observation) du modèle côtier de mesure à l'échelle régionale et mondiale.

Actions recommandées en vue du développement régional

- Le MWG devrait :

(1) constituer et tenir à jour une base de données sur les variables qui font l'objet d'une surveillance continue dans chaque région, l'(les) organisation(s) responsable(s), la durée et la portée spatiale des observations, la résolution temporaire et spatiale des mesures, les méthodes utilisées et leur précision, le stade de développement (recherche, projet pilote, stade pré-opérationnel, opérationnel), les produits et les utilisateurs finaux ainsi que les sources et les niveaux de financement (beaucoup de ces informations sont d'ores et déjà réunies dans certaines régions comme l'Europe et l'Amérique du Nord) ;
(2) élaborer une version Web de l'ensemble d'outils utilisés pour sélectionner les variables, accompagnée d'un manuel d'utilisation susceptible d'être téléchargé depuis le Web ;
(3) conduire une opération visant à assurer une large et véritable coordination entre les GRA afin d'harmoniser l'adoption, l'élaboration et l'utilisation de normes et protocoles communs pour les mesures, les télémesures et le contrôle de la qualité à l'échelle mondiale ;
(4) définir des procédures et moyens permettant (i) d'employer des technologies et procédures éprouvées dans des régions où elles sont nécessaires (par exemple des systèmes d'alerte aux tsunamis à l'échelle des bassins océaniques), (ii) de recenser des priorités de recherche en vue du développement des capacités opérationnelles dans toutes les régions, (iii) de veiller à la conformité aux normes et protocoles internationalement acceptés, et (iv) de permettre une utilisation efficace des nouvelles connaissances et technologies afin d'améliorer les capacités opérationnelles.

Actuellement, les capacités opérationnelles les plus perfectionnées sont celles destinées aux produits et services qui exigent l'observation de variables géophysiques (prévisions météorologiques marines, alertes rapides aux inondations côtières, services maritimes, recherche et secours, etc.). Mettre ces éléments du GOOS en œuvre dans des régions qui ne disposent pas de ces capacités devrait être hautement prioritaire à réaliser dans l'immédiat.

Actions recommandées en vue de la mise en place d'un réseau côtier mondial d'observation

- En collaboration avec le GSSC, l'équipe de l'IGOS chargée du thème côtier et la JCOMM, le MWG devrait :

(1) faire le point des variables communes afin de déterminer s'il convient d'en ajouter ou supprimer certaines en fonction (i) du nombre de GRA qui demandent et utilisent des données y relatives ; (ii) de leur importance en tant qu'indicateurs des changements à l'échelle planétaire ou qu'indicateurs des répercussions socioéconomiques des changements sur les systèmes côtiers ; (iii) de la possibilité technique de les intégrer au GCN en tant qu'élément opérationnel du GOOS ;
(2) conformément aux procédures de la JCOMM, adopter (ou établir s'il y a lieu), des normes et protocoles internationaux de mesure des variables communes, en faciliter l'application et spécifier la précision et la résolution spatiale exigées ;

- Le GSSC devrait :

(1) collaborer avec les GRA afin d'établir et de mettre périodiquement à jour une liste mondiale de programmes nationaux et régionaux de surveillance qui souhaitent faire partie du GCN ;
(2) identifier les programmes ou éléments de programme qu'il conviendrait de mettre en réseau et d'intégrer au GCN et les recommander à la JCOMM ou aux GRA, selon le cas ;
(3) collaborer avec l'équipe IGOS chargée du thème côtier et l'équipe spéciale chargée des besoins de la JCOMM en matière de satellites afin (i) de constituer un corpus d'évaluations des techniques, capteurs, algorithmes et activités de gestion des données, en particulier pour les eaux côtières et d'effectuer de telles évaluations s'il n'y en a pas encore de faites ; (ii) d'examiner régulièrement la qualité et l'utilité des produits satellitaires relatifs aux zones côtières (en fonction de la résolution temporelle, spatiale et spectrale requise) et de recommander clairement des perfectionnements notamment l'amélioration des algorithmes, le déploiement de nouveaux capteurs et la définition de priorités de recherche et de développement ; (iii) de formuler et de recommander des procédures normalisées d'étalonnage et de validation des produits satellitaires qui soient comparables d'une région à l'autre ; (iv) de promouvoir le développement de capacités de télédétection opérationnelle de la couleur de l'océan dans les eaux côtières ; et (v) de fixer des critères pour déterminer les emplacements les plus propices à l'étalonnage des données obtenues par télédétection et à la validation des produits satellitaires ; de recommander des sites où pratiquer les mesures et les spécifications exigées en chaque lieu (résolution temporelle et spatiale, précision) ; et d'encourager l'établissement ou le maintien de ces critères en tant que composante essentielle du GCN ;
(4) collaborer avec les GRA et l'équipe IGOS chargée du thème côtier, en vue de fixer des critères pour déterminer les emplacements les plus propices à l'installation de stations de surveillance et à la réalisation d'études et de transects ; recommander des sites où effectuer les mesures et les spécifications exigées à chaque emplacement (résolution temporelle et spatiale, précision) et encourager l'établissement ou le maintien des critères en tant que composante essentielle du GCN ;
(5) évaluer les besoins de télémesures aux plans régional et mondial et (i) réunir des informations sur les infrastructures existant dans ce domaine ; (ii) recommander des techniques simples, rentables et sûres qui puissent être appliquées immédiatement ; (iii) promouvoir le développement et la mise en place de nouveaux systèmes de télécommunication, s'il y a lieu ; (iv) élaborer des normes et protocoles pour les techniques de télémétrie utilisées pour le GOOS afin de faciliter la diffusion des données destinées à la recherche et à des fins opérationnelles ; et (v) favoriser l'exécution de programmes de soutien technique en faveur des systèmes de télécommunication utilisés pour le GOOS.

Mise en oeuvre du sous-système de gestion de données

Le sous-système de gestion des données (DMS) du module côtier du GOOS doit avoir les capacités ci-après : (i) traiter et archiver des données sur les variables communes en fonction de normes et formats scientifiquement rationnels et attestés ; (ii) diffuser des données sur les variables communes (observations et résultats des modèles) en temps réel et en différé, selon les besoins des groupes d'utilisateurs et leurs capacités techniques (diffusion automatique ainsi qu'à la demande) ; et (iii) permettre un accès efficace aux données relatives aux variables communes et aux produits dérivés (y compris les prévisions, alertes initiales et avis de danger imminent) aux utilisateurs qui disposent d'un large éventail de moyens.

La plupart des données seront intégrées dans le DMS et traitées initialement par les centres nationaux de données ou des organismes opérationnels existants en mesure d'adapter la fourniture des données et des produits aux besoins des utilisateurs locaux. Dans bien des cas, les groupes régionaux de centres nationaux et d'agences opérationnelles apporteront une efficacité d'échelle et permettront à chaque GRA de bénéficier des diverses capacités offertes par les pays de la région. De plus, là où il n'existe pas de centres nationaux, la création de centres régionaux multinationaux pourrait être le moyen le plus rentable de gérer les données. Les centres nationaux et les pôles régionaux gèreront aussi bien des données provenant des systèmes d'observation des océans côtiers que du GCN. Des pôles mondiaux assureront un niveau final d'agrégation des variables communes. Des outils éprouvés de communication, de traitement et de gestion des données à l'échelle mondiale pourront être mis à profit.

Certains organismes opérationnels, gardes-côtes, agences de contrôle de la pollution, services des pêches, organismes d'alerte aux inondations et organismes réglementaires responsables de la sécurité en mer et sur les plates-formes pétrolières et gazières offshore par exemple, ont souvent déjà installé des réseaux efficaces de gestion et de télémesure qui devraient être inclus dans les sous-systèmes régionaux de gestion des données, tant pour l'acquisition de ces dernières que pour la diffusion de produits dérivés.

La mise au point d'un sous-système de gestion des données pour le GCN et pour des systèmes régionaux d'observation des océans côtiers sera facilitée par la formation du groupe de travail chargé de la gestion des données (DMWG). Le moyen le plus efficace pour élaborer le DMS est de concevoir des logiciels ouverts. Il conviendrait pour la réalisation des actions recommandées ci-après, d'appliquer chaque fois que possible les protocoles et normes existants plutôt que de mettre au point de nouvelles solutions.

Actions recommandées

- Le GSSC devrait, de concert avec l'I-GOOS et les GRA, promouvoir la conformité à la politique de la COI en matière de données (http://ioc.unesco.org/goos/GOOSdm_final.pdf) et l'établissement et l'application d'accords internationaux régissant l'échange des données en temps voulu entre GRA et participants.
- En collaboration avec les centres nationaux de données océaniques et l'IODE, le DMWG devrait promouvoir la mise en place, en tant que de besoin, de pôles régionaux et mondiaux de gestion des données auxquels devraient être intégrées les composantes gestion des données des organismes opérationnels.
- Le DMWG devrait suivre le développement du système OBIS et du sous-système U.S. DMAC (de gestion et de communication des données) pour voir quelles leçons en sont tirées, intégrer OBIS dans l'infrastructure du DMS et déterminer quels sont les éléments du sous-système mis en place aux États-Unis susceptibles d'être transposés à plus grande échelle pour contribuer à bâtir l'infrastructure mondiale nécessaire au DMS du module côtier du GOOS.
- Le DMWG devrait, en collaboration avec les programmes et centres de données océanographiques nationaux pour le GOOS, l'équipe d'experts JCOMM-IODE sur les pratiques de gestion des données, les sites terrestres de surveillance de l'environnement (TEMS) du GTOS et certains programmes internationaux de recherche (par exemple PIGB et SCOR) :

(1) déterminer le contenu des métadonnées et fixer des normes applicables aux formats de métadonnées (ou adopter celles qui existent) ; faciliter leur application aussi bien aux données historiques qu'aux flux de données générées par le GCN et les systèmes régionaux d'observation des océans côtiers ;

(2) déterminer les capacités de recherche et de navigation nécessaires et établir une interface normalisée de machine à machine (service de localisation des données) qui permette de passer graduellement et sans solution de continuité de la découverte des données à leur accès ;
(3) élaborer des normes pour les services Web et un modèle de données global pour le transport des données entre serveur et client ;
(4) créer des services d'archive ;
(5) étudier la capacité de l'infrastructure JCOMM-IODE à superviser la mise en œuvre du DMS pour les variables côtières communes du GCN. Si nécessaire, créer un mécanisme de supervision pour constituer un DMS intégrateur qui exploite les moyens existants, comprenne des variables non physiques et permette l'interopérabilité entre les GRA, avec le Système mondial d'observation de l'océan et du climat (GOOS/SMOC) et le Système global d'observation terrestre (GTOS) ainsi qu'avec des programmes de recherche océanographique (par exemple ceux parrainés par le PIGB et le SCOR).

Mise en oeuvre du sous-système de modélisation et d'analyse

L'objet d'un sous-système de modélisation est d'assimiler les données fournies par le réseau de mesure (observations in situ et obtenues par télédétection) afin (1) de fournir des estimations plus précises des variables, leur répartition et les erreurs qui vont de pair ; (2) de mettre au point, tester et valider des modèles ; et (3) de lancer et mettre à jour des modèles afin d'améliorer les prévisions. Les modèles fourniront notamment des représentations spatiales complètes et intégrées de l'état passé (prévisions a posteriori), présent (prévisions immédiates) et futur (prévisions à terme) des océans côtiers.

Pour obtenir ces capacités, ou les améliorer, il convient de commencer par faire participer les groupes d'utilisateurs à la définition des besoins en données et en informations (produits et services) et d'établir et de mettre à jour des inventaires des moyens et activités de modélisation répondant à ces besoins. C'est sur cette base que s'opérera la sélection, le développement et/ou l'amélioration de modèles par le biais de réseaux de modélisation communautaires.

Actions recommandées

- Le groupe de travail sur la modélisation et l'analyse (MAWG), devrait, en collaboration avec les GRA, les programmes de recherche, les programmes relatifs aux grands écosystèmes marins et d'autres organismes si besoin est :

(1) encourager et orienter la mise en place de réseaux de modélisation communautaires, axés sur des besoins, problèmes techniques et produits régionaux ;
(2) établir et actualiser en permanence un inventaire des modèles côtiers éprouvés (classés par application) ; les mettre à la disposition sur la Toile mondiale (www) ; et recommander des mesures des capacités du modèle et de son statut opérationnel ;
(3) définir un ensemble de paramètres externes de contrôle et assurance de la qualité et de mesure de la satisfaction des utilisateurs vis-à-vis des produits des modèles côtiers.

- Le MAWG devrait :

(1) s'efforcer, de concert avec les réseaux de modélisation communautaires, de promouvoir l'accès à des modèles et logiciels d'assimilation et de visualisation des données, librement accessibles et bien documentés, et d'en favoriser l'élaboration ;
(2) promouvoir des projets pilotes qui accélèreront la mise au point de modèles et paramètres communautaires concernant la prévision écosystémique, y compris la gestion écosystémique des pêches et de la qualité de l'eau ;
(3) établir et mettre en permanence à jour un inventaire des données et observations nécessaires aux modèles côtiers ;
(4) s'inspirer de l'expérience acquise par d'autres groupes qui ont déjà mis en place des mesures analogues pour d'autres types de modèles (par exemple l'OOPC/GODAE pour les modèles relatifs à la haute mer), coopérer avec les réseaux de modélisation communautaires en vue de définir des paramètres internes susceptibles d'être utilisés pour évaluer la qualité, la cohérence interne et les capacités des principaux types de modèles côtiers.

Développer et améliorer les capacités

Seule l'amélioration à l'échelle mondiale des capacités d'observation des côtes et de notification peut permettre la mise en place d'un système mondial d'observation de l'océan pleinement intégré qui s'occupe des six objectifs sociaux. Les capacités doivent être renforcées à deux niveaux interdépendants : (1) en permettant aux pays et aux GRA qui sont à des stades différents de développement économique d'établir des systèmes d'observation des océans côtiers et de tirer parti des données et informations fournies par le GOOS et (2) en mettant au point par le biais de la recherche de nouvelles technologies et de nouveaux modèles qui pourraient servir à améliorer les capacités opérationnelles des systèmes régionaux d'observation des océans côtiers et le GCN. Le meilleur moyen d'atteindre ces deux objectifs est de lancer en coopération avec les GRA des projets ciblés, aux objectifs réalistes et qui laisseront derrière eux des observations, une gestion des données et une analyse sur la durée.

Actions recommandées

- Avec l'aide du GSSC et du programme GOOS-JCOMM de renforcement des capacités, les GRA et les programmes nationaux pour le GOOS devraient identifier des produits et services prioritaires qui exigent la mise en place ou l'amélioration de systèmes régionaux d'observation des océans côtiers.
- Le programme GOOS-JCOMM de renforcement des capacités devrait créer dans des établissements existants des centres de soutien technique chargés de donner des conseils et d'envoyer des techniciens à des pays bénéficiaires ou à des GRA afin de faciliter le déploiement, l'utilisation et l'entretien de nouveaux instruments et des infrastructures existantes.
- Le GSSC devrait, en collaboration avec l'ensemble des Alliances régionales pour le GOOS du monde entier et le programme GOOS-JCOMM de renforcement des capacités :

(1) recenser et étudier les initiatives de renforcement des capacités existantes utiles à la mise en place du modèle côtier du GOOS et recommander des procédures grâce auxquelles exploiter plus efficacement leurs ressources collectives pour atteindre des objectifs communs. Il conviendrait d'y inclure des activités d'aide et de formation actuellement menées par des organismes opérationnels et les organisations mondiales correspondantes (par exemple l'OMM pour la météorologie, l'Organisation maritime internationale (OMI) pour les transports maritimes et la gestion de la navigation et des organismes portuaires équivalents, les gardes-côtes, etc.). Des crédits supplémentaires, l'intensification de la formation et le développement des infrastructures pourraient améliorer ces activités dans les pays en développement ;
(2) persuader des donneurs internationaux (y compris le FEM) de financer des partenariats entre pays en développement et développés afin de mettre en place l'infrastructure nécessaire au GOOS par le biais de programmes relatifs aux grands écosystèmes marins et d'autres programmes, selon les besoins.

- Le CBWG devrait :

(1) définir, élaborer et mettre à disposition des ensembles d'outils de renforcement des capacités pour les trois sous-systèmes (d'observation, de gestion des données et de modélisation) ;
(2) conseiller le programme GOOS-JCOMM sur le renforcement des capacités en vue de l'établissement des procédures que les pays et les GRA utiliseront pour mettre en place, gérer et améliorer des systèmes régionaux d'observation des océans côtiers en fonction de leurs propres priorités ;
(3) travailler avec les GRA à la conception et à la mise en œuvre de projets pilotes qui permettront la mise en place de systèmes durables d'observation des océans dans le monde entier, surtout dans des régions qui n'ont pas les ressources nécessaires pour les développer.

Projets pilotes

Les projets pilotes sont un bon moyen de développer des capacités opérationnelles aux plans régional et mondial. À cette fin, deux catégories de projets pilotes sont recommandées : (i) ceux qui renforcent les capacités dans des régions qui n'ont pas les ressources nécessaires pour contribuer au module côtier du GOOS et en tirer parti et (ii) ceux qui sont nécessaires pour accélérer le développement de capacités opérationnelles grâce aux progrès scientifiques et technologiques.

Recommandations

- Le GSSC devrait examiner les projets pilotes recommandés dans le présent document ; évaluer ceux qui ont été financés (ou adoptés par d'autres régions) afin de déterminer s'il est possible de les intégrer au GCN ; recenser ceux dont il conviendrait de favoriser le financement en tant que projets pilotes du module côtier du GOOS ; et promouvoir le développement de nouveaux projets pilotes quand besoin est.

- Le GSSC devrait, de concert avec les GRA, identifier des problèmes et besoins régionaux auxquels il serait possible de répondre en mettant en œuvre des technologies et procédures éprouvées de mise en place de systèmes régionaux d'observation des océans côtiers et promouvoir des investissements dans des projets pilotes (y compris la formation) qui aboutiront le moment venu à des systèmes opérationnels permanents.

Evaluations des performances

Des évaluations systématiques, rigoureuses et périodiques de l'intérêt des données et de l'information fournies par le GOOS d'un point de vue socioéconomique sont indispensables pour qu'il continue de mettre en place des systèmes d'observation. L'évaluation de la performance devrait consister à mesurer d'une part le bon fonctionnement du système, et de l'autre, les avantages qu'il procure. Son fonctionnement devrait être mesuré en fonction des paramètres suivants : (i) interopérabilité entre les GRA et le GCN ; (ii) continuité, qualité, diversité et intégration des flux de données ; (iii) amélioration des capacités opérationnelles. Les avantages devraient être mesurés en fonction (i) du nombre de produits nouveaux ou améliorés imputables au module côtier ; (ii) du nombre de groupes qui utilisent ces produits ; (iii) de l'utilisation des données et de l'information fournies par le système pour satisfaire aux exigences et conditions des conventions et accords internationaux ; (iv) d'analyses coût/bénéfice - mesure du coût du système par rapport aux avantages socioéconomiques qu'il procure.

Actions recommandées

- Le GSSC devrait :

(1) promouvoir la mise en œuvre du thème côtier de l'IGOS ;
(2) collaborer avec l'équipe IGOS chargée du thème côtier et l'équipe spéciale de la JCOMM chargée des satellites afin d'établir régulièrement un rapport d'adéquation sur la télédétection par satellite (température de surface de la mer, altimétrie, diffusiométrie, SAR et couleur des océans pour les eaux côtières), la télédétection aéroportée (par exemple télémètre LIDAR et spectromètre compact aéroporté CASI) et la télédétection terrestre (par exemple radar haute fréquence) ; de recommander des procédures permettant de les améliorer (y compris des algorithmes) et de développer de nouvelles capacités de télédétection par satellite ;
(3) collaborer avec les GRA pour mettre au point des procédures permettant de mener des études d'impact-faisabilité propres à chaque produit afin d'évaluer les capacités opérationnelles actuelles du système d'observation et de définir les priorités de recherche qui permettront de les améliorer ;
(4) établir des procédures d'évaluation et de mise à jour périodiques des variables communes et des programmes d'échantillonnage du GCN et d'identification des activités prioritaires de recherche nécessaires pour améliorer les capacités d'observation opérationnelles.

- Le MWG devrait :

(1) promouvoir et coordonner les activités d'interétalonnage (ateliers, comparaison des résultats de mesures obtenues avec du matériel de référence par des laboratoires du monde entier) entre les GRA et des programmes nationaux et mondiaux afin d'améliorer et d'évaluer les mesures des variables communes ;
(2) recenser les normes et protocoles existants, et en élaborer s'il y a lieu, afin de mesurer les variables communes dont l'utilisation est recommandée par les fournisseurs de données ;
(3) suivre l'état d'avancement de nouvelles capacités opérationnelles et de nouveaux protocoles et normes destinés à la mesure de variables communes et promouvoir leur intégration dans les systèmes d'observation opérationnels (GCN, systèmes régionaux d'observation des océans côtiers).

- Le DMWG devrait définir des indicateurs de performance permettant d'évaluer si les données sont fournies en temps voulu et de manière continue, de vérifier l'interopérabilité (mise au point et utilisation de normes et protocoles communs) et d'estimer les échanges de données entre régions et pays (accords bilatéraux et multilatéraux d'échange de données et leur application) et favoriser l'utilisation de ces indicateurs.

- Le CBWG devrait définir des indicateurs de performance pour quatre activités transversales essentielles indispensables à la mise en place d'un système d'observation mondial de bout en bout adapté aux utilisateurs pour l'océan côtier, à savoir : (i) coordination et collaboration internationales pour la mise en œuvre du GCN (interopérabilité) ; (ii) renforcement des capacités se fondant sur l'efficacité avec laquelle les priorités régionales et nationales en vue du développement des trois sous-systèmes sont identifiées et traitées ; (iii) développement de la capacité opérationnelle des GRA en tant que groupe ; et (iv) définition et utilisation d'indicateurs socioéconomiques mesurant l'efficacité de la détection plus rapide et de la prévision en temps voulu des phénomènes présentant un intérêt pour l'exploitation durable des océans et des ressources qu'ils fournissent.

Resumen Dispositivo

En las naciones costeras de todo el mundo, los cambios que están experimentando los sistemas costeros marinos y de los estuarios amenazan el desarrollo sostenible, la salud y la seguridad humanas, así como la capacidad de los ecosistemas marinos para contribuir a la generación de productos y servicios de utilidad para la sociedad. Entre los cambios que provocan inquietud figuran el aumento de la vulnerabilidad de las poblaciones costeras a las inundaciones, los tsunamis, la erosión y las enfermedades, la pérdida de los hábitat, la disminución de los recursos vivos, las floraciones de algas nocivas y la mortalidad masiva de mamíferos y aves marinos. Estas tendencias reflejan los efectos combinados de los procesos naturales y los usos humanos.

Debido a esos cambios, sus causas y sus efectos que a menudo trascienden las fronteras nacionales, se han firmado numerosos tratados y convenios internacionales que exigen una observación de rutina permanente y confiable de los sistemas oceánicos, costeros, terrestres y atmosféricos en escalas local, regional y mundial. El establecimiento del Módulo sobre las Zonas Costeras (“módulo costero”) del Sistema Mundial de Observación de los Océanos (GOOS) proporcionará los datos e información necesarios sobre los sistemas costeros marinos y estuarios en todo el mundo. En este sentido, el módulo costero del GOOS es una importante contribución a la Estrategia de Observación Mundial Integrada (IGOS) y al Sistema Mundial de Sistemas de Observación de la Tierra (GEOSS).

El módulo costero del GOOS supone la elaboración de un enfoque holístico e integrado para alcanzar seis metas de interés público:

- mejorar la capacidad de detectar y predecir los efectos del cambio climático mundial sobre los ecosistemas costeros;
- aumentar la seguridad y eficiencia de las operaciones marinas;
- vigilar y mitigar con mayor eficacia los efectos de los peligros naturales;
- reducir los peligros para la salud pública;
- ü proteger y devolver la salud a los ecosistemas más eficazmente; y
- restaurar y mantener con más eficacia los recursos marinos vivos.

El suministro sistemático y continuo de los datos e información confiables que se necesitan para alcanzar esas metas permitirá evaluar de manera expedita y repetida la situación de los sistemas marinos costeros y estuarios, predecir a tiempo los efectos de los fenómenos meteorológicos extremos, del cambio climático y de las actividades humanas, y elaborar metodologías basadas en el ecosistema con fines de gestión y mitigación de los efectos de las actividades humanas y la variabilidad natural sobre los sistemas socioeconómicos que sostienen la salud y el bienestar de las poblaciones humanas.

El Plan de Diseño Estratégico Integrado para el Módulo de Observaciones Oceánicas Costeras del GOOS (COI, 2003) dispone el establecimiento de sistemas regionales de observación oceánica de las zonas costeras en todo el mundo y, mediante este proceso, el establecimiento de una Red Mundial de Observaciones Costeras (GCN). Ya se ha dado comienzo al primero y se necesita un desarrollo coordinado de estos sistemas regionales de observación para crear una GCN que i) mida, administre y analice las variables comunes que necesitan todas o casi todas las naciones y regiones costeras; ii) establezca estaciones centinela y de referencia; y iii) aplique normas y protocolos, aceptados en el plano internacional, para mediciones, telemetría de datos, gestión de datos y modelos. Las variables provisionales comunes son de orden geofísico (temperatura, salinidad, corrientes, oleaje, nivel del mar, posición de la línea de costa, batimetría, tamaño de los granos sedimentarios), químico (nutrientes inorgánicos disueltos, oxígeno disuelto, contenido de sedimentos orgánicos), biológico (indicadores fecales, biomasa de fitoplancton, biomasa bentónica) y biofísico (propiedades ópticas).

El establecimiento del módulo costero se justifica en términos de beneficios socioeconómicos, conservación ambiental, desarrollo sostenible y compromisos nacionales articulados en acuerdos y tratados internacionales. En el presente informe se proponen las medidas necesarias para poner en práctica el Plan de Diseño Estratégico. Se trata de medidas organizativas y administrativas para la dirección y recomendaciones prácticas para el desarrollo en fases de la GCN mediante la creación y la estructuración en redes de las Alianzas Regionales del GOOS (GRA), los programas nacionales del GOOS y los programas mundiales existentes.

Medidas que se recomiendan

El Panel sobre Observaciones de los Océanos y las Zonas Costeras (COOP) recomienda que, una vez finalizados el Diseño Estratégico y los planes de ejecución del Módulo sobre las Zonas Costeras del GOOS:

Se disuelva el COOP y se pida al Comité Científico de Dirección del GOOS (GSSC) que se encargue de suministrar orientaciones científicas y técnicas para el desarrollo del módulo costero del GOOS. Se debería ampliar el GSSC incorporando las especialidades costeras que proceda, y autorizarlo a integrar expertos según sea necesario. En colaboración con las GRA, el GSSC debería preparar y actualizar, cuando sea preciso, un plan de acción para aplicar las medidas que se recomiendan y evaluar periódicamente los avances en la consecución de las metas y objetivos fijados. Este plan de acción debe comprender recomendaciones sobre proyectos piloto que contribuyan al aumento de capacidades en todo el mundo.

Mecanicos de Dirección

La GCN será establecida por los países, las GRA y otros órganos internacionales apoyados por los países. Se necesitan mecanismos para asegurar el establecimiento de una red de sistemas nacionales y regionales de observación, de relevancia local y coordinados en el plano mundial. Tales mecanismos deben: 1) promover en todo el mundo el desarrollo de sistemas y servicios regionales de observación oceánica de las zonas costeras; 2) promover el establecimiento de una GCN mediante el desarrollo regional coordinado; 3) hacer participar a grupos que utilizan, administran o estudian los sistemas marinos, o que dependen de ellos (denominados colectivamente “grupos de usuarios”), en el diseño, manejo y perfeccionamiento de un módulo costero del GOOS que responda a sus necesidades de datos e información en las escalas local a mundial, y 4) interactuar eficazmente con los órganos existentes de planificación, supervisión y ejecución del GOOS, la Comisión Técnica Mixta COI-OMM sobre Oceanografía y Meteorología Marina (JCOMM), el Sistema Global de Observación Terrestre (GTOS) y el Sistema Mundial de Observación del Clima (SMOC). Hace falta un mecanismo mediante el cual las GRA y los programas nacionales del GOOS agrupados puedan orientar el desarrollo de la GCN a fin de permitir el desarrollo coordinado de las GRA con miras a su compatibilidad operativa, y facilitar el intercambio de datos e información, la transferencia de tecnología y el aumento de capacidad.

Medidas que se recomiendan

Que cada GRA y programa nacional del GOOS organicen un Foro de Usuarios para incorporar a los grupos de usuarios al diseño, manejo y perfeccionamiento de los sistemas regionales de observación oceánica de las costas y el establecimiento de la GCN. En el Foro deberían participar grupos que utilizan, administran o estudian los sistemas marinos, o que dependen de ellos, de todos los países que colaboran en la región, a fin de definir los productos y servicios de más alta prioridad y utilizarlos para orientar el desarrollo de un sistema regional de observación oceánica de las costas.

Establecer un mecanismo que asegure que las GRA puedan funcionar como grupo, con orientación técnica del GSSC y en colaboración con la JCOMM, que es el órgano internacional de coordinación, regulación y gestión para el establecimiento de los sistemas de observación de las costas, gestión de datos y análisis de la gama completa de variables relevantes de tipo geofísico, biofísico, químico y biológico. La prioridad inicial ha de ser la instalación rápida de tecnologías y procedimientos de incuestionable eficacia en las regiones a las que más puedan beneficiar, por ejemplo, el establecimiento de un sistema de alerta contra tsunamis en el Océano Índico según el modelo del Sistema de Alerta contra los Tsunamis en el Pacífico.

Crear un equipo de trabajo especial conjunto JCOMM-GSSC (Comité de Dirección de la JCOMM) que trabaje en colaboración con las GRA para establecer los requisitos y mecanismos adecuados para estructurar la GCN. Se trata de una prioridad elevada que exige medidas inmediatas. Entre las cuestiones que deben considerarse figura el establecimiento, por las agrupaciones de GRA, de cuatro grupos de trabajo de especialistas en los ámbitos siguientes: mediciones (MWG), gestión de datos (DMWG), modelos y análisis (MAWG), y aumento de capacidad (CPWG). Estos grupos de trabajo facilitarían el intercambio de datos, información, conocimientos y tecnologías entre las regiones, coordinarían a nivel mundial el desarrollo regional, e incorporarían a programas internacionales de investigación (por ejemplo LOICZ, GLOBEC, IMBER o GEOHAB), programas regionales importantes (órganos regionales del Programa de Ciclones Tropicales, los programas sobre Grandes Ecosistemas Marinos, convenciones sobre los mares regionales, órganos regionales de pesca, etc.) y a los órganos operacionales (por ejemplo, guardacostas, autoridades portuarias, órganos de reglamentación), en función de las necesidades, con el fin de asegurar el desarrollo oportuno de las capacidades operacionales para establecer un sistema integral que abarque de la medición a las aplicaciones y que considere las correspondientes variables geofísicas, biofísicas, químicas y biológicas.

Establecimiento des subsistema de mediciones

Se utilizarán plataformas in situ y remotas para medir las variables comunes de que se ocupa la GCN. Las mediciones in situ se efectuarán en una red dispersa de lugares de referencia y lugares centinela, y mediante programas mundiales existentes tales como la red mundial de mareómetros (GLOSS) y la Red Mundial de Vigilancia de Arrecifes Coralinos (GCRMN). La GCN, que medirá las variables comunes y administrará los flujos de datos resultantes, se establecerá mediante dos procesos paralelos: i) la incorporación y extensión de los programas mundiales existentes para las necesidades costeras; y ii) el desarrollo regional de técnicas que habrán sido adaptadas para su incorporación a la GCN. El Grupo de Trabajo sobre Mediciones (MWG) trabajará con el GSSC, las GRA, la JCOMM y otras organizaciones según proceda para coordinar el desarrollo de subsistemas del módulo costero para la medición (observación) en escalas regional y mundial.

Medidas que se recomiendan para el desarrollo regional

- El Grupo de Trabajo sobre Mediciones (MWG) ha de:

1) compilar y mantener una base de datos sobre las variables que se miden en cada región, la o las organizaciones responsables, el alcance temporal y espacial de las observaciones, la resolución temporal y espacial de las mediciones, los métodos utilizados y su precisión, la etapa de desarrollo (investigación, proyecto piloto, fase preoperacional, fase operacional), los productos y usuarios finales de los datos, y las fuentes y magnitud de la financiación (una gran parte de esta información ya ha sido compilada en algunas regiones como Europa y América del Norte);
2) preparar una versión para la Web de los instrumentos utilizados para seleccionar las variables, junto con un manual de instrucciones de uso de esos instrumentos, que pueda descargarse de Internet;
3) encabezar un esfuerzo de coordinación amplia y efectiva entre las GRA para armonizar la adopción, la elaboración y el uso de normas y protocolos comunes destinados a la medición, la telemetría de datos y el control de la calidad en todo el mundo; y
4) elaborar procedimientos y medios para: i) aplicar tecnologías y procedimientos de probada eficacia en las regiones en que se necesitan (por ejemplo, sistemas de alerta contra los tsunamis en escala oceánica); ii) determinar las prioridades de la investigación para desarrollar las capacidades operacionales en todas las regiones; iii) asegurar la conformidad con las normas y protocolos internacionalmente aceptados; y iv) permitir el uso eficiente de nuevos conocimientos y tecnologías para mejorar las capacidades operacionales.

En la actualidad, las capacidades operacionales más avanzadas se refieren a los productos y servicios que exigen observaciones de variables geofísicas (pronósticos meteorológicos marinos, alerta temprana contra inundaciones costeras, servicios marítimos, búsqueda y rescate, etc.). El establecimiento de estos elementos del GOOS en las regiones donde faltan esas capacidades debería tener alta prioridad y recibir atención inmediata.

Medidas que se recomiendan para el establecimiento de la Red Mundial de Observaciones Costeras:

En colaboración con el GSSC, el Equipo sobre el tema costero de la IGOS y la JCOMM, el MWG debería:

1) examinar las variables comunes para determinar cuáles deben añadirse o descartarse, basándose en: i) el número de GRA que necesitan y utilizan datos sobre ellas; ii) su valor de indicadores de cambios mundiales o de las repercusiones socioeconómicas de los cambios en los sistemas costeros; y iii) la viabilidad técnica de su incorporación en la GCN en calidad de elemento operacional del GOOS;
2) ateniéndose a los procedimientos de la JCOMM, adoptar (o crear si es preciso) y facilitar la aplicación de normas y protocolos internacionales para la medición de las variables comunes y establecer criterios relativos a su precisión y resolución temporal y espacial.

El GSSC debería:

1) colaborar con las GRA para preparar y actualizar periódicamente una lista mundial de los programas nacionales y regionales de vigilancia que podrían integrarse en la GCN;
2) localizar los programas o elementos que podrían integrarse en red en la GCN, y recomendarlos a la JCOMM o a las GRA, según proceda;
3) colaborar con el Equipo sobre el tema costero de la IGOS y el Equipo de Trabajo de la JCOMM sobre el Uso de Satélites para: i) compilar evaluaciones de técnicas, sensores, algoritmos y actividades de gestión de datos específicamente relacionadas con las aguas costeras, y elaborarlas si no se dispone de ellas; ii) examinar periódicamente la calidad y utilidad de los productos relativos a las costas obtenidos por satélite (en términos de resolución temporal, espacial y espectral) y formular recomendaciones claras sobre su ampliación, comprendidos el perfeccionamiento de los algoritmos, la instalación de nuevos sensores y las prioridades de investigación y desarrollo; iii) formular y recomendar procedimientos normalizados de calibración y validación de productos de satélites, comparables entre las regiones; iv) promover el desarrollo de capacidades operacionales de teledetección del color de océano en las aguas costeras; y v) formular criterios para determinar los lugares óptimos para calibrar datos teledetectados y validar productos de satélites; recomendar lugares y los requisitos para las mediciones (resolución temporal y espacial, precisión) en cada uno; y propiciar su establecimiento o continuación como componente crítico de la GCN;
4) colaborar con las GRA y el Equipo sobre el tema costero de la IGOS a fin de formular criterios para determinar los lugares óptimos para las estaciones centinela, estudios y transecciones; recomendar lugares y los requisitos para las mediciones (resolución temporal y espacial, precisión) en cada uno; y propiciar su establecimiento o continuación como componente crítico de la GCN;
5) evaluar las necesidades regionales y mundiales de telemetría de datos, y i) documentar la infraestructura existente para telemetría de datos; ii) recomendar tecnologías simples, económicas y robustas que puedan instalarse de inmediato; iii) promover la creación e instalación de nuevos sistemas de telecomunicaciones donde sea necesario; iv) elaborar normas y protocolos para tecnologías de telemetría utilizadas para el GOOS a fin de facilitar la difusión de los datos con fines de investigación y operacionales; y v) fomentar la ejecución de programas de apoyo técnico para sistemas de telecomunicaciones utilizados para el GOOS.

Establecimiento del subsistema de gestión de datos

El Subsistema de Gestión de Datos (DMS) para el módulo costero del GOOS debería ser capaz de: 1) procesar y archivar datos sobre las variables comunes de acuerdo con normas y formatos científicamente sólidos y bien documentados; 2) distribuir datos sobre las variables comunes (observaciones y productos modelo) en tiempo real y diferido en función de las necesidades de los usuarios y sus capacidades técnicas (difusión automática y a pedido); y 3) permitir el acceso eficiente a los datos sobre las variables comunes y productos derivados (comprendidos los pronósticos, alertas y avisos).

La mayor parte de los datos ingresarán en el DMS y serán tratados inicialmente por los centros nacionales de datos u organismos operacionales existentes allí donde el suministro de datos y productos pueda adaptarse a las necesidades de los usuarios locales. En muchas zonas, agrupaciones regionales de centros nacionales y organismos operacionales proporcionarán eficiencias de escala y permitirán a cada GRA aprovechar las diversas capacidades ofrecidas por los países de la región. Además, cuando no existan centros nacionales, el establecimiento de centros de datos regionales, multinacionales, podría ser el medio más económico para la gestión de los datos. Los centros nacionales y las agrupaciones regionales se encargarán de la gestión de datos procedentes tanto de los sistemas regionales de observación oceánica de las zonas costeras como de la GCN. Las agrupaciones mundiales proporcionarán una agregación final de las variables comunes donde se disponga de instrumentos eficaces de comunicación, tratamiento y gestión de datos mundiales.

Los organismos operacionales como los guardacostas, los servicios de vigilancia de la contaminación, los departamentos de pesca, los órganos de alerta contra las crecidas y los órganos de reglamentación encargados de la seguridad en el mar y en las plataformas de gas y petróleo en alta mar, a menudo ya han instalado redes, eficaces pero limitadas, de gestión y de telemetría de datos. Estas redes deben ser integradas a los subsistemas regionales de gestión de datos tanto para la adquisición como para la difusión de los productos de datos.

La constitución del Grupo de Trabajo sobre Gestión de Datos (DMWG) facilitará el establecimiento de un DMS para la GCN y para los sistemas regionales de observación oceánica de las zonas costeras. La DMS se desarrollará con la mayor eficacia mediante el diseño de programas informáticos de código abierto. Al aplicar las medidas que se recomiendan a continuación sería preferible utilizar, cuando sea posible, los protocolos y normas existentes en lugar de elaborar nuevas soluciones.

Medidas que se recomiendan

El GSSC debería trabajar con el I-GOOS y las GRA para promover la conformidad con la política de la COI en materia de datos (http://ioc.unesco.org/goos/GOOSdm_fi nal.pdf) y el establecimiento y la aplicación de acuerdos internacionales con miras al intercambio oportuno de datos entre las GRA y las naciones participantes.

En colaboración con centros nacionales de datos oceanográficos y el IODE, el DMWG debería propiciar, según proceda, el establecimiento de agrupaciones regionales y mundiales de gestión de datos. Deberían incluirse los componentes de gestión de datos de los organismos operacionales.

El DMWG debería observar de cerca la evolución del OBIS y del subsistema DMAC de los Estados Unidos para aprovechar la experiencia, integrar el OBIS en la infraestructura del DMS y determinar los aspectos de la iniciativa estadounidense que se podrían adaptar para contribuir a establecer la infraestructura mundial del DMS del módulo costero del GOOS.

El DMWG, en colaboración con los programas nacionales del GOOS y los centros nacionales de datos oceanográficos, el Grupo de Expertos JCOMM-IODE sobre Prácticas de Gestión de Datos, los Lugares de Seguimiento de Ecosistemas Terrestres (TEMS) del GTOS y los programas internacionales de investigación (por ejemplo, el IGBP y el SCOR) deberían:

1) determinar el contenido de los metadatos y especificar las normas de formato de metadatos (o adoptar las existentes), facilitar su aplicación tanto a los datos históricos como a los flujos de datos generados por la GCN y los sistemas regionales de observación oceánica de las zonas costeras;
2) determinar las capacidades de investigación e indagación que se necesitan y establecer una interfaz estándar entre máquinas (servicio de localización de datos) que permita pasar fluidamente de localización de los datos a su acceso;
3) preparar normas de servicios Web y un modelo integral de datos para su transferencia entre el servidor y el cliente;
4) establecer servicios de archivos;
5) examinar la capacidad de la infraestructura de JCOMM-IODE para supervisar el desarrollo del DMS para las variables costeras comunes de la GCN. De ser necesario, establecer un mecanismo de supervisión para desarrollar un DMS integrador que aproveche las capacidades existentes, incluya las variables no físicas y permita la compatibilidad operacional entre las GRA, con los sistemas de observación mundial del océano y el clima (GOOS y SMOC) y el GTOS, y con los programas investigación oceánica (por ejemplo, los patrocinados por el IGBP y el SCOR).

Establecimiento del subsistema de modelos y análysis

El Subsistema de Modelos tiene por objeto asimilar los datos generados por la red de mediciones (observaciones in situ y por teledetección) para: 1) producir estimaciones más precisas de las variables, sus distribuciones y errores conexos; 2) elaborar, ensayar y validar modelos, y 3) establecer y actualizar modelos para obtener mejores pronósticos. Los modelos permiten generar representaciones espaciales detalladas e integradas de los estados pasado, actual y futuro de las costas oceánicas.

Para realizar o mejorar esas capacidades se debería comenzar por incitar a grupos de usuarios a definir necesidades de datos e información (productos y servicios) y a preparar y actualizar inventarios de las capacidades para elaborar modelos que respondan a esas necesidades. De este modo se contará con una base para seleccionar, elaborar o mejorar modelos gracias a redes comunitarias dedicadas a los modelos.

Medidas que se recomiendan

El MAWG, en colaboración con los GRA, con programas de investigación, los programas sobre Grandes Ecosistemas Marinos y otros órganos pertinentes, debería:

1) propiciar y orientar la alentar la creación de redes comunitarias dedicadas a los modelos, centradas en las necesidades regionales y en problemas y productos técnicos;
2) preparar y mantener actualizado un inventario de modelos costeros de utilidad comprobada (organizados por aplicación), ofrecer el acceso a ellos a través de la WWW y recomendar parámetros de aptitud de los modelos y de estado operacional;
3) definir una serie de parámetros externos para el control y la garantía de calidad y para la satisfacción de los usuarios con los modelos costeros.

El MAWG debería:

1) trabajar con las redes comunitarias dedicadas a los modelos para promover el acceso libre y gratuito (mediante un inventario disponible en la WWW) a modelos y programas informáticos bien documentados para la asimilación y visualización de datos, o fomentar su elaboración;
2) promover proyectos piloto que aceleren la elaboración de modelos y parámetros comunitarios relacionados con la predicción del ecosistema, comprendida la gestión, sobre la base del ecosistema, de las pesquerías y la calidad del agua;
3) preparar y mantener actualizado un inventario de las necesidades de datos y observaciones para los modelos costeros;
4) aprovechando la experiencia de otros grupos que ya han elaborado normas de medición similares para otros tipos de modelos (por ejemplo, modelos sobre el alta mar del GODAE-OOPC), trabajar con las redes comunitarias sobre modelos para definir parámetros internos que sirvan para evaluar la calidad, la coherencia interna y la aptitud de las principales categorías de modelos costeros.

Creación y mejoramiento de la capacidad

Un GOOS plenamente integrado que aspire a alcanzar las seis metas sociales sólo podrá ser establecido mejorando en todo el mundo las capacidades de observación y preparación de informes sobre las costas. Hace falta un aumento de capacidades en dos frentes relacionados entre sí: 1) permitir a los países y a las GRA en diferentes etapas de desarrollo económico establecer sistemas de observación de las costas oceánicas y aprovechar los datos e información suministrados por el GOOS, y 2) elaborar nuevas tecnologías y modelos mediante la investigación, que puedan ser utilizados para mejorar las capacidades operacionales de los sistemas regionales de observación oceánica de las zonas costeras y la GCN. La manera más eficaz de lograr ambas cosas es emprender proyectos cooperativos con las GRA, que tengan objetivos centrados y viables, y que dejarán un legado de observaciones, gestión de datos y análisis permanentes.

Medidas que se recomiendan

Con la asistencia del GSSC y el programa de aumento de capacidades GOOS-JCOMM, las GRA y los programas nacionales del GOOS deberían determinar las prioridades en materia de productos y que exigen el establecimiento de sistemas regionales de observación oceánica de las zonas costeras o su perfeccionamiento.

El programa de aumento de capacidades GOOS-JCOMM debería establecer centros de apoyo técnico en las instituciones existentes, que asesoren y envíen técnicos a los países receptores o a las GRA para facilitar la instalación, el uso y el mantenimiento de los nuevos instrumentos y de la infraestructura existente.

El GSSC, en colaboración con el órgano mundial de las GRA y el programa de aumento de capacidades GOOS-JCOMM, debería:

1) inventariar y examinar los esfuerzos existentes de aumento de capacidades en relación con el establecimiento del GOOS sobre las zonas costeras y recomendar procedimientos que permitan aprovechar con mayor eficacia sus recursos colectivos para alcanzar las metas comunes. Habría que incluir la ayuda y las actividades que actualmente llevan a cabo los organismos operacionales y sus organizaciones mundiales (por ejemplo, la OMM para la meteorología, la Organización Marítima Internacional (OMI) para el transporte marítimo y la gestión de las naves, u órganos equivalentes para los puertos y dársenas, guardacostas, etc.) que puedan mejorarse en los países en desarrollo mediante financiación adicional, formación y desarrollo de la infraestructura;
2) convencer a los donantes internacionales (entre ellos el FMAM) de que financien alianzas entre países en desarrollo y desarrollados para crear infraestructuras para el GOOS mediante los programas sobre LME y otros programas pertinentes.

El CBWG debería:

1) definir, elaborar y facilitar juegos de materiales para fortalecer las capacidades en los tres subsistemas (observaciones, gestión de datos y modelos).
2) asesorar al el programa de aumento de capacidades GOOS-JCOMM sobre la creación de procedimientos para que los países y las GRA establezcan, manejen y mejoren sistemas regionales de observación oceánica de las zonas costeras sobre la base de sus propias prioridades;
3) trabajar con las GRA en el diseño y ejecución de proyectos piloto que permitan establecer sistemas sostenibles de observación oceánica de las zonas costeras en todo el mundo, especialmente en las regiones donde escasean los recursos necesarios para ese fin.

Proyectos piloto

Los proyectos piloto son un importante mecanismo para desarrollar las capacidades operacionales en los planos regional y mundial. Con este fin se recomienda la realización de proyectos piloto de dos categorías: i) los que fortalecen las capacidades en las regiones donde faltan los recursos necesarios para contribuir al módulo costero del GOOS y aprovechar sus ventajas; ii) los que permiten acelerar el desarrollo de las capacidades operacionales mediante el avance científico y tecnológico.

Recomendaciones

La GSSC debería examinar proyectos piloto como los que se recomiendan evaluar los que han recibido financiación (o que han sido aprobados por otras regiones) para determinar si es posible incorporarlos en la GCN), determinar cuáles habría que promover para que sean financiados como proyectos piloto del módulo costero del GOOS, y promover la ejecución de nuevos proyectos piloto en función de las necesidades.

El GSSC debería colaborar con las GRA para determinar los problemas y necesidades regionales que podrían resolverse mediante tecnologías y procedimientos manifiestamente eficaces para establecer sistemas regionales de observación oceánica de las zonas costeras y promover las inversiones en proyectos piloto (entre otras cosas de capacitación) que con el tiempo den lugar a sistemas operacionales permanentes.

Evaluación de resultados

Las evaluaciones sistemáticas, rigurosas y periódicas de resultados en términos de los beneficios socioeconómicos de los datos e información suministrados por el GOOS son críticos para el desarrollo sostenido de sistemas de observación. Los resultados deben ser medidos en relación tanto con la manera en que el sistema funciona como con los beneficios que otorga. El funcionamiento del sistema ha de medirse en términos de: i) compatibilidad operacional entre las GRA y la GCN; ii) la continuidad, calidad, diversidad e integración de los flujos de datos; y iii) el mejoramiento de las capacidades operacionales. Los beneficios han de medirse en términos de: i) el número de productos nuevos o mejorados relacionados con módulo costero; ii) el número de grupos que utilizan esos productos; iii) el uso de datos e información suministrados por el sistema para responder a las exigencias y condiciones estipuladas en las convenciones y acuerdos internacionales; y iv) análisis de costos del sistema en relación con sus beneficios socioeconómicos.

Medidas que se recomiendan

El GSSC debería:

1) promover la ejecución del tema costero de la IGOS;
2) colaborar con el Equipo sobre el tema costero de la IGOS y el Equipo de Trabajo de la JCOMM sobre el Uso de Satélites para preparar periódicamente un informe de adecuación sobre teledetección por satélite (temperatura de la superficie del mar, altimetría, dispersometría, radar de abertura sintética (SAR) y color del océano para las aguas costeras), teledetección mediante aeronaves (por ejemplo, instrumentos de detección y localización por ondas luminosas o LIDAR, y espectrómetro compacto aerotransportado o CASI), y teledetección en tierra (por ejemplo, radar de alta frecuencia); recomendar procedimientos para mejorarlos (algoritmos incluidos) y desarrollar nuevas capacidades en teledetección por satélite;
3) colaborar con las GRA en el diseño de métodos de aplicación de procedimientos relacionados específicamente con los productos y de viabilidad en relación con el impacto, a fin de evaluar las actuales capacidades operacionales del sistema de observación y determinar cuáles son las investigaciones prioritarias necesarias para mejorarlas.
4) establecer procedimientos para evaluar y actualizar periódicamente las variables comunes y los programas de muestreo para la GCN, y para determinar cuáles son las actividades prioritarias de investigación necesarias para mejorar las capacidades operacionales de observación.

El MWG debería:

1) promover y coordinar las actividades de intercalibración (por ejemplo, talleres, comparación, entre laboratorios de todo el mundo, de resultados de mediciones de materiales de referencia) entre las GRA y los programas nacionales y mundiales para mejorar y evaluar las mediciones de las variables comunes;
2) localizar las normas y protocolos existentes y elaborar los que sean necesarios, para medir las variables comunes cuyo uso recomiendan los proveedores de datos;
3) informarse sobre el desarrollo de nuevas capacidades operacionales, normas y protocolos para medir las variables comunes y fomentar su incorporación en los sistemas operacionales de observación (GCN, sistemas regionales de observación oceánica de las zonas costeras en curso de formación).

El DMWG debería elaborar y promover indicadores de resultados para evaluar la puntualidad y continuidad del suministro de datos, la compatibilidad operacional (elaboración y utilización de normas y protocolos comunes) y el intercambio de datos entre regiones y naciones (acuerdos bilaterales y multilaterales sobre intercambio de datos, y su aplicación).

El CBWG debería elaborar indicadores de resultados para cuatro actividades transversales críticas para el establecimiento de un sistema mundial integral de observación oceánica de las zonas costeras centrado en los usuarios: i) la coordinación y colaboración internacionales en la creación de la GCN (compatibilidad operacional); ii) el aumento de capacidades en términos de la eficacia con que se definen y abordan las prioridades regionales y nacionales para el desarrollo de los tres subsistemas; iii) el desarrollo de capacidad operacional por las GRA como grupo; y iv) la elaboración y el uso de indicadores socioeconómicos que midan la eficacia de la detección más rápida y los pronósticos oportunos de fenómenos de interés para el aprovechamiento sostenible de los océanos y los recursos que alberga.

Рабочее резюме

В прибрежных странах всего мира происходит изменение прибрежных морских и эстуарных систем, находящихся на их территории, что создает угрозу для устойчивого развития, здоровья и безопасности человека, а также способности морских экосистем поддерживать продукты и услуги, имеющие ценное значение для общества. К изменениям, которые вызывают озабоченность, относятся все большая подверженность населения прибрежных районов опасности наводнений, цунами, эрозии, а также распространения болезней, утраты жилищ, истощения живых ресурсов, вредоносного цветения водорослей, массовой гибели морских млекопитающих и птиц. Такие тенденции отражают совокупное воздействие как природных, так и антропогенных процессов.

Поскольку эти изменения, их причины и последствия зачастую выходят за рамки национальных границ, было принято много международных договоров и конвенций, в связи с которыми требуется проведение устойчивых, регулярных и надежных наблюдений за океаническими, прибрежными, наземными и атмосферными системами местном, региональном и глобальном масштабах. Создание прибрежного модуля Глобальной системы наблюдений за океаном (ГСНО) позволит получать необходимые данные и информацию о прибрежных морских и эстуарных системах по всему миру. В этом отношении прибрежный компонент ГСНО является важным вкладом в Комплексную стратегию глобальных наблюдений (КСГН) и в Глобальную систему систем наблюдения Земли (ГЕОСС).

Прибрежный модуль ГСНО позволит разработать комплексный и целостный подход к достижению шести целей в интересах общественного блага:

- повышение способности обнаружения и прогнозирования воздействия климатических изменений на прибрежные экосистемы;
- повышение безопасности и эффективности морских операций;
- более эффективный контроль и смягчение последствий стихийных бедствий;
- уменьшение рисков для здоровья населения;
- более эффективная защита и восстановление здоровых экосистем;
- более эффективное восстановление и поддержание живых морских ресурсов.

Регулярное предоставление на постоянной основе надежных данных и информации, необходимых для достижения этих целей, позволит быстро и многократно проводить оценку состояния прибрежных морских и эстуарных систем; составлять своевременные прогнозы воздействия экстремальных погодных условий, климатических изменений и деятельности человека; разрабатывать основанные на экосистемах подходы к регулированию и смягчению влияния человеческой деятельности и естественной изменчивости на социально-экономические системы, которые обеспечивают здоровье и благосостояние населения.

Комплексный концептуальный план создания прибрежного модуля ГСНО (МОК, 2003 г.) предусматривает формирование региональных систем наблюдений за прибрежной зоной океана (РСНПЗО) по всему миру и развитие в ходе этого процесса Глобальной прибрежной сети (ГПС). По первому направлению работа уже началась, и требуется скоординированное развитие этих региональных систем наблюдений для создания такой ГПС, которая обеспечивала бы возможность (i) измерения, применения и анализа общих переменных параметров, необходимых для всех или большинства прибрежных стран и регионов; (ii) создания опорных и контрольных станций; (iii) применения международно согласованных стандартов и протоколов для измерений, телеметрии данных, управления данными и моделирования. К числу предварительных общих переменных параметров относятся геофизические переменные (температура, соленость, течения, волны, уровень моря, положение береговой линии, батиметрия, зернистость осадков), химические переменные (растворенные неорганические питательные вещества, растворенный кислород, содержание в осадках органических веществ), биологические переменные (фекальные показатели, фитопланктонная биомасса, бентическая биомасса) и биофизические переменные (оптические свойства).

Создание прибрежного модуля оправдано с точки зрения экономических выгод, сохранения окружающей среды, устойчивого развития, а также национальных обязательств, принятых в международных соглашениях и договорах. В настоящем докладе предлагаются меры, необходимые для реализации Концептуального плана. В него включены предложения организационного и административного характера для целей управления и практические рекомендации для поэтапного развития ГПС посредством формирования и объединения региональных альянсов ГСНО (РАГ), национальных программ ГСНО и существующих глобальных программ.

Рекомендуемые меры

С учетом завершения составления Стратегического концептуального плана и Плана создания прибрежного модуля ГСНО КООП сформулировала следующую рекомендацию:

- Распустить КООП и обратиться к РНКГ с просьбой взять на себя ответственность за обеспечение научного и технического руководства работой по созданию прибрежного модуля ГСНО. РНКГ должен быть расширен, для того чтобы он охватывал прибрежную тематику, и ему должны быть предоставлены полномочия привлекать в случае необходимости экспертов. Во взаимодействии с РАГ РНКГ должен подготовить и при необходимости обновлять план действий для осуществления рекомендованных мер и периодически проводить оценку прогресса на пути к достижению поставленных целей и задач. План действий должен включать рекомендации в отношении пилотных проектов, необходимых для создания потенциала в глобальном мас¬штабе.

Вопросы управления

Формирование ГПС будет обеспечиваться странами, РАГ и другими международными органами при поддержке различных стран. Необходимы механизмы, обеспечивающие развитие сети национальных и региональных систем наблюдений, отвечающих местным потребностям и скоординированных на глобальном уровне. Такие механизмы должны (1) содействовать формированию региональных систем и служб наблюдений за прибрежной зоной океана по всему миру; (2) содействовать развитию ГПС на основе скоординированных региональных мероприятий; (3) привлекать группы, которые используют, регулируют и изучают морские системы или зависят от них (в совокупности называемые «группы пользователей»), к разработке, обеспечению функционирования и совершенствованию прибрежного модуля ГСНО, отвечающего их потребностям в данных и информации в масштабах от местного до глобального; (4) иметь эффективную взаимосвязь с существующими органами ГСНО, СКОММ, ГСНС и ГСНК, которые занимаются вопросами планирования и осуществления. Требуется соответствующий механизм для обеспечения того, чтобы РАГ и национальные программы ГСНО как отдельная группа направляли развитие ГПС в целях скоординированного формирования РАГ и обеспечения возможности их лучшего взаимодействия, а также облегчения обмена информацией и данными, передачи технологии и создания потенциала.

Рекомендуемые меры

- Каждому РАГ и каждой национальной программе ГСНО следует организовать форум пользователей для привлечения групп пользователей к разработке, обеспечению функционирования и совершенствованию региональных систем наблюдений за прибрежной зоной океана и к развитию ГПС. Необходимо, чтобы в работе такого форума участвовали группы, которые используют, регулируют и изучают морские системы или зависят от них, из всех партнерских стран в данном регионе в целях определения высокоприоритетных продуктов и услуг, а также использования их для ориентирования работы по созданию региональной системы наблюдений за прибрежной зоной океана.

- Создать механизм, позволяющий обеспечить возможность функционирования РАГ как отдельной группы на основе технических указаний со стороны РНКГ и во взаимодействии со СКОММ в качестве международного координационного, регулирующего и управленческого механизма, предназначенного для формирования прибрежных систем наблюдений, управления данными и проведения анализа с охватом всего спектра необходимых геофизических, биофизических, химических и биологических переменных параметров. На первоначальном этапе приоритет следует предоставить быстрому применению в регионах проверенных технологий и процедур, которые принесут наибольшие выгоды, например создание системы предупреждения о цунами в Индийском океане по образцу Системы предупреждения о цунами в Тихом океане.
- Учредить на совместной основе Специальную целевую группу СКОММ-РНКГ (СКОММ – Комитет по вопросам управления), которая будет работать во взаимодействии с РАГ с целью определения потребностей и механизмов для реализации ГПС. Это ближайшая высокоприоритетная задача. К числу тех вопросов, которые следует рассмотреть, относится создание путем объединения РАГ четырех рабочих групп экспертов в следующих областях: измерения (РГИ), управление данными (РГУД), моделирование и анализ (РГМА) и создание потенциала (РГСП). Эти рабочие группы могли бы способствовать обмену данными, информацией, знаниями и технологиями между регионами; координировать региональное развитие на глобальном уровне; обеспечивать участие в случае необходимости международных исследовательских программ (например, ЛОИКЗ, ГЛОБЕК, ИМБЕР, ГЭОВЦВ), соответствующих региональных программ (региональные органы программы по тропическим циклонам, программы по крупным морским экосистемам, конвенций о региональных морях, региональные органы рыболовства и т.д.) и оперативных учреждений (например, органы береговой охраны, контролирующие органы) в решении задачи обеспечения своевременного развития оперативных возможностей сквозной системы (от проведения измерений до решения прикладных задач), охватывающей в случае необходимости геофизические, биофизические, химические и биологические переменные.

Создание подсистемы для измерений

Для проведения измерений общих переменных параметров в качестве части ГПС будут использоваться как средства измерения in situ, так и удаленные платформы. Измерения in situ будут проводиться на основе редкой сети местных опорных и контрольных пунктов, а также в рамках существующих глобальных программ, таких, как глобальная сеть мареографов (ГЛОСС) и глобальная сеть мониторинга коралловых рифов (ГСМКР). Формирование ГПС, позволяющей проводить измерение общих переменных параметров и осуществлять управление получаемыми в результате этого потоками данных, будет обеспечиваться благодаря двум параллельным процессам: (i) использование и расширение существующих глобальных программ для удовлетворения потребностей, связанных с прибрежной зоной; (ii) региональная разработка методов измерений, адаптируемых для включения в ГПС. Предполагается, что Рабочая группа по измерениям (РГИ) будет действовать в сотрудничестве с РНКГ, РАГ, СКОММ и, в случае необходимости, с другими организациями с целью координации развития подсистем измерений (наблюдений) как регионального, так и глобального масштаба для прибрежного модуля.

Рекомендуемые меры для развития деятельности на региональном уровне

- РГИ следует:

(1) обеспечить составление и ведение базы данных о переменных параметрах, мониторинг которых осуществляется в каждом регионе, об ответственных организациях, продолжительности и пространственном охвате наблюдений, временной и пространственной разрешающей способности измерений, используемых методах и их точности, стадии разработки (исследования, пилотный проект, доэксплуатационная, оперативная), продуктах и конечных пользователях данных, а также об источниках и уровнях финансирования (во многих случаях для такой информации проведено сравнение по некоторым регионам, таким, как Европа и Северная Америка);

(2) сформулировать концепцию разрабатываемого на базе Интернета набора средств, применяемых

для отбора переменных параметров, с сопроводительным справочником по его использованию, который можно загрузить из Интернета;
(3) возглавить работу по обеспечению широкой и эффективной координации между РАГ с целью согласования порядка принятия, разработки и использования общих стандартов и протоколов для измерений, телеметрии данных и контроля качества на глобальном уровне;
(4) разработать процедуры и средства для (i) применения проверенных технологий и процедур в тех регионах, где они необходимы (например, системы предупреждения о цунами в масштабах океанического бассейна); (ii) определения приоритетов исследований для развития оперативных возможностей во всех регионах; (iii) обеспечения соответствия международно принятым стандартам и протоколам; (iv) обеспечения эффективного использования новых знаний и технологий для расширения оперативных возможностей.

В настоящее время оперативные возможности наиболее развиты в отношении продуктов и услуг, которые требуют проведения наблюдений за геофизическими переменными (морские прогнозы погоды, раннее предупреждение о наводнениях в прибрежной зоне, морские службы, поиск и спасение и т.д.). Формирование этих элементов ГСНО в регионах, где отсутствуют такие возможности, должно быть одной из первостепенных ближайших задач.

Рекомендуемые меры для развития Глобальной прибрежной сети наблюдений:

- В сотрудничестве с РНКГ, Группой КСГН по прибрежной тематике и СКОММ РГИ следует:

(1) провести обзор общих переменных параметров для определения того, какие переменные следует добавить или исключить с учетом (i) числа РАГ, которым необходимы данные по этим переменным и которые их используют; (ii) их важности в качестве показателей глобальных изменений или показателей социально-экономического воздействия этих изменений в прибрежных системах; (iii) технической возможности включения таких переменных в ГПС в качестве оперативного элемента ГСНО;
(2) в соответствии с процедурами СКОММ принять (или, в случае необходимости, установить) международные стандарты и протоколы для измерения общих переменных параметров и содействовать их применению, а также сформулировать требования в отношении их точности, временной и пространственной разрешающей способности;

- РНКГ следует:

(1) осуществлять сотрудничество с РАГ с целью подготовки и периодического обновления глобальных перечней национальных и региональных программ мониторинга, которые можно предложить для ГПС;
(2) определять те программы или элементы этого перечня, которые следует объединять и включать в ГПС, и представлять по ним рекомендации, соответственно, СКОММ или РАГ;
(3) взаимодействовать с Группой КСГН по прибрежной тематике и с Целевой группой СКОММ по потребностям в спутниковых наблюдениях в целях (i обобщения оценок методов, датчиков, алгоритмов и деятельности по управлению данными, особенно в отношении прибрежных вод, и подготовки таких оценок, если они отсутствуют; (ii) регулярного обзора качества и полезности спутниковых продуктов по прибрежной зоне (в плане необходимой временной, пространственной и спектральной разрешающей способности) и подготовки четких рекомендаций относительно модернизации, включая совершенствование алгоритмов, размещение новых датчиков и определение приоритетов для исследований и разработок; (iii) формулирования и рекомендации стандартных процедур для калибровки и подтверждения достоверности спутниковых продуктов, сопоставимых между регионами; (iv) содействия развитию оперативных возможностей дистанционного зондирования для наблюдения цвета океана в прибрежных водах; (v) формулирования критериев определения оптимальных местоположений для калибровки данных дистанционного зондирования и подтверждения достоверности спутниковых продуктов; подготовки рекомендаций относительно мест проведения измерений и требований к ним, предъявляемых в каждом случае (временная и пространственная разрешающая

способность, точность); поощрения организации или продолжения таких измерений в качестве критического компонента ГПС;

(4) взаимодействовать с РАГ и Группой КСГН по прибрежной тематике в целях формулирования критериев для определения оптимальных мест размещения контрольных станций, проведения съемок и изучения разрезов; рекомендовать места проведения измерений и требования для них в каждом случае (временная и пространственная разрешающая способность, точность), а также поощрять проведение или продолжение таких измерений в качестве критического компонента ГПС;

(5) проводить оценку потребностей в телеметрии данных на региональном и глобальном уровнях и (i) подготавливать документацию по существующей инфраструктуре телеметрии данных; (ii) рекомендовать простые недорогостоящие и надежные технологии, которые можно применять незамедлительно; (iii) содействовать в случае необходимости разработке и развертыванию новых телекоммуникационных систем; (iv) разрабатывать стандарты и протоколы для технологий телеметрии, используемых в ГСНО, для содействия распространению данных в исследовательских и оперативных целях; (v) содействовать осуществлению программ технической поддержки для телекоммуникационных систем, используемых в целях ГСНО.

Создание подсистемы управления данными

Подсистема управления данными (ПУД) для прибрежного модуля ГСНО должна выполнять следующие функции: (1) обработка и архивация данных об общих переменных параметрах в соответствии с научно обоснованными и хорошо документированными стандартами и форматами; (2) распространение данных об общих переменных параметрах (наблюдения и результаты моделирования) в режимах реального времени и «запаздывания» в зависимости от потребностей групп пользователей и их технических возможностей (автоматическое распространение, рассылка по «запросу»); (3) обеспечение эффективного доступа к данным об общих переменных параметрах и к производным продуктам (включая прогнозы, тревожные сообщения и оповещения) для пользователей, обладающих широкими возможностями. Большинство данных будут поступать в ПУД и первоначально обрабатываться национальными центрами данных или существующими оперативными учреждениями, где предоставление данных и продуктов может быть согласовано с потребностями местных пользователей. Во многих областях региональные кластеры национальных центров и оперативных учреждений обеспечат эффективность деятельности благодаря ее масштабу и позволят каждому РАГ использовать преимущества тех различных возможностей, которые предоставляют страны в соответствующем регионе. В дополнение к этому, там, где не существует национальных центров, наиболее эффективным, с точки зрения затрат, способом управления данными может быть создание многонациональных региональных центров данных. Национальные центры и региональные кластеры будут обеспечивать управление данными, поступающими как от региональных систем наблюдений за прибрежной зоной океана, так и от ГПС. Наивысший уровень агрегации общих переменных параметров обеспечат глобальные кластеры, где могут использоваться хорошо опробованные средства передачи и обработки глобальных данных, а также управления ими.

Зачастую эффективные, но ограниченные системы управления данными и телеметрии данных имеются у таких оперативных учреждений, как береговая охрана, службы контроля за загрязнением, управления по вопросам рыболовства, службы предупреждения о наводнениях, а также регулирующие органы, ответственные за безопасность на море и на морских нефтяных и газовых платформах. Такие структуры следует включать в региональные подсистемы управления данными как в целях получения данных, так и распространения продуктов данных.

Развитию ПУД для ГПС и региональных систем наблюдений за прибрежной зоной океана будет способствовать создание Рабочей группы по управлению данными (РГУД). Развитие ПУД наиболее эффективно можно обеспечить с помощью применения открытого программного обеспечения. В процессе осуществления рекомендуемых ниже мер, по возможности, предпочтительно использовать существующие протоколы и стандарты, а не разрабатывать новые решения.

Рекомендуемые меры

- РНКГ следует проводить работу совместно с МГСНО и РАГ для обеспечения соответствия политике МОК в отношении данных (http://ioc.unesco.org/goos/GOOSdm_final.pdf), а также заключения и осуществления международных соглашений для своевременного обмена данными между РАГ и участвующими странами.
- В сотрудничестве с национальными центрами океанических данных и МООД РГУД следует содействовать созданию в случае необходимости региональных и глобальных кластеров по управлению данными. Следует включать компоненты управления данными, имеющиеся у оперативных учреждений.
- РГУД необходимо следить за развитием ОБИС и подсистемы США ДМАК для изучения накопленного опыта с целью интеграции ОБИС в инфраструктуру ПУД, а также определения того, какие аспекты подсистемы США могут использоваться для содействия созданию глобальной инфраструктуры ПУД в рамках прибрежного модуля ГСНО.
- РГУД в сотрудничестве с национальными программами ГСНО и центрами океанических данных, Группе экспертов СКОММ-МООД по практике управления данными, станциям наземного экологического мониторинга (СНЭМ) Глобальной системы наблюдения за сушей (ГСНС), а также международным исследовательским программам (например, МПГБ и СКОР) следует:

(1) определить содержание метаданных и указать (или принять существующие) стандарты формата метаданных; содействовать их применению в отношении как исторических данных, так и потоков данных, поступающих от ГПС и региональных систем наблюдений за прибрежной зоной океана;
(2) определить, какие требуются средства поиска и просмотра, и установить стандарт интерфейсов «машина-машина» (служба локализации данных) для обеспечения плавного перехода от обнаружения данных к доступу к ним;
(3) разработать стандарты веб-услуг и всеобъемлющую модель данных для передачи данных между сервером и пользователем;
(4) создать службы архивации;
(5) изучить способность инфраструктуры СКОММ-МООД обеспечивать контроль за реализацией ПУД в отношении общих переменных параметров по прибрежной зоне в рамках ГПС. При необходимости создать механизм контроля за развитием комплексной ПУД, который будет использовать существующие возможности и включать нефизические переменные, а также обеспечивать взаимодействие между РАГ, с Глобальной системой наблюдений за климатом (ГСНО/ГСНК) и Глобальной системой наблюдений за сушей (ГСНС), а также с программами океанических исследований (например теми, которые финансируются МПГБ и СКОР).

Создание подсистемы моделирования и анализа

Целью подсистемы моделирования является ассимиляция данных, поступающих от сети измерений (наблюдения in situ и дистанционное зондирование) для (1) проведения более точной оценки переменных параметров, их распределения, а также соответствующих погрешностей; (2) разработки, опробования и апробирования моделей; (3) внедрения и обновления моделей в целях совершенствования прогнозирования. Продукты таких моделей включают всеобъемлющие и комплексные пространственные описания прошлого (ретроспективного), нынешнего (современного) и будущего (прогнозируемого) состояния прибрежной зоны океана.

Работу по созданию или совершенствованию таких средств следует начинать с привлечения групп пользователей к определению потребностей в данных и информации (продуктах и услугах), а также составления и обновления перечней средств и способов моделирования, которые позволяют удовлетворять эти потребности. Это обеспечит основу для отбора, разработки и/или совершенствования моделей с помощью сетей моделирования, действующих на базе различных сообществ.

Рекомендуемые меры

- Рабочей группе по моделированию и анализу (РГМА) в сотрудничестве с РАГ, научными программами, программами по крупным морским экосистемам и, в случае необходимости, с другими органами следует:

(1) поощрять и направлять развитие сетей моделирования, действующих на базе различных сообществ, уделяя внимание региональным потребностям, техническим проблемам и продуктам;
(2) составить и постоянно обновлять перечень опробованных прибрежных моделей (организованный по принципу практического применения); разместить перечень этих моделей на Интернете; рекомендовать критерии оценки возможностей и оперативного статуса моделей;
(3) определить ряд внешних показателей для контроля и обеспечения качества и выяснения того, в какой мере продукты прибрежного модуля удовлетворяют потребности пользователей.

- РГМА следует:

(1) работать в сотрудничестве с сетями моделирования, действующими на базе различных сообществ, для расширения доступа (с помощью перечня, размещенного в Интернете) к имеющимся в свободном пользовании, хорошо документированным моделям и компьютерным программам, а также содействовать разработке таких моделей и программ в целях ассимиляции и визуализации данных;
(2) содействовать осуществлению пилотных проектов, позволяющих ускорить разработку моделей и показателей на базе сообществ для прогнозирования состояния экосистем, в том числе в целях управления рыболовством и качеством водных ресурсов, на основе экосистемного подхода;
(3) составить и постоянно обновлять перечень потребностей в данных и наблюдениях для прибрежных моделей;
(4) на основе опыта, накопленного другими группами, уже разработавшими аналогичные критерии оценки для других типов моделей (например, ООПК/ГОДАЕ для моделей глубоководных участков океана), взаимодействовать с сетями моделирования на базе различных сообществ в целях определения внутренних показателей, которые могут быть использованы для оценки качества, внутренней согласованности и техники основных классов прибрежных моделей.

Развитие и совершенствование потенциала

Полностью интегрированная ГСНО, ориентированная на достижение всех шести поставленных целей общества, может быть создана только путем совершенствования в глобальном масштабе потенциала для проведения наблюдений в прибрежной зоне и предоставления соответствующей информации. Укрепление потенциала необходимо осуществлять по двум направлениям: (1) создание в странах и РАГ, находящихся на различных стадиях экономического развития, условий для формирования систем наблюдений за прибрежной зоной океана и использования данных и информации, поступающих от ГСНО; (2) разработка на основе исследований новых технологий и моделей, которые могут быть использованы для расширения оперативных возможностей региональных систем наблюдений за прибрежной зоной океана и ГПС. Обе эти задачи наиболее эффективно можно решать путем осуществления, совместно с РАГ, различных проектов, перед которыми будут поставлены четкие, вполне достижимые цели и которые позволят обеспечить устойчивое проведение наблюдений, управление данными и соответствующую аналитическую работу.

Рекомендуемые меры

- С помощью РНКГ и Программы ГСНО-СКОММ по созданию потенциала для РАГ и национальных программ ГСНО следует определить приоритетные продукты и услуги, которые требуют развития или усовершенствования региональных систем наблюдений за прибрежной зоной океана.
- В рамках Программы ГСНО-СКОММ по созданию потенциала следует сформировать при существующих учреждениях центры технической поддержки, которые будут предоставлять консультации и направлять технических специалистов в принимающие страны или в РАГ для содействия размещению, использованию и эксплуатационному обслуживанию новых инструментов и существующей инфраструктуры.
- РНКГ в сотрудничестве с глобальным органом РАГ и Программой ГСНО-СКОММ по созданию потенциала следует:

(1) провести учет и обзор существующих мероприятий в области создания потенциала, кото-

рые связаны с развитием прибрежного модуля ГСНО, и рекомендовать процедуры для обеспечения более эффективного использования их совместных ресурсов для достижения общих целей. Такая деятельность должна включать мероприятия по оказанию помощи и профессиональной подготовке, которые в настоящее время проводятся оперативными учреждениями и их всемирными организациями (например, ВМО в отношении метеорологии, Международной морской организацией (ИМО) в отношении судоходства и его регулирования и эквивалентными органами в отношении портов, гаваней, береговой охраны и т.д.) и которые могут быть улучшены в развивающихся странах благодаря дополнительному финансированию, подготовке кадров и развитию инфраструктуры;

(2) убедить международных доноров (включая ГЭФ) в необходимости финансирования партнерства между развивающимися и развитыми странами в целях создания инфраструктуры для ГСНО с помощью программ по КМЭ и, при необходимости, других программ.

- РГСП следует:

(1) определить, разработать и сделать доступными наборы средств для создания потенциала в отношении всех трех подсистем (наблюдения, управление данными и моделирование);

(2) консультировать Программу ГСНО-СКОММ по созданию потенциала относительно разработки процедур для стран и РАГ в целях формирования, оперативного использования и совершенствования региональных систем наблюдений за прибрежной зоной океана с учетом их собственных приори¬тетов;

(3) сотрудничать с РАГ в деле разработки и осуществления пилотных проектов, которые обеспечат возможности создания устойчивых систем наблюдений за прибрежной зоной океана по всему миру, особенно в регионах, испытывающих нехватку ресурсов для развития таких систем.

Пилотные проекты

Пилотные проекты являются важным механизмом развития оперативных возможностей на региональном и глобальном уровнях. В этих целях рекомендуются две категории пилотных проектов: (i) проекты, позволяющие создавать потенциал в регионах, испытывающих нехватку ресурсов, необходимых для того, чтобы участвовать в создании прибрежного модуля ГСНО и получать от него пользу; (ii) проекты, необходимые для ускоренного расширения оперативных возможностей на основе достижений науки и техники.

Рекомендации

- РНКГ следует провести обзор рекомендуемых здесь пилотных проектов; осуществить оценку проектов, получивших финансирование, с целью определения их потенциала для включения в ГПС (или распространения на другие регионы); определить проекты, которым следует оказать поддержку в целях финансирования в качестве пилотных проектов прибрежного модуля ГСНО; содействовать в случае необходимости разработке новых пилотных проектов.
- РНКГ следует сотрудничать с РАГ в целях определения региональных проблем и потребностей, решение или удовлетворение которых может быть обеспечено путем применения проверенных технологий и процедур для развития региональных систем наблюдений за прибрежной зоной океана, а также содействовать инвестициям в пилотные проекты (включая подготовку специалистов), которые со временем приведут к созданию постоянных оперативных систем.

Оценка эффективности

Систематическое, строгое и периодическое проведение оценок эффективности с точки зрения социально-экономической пользы от данных и информации, получаемых благодаря ГСНО, имеет критически важное значение для устойчивого развития ею систем наблюдений. Эффективность работы следует измерять как в плане успешного функционирования систем, так и получаемых от них выгод. Функционирование систем следует оценивать с учетом следующих критериев: (i) взаимодействие между РАГ и ГПН; (ii) непрерывность, качество, разнообразие и интеграция потоков данных; (iii) совершенствование оперативных возможностей. Выгоды следует оценивать в плане: (i) количества новых или усовершенствованных продуктов, относимых к прибрежному модулю; (ii) числа групп, использующих эти продукты; (iii) использования данных и информации, поступающих от этой системы для удовлетворения потребностей и условий международных конвенций и соглашений; (iv) анализа затрат/выгод – измерения затрат на систему в сравнении с социально-экономическими выгодами.

Рекомендуемые меры

- РНКГ следует:

(1) содействовать работе по прибрежной тематике КСГН;
(2) сотрудничать с Группой КСГН по прибрежной тематике и Целевой группой СКОММ по спутниковым наблюдениям в целях подготовки на регулярной основе докладов об адекватности спутникового дистанционного зондирования (температура морской поверхности, альтиметрия, скаттерометрия, САР и цвет океана в прибрежных водах), дистанционного зондирования с летательных аппаратов (например, лазерный локатор ИК-диапазона или ЛИДАР и компактный авиационный спектрометр или КАСИ), дистанционного зондирования с помощью приборов наземного базирования (например, высокочастотный радар); рекомендовать процедуры по их совершенствованию (включая алгоритмы) и разработке новых средств дистанционного зондирования со спутников;
(3) сотрудничать с РАГ с целью разработки процедур проведения исследований, ориентированных на конкретные продукты, анализа их целесообразности и воздействия для оценки существующих оперативных возможностей систем наблюдений и определения исследовательских приоритетов для совершенствования таких систем;
(4) устанавливать процедуры для периодической оценки и обновления общих переменных параметров и программ забора проб для целей ГПС, а также определения приоритетов исследовательской деятельности, необходимой для расширения возможностей оперативных наблюдений.

- РГИ следует:

(1) поддерживать и координировать деятельность по взаимной калибровке (например, проведение семинаров, сравнение результатов измерений по эталонным материалам между лабораториями всего мира) между РАГ и национальными и глобальными программами с целью совершенствования и оценки измерений в отношении общих переменных параметров;
(2) выявлять существующие стандарты и протоколы и разрабатывать, в случае необходимости, новые для измерения общих переменных параметров, которые рекомендуют использовать провайдеры данных;
(3) отслеживать прогресс в создании новых оперативных возможностей, стандартов и протоколов для измерения переменных параметров и содействовать их включению в оперативные системы наблюдений (ГПС, региональные системы наблюдений за прибрежной зоной океана).

- РГУД следует разработать и поощрять использование показателей эффективности для оценки своевременности и непрерывности предоставления данных, функциональной совместимости (разработка и применение общих стандартов и протоколов) и обмена данными между регионами и странами (двусторонние и многосторонние соглашения об обмене данными и их осуществление).
- РГСП следует разработать показатели эффективности для четырех ключевых сквозных видов деятельности, которые имеют критическое значение для создания комплексной, ориентированной на пользователя глобальной системы наблюдений за прибрежными районами океана: (i) международная координация и сотрудничество в деле создания ГПС (возможность совместной работы); (ii) создание потенциала в плане эффективности определения и реализации региональных и национальных приоритетов формирования всех трех подсистем; (iii) развитие оперативных возможностей РАГ в качестве группы; (iv) разработка и использование социально-экономических показателей для измерения эффективности более быстрого обнаружения и своевременного прогнозирования явлений, представляющих интерес с точки зрения устойчивого использования океанов и ресурсов, которые они поддерживают.

Prologue

Earth Observations and the Global Ocean Observing System

Changes in physical and ecological states of marine systems, often caused by human activities, directly affect the safety and well being of human populations (Field et al., 2002; GESAMP, 2001; IWCO, 1998; Watson et al., 1998). Coastal marine and estuarine ecosystems (Jackson et al., 2001) and human populations (Nicholls and Small, 2002) are especially vulnerable to the negative impacts of these changes. These realities have led to numerous international agreements that require sustained and routine observations of oceanic and coastal systems to achieve their goals, including the following:

- UN Convention on the Law of the Sea (UNCLOS, including the agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks),
- Regional Seas (target water quality) and Fisheries Management Conventions and Agreements,
- Jakarta Mandate (biodiversity),
- Ramsar Convention on Wetlands,
- Global Plan of Action on Land-Based Sources of Pollution,
- Safety of Life at Sea (SOLAS) Convention,
- Framework Convention on Climate Change,
- UN Conference on Environment and Development (UNCED) (Rio de Janeiro, 1992),
- Convention on International Trade in Endangered Species (CITES), and
- UNCED Programme of Action for Sustainable Development (Johannesburg, 2002).

In 2003, over thirty nations agreed to a declaration at the Earth Observing Summit[1] affirming the need "to monitor continuously the state of the Earth, to increase understanding of dynamic Earth processes, to enhance prediction of the Earth system, and to further implement our international environmental treaty obligations", and, thus the need for "timely, quality, long-term, global information as the basis of for sound decision making." The declaration called for the following:

- Improved coordination of strategies and systems for observations of the Earth and identification of measures to minimize data gaps, with a view to moving toward a comprehensive, coordinated, and sustained Earth observation system or systems;
- A coordinated capacity building effort to involve and assist developing countries in improving and sustaining their contributions to earth observing systems including access to and effective utilization of observations, data and products, and related technologies;
- The exchange of observations recorded from in situ, aircraft, and satellite networks, dedicated to the purposes of the Earth Observing System, in a full and open manner with minimum time delay and minimum cost, recognizing relevant international instruments and national policies and legislation; and
- Formulation of a 10-year Implementation Plan for a Global Earth Observing System of Systems (GEOSS) that builds on existing systems and initiatives.

A draft of the 10-year plan has been completed[2] and will be used as the basis for negotiating the final plan at the fifth meeting of the Group on Earth Observations (GEO) in late 2004.

Establishing a global system of observations for the coastal ocean as part of the Integrated Global Observing Strategy (IGOS)[3] will be a major contribution toward establishing the GEOSS and an important step toward making it possible for the world's nations to achieve the goals and requirements of international agreements and conventions.

1 http://www.earthobservationsummit.gov/declaration.html
2 http://earthobservations.org/docs/IPTT_201-1web.pdf
3 http://www.igospartners.org/

Developing the Coastal Module of the Global Ocean Observing System

The Global Ocean Observing System (GOOS) is evolving as two interdependent modules, one for the global ocean and one for coastal marine and estuarine systems (IOC, 1998). The global module is primarily concerned with improving marine weather forecasts and marine services, predicting basin scale oscillations (e.g. the ENSO, PDO, NAO), and predicting decadal scale climate changes (e.g. global warming and sea level rise). Initial plans for this module have been completed (IOC, 1999) and implementation has begun[4].

Applications of data and information from the global module for mitigating and controlling the effects of natural hazards and climate change on ecosystems and socio-economic systems are most valuable in the coastal zone where human population density is highest and growing rapidly (Nicholls and Small, 2002) and ecosystem goods and services are most concentrated (Costanza et al., 1997). Thus, the use of data and information from the global ocean module for these purposes depends to a significant extent on implementing the coastal module both regionally and globally.

The coastal module[5] is primarily concerned with establishing an observing system that provides data and information required to mitigate and manage the effects of natural hazards (e.g. tsunamis, tropical storms), climate change (e.g. sea level rise, warming) and human activities (e.g. land-use practices, extraction of natural resources, shipping) on coastal systems and their capacity to sustain goods and services of value to human society. To these ends, the Integrated Design Plan for the coastal module (IOC 2003, p. 51-54) calls for the implementation of regional coastal ocean observing systems and the networking of these systems globally to form a Global Coastal Network (GCN). The former has already begun.

Regional observing systems are most advanced in the developed world and less advanced or non-existent in the developing world. In addition, although global observing programmes exist (e.g. satellite-based remote sensing[6], marine meteorology, global tide gauge network[7], global coral reef monitoring network[8], and the global seagrass monitoring network[9]), a multidisciplinary GCN that incorporates these into an integrated system of observations, data management, and data analysis has yet to be established. Here we present the COOP plan for the phased evolution of such a GCN through the establishment and networking of GOOS Regional Alliances (GRAs), National GOOS programmes, and existing global programmes. The plan focuses on policies and procedures for establishing regional scale coastal ocean observing systems. This is an "organic" plan that should be updated periodically and used to guide the formulation and implementation of action plans as GRAs mature, the diversity of user groups grows, and new technologies and understanding enable the evolution of a fully integrated and comprehensive system.

4. http://www.wmo.ch/web/gcos/publications
5 http://ioc.unesco.org/goos/docs/GOOS_125_COOP_Plan.pdf
6 http://www.ceos.org/
7 http://www.pol.ac.uk/psmsl/programmes/gloss.info.html
8 http://www.gcrmn.org/
9 http://www.seagrass.net/

BOX 1. POTENTIAL ECONOMIC BENEFITS OF AN INTEGRATED GLOBAL OBSERVING SYSTEM (CHEVES, 2003)

- For developed countries, national institutions providing weather, climate and water services to their citizens contribute an estimated $20-$40 billion U.S. each year to their national economies. Topical cyclones and tsunamis caused damage estimated at $300 billion U.S. during 1990-1999. Natural hazards have a disproportionate impact on developing countries where they a major barriers to sustainable development. Although risks cannot be completely eliminated, improved forecasts made possible by integrated global ocean, climate and terrestrial observing systems will reduce the loss of life and property and help to mitigate their effects on renewable resources.
- The annual cost of electricity could be decreased by > $1 billion U.S. by improving the accuracy of regional weather forecasts by 0.5°C through improved ocean-climate observations.
- Through improved models and more accurate and timely estimates of sea surface current and wave fields, the cost (economic and environmental) of oil pollution can be reduced significantly by more efficient and effective deployment of clean-up equipment. A 1% reduction in oil spill volume in the Gulf of Maine alone is estimated to save $750,000 U.S. per year.
- Shipping accounts for 95% of transported goods worldwide. More accurate and timely forecasts of water depth in ports and harbors will allow ships to carry more cargo increasing the safety of profits of marine operations. More accurate and timely forecasts of surface current and wave fields will reduce time and fuel costs through more effective ship routing[10].
- The Global Burden of Human Disease, caused by sewage pollution of coastal waters is estimated at 4 million lost 'man-years' every year, which equals an economic loss of approximately 16 billion US$ a year[11]. The annual income from recreational activities in the world's coastal zone (including the use of bathing beaches and seafood consumption), which is estimated to be on the order of $100 billion U.S. per year, is threatened by pollution from land-based sources from both point (e.g., increases in the discharge of partially treated waste water containing human pathogens, nutrient pollution, and toxic chemicals) and non-point sources (e.g., inputs of contaminants through surface runoff and atmospheric deposition). Improved estimates of these inputs and models of coastal circulation and water quality will reduce risks of human exposure, provide the data and information needed for more effective control of anthropogenic inputs, and recreational income.
- In recent years, the economic losses caused by Harmful Algal Blooms (HABs) worldwide are causing great concern. Recently, HAB outbreaks along Chinese coast have been estimated to be greater than $1.2 billion U.S. An HAB (NSP) outbreak in 1987-88 closed more than 400 km of North Carolina coastline for shellfishing during the peak harvesting season, causing economic losses estimated at $25 million. More rapid detection and timely predictions of HABs will reduce economic losses.
- Nearly 75 per cent of fisheries are categorized as overfished or fished to the limit, and large fish stocks have fallen to 10 per cent or less of their numbers at the onset of commercial fishing (Balmford et al. 2004)[12]. The associated economic losses are very large ($ billions) and impossible to realistically measure. Establishment of the coastal module of GOOS is required to engage in ecosystem-based, adaptive management of fisheries and other living marine resources as the means to restore and sustain healthy stocks of living marine resources.

10 http://www.us.weathernews.com
11 http://www.gpa.unep.org/pollute/sewage.htm
12 http://www.pnas.org/cgi/content/abstract/0403239101

1. Meeting Societal Needs in the Coastal Ocean

1.1 The Implementation Strategy - Overview

The coastal module of GOOS is being implemented by nations, GOOS Regional Alliances (GRAs), and international bodies supported by nations. Coordinated development of a sustained and integrated observing system for the coastal ocean on a global scale requires a dual-track approach that addresses (i) the unique needs of individual nations and GRAs for data and information on coastal marine and estuarine systems as well as (ii) needs that are common to all or most nations and GRAs. The rationale for and the conceptual design of such a system are given in the Integrated Design Plan (IOC, 2003; p.51-54) and summarized in Chapters 1 and 2 herein. A governance structure for managing development of the coastal module is also recommended in Chapter 2. Recommended actions for implementing the observing, data management, and data analysis subsystems are set forth in Chapters 3, 4 and 5, respectively.

Developing a fully integrated, multi-disciplinary global system for the coastal module of GOOS is especially challenging for at least two reasons: (1) monitoring and research activities in much of the world's coastal ocean are non-existent or primitive at best; and (2) operational capabilities for detecting, assessing and predicting changes in public health risks, ecosystem health, and the sustainability of living marine resources are poorly developed relative to those for marine operations, weather forecasting, and climate prediction. Meeting these challenges will require major investments in capacity building (Chapter 6).

Pilot projects (section 1.5 below) are critical to the development of both regional coastal ocean observing systems and the GCN. Throughout the document, pilot projects are given as examples to illustrate processes of implementation. Because of their importance in accelerating implementation, a set of pilot projects is described in Chapter 7 to highlight the kinds of efforts that will be needed.

Sustained operation and development will require the support of data providers, a diverse community of end-users, and sponsors. For the more complex and advanced operational activities this can best be achieved through the formulation and repeated use of metrics or indicators that measure system performance in terms of the sustained provision of required data streams, quality control, access to data, efficient linkages between research and the development of operational capabilities, and the provision of data-products at rates and in forms specified by the users. Thus, the implementation strategy concludes with a chapter on developing performance metrics (Chapter 8).

Finally, this plan represents the work of the Coastal Ocean Observations Panel (COOP), invited experts, and the IOC-GOOS Secretariat (Annex I). This implementation strategy presents recommended first steps that should be taken to develop an integrated and sustained observing system for the coastal ocean on a global scale. This is a "living document" that will need to be updated periodically as the coastal module evolves in response to growing demand for data and information, advances in technology and understanding, and funding by participating countries.

With the completion of this strategic plan, the COOP will have completed its charge, and a new panel should be formed to formulate and promote action plans for implementing this strategic plan.

Action 1.1: The COOP recommends that it be dissolved once the "Implementation Strategy for the Coastal Module of the Global Ocean Observing System" has been approved by the GSSC and the I-GOOS. The GSSC should take on the responsibility for the provision of science and technical guidance for implementing the coastal module of GOOS. The GSSC must be expanded to include the required areas of coastal expertise and given the authority to include experts as needed. In collaboration with the GRAs, the GSSC should periodically assess progress in implementing the coastal module and prepare, and update as needed, an action plan for implementing actions recommended herein. The action plan should include recommendations for pilot projects needed to build capacity globally.

1.2 An Integrated Approach to Meeting Societal Needs

The coastal module of GOOS is intended to develop an integrated[13] and holistic approach to achieving **six societal goals**:

- improve the capacity to detect and predict the effects of global climate change on coastal ecosystems;
- improve the safety and efficiency of marine operations;
- more effectively control and mitigate the effects of natural hazards;
- reduce public health risks;
- more effectively protect and restore healthy ecosystems; and
- more effectively restore and sustain living marine resources.

Coastal systems are experiencing unprecedented changes and becoming more susceptible to natural hazards (e.g. tsunamis, storm surge flooding), more costly to live in, and less able to support living resources. A broad spectrum of phenomena from global warming and sea level rise to harmful algal blooms (HABs) and losses of biodiversity (Figure 1.1) are exhibiting troubling trends in their magnitude or frequency. Industries working in the coastal zone need ever more detailed information to comply with environmental standards and to reduce accidents. Trends such as these are related to both natural processes and increasing human demands on coastal ecosystems to support commerce, living resources, recreation, and living space and to receive, process, and dilute the effluents of human society. Informed management for sustained use of these goods and services requires the capacity to routinely and rapidly assess the state and health of marine systems, detect changes on a broad spectrum of time and space scales, and provide timely predictions of likely future states. We do not have this capacity today.

Examples of the data-products needed to achieve the goals that establishment of the coastal module will make possible are listed in Table 1.1. Although each of these goals and associated products have unique requirements for data and information, there are also many shared data and information needs. Likewise, many of the requirements for data communications and management are similar across all six goals. Thus, an integrated approach to developing this multi-use, multi-disciplinary observing system is feasible, sensible, and cost-effective. Some installations can be started at once on a pragmatic basis, but the fully integrated system meeting all six goals will take many years. In particular, systems that have proven useful in one region (e.g. the Tsunami Warning System in the Pacific, Box 1.1) should be established in other regions with similar risks as soon as possible.

In addition to sustained and timely provision of marine data and information to decision makers, achieving these goals will require an informed and supportive public. Thus, the developers of the coastal module will work closely with UN agencies to facilitate public access to and use of GOOS data and information.

13 An integrated system efficiently links observations to models via a data management and communications subsystems that provides rapid access to diverse data from many sources (Chapters 2 – 5); is multidisciplinary (measures and manages meteorological, physical, chemical, biological and geological data); provides rapid access to diverse data from many different sources; and serves data and information required for many applications.

BOX 1.1. OVERVIEW OF THE PACIFIC TSUNAMI WARNING SYSTEM

The Pacific Tsunami Warning System (PTWS) monitors seismic activity and sea level throughout the Pacific Basin to provide early warning and mitigate the impacts of tsunamis on the populations and economies of 26 participating nations. As part of an international cooperative effort to save lives and protect property, the U.S. National Oceanic and Atmospheric Administration's (NOAA) National Weather Service operates tsunami warning centers in Palmer, Alaska and Ewa Beach, Hawaii. The latter serves as the regional Tsunami Warning Center for Hawaii and as a national/international warning center for tsunamis that pose a Pacific-wide threat. This international warning effort became a formal arrangement in 1965 when the Hawaii center assumed the international warning responsibilities of the Pacific Tsunami Warning System (PTWS).

Tsunami Watch and Warning Determination – The PTWS detects, locates, and determines the magnitude earthquakes that are likely to cause tsunamis in the Pacific basin and its margins. When the location and magnitude of an earthquake meet specified criteria for tsunami generation, a warning (arrival time, sea level) is issued to alert coastal populations of an imminent tsunami hazard. The International Tsunami Information Center of the Intergovernmental Oceanographic Commission monitors and evaluates the performance and effectiveness of the Pacific Tsunami Warning System. This encourages the most effective data collection, data analysis, tsunami impact assessment and warning dissemination to all PTWS participants.

Tsunami Warning Dissemination – Tsunami watch, warning, and information bulletins are disseminated to appropriate emergency officials and the general public by a variety of communication methods. Tsunami watch, warning and information bulletins are disseminated to local, state, national and international users as well as the media. These users, in turn, disseminate the tsunami information to the public, generally over commercial radio and television channels. The NOAA Weather Radio System, based on a large number of VHF transmitter sites, provides direct broadcast of tsunami information to the public. The U.S. Coast Guard also broadcasts urgent marine warnings and related tsunami information to coastal users equipped with medium frequency (MF) and very high frequency (VHF) marine radios. Local authorities and emergency managers are responsible for formulating and executing evacuation plans for areas under a tsunami warning. The public should stay-tuned to the local media for evacuation orders should a tsunami warning be issued. And, the public should NOT RETURN to low-lying areas until the tsunami threat has passed and the "all clear" is announced by the local authorities.

http://www.geophys.washington.edu/tsunami/general/warning/warning.html

SOCIETAL GOALS	EXAMPLE PRODUCTS
Weather & Climate	(1) Improved estimates of surface fields of temperature, salinity, currents & waves; (2) Improved estimates of air-sea exchanges of heat, water, and carbon; (3) Improved predictions on seasonal and longer time scales.
Maritime Operations	(1) Maintain navigable waterways more effectively; (2) Route ships more safely & cost-effectively; (3) Improved search, rescue, and emergency response capabilities; (4) Safety forecasts for offshore energy production.
Natural Hazards	(1) Improved forecasts of the temporal and spatial extent of storm surge coastal flooding; and tsunamis; (2) Rapidly detect and predict the effects of habitat modification and loss in the coastal zone on flood and health risks; (3) Disseminate and provide rapid access to real-time observations and warnings of hazards.
Public Health	(1) Establish international standards for estimating risks of illness or injury from exposure to pathogens, toxins, and hazards (water contact); (2) Establish international standards for estimating risks of illness from consuming seafood.
Ecosystem Health	(1) Regional climatologies for sea surface temperature, salinity, dissolved nutrients, chlorophyll-a, and harmful algal blooms; (2) More timely assessments and predictions of changes in the distribution and condition of benthic (coral reefs, sea grasses, mangroves, and tidal marshes) and pelagic (hydrography, currents and waves, anoxia) habitats and species diversity; (3) More timely assessments and predictions of the distribution and toxicity of harmful algae, presence of invasive species, and occurrence of diseases in and mass mortalities of marine animals (fish, mammals, & birds).
Living Resources	(1) More accurate & timely predictions of annual fluctuations in spawning stock size, distribution, recruitment, and sustainable yields for exploitable fish stocks; (2) Detect changes in the spatial extent and condition of essential fish habitat more rapidly; (3) Improve assessments and predictions of the effects of fishing on habitats and biodiversity; (4) Establish and monitor the effectiveness of Marine Protected Areas.

Table 1.1. The six societal goals and examples of products needed to achieve these goals. Collectively, the six goals have common requirements for data and information. For example, search and rescue, health risks of exposure to pathogens while swimming, and forecasts of the trajectories of oil spills and harmful algal blooms all required nowcasts of surface current fields. The coastal module of GOOS is being designed and implemented to meet common data requirements and to provide data needed to serve products such as those listed.

1.3 An Observing System for Sustained Use of the Oceans and Its Resources

Sustainable use of marine systems and the goods and services they support depends on (1) efficient coupling between advances in the environmental sciences and their application for the public good (Figure 1.2) and (2) our understanding of the interdependency of ecological and socio-economic systems (section 1.2.2). Today, there are unacceptable disconnects between these processes on both counts (Malone et al., 1993; Bowen and Riley, 2003). Although the challenges are many, coordinated development of the coastal modules of GOOS and GTOS provides an important means to bridge the gap between science and management through the routine and repeated provision of scientifically credible, quantitative assessments of the status of coastal ecosystems across the land-sea interface on local, regional and global scales.

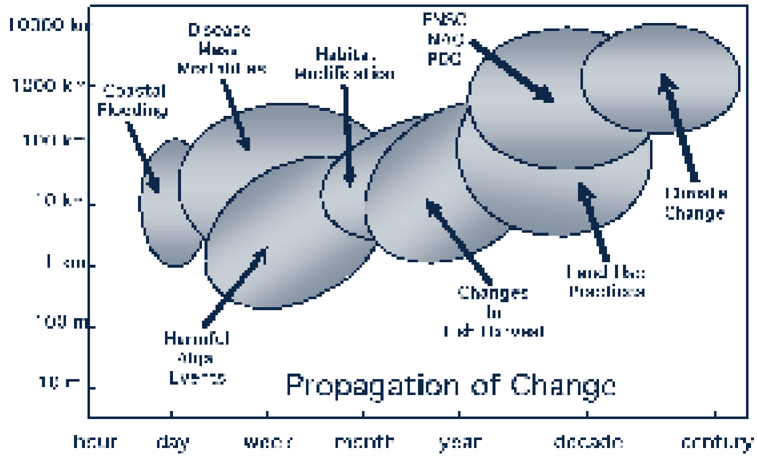


Figure 1.1. The state and health of marine systems are defined by the phenomena of interest which are often local expressions of larger scale forcings that may be of natural origin, anthropogenic origin, or both. (IOC, 2003). Forcings include natural hazards (extreme weather, tsunamis, volcanic activity, earthquakes), global climate change, land-based sources of pollution, extraction of natural resources, shipping (including oil spills and introduction of non-native species), dredging and the construction of dams. As a group, these forces and phenomena span a broad spectrum of variability in time, space and ecological complexity.

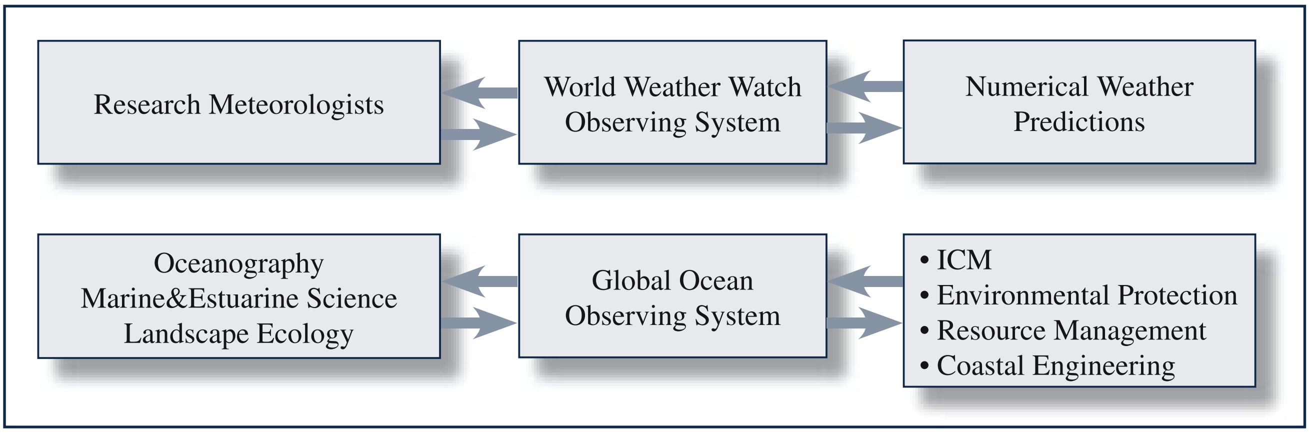


Figure 1.2. The observing system for the World Weather Watch is operational (routine, continuous provision of data and products of known quality) with guaranteed data streams and products (numerical weather and climate predictions). Numerical weather nowcasts and forecasts are not dependent on the meteorological research community directly, but the observing system benefits from meteorological research through improved technologies and models. The observing system also contributes to advances in the science of meteorology and to improved predictions of climate change on decadal time scales. However, its primary purpose (and motivation for government funding) is to predict the weather for the public good. A similar, but far more complex system, is needed for coastal and oceanic environments. It is more complex in terms of the sheer number of variables, the multiplicity of site-specific processes, the diversity of applications and the multi-disciplinary science foundation required to develop a fully integrated system that addresses all six societal goals.

1.3.1 Ecosystem-Based Management

All coastal ecosystems are subject to multiple forcings from both natural and anthropogenic sources, and the effect of one is often exacerbated by others (e.g. storm surge hits a coast community at high tide; oyster harvests increase the susceptibility of estuaries to eutrophication). Changes in frequency or long-term trends in the magnitude of the phenomena of interest (frequency of tropical cyclones, interannual declines in fish catch, seasonal oxygen depletion, episodic harmful algal blooms, etc.) reflect both the dynamics of coastal ecosystems and the nature of the external forces that impinge on them directly or indirectly via the propagation of variability across global, regional, and local scales. Thus, implementation of the coastal module must take into account the effects of both natural processes and human uses.

However, current efforts to manage human uses and mitigate their impacts, and those of natural hazards, typically focus on specific human activities (e.g. fishing mortality, sewage pollution, physical alteration of habitats), specific habitats and places (mangrove forests, marshes, coral reefs, sea grass beds, estuaries, flood plains, etc.) or individual species (fisheries management, identification of endangered species). In most circumstances, due consideration is not given to the propagation of variability and change across multiple scales in time, space (Arcos et al., 2001; Beaugrand et al., 2002; Platt et al., 2003) or ecological complexity (Botsford et al., 1997; Gardner et al., 2001).

As environmental research reveals the ecological dynamics governing the distribution and abundance of organisms and their interactions with each other and their environment, ecosystem-based management is emerging as a unifying approach to safe and efficient marine operations, natural hazard mitigation, environmental protection, resource

BOX 1.2. THE ANNAPOLIS PROTOCOL: AN ECOSYSTEM-BASED APPROACH TO PUBLIC HEALTH

Tourism is the most important source of revenue for many coastal states. When access to bathing beaches is denied due to elevated concentrations of pathogenic microorganisms, significant declines in the value of tourism to national economies often result. The development of an integrated and sustained observing system that provides the data and information for rapid detection of pathogens and timely forecasts of exposure risk (by combining current fields with indicators of risk) would be of great societal benefit. The issue of assessing and forecasting risk has recently been addressed by the "Annapolis Protocol."[a] The protocol highlights the limitations of using a single indicator organism and the need for a more comprehensive and integrated effort. Two microbial indicators of faecal contamination were selected for this sampling study protocol: faecal streptococci/enterococci and sulphite-reducing Clostridium/Clostridium perfringens. Guidelines are provided for the establishment of a beach classification scheme that uses a suite of factors (e.g., proximity to likely sources of contamination, levels of wastewater treatment, riverine inputs, seasonal variations in human population density, and patterns of coastal circulation) to assess potential health risks and recommend best management practices for risk mitigation.

Several governments have used the Annapolis Protocol to establish a more comparable, consistent and integrated approach to bathing beach quality. [b] Most recently, the initial intergovernmental process was revisited and a revised and expanded set of guidelines were released by the World Health Organization.[c] Implementation of the Coastal Module of GOOS with the development of measurements and products will allow nations to achieve the objectives of the Annapolis Protocol and expand the concept to measurement of many other parameters.

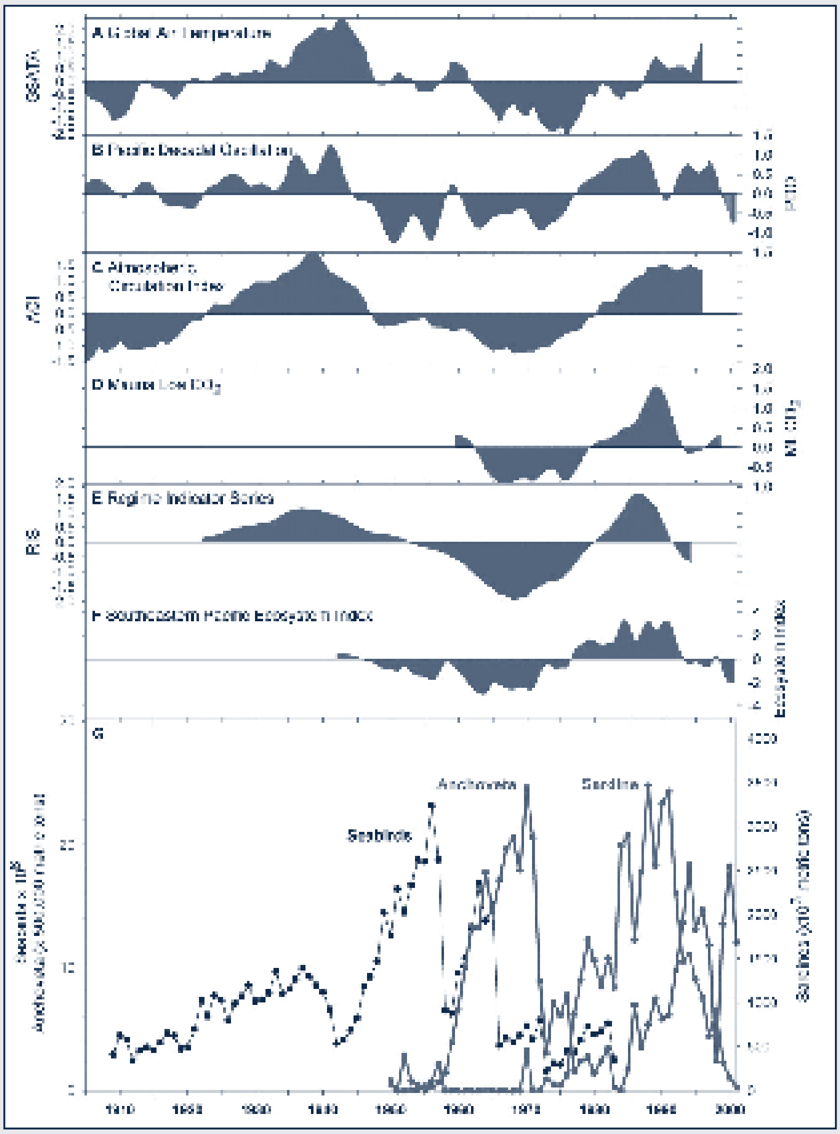
a WHO/SDE/WSH/99.1 – Health-Based Monitoring of Recreational Waters: The Feasibility of New Approach (the Annapolis Protocol).

b U.S.E.P.A., National Beach Guidance and Required Performance Criteria for Grants, June 2002, EPA-823-B-02-004 (http://www.epa.gov/waterscience/beaches/grants/guidance/all.pdf); New Zealand, Ministry of the Environment, Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas June 2003, Ref. ME474. http://www.mfe.govt.nz/publications/water/microbiological-quality-jun03/index.html

c Guidelines for Safe Recreational Water Environments – Vol. 1: Coastal and Fresh Waters. WHO, 2003, ISBN 92 4 1545801. http://whqlibdoc.who.int/publications/2003/9241545801_contents.pdf management, land-use planning and environmental engineering (NRC, 1999; Sherman and Duda, 1999; UNEP, 2001; Cicin-Sain and Knecht, 1998; Brander et al., 2003; Turrell, 2004). This is especially significant in coastal systems where the combined effects of habitat alterations, land-based sources of pollution, over fishing, harmful algal blooms, and invasive species are most severe (Botsford et al., 1997). Ecosystem-based strategies consider the effects of human activities in the context of natural variability and change, e.g. changes in hydrographic regimes and fish landings (Francis et al., 1998; Peterson and Schwing, 2003; Reid et al., 2003a).

BOX 1.3. TIME SERIES OF SARDINES/ ANCHOVIES-CLIMATE IN PACIFIC

The coherence in catches of sardines throughout the Pacific and alteration in the dominance of anchovies and sardines in long-term catch records have been related to decadal scale cycles in air and water temperatures, atmospheric circulation, atmospheric carbon dioxide levels, and ecosystem indicators (Chavez et al. 2003). Alternating periods of sardine- and anchovy-dominance are associated with alternating periods of warm and cold water caused by the Pacific Decadal Oscillation (PDO). These relationships illustrate that ecosystem-based, adaptive management of these fisheries must account for low frequency changes in hydrographic regimes that, in this case, appear to be related to the PDO.



Anomalies of (A) global air temperature, with the long-term increase removed; (B) the Pacific decadal oscillation (PDO) index (°C), derived from principal component analysis of North Pacific SST; (C) the atmospheric circulation index (ACI), which describes the relative dominance of zonal or meridional atmospheric transport in the Atlantic-Eurasian region; (D) atmospheric CO2 measured at Mauna Loa (parts per million) with the long-term anthropogenic increase removed; (E) the regime indicator series (RIS) that integrates global sardine and anchovy fluctuations; and (F) a southeastern tropical Pacific ecosystem index based on (G) seabird abundance and anchoveta and sardine landings from Peru. All series have been smoothed with a 3-year running mean.

Implementing a strategy of ecosystem-based management requires the capability to engage in adaptive management, a decision making process that depends on routine and rapid detection of changes in the state of coastal ecosystems and on timely predictions (with estimates of uncertainty) that such changes will occur, both of which depend on the sustained and routine provision of data and information on oceans and coasts. Recent attempts to quantify the state of coastal marine and estuarine ecosystems on regional to global scales demonstrate the inadequacy of current monitoring and data management activities (Malone et al., 2004).

1.3.2 Indicators of the State of Marine Systems

Societal needs can only be met efficiently, and continued investment in coastal ocean observing systems justified, if the efficacy of environmental management decisions based on data and information from ocean observations can be measured. For some applications, such as ship routing and search and rescue, benefits are relatively easy to determine. However, where coastal observing systems are intended to support management of many activities in intensively used regions or in a fragile ecosystem, more complex methods for monitoring success or failure are required. In these cases, there is an immediate need for regional and global scale marine indicators that can be used as cost-effective tools for ecosystem-based management, understanding the impacts of human activities, managing for sustainable human uses, promoting collaboration among nations and disciplines, and establishing standards and protocols for data collection and quality assurance (Corcoran, 2003; Malone et al., 2004).

Marine indicators must be credible and command the attention of decision makers. Like economic indicators, indicators of the state of marine systems are needed because it is not possible to measure everything, everywhere, all of the time. Providing the data needed to monitor indicators over time can help to determine whether problems are developing, whether action is necessary, and what action is likely to be most effective. Changes in indicators over time can also be used to evaluate the efficacy of past decisions and actions. Some indicators of the state of the physical environment (e.g. global mean temperature of the atmosphere, heat content of the oceans, atmospheric carbon dioxide) are in use today. A manageable set of indicators of comparable power for public health risks, the condition of marine ecosystems, and the sustainability of living marine resources is clearly needed.

The development of a consistent set of internationally accepted indicators that describe the state of ecosystems and natural resources on national, regional and global scales has been elusive, in part because of the lack of accepted criteria for evaluating indicators and in part because the data required to quantify them repeatedly and routinely over time are lacking or difficult to access. Implementation of the coastal module of GOOS will address the latter once data requirements have been specified and implementation has begun. To provide a common framework for indicator development, a checklist of criteria for evaluating indicators has been prepared (NRC, 2000):

- Does the indicator provide information on the state or condition of important ecosystems, habitat or living resources on appropriate scales in time and space?
- Is the indicator based on generally accepted models of the structure and function of the system to which it is applied?
- Is the indicator reliable and what is the evidence for this? Does the indicator serve its intended purpose in terms of accuracy, sensitivity, precision and robustness (the indicators ability to provide useful assessments in the context of environmental "noise")?
- Have the data requirements for calculating the indicator repeatedly at appropriate rates, with known accuracy and precision, and on appropriate time-space scales been determined?
- Are the required, quality controlled data available in real time or delayed mode as specified by the users?
- What technical and conceptual skills must the data providers possess for users to have confidence in the indicator?
- Is the indicator comparable or compatible with indicators in use elsewhere, and is it consistent with internationally accepted standards?
- Is the indicator cost effective in terms of the cost of providing the required data and its effectiveness to decision makers?

Improved models of ecosystem dynamics and the ability to more rapidly detect changes in those variables required to parameterize and initialize these models are needed to establish a set of indicators that meet these criteria. Emergence of the science of ecological forecasting (Clark et al., 2001; Hofmann and Friedrichs, 2002) and rapid advances in sensor technologies, capacity for real-time data telemetry, and computing power are making it possible to achieve this goal. Development of the coastal module of

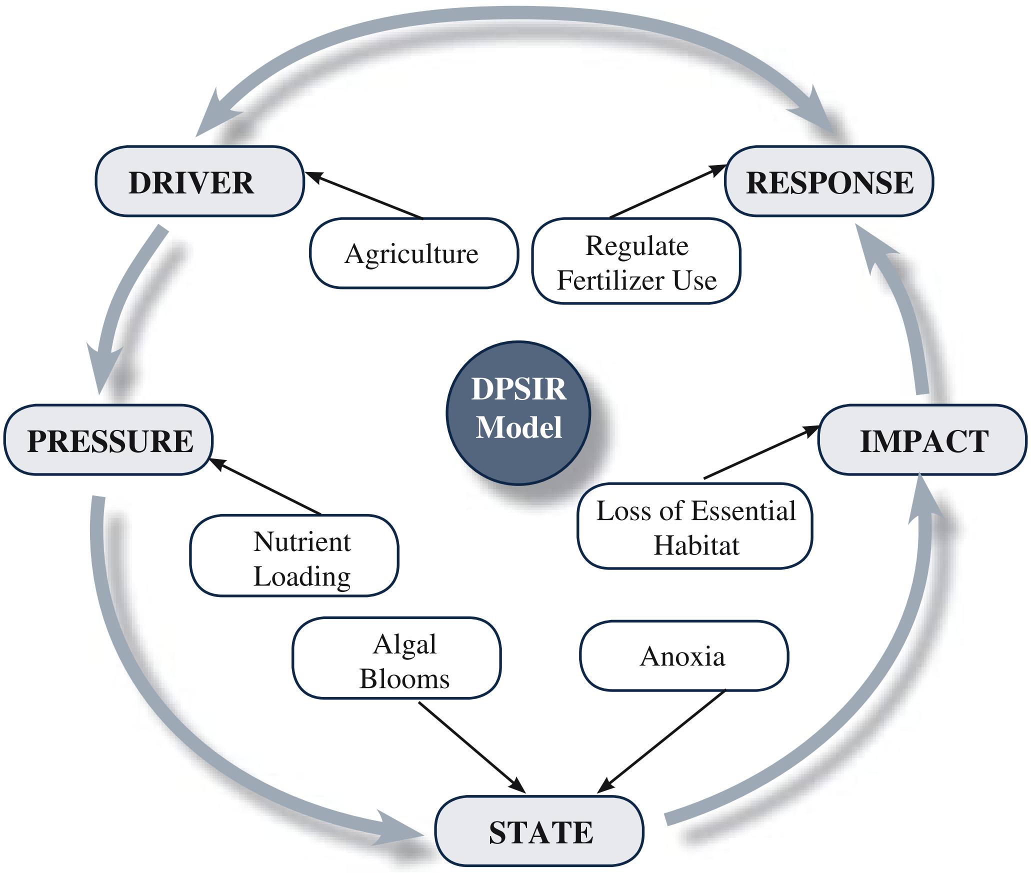


Figure 1.3. Example schematic of the Driver-Pressure-State-Impact-Response (DPSIR) model. Drivers describe large-scale patterns of human activity, e.g. agricultural practices and the use of fertilizers in a drainage basin. The resulting pressure is in the form of increases in nitrogen and phosphorus loading which change the state of coastal marine ecosystems by causing algal blooms and depletion of oxygen (anoxia) in bottom water. Algal blooms result in the loss of sea grass beds and benthic habitats reducing the carrying capacity of the marine ecosystem for living resources and associated declines in fish landings or consumer demand (impact). Government institutions respond by regulating the use of fertilizers by agriculture (driver) to control nutrient loadings (pressure), etc. In this example, all of the arrows are one way. However, feedbacks (2-way arrows) often occur among compartments. For example, the driver (agriculture community) may fight the passage of laws to regulate fertilizer use (response) resulting in a different outcome. Grey compartments indicate human activities that have social and economic consequences. White compartments indicate environmental conditions.

GOOS as part of the Integrated Global Observing Strategy and the Global Earth Observing System of Systems[14] will provide the framework for linking these advances to provide data at rates and in forms required for routine and regular reports on state and state changes in marine systems and for ecosystem-based, adaptive management.

1.3.3 A Unifying Approach Across the Land-Sea Interface

There is a clear need for a more holistic view of system dynamics that links ecological and socio-economic across the land-sea interface. As discussed in the Strategic Design Plan (IOC, 2003; p. 86-87 and Annex X)[15] and illustrated in Figure 1.3, the Driver-Pressure-State-Impact-Response (DPSIR) model (Bowen and Riley, 2003; IUCN, 2000) provides a framework for achieving this by relating large-scale human **drivers** of change (e.g. increases in population density and land use patterns in coastal drainage basins) to **pressures** (e.g. extraction of living resources, nutrient loading and contaminant loading of coastal marine ecosystems), changes in **state** (harmful algal dynamics, eutrophication) of coastal ecosystems, their consequences or **impacts** (e.g. loss of commercial fishing value, public health costs, costs of coastal flooding), and management **responses** to them (e.g. fishery management, management of land-use activities, sewage treatment). Simultaneous, integrated and sustained observations of both socio-economic and environmental variables are needed to effec-

14 http://www.epa.gov/geoss/
15 http://ioc.unesco.org/goos/docs/GOOS_125_COOP_Plan.pdf

tively link each of these phases. A user-driven procedure has been developed to help identify key socio-economic indices of human activities required to make this linkage (Annex II). The procedure is a modification of that used to identify the "common" variables for the GCN15 and can be used as a guide for GRAs to determine priorities for observations and data analysis.

As emphasized in the IGOS Coastal Theme Report (http://www.igospartners.org), the DPSIR approach provides a useful model for guiding the coordinated development of the coastal modules of GOOS and GTOS (FAO, 2005). Both systems clearly have common needs for socio-economic and environmental information and their respective Panels should collaborate in the development of the DPSIR model as a means to establish priorities for implementation of observing systems that transcend the land-sea interface.

BOX 1.4. PUBLIC HEALTH AND ECONOMIC IMPACTS OF WASTEWATER POLLUTION FROM LAND-BASED SOURCES

The annual global cost of infectious diseases caused by sewage disposal into coastal marine and estuarine ecosystems is estimated to be $12 B U.S.

A recent study of human infectious diseases associated with bathing in sewage polluted coastal waters and eating raw (or lightly steamed) shellfish harvested from such waters showed a strong correlation between exposure and the incidence of gastrointestinal and respiratory diseases (Shuval, 2003). It is estimated that there are about 4 million cases of infectious hepatitis A and E (HAV/HEV) resulting in about 40,000 deaths and 40,000 cases of long term disability due primarily to chronic liver damage from shellfish consumption. Until recently, these have been viewed as being local problems. However, human wastes from some 3 billion people (about 50% of the world's coastal population) are discharged into coastal waters globally. This is clearly a problem that requires coastal observations on a global scale.

1.4. Linking Observations to Applications: A Hierarchy of Systems

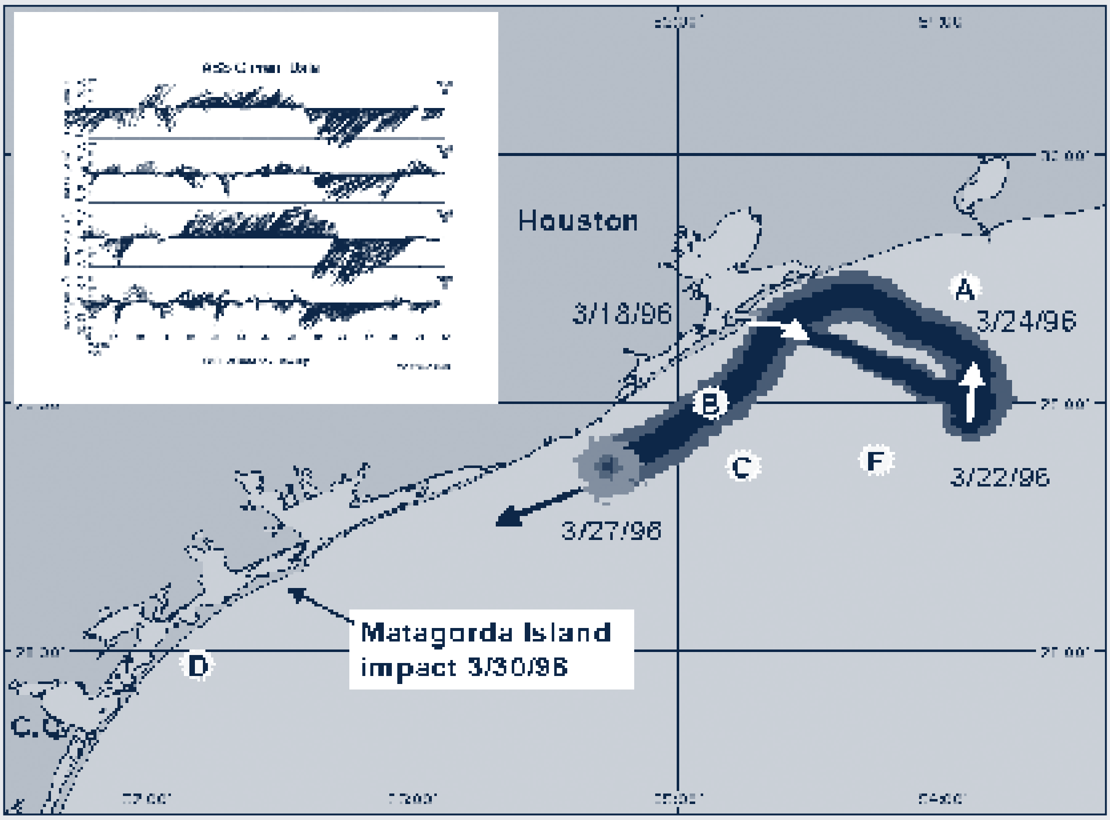
Successful prevention, control and mitigation of the effects of human activities, natural hazards and climate change depend on the capacity to anticipate changes with sufficient lead-time to make informed decisions with desired outcomes (Clark et al., 2001). Informed decisions, whether they are concerned with ship routing, beach closures, fisheries management, pipe-laying, mitigating the effects of an oil spill or global change, require the provision of useful marine data and information at rates tuned to the time scales at which decisions must or should be made. To these ends, the coastal module of GOOS must develop to meet the following criteria:

- measurements, data streams, and analyses required by user groups are sustained, routine, guaranteed, continuous (or repetitive as needed), and of known quality;
- measurements and data analyses (e.g. modelling) are efficiently linked via integrated data management and communications;
- observations capture a broad spectrum of variability in time, space and ecological complexity (Figure 1.1);
- observations are multi-disciplinary and the resulting data streams and products support a broad diversity of applications (Figure 1.2); and
- the system provides data and information required to relate changes in environmental systems to changes in socio-economic systems.

The establishment and maintenance of such a user-driven, sustained, integrated and end-to-end system is the purpose of the coastal module of the Global Ocean Observing System (GOOS). As discussed in Chapters 2 and 3, the coastal module consists of regional coastal ocean observing systems (RCOOSs) and a Global Coastal Network (GCN) (Figure 1.4). Driven by national and regional priorities, RCOOSs are currently developing globally. The GCN measures and processes common variables through both remote sensing and in situ observations at a sparse network of reference and sentinel stations. The GCN will be established by networking RCOOSs and incorporating existing global observing systems, such as the global sea level observing system (GLOSS). Thus, RCOOSs will both contribute to and benefit from the GCN.

BOX 1.5. EMERGENCY RESPONSE TO OIL SPILLS

Accurate predictions of surface currents are required to mitigate the effects of oil spills cost-effectively. Forecasts of oil spill trajectories can be made more accurate and timely through real-time observations and model predictions of surface currents. To this end, the Texas General Land Office (TGLO) in the United States established a network of moored current meters (the Texas Automated Buoy System or TABS) in the Gulf of Mexico in 1994. Surface current vectors are reported in real-time to validate numerical model nowcasts and forecasts of surface current fields over the Louisiana-Texas shelf. The importance of this observing-modelling system was demonstrated in March of 1996 when 5,000 barrels of intermediate fuel oil was spilled at the entrance of Galveston Bay. Working together, the U.S. National Oceanic and Atmospheric Administration (NOAA) HAZMAT modelling team and the TGLO's trajectory modelling team used TABS data and computer simulations to forecast the movement of the oil patch with unprecedented accuracy. For the first time, models were initialized with real-time data rather than educated guesses based on climatologies. The current field was known within minutes of the spill which was tracked continuously for 24 days.



Initially, currents were to the northeast currents (an unusual condition by historical standards) suggesting that Sabine Pass on the Louisiana-Texas border was at risk (A) and an alert was issued setting in motion an emergency response. Using TABS data and model predictions, flow was predicted to shift to the southwest hours prior to the actual reversal (B). TABS real-time data gave decision makers the confidence needed to discontinue the alert and allowed the emergency response team to refocus the emergency response on the Matagorda Island region where the spill was now projected to make land-fall. Without TABS data and improved model predictions (more accurate and timely), preparations for protecting Sabine Pass would have continued, resulting in wasted time, effort, and resources ($225,000) in an area that was no longer threatened. Since then, TABS has been called on to provide information for command decisions in more than two dozen spills along the Texas coast (URL: http://www.csc.noaa.gov/coos/texas_gulf.html#tabs).

1.4.1 Regional Coastal Ocean Observing Systems

The phenomena of interest encompassed by the six societal goals are diverse and exhibit a broad range of characteristic time-space scales of variability and change (Figure 1.1). The challenges of developing observing systems that provide required data at appropriate rates are made more difficult by the reality that the coastal zone is complex and differs substantially from place to place on a global scale in terms of both environmental characteristics and human uses. Thus, development of the coastal module must take into account the following:

- Globally, the mix of habitats, ecosystems and resources that constitute coastal environments differ regionally;
- The relative important of the phenomena of interest and how they are expressed differ regionally;
- Political, social and economic priorities for detecting and predicting phenomena of interest differ among nations and regions; and
- Most international agreements and conventions that target one or more of the six societal goals are implemented regionally.

Clearly, observing system requirements, from applications to measurements, will differ from region to region, and decisions on which variables to measure, the time and space scales of measurements, and which models to use are best made by nations and stakeholders in the regions affected. In this context, it is clear that **national and regional bodies provide the most effective venue for identifying user groups and for establishing a user-driven observing system that effectively link observations to products and services** (IOC, 2003). GOOS Regional Alliances (GRAs[16]) and National GOOS Programmes are forming to meet these needs (Chapter 3), and a GOOS Regional Policy (Annex III) is in place to guide their development. Issues of implementation, including the need for global coordination, are addressed in Chapters 2 and 3.

1.4.2 The Global Coastal Network (GCN)

In addition to regional specificity, design and implementation of coastal GOOS must also take into account the following:

- The six societal goals have common requirements for data (Table 1.1), data management and analysis; and
- The phenomena of interest are occurring in coastal

Geophysical	Sea level and Bathymetry
	Shoreline position
	Temperature and Salinity
	Currents and Surface Waves
	Sediment grain size
Chemical	Sediment organic content
	Dissolved inorganic nitrogen, phosphorus, and silicon
	Dissolved oxygen
Biological	Benthic biomass
	Phytoplankton biomass
	Fecal indicators
Biophysical	Attenuation of solar radiation

Table 1.2. The provisional common variables recommended by the Coastal Ocean Observations Panel to be measured as part of the Global Coastal Network (IOC, 2003; p. 55-58 and Annex IV). These variables are the minimum number that must be measured to provide data needed to detect or predict changes of interest to a maximum numbers of user groups. In most cases, additional variables will need to be measured and analyzed to detect and predict all of the phenomena of interest. This provisional list of common variables is a first step in the process of determining what variables to measure globally as part of the coastal module of GOOS. The list will change as the global network of GRAs is established and the coastal module evolves.

16 For the purposes of this document, GRAs include both multi-national alliances and national GOOS programmes

waters worldwide and are often local expressions of larger scale forcings.

Thus, a global approach to the development of the coastal module is needed to measure and manage common variables (Table 1.2) and to capture variability and change across global to local scales.

The observing and data management subsystems of the GCN measures and processes variables that are required by most regional systems. These are the common variables. Depending on national and regional priorities, GRAs may increase the resolution at which the common variables are measured, supplement common variables with the measurement of additional variables and provide data and information products that are tailored to the requirements of stakeholders in the respective regions. For the data analysis and modelling subsystem, the GCN is critical for comparative analyses of changes occurring within regions on global scales, for global assessments of changes in the state of coastal marine systems, and for serving global products including global maps of warming and sea level rise on national to regional scales. A major benefit of the GCN, especially for the detection of global change, is the measurement of key variables with comparable techniques that are calibrated using accepted protocols, standards and reference materials (Annex IV). In these ways, GRAs both contribute to and benefit from the GCN.

The coastal module will develop into a global network that links global, regional and local scales of variability through a hierarchy of observations, data management and models (Figure 1.4). The network provides economies of scale, minimizes redundancy, and allows regional observing systems to be more cost effective. Such a linked hierarchy can best be established through the formation of a globally organized and coordinated network of national and regional observing systems. The GCN will develop to achieve the following objectives:

- Measure, manage and analyze the common variables that benefit most if not all National GOOS Programmes and GRAs (Table 1.1);
- Establish common standards and protocols for measuring common variables and for managing, transporting and analyzing the resulting data streams (Chapters 3, 4 and 5);
- Enable efficient communications of data and information among regions and nations (Chapter 4);
- Establish sentinel and reference stations in coastal waters (Chapter 3);
- Facilitate capacity building, research and technology transfer among regions (Chapter 6); and
- Enable comparative ecosystem analyses required to develop and implement ecosystem-based management of resources and the environment (section 1.2.1)

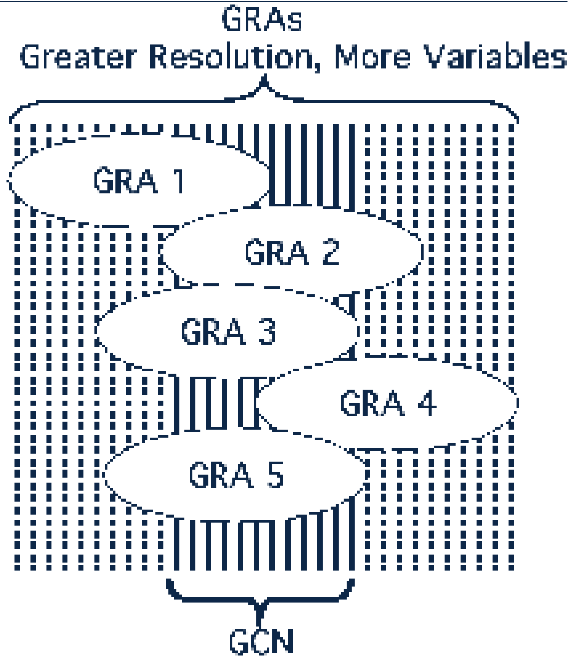


Figure 1.4. The coastal module of GOOS consists of regional coastal ocean observing systems (RCOOSs) and a Global Coastal Network (GCN). GOOS Regional Alliances and National GOOS Programmes (GRAs) build the Global Coastal Network (GCN, solid lines – data streams for the common variables managed as part of the GCN) and enhance the network based on regional and national priorities (dotted lines – additional variables, data management and modelling capabilities). Note that all of the common variables may not be measured by all GOOS Regional Alliances.

Finally, the development of the coastal module of GOOS must be coordinated with the ocean-climate module of GOOS and the coastal module of GTOS (IOC, 2003, p. 29-30, 113 and Annex VI). Additional variables must be monitored to quantify external forcings of coastal ecosystems. These include large-scale ocean processes and inputs from atmospheric and land-based sources to be measured as part of the overall Integrated Global Observing Strategy (Table 1.3). Of these, the most important drivers of change in coastal waters are vector winds, precipitation, air temperature, solar radiation, and land-

Meteorological (WWW)	Atmosphere-Ocean (GOOS, GCOS)	Land-Based Inputs (GTOS)
Air temperature		
Vector winds	pCO_2	Fresh water
Humidity		Nutrients
Wet and dry precipitation		Sediments
Incident solar radiation		Chemical contaminants & pathogens

Table 1.3. Variables needed from other observing systems that comprise the Integrated Global Observing Strategy (WWW – World Weather Watch, GCOS – Global Climate Observing System, GOOS – Global Ocean Observing System, GTOS – Global Terrestrial Observing System).

based inputs. In all cases, increases in the temporal and spatial resolution of these measurements are needed.

1.5 Phased Implementation

The coastal module will evolve into a fully integrated global system over time on five fronts, some or all may be active simultaneously:

- Establishing regional systems, networking them, and integrating existing global assets (remote sensing, GLOSS, GCRMN, etc.) through the development of integrated data management and communications (Chapters 3 and 4);
- Enhancing the initial system by increasing the time-space resolution of observations, increasing the number and diversity of data sets that can be accessed and analyzed rapidly, and increasing the skill of model assessments and predictions (Chapters 3 and 5);
- By establishing RCOOSs globally and implementing pilot projects (Chapters 3, 6 and 7), engage user groups from government ministries, industry, non-governmental organizations and universities in developing a coastal system that provides data at rates and in forms specified by them;
- Build capacity, especially in tropical regions and the Southern Hemisphere (Chapter 6); and
- Build capacity through research and development that leads to improvements in operational capabilities required to achieve all six societal goals.

Each of these will develop at different but related rates depending on the priorities, resources and interests of nations and GRAs (e.g. more rapidly in European coastal waters than in the coastal waters of Africa or South America). On a global scale, progress will depend on how rapidly GOOS Regional Alliances are established worldwide and on the availability of funds for capacity building (Chapters 3, 6 and 8).

For all regions, those aspects of the observing system that provide data and information for improved climate and weather predictions, safer and more efficient marine operations, and improved predictions of coastal hazards are likely to develop more rapidly than those required for reducing public health risks and for sustaining and restoring healthy marine ecosystems and living marine resources (Figure 1.5). This figure shows that the observations, data management and models required for safe and efficient marine services are operational now and are currently provided in many regions by government agencies and commercial, value-added companies. Research may improve these services, but they are currently operational. Unfortunately, as demonstrated by the recent (December, 2004) catastrophic tsunami in the Indian Ocean, such operational capabilities have not been established in all regions globally. This underscores the importance of building capacity in the developing world. At the same time, the current lack of capacity for detecting and predicting those phenomena that are critical to restoring and sustaining healthy marine ecosystems and living resources underscores the importance of research and of linking research to the development of operational capabilities more efficiently (IOC, 2003; p. 53; Nowlin and Malone, 2003).

BOX 1.6. DEVELOPING OPERATIONAL CAPABILITIES THROUGH RESEARCH

GOOS evolves in response to user requirements for data and data-products and services. The evolution of the system depends on implementation of known technologies, and on research and pilot projects to develop new operational capabilities, especially for those goals related to public health, ecosystem health and sustainable resources. Transition from research and development to pre-operational status is a major step and the joint responsibility of both research and operational communities. Requirements for incorporating candidate elements into each stage are as follows:

Research Projects (experiments) relevant to the development of the GOOS are needed to:

- Develop indicators for pollution risks, fisheries management, ecosystem condition, risks of harmful algal blooms, etc.
- Provide improved and/or new techniques for more rapid or accurate sensing of one or more of the core variables, more efficient data management and communications, more accurate hindcasts (e.g. climatology), nowcasts (e.g. more accurate estimates of sea surface temperature, salinity, or chlorophyll fields), or forecasts of the phenomena of interest (modelling);
- Establish the most efficient mix of remote and in situ sensing networks needed to estimate core variable fields and features; and/or
- Consistently provide data of known quality using established data management protocols and standards to achieve GOOS goals.

Pilot Projects repeatedly test (over a range of conditions) technologies, sampling strategies, models, and software that show promise as potential elements of the operational system. Such projects may target specific elements of GOOS (e.g. sensors, models) or the development of end-to-end observing capabilities (e.g. the Global Ocean Data Assimilation Experiment, GODAE). This process illuminates weaknesses, provides opportunities to address those weaknesses, permits a more effective understanding of how capabilities may be applied, and gains community acceptance of new techniques (from measurements to models).

- Proposed pilot projects must specify (1) contributions to the development of GOOS and the benefits to potential user groups; (2) objectives and milestones that can be achieved within a specified, finite period (e.g. less than 5 years); and (3) a management plan with performance metrics that advance the GOOS mission.

Pre-Operational Projects are designed to demonstrate that incorporation of new techniques from pilot projects into the operational system are likely to lead to more cost-effective operations or improved capabilities (value added products) and will not compromise the integrity and continuity of existing data streams and product delivery of the operational system. Successful pilot projects or elements thereof may be considered for pre-operational status when they meet the following requirements:

- Demonstrate that incorporation will improve existing products or produce new products in response to user priorities;
- Provide a cost-effective means of delivering value added products without compromising the integrity and continuity of existing data streams and product delivery mechanisms; and
- Provide the supporting infrastructure needed to operate and maintain the capability.

The Operational System routinely, reliably and repeatedly provides data and data products in forms and at rates specified by user groups. In the early stages this is may be achieved by integrating existing observational systems from different agencies or countries and improving the data delivery system to synthesize better products. This stage is improved through the incorporation of elements that are successful in a pre-operational mode. Decisions to incorporate a new or additional capability into the operational system must be approved by the body (e.g. government ministry, international organization, or GRA) that is to be responsible for operating and maintaining that capability. Successful pre-operational projects may be considered for operational GOOS status upon meeting all of the following requirements:

(Continued on next page)

- Compliance with GOOS design principles;
- Provide (1) data and information required by the global module of GOOS, by the GCN or by one or more GRAs; or (2) new or better products that enable one or more of the six goals to be achieved more effectively or more efficiently;
- Data are quality controlled and managed in compliance with established standards and protocols;
- Data and products are delivered on schedule according to predetermined deadlines;
- There are dedicated staff responsible for acquisition and quality control of data and dissemination of products;
- Methods are economical and efficient;
- Expected benefits are realized on a predetermined time schedule; and
- The responsible institution or organization has a clearly identified strategy for sustained funding.

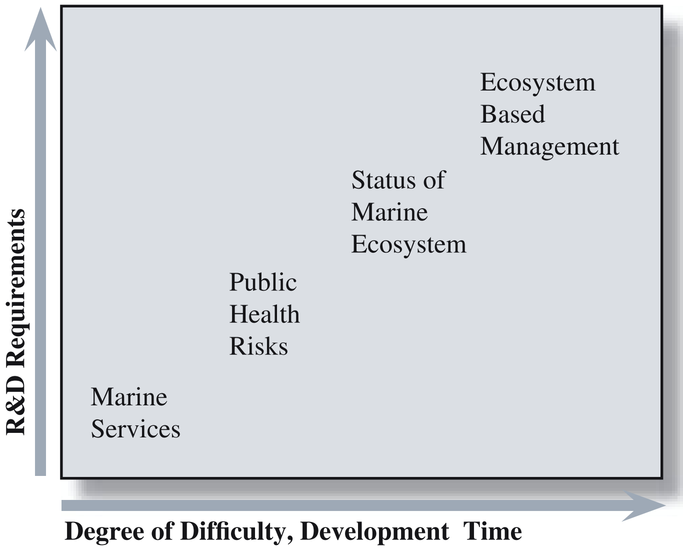


Figure 1.5. Time-dependent development of a fully integrated observing system. Predictions of most of the phenomena of interest require the same physical and meteorological data acquired for marine services and forecasting natural hazards. Those elements of an operational observing system required for improved marine services and forecasts of natural hazards are most developed (including the required operational models) while those required for ecosystem-based management of living resources are least developed. Capabilities to assess public health risks and the status of marine ecosystems are somewhere in between. Given current capabilities and the importance of physical processes to the phenomena of interest relevant to the goals of ecosystem health and living marine resources, initial development of the global system will target the measurement and processing of physical variables and those biological and chemical variables that can be measured routinely and for which products can be clearly defined. To the extent that they are operational, non-physical variables should be incorporated into the observing system now (e.g. chlorophyll fluorescence, dissolved oxygen). As technologies and procedures for rapid measurement and analysis of additional biological (e.g. phytoplankton species, zooplankton abundance, fish abundance, concentrations of pathogens, biomarkers) and chemical properties (e.g. nutrients, pesticides, PAHs) are developed, they will be incorporated into the system to achieve regional priorities and meet the needs of user groups.

2. Sustained Observing Systems for the Coastal Ocean

2.1 System Architecture

A major objective of GOOS is to reduce the time required to acquire, process and analyze data of known quality, and to tune the delivery rates of these data and information to the time scales required for environmental decision making. Thus, such systems are being developed for both real-time and delayed mode data dissemination and access, and they will allow users to rapidly exploit multiple data sets from many diverse sources. To these ends, three subsystems (functions) must be efficiently linked to ensure reliable and routine delivery of data and information to users (Figure 2.1):

- Measurements (sensing), sampling and data transmission (monitoring);
- Data management and dissemination; and
- Data analysis and modelling (including data assimilation).

The measurement subsystem (Chapter 3) samples the ocean both remotely and in situ and consists of the mix platforms, sensors, sampling devices and measurement techniques needed to measure variables on required time and space scales. The data management subsystem (Chapter 4) is the "life blood" of the observing system that links observations to the data analysis and modelling subsystem (Chapter 5) and ultimately to products and services (Chapters 6 and 7). Together, data management and modelling are the system integrators.

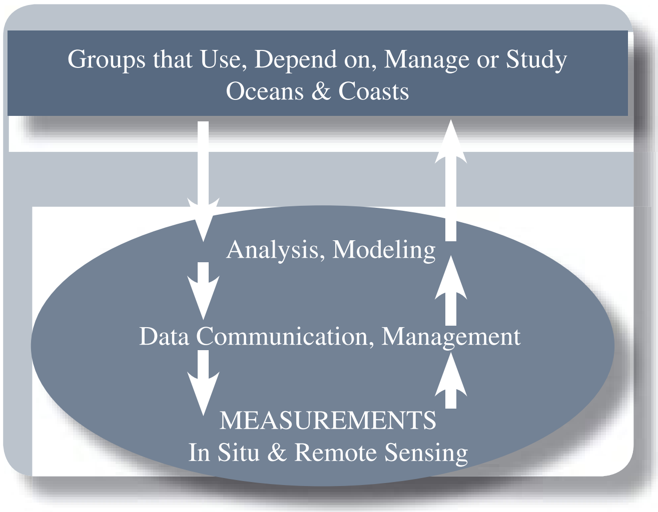


Figure 2.1. The observing system efficiently links three subsystems for measurements, data management and analysis to provide products and services to user groups. The term "subsystem" is used here to describe functions, not actual organizational entities. Their development is to be driven by user requirements for products and services, technical capabilities, and sustainable investments in infrastructure (capitalization) and operations (including the required technical expertise). Depending on capabilities and needs, user groups may access data from any one or all of the subsystems directly. The arrow from users to the observing system carries two kinds of information: (1) requirements for data and information and (2) performance evaluation ("user satisfaction").

2.2 Governance Goals

The Coastal Module of GOOS is designed to be a locally relevant, globally coordinated system. The GCN will develop by (i) integrating existing global programmes, (ii) networking regional and national environmental programmes, (iii) developing national and regional coastal ocean observing systems, and (iv) establishing new global programs (e.g. satellite-based remote sensing, GLOSS). Managing the development of the coastal module must be guided by three realities:

- The coastal module of GOOS is being built by nations, GRAs, and international bodies supported by nations;

- Global development of the coastal module requires coordination among nations, GRAs, and international bodies to establish common standards and protocols for measurements, data telemetry, data management and modelling; and

- Many coastal states do not have the resources to contribute to or benefit from the development of coastal ocean observing systems.

A mechanism is needed to enable GRAs as a group to (i) manage the development of a GCN that benefits national and regional observing systems and (ii) play a strong role in adopting common standards and protocols, transferring technology and knowledge, and setting of priorities for capacity building. Such a mechanism must function to achieve the following goals:

- Promote and facilitate the coordinated development of regional coastal ocean observing systems for both interoperability among regional observing systems and the development of a GCN that provides data and information needed by most GRAs as well as for global analyses of change;

- Provide the means for groups that use, depend on, manage or study marine systems to ensure the development of a coastal module that meets their data and information needs; and
- Interface effectively with the existing governance structure of GOOS and JCOMM (Figure 2.2) and emerging implementing bodies for GTOS (FAO, 2005).

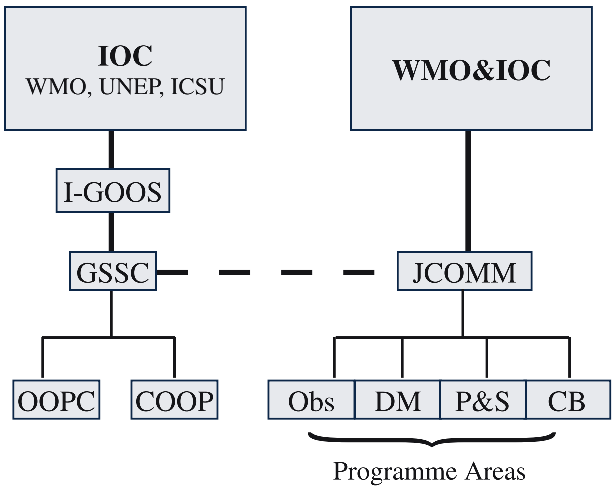


Figure 2.2. Current governance structure of GOOS. The dotted line indicates informal exchanges of information, guidance and recommendations that are not institutionalized. The functions of the I-GOOS, JCOMM, GSSC, OOPC and COOP are described on the IOC-UNESCO web site[17].

17 The intergovernmental IOC-WMO-UNEP Committee for GOOS (I-GOOS) –http://ioc.unesco.org/goos/i_goos.htm;
The GOOS Scientific Steering Committee (GSSC) – http://ioc.unesco.org/goos/GSC/gsc.htm;
The Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) – http://ioc.unesco.org/jcomm/
The Ocean Observations Panel for Climate – http://ioc.unesco.org/oopc/;
The Coastal Ocean Observations Panel – http://ioc.unesco.org/goos/coop.htm

2.3 Managing the Development of the Coastal Module

Although many entities are expected to participate (including intergovernmental organizations, governments, academia, private sectors and NGOs), national contributions to the development and management of the coastal module are critical. Thus, IOC Member States have been requested to establish National GOOS Coordinating Committees. Many coastal states (or entities within those states) are also electing to coordinate or manage some aspects of their GOOS activities through GOOS Regional Alliances (GRAs) (Figure 2.3). Thus, the 22nd IOC Assembly (June 2003) endorsed a Regional GOOS Policy (Annex III) and the creation of GRAs as a mechanism for promoting and implementing GOOS regionally as appropriate. The Regional policy includes qualifications that regional organizations must meet to become a GRA, procedures for approval of new GRAs, and expected accountability of GRAs.

2.3.1 Regional Development

As articulated in the Strategic Design Plan (IOC, 2003, p. 51-52), GRAs provide the most effective means to design and implement a coastal module that effectively involves a broad spectrum of user groups in its design and evaluation. GRAs are needed to:

(1) work with user groups that use, depend on, manage or study marine systems to establish national and regional priorities for data and data-products;
(2) guide and manage the establishment of regional ocean observing systems based on these priorities;
(3) engage user groups in the design and evaluation of regional observing systems and the GCN;
(4) promote the design and implementation of pilot

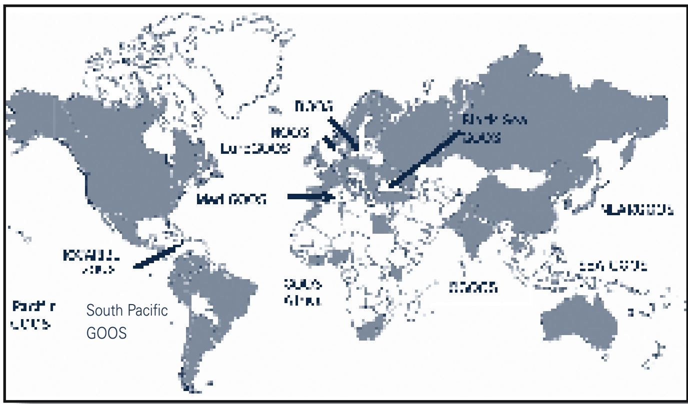


Figure 2.3. GOOS Regional Alliances (black labels) and National GOOS Programmes (red) are forming to establish the global ocean and coastal modules of GOOS worldwide. The list of contributing countries and descriptions of GRAs can be found at http://ioc.unesco.org/goos/key3.htm#reg.

GRAs (Figure 2.4) should be formed through agreement among participating countries, national organizations, international bodies, and other regional organizations with common goals. The latter includes Large Marine Ecosystem Programmes, Regional Seas Conventions, Regional Fishery Bodies, Marine Protected Areas, and coalitions of marine-oceanographic laboratories. Members should represent the community of users (government ministries, intergovernmental bodies, private sectors, non-governmental organizations, educators, scientists, etc.) in the region, including those with statutory responsibilities to protect and manage the marine environment, resources, and public health and safety.

To be recognized as a GRA, the alliance must conform to GOOS principles, policies and practices that are established and endorsed by the I-GOOS and the GSSC. Each GRA is expected to be represented at and report to meetings of the I-GOOS and to contribute to and benefit from the activities of the GOOS Regional Forum established by the Intergovernmental Committee for GOOS (I-GOOS).

Action 2.1: Each GRA and national GOOS programme should establish a Users' Forum to engage user groups in the design, operation and improvement of observing systems that meet their needs. The forum should involve groups that use, depend on, manage and study marine systems from all partnering countries in the region in the development of a regional coastal ocean observing system.

2.3.2 Global Coastal Network Development

Implementation, operation and improvement of the coastal module are critically dependent on the coordinated development of GRAs that contribute to and benefit from the establishment of a GCN. Thus, it is recommended that a mechanism be established to ensure that GRAs and national GOOS programmes as a group can perform the following functions:

- represent the interests of GRAs to the I-GOOS;
- coordinate the development of regional coastal ocean observing systems according to GOOS design principles;
- guide the development of a GCN that meets regional needs;
- enable effective communications among GRAs and with the GSSC and its science and technical panels;
- promote international collaboration for effective transfer of technologies and knowledge (including community-based modelling activities) and identify capacity building needs where necessary;
- promote the development and implementation of common standards and protocols for observations, data exchange, data management and modelling; and
- promote funding for and the establishment of sustainable GRAs and regional coastal ocean observing systems worldwide.

The GOOS Regional Forum could perform these functions.
To ensure the effective coordination among and integration across programmes, it is recommended that the

Action 2.2: Establish a mechanism (possibly through the GOOS Regional Forum) to ensure that GRAs as a group can function, with technical guidance from the GSSC and in collaboration with the JCOMM, as the international co-ordination, regulation and management mechanism for coordinated development of regional coastal ocean observing systems that are interoperable and networked to form a GCN that meets regional needs (Figure 2.3). The GRAs as a group should coordinate with JCOMM to perform functions similar to those of the JCOMM for implementing those aspects of GOOS that JCOMM has not or will not take on, e.g. GOOS elements needed to address public health, ecosystem health and living marine resource goals on both regional and global scales.

global body of GRAs establish working groups (WGs) of experts for observations (MWG), data management (DMWG), modelling and analysis (MAWG) and capacity building (CBWG). Recommended activities of these working groups are presented in Chapters 3 (MWG), 4 (DMWG), 5 (MAWG) and 6 (CBWG). In collaboration with JCOMM programme areas, these WGs would provide expertise and advice concerning the development of operational capabilities and the operational suitability of non-physical, physical and socio-economic data streams and related data management, analysis and capacity building needs for the coastal module (Figure 2.4).

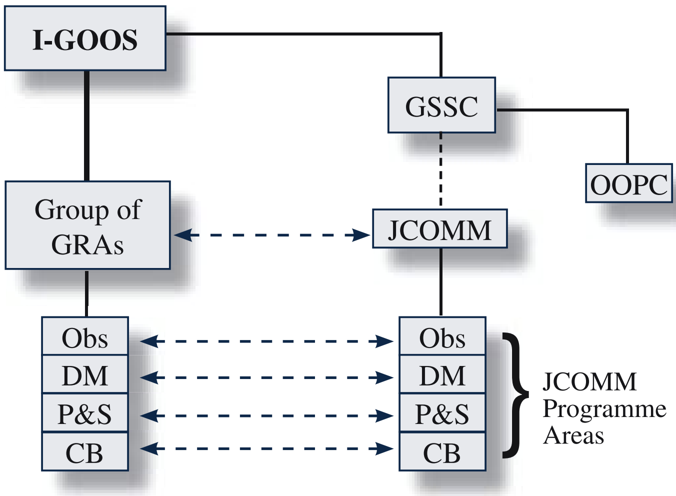


Figure 2.3. A global body that represents the interests of GRAs as a group is needed to implement the coastal module. The body could be established through the GOOS Regional Forum. The COOP would be dissolved and the GSSC will take on the responsibility for the provision of science and technical guidance for implementing the coastal module of GOOS. The Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) has established working groups in four programme areas (Observations – Obs, Data Management – DM, Products and Services – P&S, and Capacity Building – CB). It is recommended that the GRAs as a group and through the GOOS Regional Forum establish a parallel set of programme areas.

Action 2.3: Establish an ad hoc joint JCOMM-GSSC Task Team (JCOMM-Management Committee) to work in collaboration with the GRAs to establish requirements and mechanisms for GCN implementation. This is a high, immediate priority. Among those issues that should be considered is the establishment by the GRAs of four working groups of experts in the following areas: measurements (MWG), data management (DMWG), modelling and analysis (MAWG), and capacity building (CBWG). These WGs would facilitate exchanges of data, information, knowledge and technologies among regions; coordinate regional development globally; engage international research programmes (e.g. LOICZ, GLOBEC, IMBER, GEOHAB), Large Marine Ecosystem Programmes, Regional Seas Conventions, Regional Fishery Bodies, and other regional organizations as appropriate to ensure timely development of operational capabilities for the non-physical variables and their applications.

3. Implementing the Measurement Subsystem

Establishing the coastal module of GOOS requires two interdependent approaches:

- development of national and regional observing systems (collectively referred to as regional coastal ocean observing system, RCOOSs) that measure a suite of variables determined by national and regional priorities (common variables supplemented by additional variables as needed) (section 3.1); and
- development of a global coastal network (GCN) to measure, manage and analyze the common variables that will serve the collective needs of nations and regions (section 3.2).

Establishment of a working group on measurements (MWG) by the group of GRAs will provide the means to coordinate development of both tracks in collaboration with JCOMM and the GSSC).

Action 3.1: The GRAs as a group should establish a working group on measurements (MWG) to perform functions such as those recommended below.

In addition to sustained observations of environmental conditions in marine and estuarine systems, knowledge of how environmental changes interact with socio-economic systems across the land-sea interface is important for successful development of GOOS (Chapter 1, Section 1.3.3). Developing the capacity to monitor these linkages[19] is critical to meeting societal needs encompassed by the six broad goals of GOOS. To the extent that data and information requirements are unique to each region, GRAs and national GOOS programmes provide the most effective means for developing these capacities.

3.1 Regional Development

National GOOS Programmes and/or GRAs are needed to perform the following functions, all of which may be active simultaneously:

(1) Early in the development of the integrated observing system,

- implement and maintain a "Users' Forum" to engage government ministries, marine industries, commercial services, scientists, and other stakeholders in specifying and updating data and information needs and priorities, evaluate system performance, and collaborate with other national and regional organizations in the area that have mutual interests and would benefit from the development of an integrated coastal observing system[20];
- inventory and assess existing programmes and activities that measure and report these data and establish procedures for updating the inventory and associated assessments;

19 Two examples illustrate the importance of understanding and monitoring linkages between environmental and socio-economic systems: (i) relationships between human waste discharges into coastal waters, increasing health risks through water contact or seafood consumption, impacts of consequent increases in the rate of enteric diseases and association mortalities on national economies, and actions to treat human waste discharges to reduce health risks; and (ii) relationships between land-use practices, inputs of land-based nutrients to coastal waters, subsequent development of "dead zones" and declines in living marine resources due to oxygen depletion, and actions to control nutrient loading and manage fisheries using ecosystem-based management practices.

20 Large Marine Ecosystem Programmes, Regional Fishery Bodies, and Regional Seas Programmes that are active in the area are examples of regional programmes that should be involved.

Action 3.2: Each GRA and national GOOS programme should establish a Users' Forum, with representatives of all major stakeholders and partnering countries in the region, to begin the ongoing process of specifying data and information needs, including those for monitoring socio-economic indicators of environmental impacts and the efficacy of environmental policies and management.

(2) Implement and sustain procedures for
- incorporating existing observation programmes and activities into the measurement subsystem that meet specified criteria based on user group needs and priorities;
- establishing standards and protocols for measurements (and for data communications and modelling) in collaboration with the grouping of GRAs;
- identifying gaps or weaknesses in observing system capabilities by comparing user requirements for data and information with existing observing system capabilities; and
- enhancing operational capabilities to fill gaps through research and development. The capacity to engage in this process as the means to build the measurement subsystem varies enormously among nations and regions, and major investments in capacity building will be needed in most cases (Chapter 6).

The capacity to engage in this process as the means to build the measurement subsystem varies enormously among nations and regions, and major investments in capacity building will be needed in most cases (Chapter 6).

3.1.1 Users' Forum

A standing forum is needed to engage both the users and providers of data in the processes of specifying data and information requirements (variables to be measured, precision and accuracy of measurements, temporal a spatial resolution, spatial extent, rate and form of delivery), system development and operation, and performance evaluation (Chapter 8). In addition to targeting data providers (governmental and non-governmental), this should target current users of data and information on marine and estuarine systems (shipping, oil and gas sectors; search and rescue; government ministries responsible for stewardship of marine systems and resources, etc.) to ensure that the development of an integrated sys-

BOX 3.1. THE GOOS REGIONAL ALLIANCES NETWORK

The GOOS Regional Alliances Networking Development (GRAND) Programme, funded by the European Union, plans to carry out a significant inventory task. GRAND brings together all GRAs, major international bodies involved in design and implementation of GOOS (IOC, JCOMM, and I-GOOS), and a network of oceanographic institutions (Partnership for Observation of the Global Ocean, POGO, http://ocean-partners.org/). The goal of GRAND is to harmonize the diverse regional systems within GOOS, while advancing the European contribution to the global system. GRAND will facilitate the dissemination of best practice, technology transfer, development of international co-operation, establishment of observing systems in developing countries, application of results of EU projects to the broader international community active in the GRAs. A first step is to survey and evaluate the present capabilities and activities, for systematic observations of the marine environment and ecosystem in all GOOS Regional Alliances and participating countries. To make this effort more comprehensive, provision must be made to inventory programmes in nations that are not currently participating in GOOS as well as global programmes such as the Global Coral Reef Monitoring Network (GCRMN; www.gcrmn.org/), the Global Sea Grass Monitoring Network (SeaGrassNet; www.seagrassnet.org/) and the Global Sea Level Observing System (GLOSS; www.nbi.ac.uk/psmsl/programmes/gloss.info.html). There must also be an open call by GSSC for programmes to register their interest in being part of the GCN.

tem of ocean observations will benefit them. Once established, the Users' Forum should be expanded to engage groups that are most likely to benefit, but either have not had access to the data and information they need or have not realized the usefulness of rapid access to data and information on marine systems for achieving their missions and goals (e.g. insurance/re-insurance, energy, and recreational sectors). User Forums must be sustained to establish an ongoing dialogue among data providers and users for product development and to broaden the diversity of data and information served by the observing system (including review and updating the provisional suite of common variables recommended for the GCN).

In addition to engaging recognized members of a Users' Forum, GRAs should conduct market research on data needs through surveys, questionnaires, or lectures and presentations at trade fairs and exhibitions attended by large numbers of marine organizations. Catalogues of registrants and exhibitors at marine trade fairs provide valuable addresses, and similar information can be gained from trade magazines aimed at specialist groups such as shipping companies, port authorities, waste disposal companies, tourist agencies, hotel chains, etc.

3.1.2 Inventory and Assess

GRAs should work with other regional organizations in the area (Regional Fishery Bodies, Regional Seas Programmes, Large Marine Ecosystem Programmes, WWW Regions, associations of commercial operators, etc.) to establish and periodically update inventories of existing routine observational programmes that measure variables considered important to meeting regional priorities for data and information, including but not exclusive to the common variables. The inventory should supplement that being developed through the GOOS Regional Forum as part of the GOOS Regional Alliances Networking Development (GRAND) project by directly contacting government ministries, operational agencies, research institutions and other organizations that use, depend on, manage or study marine and estuarine systems. In addition, some GRAs may wish to follow the example of EuroGOOS which has compiled a comprehensive inventory of existing observing installations at the level of individual platforms and sensor packages. This system has been set up as a permanent web-accessible inventory with the title European Directory of the Instrumental Observing System (EDIOS).

The following information (metadata) should be included as part of an inventory:

- The organization(s) responsible for making the measurements, collecting the data, quality assurance, data transmission, and archival;
- Variables measured;
- Temporal and spatial extent and resolution of the measurements;
- Methods being used for measurements and their precision;
- Developmental stage (research, pilot project, pre-operational, operational);
- If operational, products and end users of the data, and
- Sponsors (funding sources and levels).

Action 3.3: Through its parent body or the Regional GOOS Forum, the MWG should issue a call for programmes and organizations interested in participating in the development of integrated coastal ocean observing systems to provide the metadata above as a first step in identifying monitoring programmes for possible incorporation into the system. This information will be needed to select programmes for incorporation into the integrated system based on societal benefits (the six goals of GOOS) and related needs of user groups for data and information. To these ends, it is recommended that GRAs adopt an approach similar to that used to select the initial suite of common variables for the GCN (IOC, 2003). A flexible toolkit for the determination of priorities of socio-economic variables, including software for the weighting algorithms, has been developed by COOP and is available as a guide for nations and regions (Annex II). This procedure recognizes that the common variables are provisional and will change and evolve as the GCN develops. Such an evolution should include the incorporation of socio-economic variables.

Action 3.4: The MWG should formulate a web-based version of the toolkit used to select variables with an accompanying guidebook for its use that can be downloaded from the web.

3.1.3 Adopt or Develop Common Standards and Protocols

Successful development of an integrated, end-to-end observing system depends on adopting and/or developing internationally accepted standards and protocols for measurements and data transmission. For each coastal GOOS variable, existing standards should be reviewed and decisions made on the appropriate frequency of measurements, spatial extent and resolution of sampling, units of measure, and precision and accuracy of measurement. The resolution of in situ measurements in time and space will change from region to region, and this must be factored into the implementation of the data management subsystem for the coastal module.

Where regional or global programmes exist that employ internationally accepted standards and protocols these should be adopted in collaboration with the relevant organizations. Important examples of such organizations are

- JCOMM for physical and meteorological variables,
- FAO for fisheries,
- the RAMSAR network for coastal wetlands,
- the Global Coral Reef Monitoring Network (GCRMN), and
- the Global Seagrass Monitoring Network (SeaGrass Net).

For those measurements that do not have internationally accepted standards and protocols, GRAs should work with relevant regional and international bodies (e.g. JCOMM, SCOR, ICES, PICES, and IGBP).

Action 3.5: The MWG should lead an effort to ensure broad and effective coordination among GRAs to harmonize the adoption, development and use of common standards and protocols for measurements, data telemetry, and quality control globally.

BOX 3.2. GLOBAL CORAL REEF MONITORING NETWORK (GCRMN)

The GCRMN is an operational programme that monitors coral reefs from East Africa and Southeast Asia to the Caribbean to document changes in their condition (http://www.gcrmn.org). The primary product is a biannual status report on the overall health of coral reefs worldwide every 2 years. The first status report was published in 1998 (Wilkinson, 1998).

The goals of the GCRMN are as follows:

- improve the conservation, management and sustainable use of coral reefs and related coastal ecosystems by providing data and information on the trends in biophysical status and social, cultural and economic values of these ecosystems; and
- provide individuals, organizations and governments with the capacity to assess the resources of coral reefs and related ecosystems and collaborate within a global network to document and disseminate data and information on their status and trends.

The collection of data and information on reef status and trends began in 1997. Regional nodes have been created within participating countries to coordinate training, monitoring, and data management in regions based on UNEP Regional Seas Programmes in the Middle East, western Indian Ocean and east Africa, south Asia, east Asia, the Pacific, and the Caribbean and tropical Americas.

There are at least two important features of the GCRMN that are relevant to coastal module beyond the degradation of coral reefs and the living resources and recreational activities they support: (1) programmatic emphasis on community awareness through the involvement of all users in the collection of data on status and trends, and (2) coral reef bleaching may be an early warning of global warming (Wilkinson et al., 1998).

The programme is sponsored by the IOC, UNEP and IUCN. Many volunteer laboratories and researchers collect data which is centralized at the Australian Institute of Marine Science (http://www.aims.gov.au).

3.1.4 Coordinated Incorporation

Programmes, or elements thereof, that are considered for incorporation in the coastal module should meet the requirements of one of the four development stages (Chapter 1), be willing to adopt common standards and protocols (Chapter 4), be backed by a commitment to fund sustained measurements, and conform to GOOS design principles (IOC, 2003). Programmes incorporated into the observing system should also provide value added benefits by being a part of an integrated system or improve products that are currently being served.

Once programmes are endorsed for incorporation by a GRA, additional efforts will be needed to coordinate observing subsystem activities and their incorporation with the development of capabilities for data communications and management (Chapter 4).

3.1.5 Gap Analysis

In areas where resources have not been available to implement sustained observing systems or where only limited efforts have been possible, comparisons of data and information needs established through the User Forum with capabilities determined from the inventory will provide the information needed to identify gaps in the observing system and establish priorities for capacity

BOX 3.3. EXAMPLES OF POTENTIAL TECHNOLOGIES FOR ENHANCING THE GCN

Two technologies are currently being developed for operational use in EuroGOOS and U.S. GOOS that have potential for being scaled up for global applications as part of the GCN: high frequency radar and light detecting and ranging (LIDAR) laser technologies.

Surface Current Maps – Surface currents are a highly ranked common variable. It is now possible to measure surface currents in coastal waters using high frequency (HF) radar techniques. This technology produces detailed maps of surface currents from the coast to nearly 200 kilometers offshore. Although the theory underlying the estimation of near-surface currents from the backscattered radar signal has been known for many years, it is only relatively recently that the hardware and software has matured to the point that current maps can be provided in an operational setting. In addition to improved surface current maps for ship routing, search and rescue, and predictions of coastal erosion and flooding, more accurate estimates of current fields are critical to achieving the goals of ecosystem-based management of human health risks, environmental protection, and fisheries management. Thus, the regular release of surface current maps and access to the data used to derive them are important for achieving the six societal goals of GOOS. Pilot projects, e.g., a coastal data assimilation experiment (CODAE), are needed to develop capacity for integrating data streams from space-based sensors (altimetry, scatterometry, AVHRR, ocean colour), in situ sensors (ADCPs), and HF radar to provide real-time maps of surface currents.

Coastal erosion, sediment transport and shoreline position – Combining aircraft- and satellite-based LIDAR technology with hyperspectral technologies promises to provide new mapping products of great use to hydrographers, coastal engineers and resource managers, scientists and decision makers. Pilot projects are needed to address integration issues, including sampling specifications, geometries, development of visualization and interpretation techniques, and physics-based aspects related to fusing physical and environmental measurements to characterize the coastal zone. Final products should include maps of land cover and benthic habits across the land-sea interface, habitat condition and change, characterization of bottom characteristics, and time-series visualizations of coastal erosion and sediment transport patterns. These data products are essential to development of robust models of vulnerability and change in coastal environments. Enhancement of data collection platforms and analysis tools, effectively combining LIDAR, photographic, and hyperspectral data, will provide new capabilities to survey sandy beaches and coastal bluffs, coastal vegetation, shallow water bathymetry and both benthic and terrestrial habitats.

building that should be addressed by capacity building programs of JCOMM and the IOC (Chapter 6). Of particular importance are inter-region comparisons among GRAs to identify programmes that are working well in one region and are relevant to other regions where they have yet to be established, e.g. basin scale tsunami warning systems (Chapter 1, Box 1.1). Where technologies and scientific understanding are sufficiently advanced and proven in one or more regions, practical efforts should be made to implement these technologies and operational procedures in other regions based on the priorities of the respective GRAs (Chapter 6).

3.1.6 Enhance Operational Capabilities

Regional observing systems will develop operational capabilities through capacity building and by incorporating existing operational programmes, introducing operational programmes from other regions, and establishing research priorities for building new operational capabilities. An important function of the group of GRAs (e.g. the GOOS Regional Forum) will be to provide a venue for GRAs to exchange information on operational capabilities and research activities in each region (e.g. Box 3.3) and to communicate regional capacity building priorities to the international community. Capacity building is addressed in Chapter 6.

The tragic tsunami disaster of 26 December 2004, triggered by a Richter scale 9 earthquake off the Aceh coast of Indonesia, illustrates in horrifying fashion the importance of investing in the development of the Global Ocean Observing System. Although the event has not yet been fully analyzed, it is clear that had a tsunami warning system been in place, similar to the existing warning system in the Pacific, many lives would have been saved. There are many other examples of proven technologies and models operating in a region that should be implemented in other regions for the public good – given sufficient investment and training (Chapter 6). Expanding the use of operational capabilities that have proven useful in one region to other regions where needed is essential to successful implementation of the coastal module of GOOS.

Identification of areas where augmentation of existing programs is needed should be followed by development of a strategy to enhance capabilities. The enhancements may take the form of increased spatial and temporal resolution for existing sampling programs and incorporation of new measurement systems and technologies. In most cases relevant to the goals of public health, healthy ecosystems and sustainable living marine resources, research and pilot projects will be needed to develop operational capabilities based on identified needs. Thus, mechanisms are needed to (1) implement and sustain proven technologies and procedures in regions where they are needed, (2) identify research priorities to improve operational capabilities, (3) ensure that candidate operational systems meet internationally accepted standards and protocols (see action 3.4), and (4) enable efficient use of new knowledge and technologies to improve operational capabilities.

Action 3.6: The MWG should develop procedures and the means to (1) implementing proven technologies, procedures and models in regions where they are needed and where there are gaps in capability or investment, (2) identify research priorities for developing operational capabilities, (3) ensure conformance to internationally accepted standards and protocols (see action 3.4) and (4) enable efficient use of new knowledge and technologies to improve operational capabilities.

3.2 Establishing the Global Coastal Network

A GCN that measures the common variables and manages the resulting data streams will be established through two parallel processes:

- the incorporation of global programs such as satellite-based remote sensing and in situ programs such as GLOSS, GCRMN, and SeagrassNet; and
- national and regional development of in situ measurement and land- and aircraft-based remote sensing programs that are networked or scaled up for incorporation into the GCN.

The GCN will include space-based remote sensing, a sparse network of in situ sentinel sites[21] for measuring the common variables, and the global network of tide

21 Sentinel sites or stations will be especially important for timely detection of the effects of land-based sources of pollution (e.g., coastal eutrophication, chemical contamination of sediments, and human pathogens); basin scale changes (e.g., the ENSO, PDO and NAO); transports of heat, water and carbon by boundary currents and between basins through straights; shipping (e.g., oil spills and introductions of non-indigenous species), and the establishment of marine protected areas.

	Parameter	Hor. Res	HR min	Obs. cycle	OC Min	Avail	Avail	Accuracy	Acc. Min
Geophysical Observations	Sea surface temperature	100 m	1 km	3 h	6 h	1 h	3 h	0.2° C	0.5° C
	Wind speed and direction	300 m	10 km	1 h	6 h	1 h	3 h	1 m/s 10°	2 m/s
	Sea surface height	1 km	15 km	1d	10 d	1 h	3 h	4 cm	6 cm
	Surface wave height & direction	1 km	10 km	3 h	1 d	1 h	3 h	0.2 m 5°	0.2 m 10°
	Salinity	1 km	25 km	24 h	7 d	1 h	3 h	0.1 psu	0.3 psu
	Currents	300 m	5 km	1 h	24 h	1 h	3 h	3 cm/s	10 cm/s
	Streamflow	1 km	10 km	1 h	24 h	1 h	3 h	10%	30%
	Precipitation	1 km	15 km	1 h	8 h	1 h	3 h	0.5 mm/h	2 mm/h
	Ice cover	50 m	100 m	6 h	24 h	1 h	3 h	100 m	200 m
Biological/ Biogeochemical Observations	Phytoplankton pigments	100 m	500 m	1.5 h	3 h	1 h	3 h	20%	30%
	Total suspended matter	100 m	500 m	1.5 h	3 h	1 h	3 h	30%	40%
	Colored dissolved organic matter	100 m	500 m	1.5 h	3 h	1 h	3 h	30%	40%
	Optical properties (includes PAR)	100 m	500 m	1.5 h	3 h	1 h	3 h	10%	20%
	Chlorophyll fluorescence	100 m	500 m	1.5 h	4 h	1 h	3 h	30%	40%
	Aerosol properties (includes AOT)	100 m	500 m	1.5 h	4 h	1 h	3 h	10%	20%
	Nutrients	10 km	100 km	1 d	1 mo	1 d	7 d	10%	30%
	O2 and pCO2	10 km	100 km	1 d	1 mo	1 d	7 d	10%	30%
	Slicks/films (sea surface roughness)	25 m	50 m	3 h	2 d	1 h	3 h	50 m	100 m
Mapping (Phys./Ecol./ Socio.)	Bathymetry	30 m	50 m	2 d	24 d	4 h	1 d	0.1 m (depth)	1 m (depth)
	Land Topography	30 m	50 m	3 mo	1 yr	--	--	5 cm (height)	10 cm (height)
	Shoreline position	1 m	5 m	15 d	3 mo	1 d		7 d	1 m
	Habitat maps (e.g., mangroves)	5 m	20 m	15 d	3 mo	1 d	7 d	–	–
	Reef maps	1 m	5 m	15 d	3 mo	1 d	7 d	2 m	10 m
	Land cover/use	15 m	1 km	1 yr	10 yr	--	--	--	--
	Night-time lights	1 km	5 km	1 yr	5 yr	--	--	--	--

Table 3.1. Coastal observing requirements (time-space resolution, accuracy) from the IGOS Coastal Theme Report (Desired and minimum requirements for horizontal resolution, observing cycle, availability, and accuracy).

gauges. The GCN will provide products, such as of climatologies (sea surface temperature, currents, waves, sea level, salinity, nutrients, chlorophyll a, etc.), which can be used by a range of end-users to assess state changes in the phenomena of interest, including GRAs. The rationale for and characteristics of the GCN and its relationship to national and regional scale coastal ocean observing systems are discussed in Chapter 1.

The COOP has recommended a suite of provisional common variables to be measured as part of the GCN (Chapter 1, Table 1.2). The list should be reviewed and updated and measurement requirements established for each. This should include the identification and incorporation of socio-economic variables needed to relate changes in coastal marine and estuarine systems to socio-economic impacts and decision making.

Action 3.7: In collaboration with GSSC, the IGOS Coastal Theme Team, and JCOMM, the MWG should review the common variables to determine if variables should be added or dropped based on the following: (1) the number of GRAs that require and use data on them; (2) their significance as indicators of global changes or as indicators of socio-economic impacts of changes in coastal systems; and (3) the technical feasibility of incorporating them into the GCN as an operational element of GOOS.

The IGOS Coastal Theme Report (http://www.igospartners.org) recommends requirements for estimating the distribution of many of the common variables (Table 3.1).

Action 3.8: Using the recommendations in the Coastal Theme Report as a starting point and consistent with JCOMM procedures, the MWG should adopt (or establish as needed) and facilitate the implementation of internationally accepted standards and protocols for measuring the common variables and establish requirements for measuring them in terms of time and space resolution and accuracy.

3.2.1 Networking Regional Coastal Ocean Observing Systems

A preliminary assessment of stakeholders, products and variables for the GCN has been completed (IOC, 2003; p. 55-62 and Annex IV). Development of the GCN will be initiated by synthesizing and updating the collective inventories conducted by GRAs (section 3.1) with the results of a call by the GSSC for interested parties to register relevant programmes. The synthesized inventory will target operational programmes committed to sustained measurements of one or more of the common variables as well as pilot and pre-operational projects that have the potential of improving operational capabilities of the GCN.

Action 3.9: In collaboration with the global body of GRAs, the GSSC should prepare and periodically update a global listing of national and regional monitoring programs that are candidates for the GCN.

The next step is to determine which of the programmes identified in the inventory can benefit from and contribute to the GCN according to GOOS principles (IOC, 2003; p. 55-62 and Annex IV). In addition, contributing programmes should be committed to:

- Sustained measurements of one or more of the common variables;
- Participating in the development of international standards and protocols for measurements and data management and exchange; and
- Adapting methodologies to conform to existing or new internationally accepted standards and protocols for measurement and data management and exchange as they are developed.

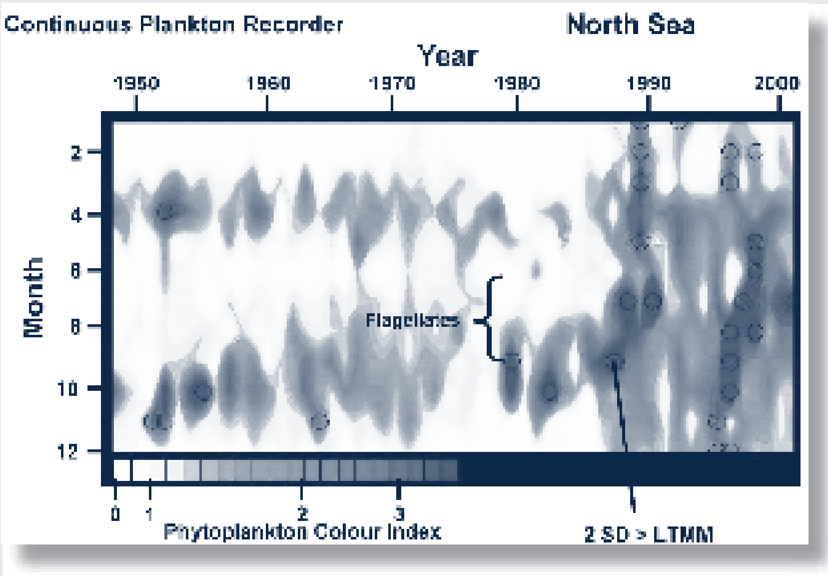
The MWG will work with GRAs to adopt internationally established standards and protocols for measurements and quality control procedures and, where these do not exist (especially for non-physical variables), to work with the appropriate international and national bodies to establish them. The MWG should also work with GRAs to optimize the spatial and temporal resolution of measurements. Once standards and protocols have been established, the GSSC will work with the Observation Programme Area of JCOMM, or the GRAs as appropriate, to promote their use.

Action 3.10: The MWG, in collaboration with the GRAs and the JCOMM Observations Programme Area, should identify those programmes or elements thereof that should be networked and incorporated into the GCN.

Action 3.11: Once standards and protocols for measurements have been accepted by the global body of GRAs (action 3.5), the MWG should work with the Observations Programme Area of JCOMM to facilitate their adoption by JCOMM as appropriate and consistent with JCOMM priorities.

Coordinated integration of contributing programmes is critical to the effective development of the GCN. The primary tools for integrating data streams from contributing measurement programmes are data communications and management (Chapter 4) and modelling (Chapter 5). Thus, in most cases, contributing programmes should conform to standards and protocols established by these subsystems for them to be integrated into the observing system. Exceptions should be made on a case-by-case bases with agreement that capacity will be built to enable adoption of common standards and protocols over time.

BOX 3.4. THE CONTINUOUS PLANKTON RECORDER (CPR) SURVEY: AN EXAMPLE OF A PROGRAM THAT SHOULD BE SCALED UP TO BECOME A GLOBAL COMPONENT OF THE GCN



The CPR survey, conceived by Sir Alister Hardy in the 1920s and implemented in 1931, is the most extensive long-term time series of marine organisms in the world (Reid et al., 2003a). The CPR is a reliable, easy to handle instrument for sampling phytoplankton and zooplankton communities upon which most living marine resources depend. Operating from ships of opportunity, the survey focused on the North Sea until 1959 when it expanded to include much of the North Atlantic and 2000 when additional lines were added in the North Pacific. The CPR is the main source of regional and basin scale information on plankton communities and their trophic structure in the North Atlantic, changes in which are sensitive to global climate change, basin scale oscillations, and coastal eutrophication. The examples given below, and many others (Reid et al., 2003b), show the clear need to incorporate existing CPR surveys into regional coastal ocean observing systems worldwide.

(1) The CPR colour index, a measure of phytoplankton biomass, for the North Sea from 1948 to 2000 shows a dramatic increase during the early 1980s (above), primarily due to increases in the summer biomass of dinoflagellates, a trend that may be related to excess anthropogenic nutrient enrichment. Richardson and Schoeman (2004) show that warming of the NE Atlantic is accompanied by increasing phytoplankton abundance in cooler regions and decreasing abundance in warmer regions. This effect propagates up the food web through zooplankton herbivores and carnivores. They conclude that future warming is likely to alter the distribution of primary and secondary production and, therefore, fish production.

(2) CPR time-series observations suggest that changes in the abundance and distribution of calanoid copepods are related to global warming and basin scale oscillations such as the NAO and to variations in cod recruitment and the abundance of the North Atlantic right whale, an endangered species (Beaugrand et al., 2003; Greene and Pershing, 2004).

CPRs are or will soon be in use in the Baltic (as part of the Baltic Operational Observing System), Gulf of Guinea (Large Marine Ecosystem Programme), Indian Ocean (Indian Ocean GOOS), Mediterranean (MedGOOS), north Pacific (PICES), and the Southern Ocean (International LTER). GRAs are encouraged to embrace these efforts and to incorporate the data streams into integrated data communications and management to enable rapid access and analysis.

Action 3.12: The GRAs as a group should ensure effective exchanges of information on standards and protocols between all of its WGs.

3.2.2 Satellite-Based Remote Sensing

Remote sensing figures prominently in the Design Plan for the Coastal Module of GOOS (IOC, 2003; p. 67-68), and implementation of effective satellite-based coastal remote sensing, with efficient data transmission to users, is a high priority. During the past two decades, satellite remote sensing has become a mature technology for global scale, spatially synoptic measurements of surface and near-surface ocean properties (sea surface height, ocean vector winds, sea surface temperature, sea ice extent, and ocean colour). Global coverage with near-synoptic spatial observations and time series observations are provided by polar orbit-

BOX 3.5. LIMITATIONS OF SATELLITE REMOTE SENSING IN COASTAL WATERS

Ocean colour sensors Ocean colour remote sensing is a mature technique for application in open ocean waters. The major product derived from ocean colour is concentration of chlorophyll a near the surface, with ± 35% uncertainty (chlorophyll a concentration varies over 4 orders of magnitude in the ocean). Although no operational ocean colour missions have yet been conducted, the research sensors (e.g., CZCS and SeaWiFS from NASA) have allowed consistent time series to be developed at various time and space scales. Another valuable product derived from ocean colour is primary production and models have been developed and basin and global scale estimates have been derived.

Some coastal waters, such as those found around the Mediterranean Sea, behave like open ocean waters in that the dominant source of optical variability is phytoplankton and co-varying substances. In such Case 1 waters, ocean colour data products such as chlorophyll a and the attenuation coefficient for sunlight are suitable for operational distribution and can be used with some confidence. In coastal waters where re-suspension of bottom sediments and input of terrigenous matter from effluents are important, the interpretation of ocean colour is more difficult because of the optical complexity of these waters (IOCCG, 2000). There is also a need for improving atmospheric corrections. For many coastal waters, therefore, ocean colour data products are not appropriate for operational use because quality control issues cannot yet be resolved. In the meantime, calibrated data (top of atmosphere radiance or reflectance) can be distributed and archived, and provisional data products can be distributed for use with appropriate cautions.

Microwave sensors Because of the principles of microwave remote sensing, contamination of signals from the land degrade the quality of satellite-based products for coastal waters.

1) Sea surface height, scalar wind and significant wave height from altimeters: there is an observational gap approximately 20-30 kilometers from coasts.
2) Winds and temperature from a Scatterometer/Microwave radiometer: There is an observational gap approximately 20 to 50 km from coasts.

Infrared/visible sensors The present IOC-GOOS satellite resolution requirements for sea-surface temperature and ocean colour products are about 1 km, and most of the major satellite imagers provide the 1-km high-resolution products. However, the product qualities of pixels over coastlines are degraded because of land/water sub-pixel problem. There is therefore an observational gap of one kilometer from coastlines.

ing and geostationary satellites respectively. Data streams from satellite-based sensors provide synoptic and sustained observations of ocean processes that could not otherwise be obtained.

The IGOS Coastal Theme Report (http://ioc.unesco.org/igospartners/coastal.htm) summarizes current and planned satellite missions for observing oceans and coasts. At present, operational and research satellites provide observations of some common variables for the surface ocean (sea surface temperature, currents, waves, and chlorophyll a), and new satellite missions are planned to measure additional common variables (e.g. salinity).[22]

However, current satellite-based observations, while useful for open ocean, basin scale observations, are of limited value for coastal waters which are shallow, optically complex and characterized by high frequency variability and strong gradients. Most coastal systems require increases in temporal, spatial and spectral resolution and improved algorithms (e.g. for translating ocean colour into concentrations of chlorophyll a, sediments and coloured dissolved organic matter) to provide useful products and services. Thus, GOOS requirements for satellite-base remote sensing of coastal systems (Annex V) call for increases in spatial (<1km) and temporal resolution (<1 day).

22 http://ioc.unesco.org/goos/Remote_sensg/index.html

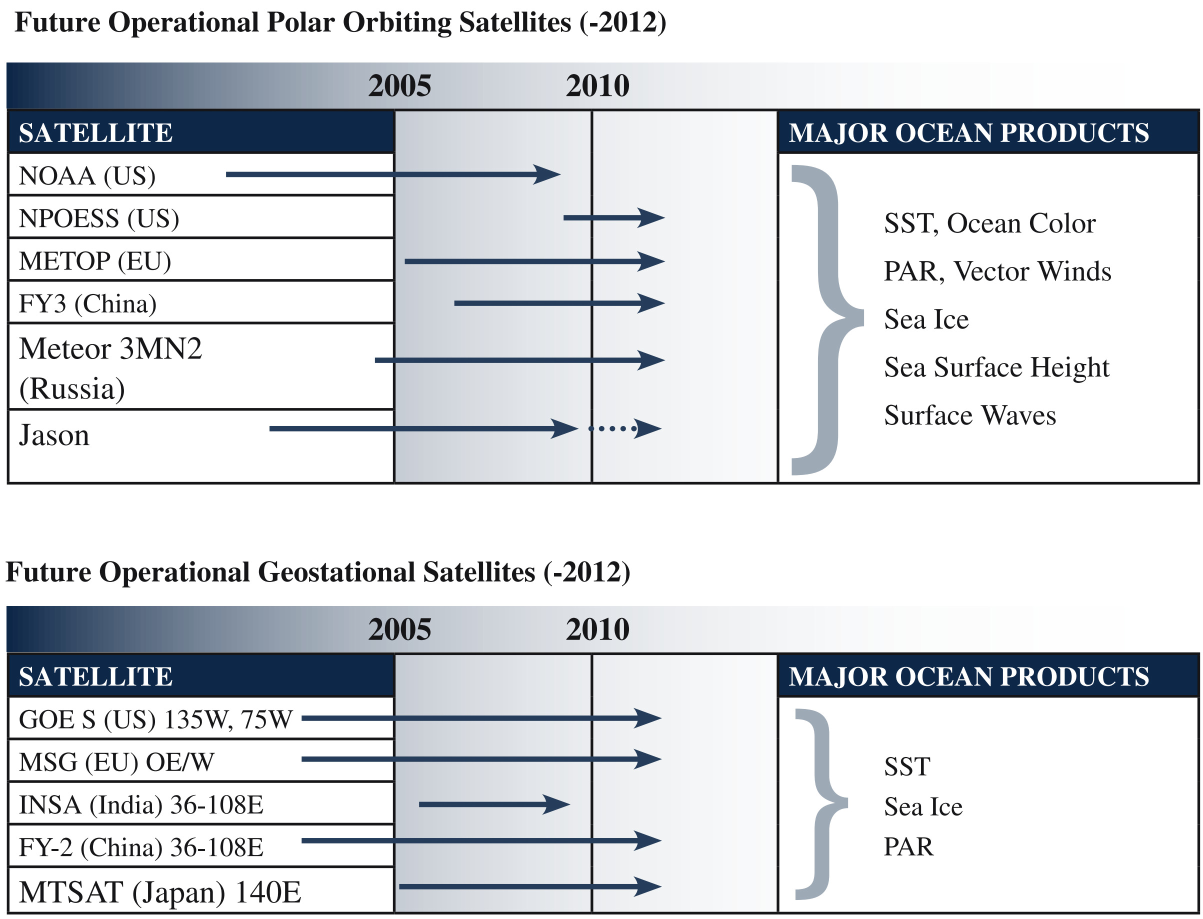


Figure 3.1. Future operational polar orbiting and geostationary satellites. Major ocean parameters supplied by these future satellites are also indicated in the figure. NPOESS and METOP plan to carry scatterometers (*Ocean surface vector winds*), and NPOESS has one altimeter (*Sea surface height*). The JASON-2 programme by CNES, EUMETSAT, NASA and NOAA has a high-accuracy altimeter and will be the successor of JASON-1. *Significant wave heights* are measurable by the altimeters. *Sea surface temperature and sea-ice* can be monitored by the infrared radiometers on board NPOESS, METOP, FY3 and geostationary satellites, and microwave radiometers on board NPOESS. *Ocean Colour products* are derived from the visible sensors on board NPP/NPOESS. *Photosynthetically Active Radiation (PAR)* is estimated by visible radiometers onboard operational polar orbiting/geostational satellites. All the future polar orbiting satellites plan direct broadcasting of all the high-resolution observation data (drawn from the report of CGMS-31 meeting, Ascona, 10-13 November 2003).

GSSC should focus on the following four tactical activities for timely and efficient provision of remote sensing data for coastal systems of known quality:

(1) Work with CGMS/CEOS and their member agencies to guarantee a sustained flow of satellite remote sensing data to GRAs.
(2) Establish the infrastructure for efficient acquisition, distribution and processing of regional remote sensing data in real time.
(3) Take an active role in recommending enhancements to remote sensing capabilities in coastal waters (both improved algorithms and new sensors for improved temporal, spatial and spectral resolution) supported by appropriate research and development.
(4) Ensure that the quality of data for all satellite data products distributed by the coastal module is assessed quantitatively.

Sustained Provision of Satellite Data

Long-term continuity of ocean satellite observations of proven quality is critical to the successful development of the coastal module, and GSSC should work to promote sustained delivery of high quality satellite data to users worldwide. At present, most satellite products served by operational agencies depend on sensors that are operated by research agencies, and are not, therefore, operational. During 2005-2010, proven pre-operational satellite-based sensors will be transitioned into an operational mode (Figure 3.1). In the meantime, it is important to successful implementation of the coastal module that current satellite capabilities be maintained to ensure temporal continuity of the data streams. It is also important to improve access to satellite data, especially for capacity building purposes.

Data Acquisition, Distribution and Processing

Many user-needs require rapid detection and timely forecasts of changes in the state of marine systems, so real-time dissemination of the high-resolution satellite products is essential to an effective observing system. Infrastructure to do this for coastal users is needed. The centerpiece of this infrastructure should be the establishment of GRA Remote Sensing Centers (GRSCs) in one or more regions (Figure 3.2). Such centers would collect and transmit satellite data (Level 0, 1, 2 and 3) for the region. To do this in real time, GRSCs would receive direct broadcasting from operational and research satellites as well as data transferred through the Alternative Dissemination Method (ADM) from major satellite operational systems. In order to cope with the future data volume requirements and geographical data dissemination requirements, GRSC data acquisition and transmission systems need to be designed for optimal connectivity with GRAs and their user members for timely delivery of data and data products. The pursuit of alternative methods of distribution is important as the volume of information increases in the future, and satellite constellations become more unique. The GRSC-ADM system will receive data from satellite ground stations and product processing facilities. Received data are further processed and formatted and then transmitted to dedicated and public users (Figure 3.2a, b).

BOX 3.6. THE ALTERNATIVE DISSEMINATION METHOD

The Alternative Dissemination Method (ADM) is a generic term of data transfer technology considered for the distribution of environmental satellite data and products. The ADM communications are separated from the technology utilized in Direct Readout (DR) services, which is a broadcast from government owned satellites. For example, commercial space communications, landlines, Internet infrastructures, etc. are the potential technology of ADM. Presently, the Internet distribution of ADM is best handled by File Transfer Protocol (FTP) requests.

A network of specialists trained in the use of remotely sensed data can enhance the RSC capability for research and product development as well as GRA awareness and acceptance of the satellite-based products. The transition from low-resolution analog imagery satellite services common today to digital high-resolution (radiometric resolution) products and services needs training of users and significant capacity building.

Satellite Remote Sensing System Enhancements

As the body responsible for oversight of technical developments toward the establishment of a global system for observation of coastal waters, GSSC must assume an important role in recommending research and development priorities and enhancements to satellite remote sensing capabilities that address the needs of users. Assessment of data product quality in the context of user needs generates a clear picture of gaps in system performance. It is thus important to follow through on assessments by making recommendations for satellite remote sensing system enhancements.

Action 3.13: In collaboration with the IOCCG and the JCOMM Satellite Requirements Task Team, it is recommended that the MWG promote the development of operational remote sensing capabilities for ocean colour in coastal waters. This should include promoting the sustained flow of satellite data to the GRAs, the establishment of needed infrastructure, ensuring data quality, and recommending enhancements and research priorities to CGMS/CEOS and their member nations to enhance operational capabilities of satellite-based remote sensing. Priorities include the following: (1) recommend standard protocols for in situ measurements of the optical and chemical properties necessary for determining the quality of the products derived from ocean colour remote sensing in coastal waters; (2) prepare and distribute toolkits for development and evaluation of ocean colour algorithms for both regional and global products (with the latter requiring intercalibration of algorithms developed for different regions); (3) support efforts to use these toolkits for capacity building; (4) create a global forum of ocean co-

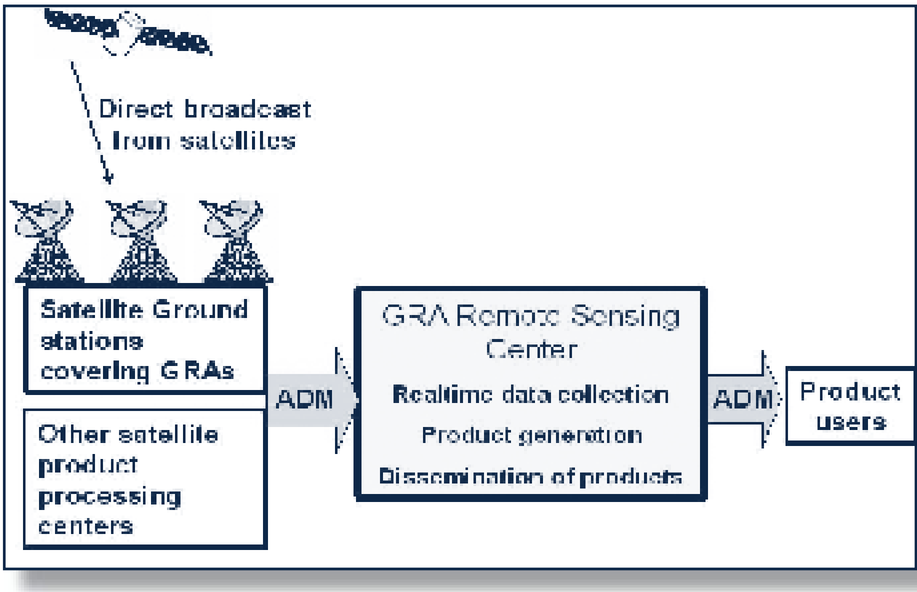


Figure 3.2 a. Functions of GRA Remote Sensing Center. GRSCs receive direct broadcasting from operational and research satellites as well as data transferred through the Alternative Dissemination Method (ADM) from major satellite operational systems. Received data are further processed and formatted and then transmitted to dedicated and public users in real-time and delayed modes.

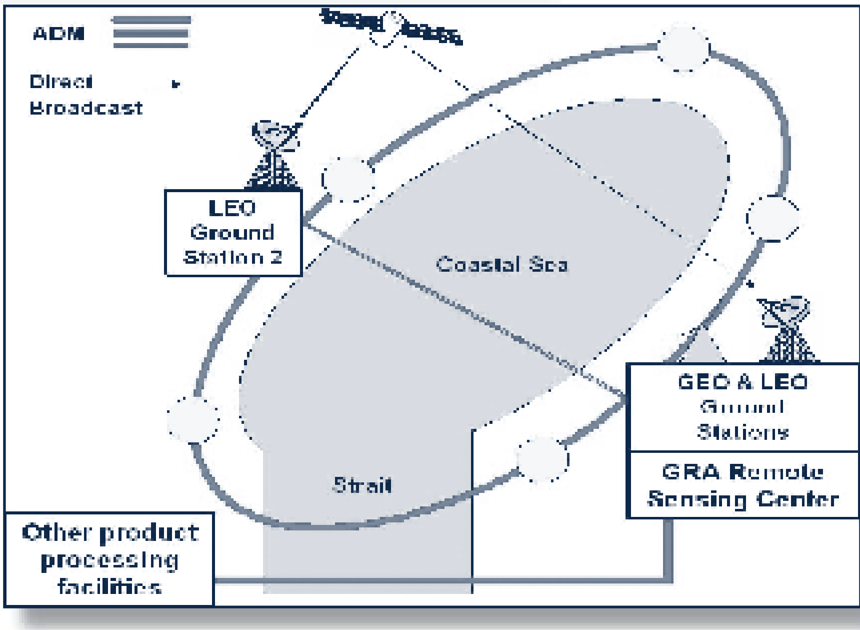


Figure 3.2 b. Schematics of a GRA Remote Sensing Center, which identifies user groups, specifies their satellite data requirements in a region, and then delivers data and data products to users. It collects all available satellite data (Level 0, 1, 2 and 3) for the region. The GRSC ADM system will receive data from satellite ground stations and product processing facilities, and disseminate regional products in timely manner.

lour algorithm developers and users to conduct inter-comparison exercises and coordinate activities for algorithm development; and (5) promote the transition of satellite missions from research to operational status.

These recommendations will be widely distributed, but also directed through appropriate channels. For example, requirements for sensor performance will be submitted to the CEOS/WMO database of satellite requirements for better coordination of space-based observing systems. For techniques that will become mature for the observation of coastal ocean, the transition from research sensors (generally developed by space agencies) to operational missions (generally conducted by meteorology agencies such as EUMETSAT, or others such as NOAA) will be recommended.

Assessment of Data Quality

In order to achieve the primary goal of providing remote sensing data of known quality to users, there is a need to assess the techniques, sensors, algorithms and data management specifically for coastal waters efficiently and in a timely fashion. The major remote sensing techniques (altimetry, scatterometry, SAR and ocean colour) should be assessed to determine their status as providers of products for coastal observations (e.g. adequacy in terms of spatial and temporal resolution, near-shore degradation of the signal, measurement uncertainty, product quality, data format and distribution). For many satellite data products, assessments have already been done, although not necessarily for the range of coastal applications of interest to users; they must be regularly reviewed and revised.

Action 3.14: GSSC should compile assessments of techniques, sensors, algorithms and data management specifically for coastal waters and prepare them if they are not available.

Action 3.15: In collaboration with the IGOS Coastal Theme Team, GSSC should regularly review the quality and utility of coastal satellite products (in terms of required time, space and spectral resolution) and make clear recommendations for enhancements, including improvements to algorithms, deployment of new sensors and priorities for research and development.

Experience over the past decade has clearly demonstrated that space-based observations are best when used in conjunction with complementary in situ data. Most retrieval algorithms for satellite oceanography products are tuned against in situ measurements. The GCN in situ measurements can be used to generate data products using regionally derived algorithms. Additional validation measurements may be necessary. The quality of satellite products should be assessed quantitatively using regional in situ measurements and product quality information should be accessible for all the product uses. Algorithm improvement may have to be conducted at the regional scale. Merging the satellite and in situ measurements to improve coastal products is a challenge that should be addressed through pilot projects, e.g. establish globally comparable approaches for developing regional ocean colour data products for coastal waters as recommended in Chapter 5.

An important aspect of assessing the quality of satellite products is the extent to which there is continuity and consistency among regions, e.g. algorithms for calculating chlorophyll a concentration from ocean colour provide comparable results for the Adriatic Sea and the coastal plume of the Amazon River. To these ends, internationally accepted procedures are needed for satellite calibration (including multi-satellite intercalibration by the regional remote sensing centers), for algorithm development, and for the validation of satellite products.

Action 3.16: GSSC should work with the JCOMM Satellite Requirements Task Team and the IGOS Coastal Theme Team to formulate and recommend standard procedures for calibration and validation of satellite products that are comparable across regions.

3.2.3 In Situ Sampling

The GCN is to establish a sparse network of reference stations (e.g. satellite calibration sites) and sentinel sites for sustained time-series observations (fixed time-series stations, repeat transects across key straights, and areas for repeat Lagrangian surveys, etc.). A global network of stations for in situ measurements for calibrating and validating remotely sensed products should be established as part of the GCN.

Sentinel stations are needed for early detection and timely predictions of the effects of changes in ocean basins (ENSO events, the PDO, NAO, etc.) and coastal drainage basins (land-based sources of pollution, changes in the hydrological cycle, etc.) as well as direct impacts of human activities (fishing, introductions of non-native species by discharging ballast water, oil spills, etc.).

Action 3.17: In collaboration with the IGOS Coastal Theme Team and the JCOMM Remote Sensing Task Team, GSSC should formulate criteria for determining optimal locations for calibrating remotely sensed data and validating satellite products; recommend locations and requirements for measurements (time-space resolution, accuracy) at each; and encourage their establishment or continuation as a critical component of the GCN.

Action 3.18: In collaboration with the GRAs and the IGOS Coastal Theme Team, GSSC should formulate criteria for determining optimal locations for sentinel stations, surveys and transects; recommend locations and requirements for measurements (time-space resolution, accuracy) at each, and encourage their establishment or continuation as a critical component of the GCN.

3.3 Data Telemetry

The first step of telemetry of raw data from the sensor will be considered as part of the observing system, rather than data management (Chapter 4). There are many challenges to efficiently transmit the broad diversity of data types (geophysical, chemical, biological) and data volumes from in situ and remote sensing platforms and sensors to shore stations and data assembly centres. Platforms such as drifting buoys with simple sensor systems (e.g. SST and basic meteorology) may transmit a few bytes of data daily or even less frequently. Gliders may transmit tens of kilobytes in bursts while at the surface, and some moored buoy systems can now transmit Megabits per second (including streaming video in real time). Some sensing systems deployed in the field can be reprogrammed remotely, some with two-way communications that enable continuous adaptive control. There are phenomena critical to coastal GOOS that will require continuous real-time monitoring and reporting (e.g. surface currents, harmful algal blooms, beach contamination) while other variables may require data to be reported at monthly or at less frequent intervals (e.g. spatial extent and condition of coral reefs; distribution and abundance of large, long-lived fish populations). For example, ecosystem-based management of fisheries requires real-time, and near real-time data on ecosystem states (e.g. temperature, salinity and chlorophyll fields) and delayed mode data on fish stocks (e.g. monthly, seasonal, or annual, depending on the species) where "delayed" refers to the time lag between real-time changes in fish stocks and the detection of such changes.

Observing system platforms have a wide variety of options for transmitting data. Those deployed within line-of-sight (LOS) of shore or of other platforms that can relay the signal can benefit from any one of a number commercial and affordable LOS telemetry technologies (VHF, MF, Digital Switched Calling (DSC), point-to-point and point-to-multipoint microwave or even cellular telephone networks in some near coastal instances). Emerging "WiMax" (the 802.16 protocol with higher power and longer range than the 802.11x that currently enables WiFi hotspots for wireless internet connections at coffee shops) technology holds particular promise for broadband telemetry of nearshore coastal measurements. Coastal platforms farther off shore (typically beyond 25 km) or those over-the-horizon (OTH) sites that comprise the global ocean module of GOOS can still reliably report at varying data throughput rates (up to Mbps) and frequency intervals (up to continuous streaming real-time) through HF and HF-DSC links or a variety of deployed and operational communication satellite constellations. Some of these communications satellites are government owned and operated while commercial providers lease bandwidth on others in a variety of frequency bands (commercial Ku-, C-, L-Band transponders are all currently in use for telemetry of oceanographic data and the emergence and increasing adoption of Ka-Band portends to further increase data throughput rates. Sensors deployed beneath the sea surface can also report data and be remotely controlled from shore through a variety of methods, chief among them electrical/optical cables either ending at shore or terminated at a surface telemetry buoy, acoustic data modems transmitting to a surface vessel or float, or releasable data packages, which ascend to the surface to telemeter data ashore or to be retrieved by vessels. Once transmitted ashore, GOOS data are ported into data assembly centers.

Action 3.19: GSSC should assess requirements for data telemetry regionally and globally and (i) document existing infrastructure to achieve objectives of both the regional and global components of the coastal module; (ii) recommend simple and robust technologies that can be implemented by users immediately; (iii) promote the development and deployment of new telecommunications systems as needed; (iv) develop standards and protocols for telemetry technologies used for GOOS in order to facilitate dissemination of the data for research and operational purposes; and (v) promote implementation of technical support programs for telecommunications systems utilized for GOOS.

4. Implementing Data Management Subsystem

4.1 General Requirements and Design

Data communications and management are the primary integrators of the observing system. Consequently, a high priority for implementing the coastal module is the development of a data communications and management subsystem (DMS) for the discovery and delivery of data within GOOS and for interoperability[23] with other relevant observing systems and research programmes. The objectives are to serve data at rates and in forms specified by GRAs and other user groups[24] and to enable all participants to collaborate at levels appropriate to their responsibilities and resources while maintaining the integrity of data bases (IOC, 2003; p. 89-104).

In addition to providing a framework for interoperability, the DMS must (1) ensure feedback between data assembly centers and data providers for quality assurance; (2) enable multiple user groups to easily and seamlessly locate, access and use large volumes of data and information (from both observations and models); (3) efficiently broadcast data to users; (4) archive irreplaceable observations, data products of lasting value, and associated metadata; and (5) adapt over time as user demand grows and operational capabilities improve with advances in technology and understanding. To these ends, the DMS for the coastal module should have the following capabilities:

- process and archive data on the common variables according to scientifically sound and well-documented standards and formats;
- serve data on the common variables (observations and model outputs) in real time (24/7) and in "delayed" modes depending on the needs of user groups and their technical capabilities (automatic dissemination as well as "on demand"); and
- enable efficient access to data on the common variables and derived products by users who have a broad range of capacities.

These capabilities are also needed by regional coastal ocean observing systems for those variables that are unique to their region. For both the GCN and regional systems, the DMS must provide the means to assess system performance, an issue that is addressed in Chapter 7 for the observing system as a whole.

The DMS will develop most efficiently through open software design. It should be emphasized that, in carrying out the actions identified in section 4.2, existing information technologies and scientific standards should be used whenever possible in preference to development of new solutions. Some standards already exist for existing multi-national operational programmes, usually run by agreements between national operational agencies at the regional level. The process for adoption of existing and development of new standards and protocols should be open and inclusive to foster "buy-in" by all stakeholders. All standards and protocol definitions should be openly published so that participating organizations may create interoperable DMS components based on these specifications.

23 "Interoperable" is the capacity to access, exchange and blend data from different programmes seamlessly without detailed knowledge of their origins.

24 It must be emphasized that measurement of the common variables measured and managed by the GCN will provide data needed to serve some global products (Chapter 5), but most applications will require additional observations to serve data and products based on the priorities of participating nations and GRAs. Thus, the GCN will be customized to meet the particular needs of participating nations and GRAs (Chapter 5).

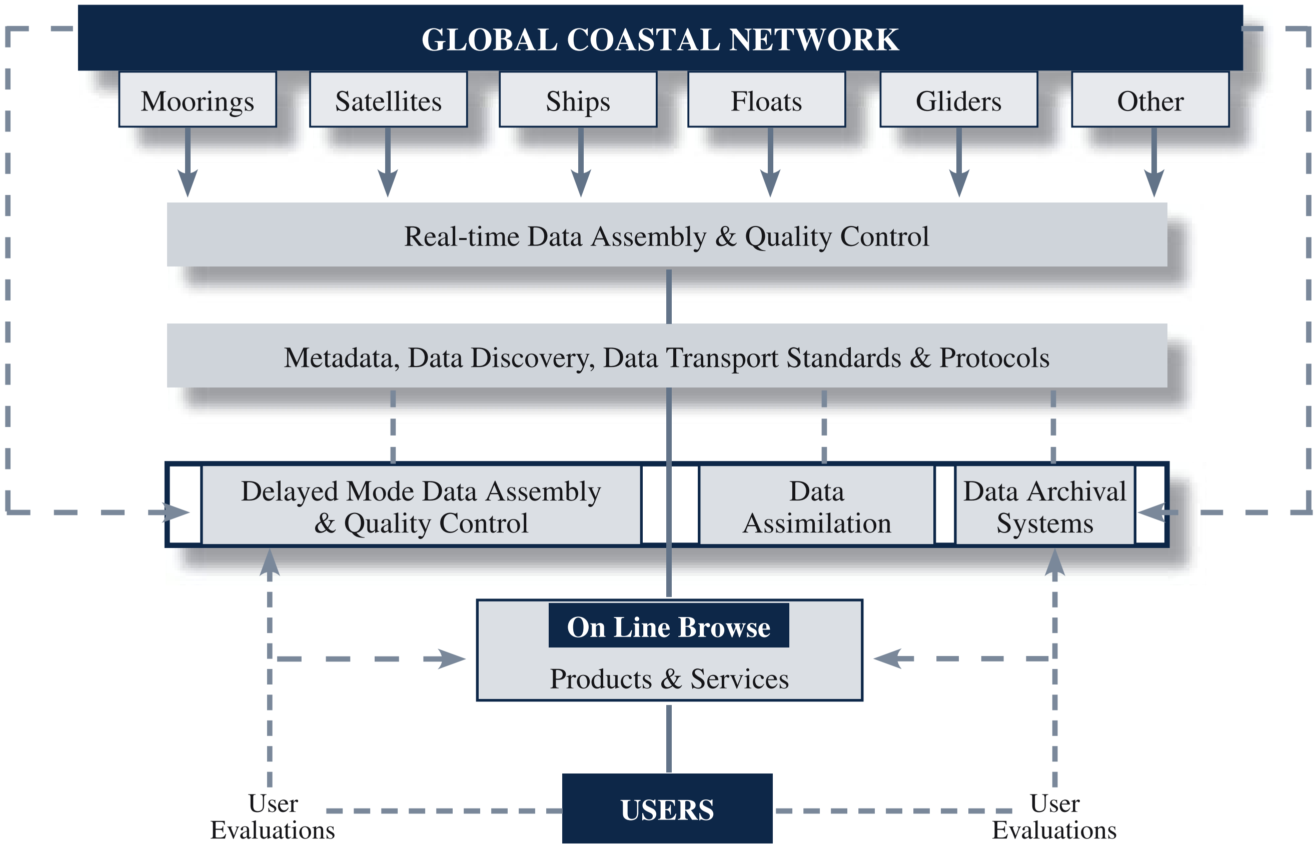


Figure 4.1. Elements of the data management subsystem for the Global Coastal Network (GCN). The GCN measures and manages a relatively small suite of common variables required by most national GOOS Programmes and GOOS Regional Alliances. Data are served in both real time (solid line) and delayed mode (dotted line). Incoming data streams are provided by both global observing programmes such as GLOSS and satellites and by GOOS Regional Alliances (GRAs) that, as a group, contribute to the GCN. On line browse provides guaranteed minimum geo- and time-referenced capability for coastal GOOS data. Periodic user evaluations (dashed line) of access to data and to data-products are used to improve performance (Chapter 8).

Data streams will originate from many different platforms operated by international partners, GRAs, national programmes responsible for quality assurance, and commercial offshore industries (Figure 4.1). Generally, some form of primary data assembly will be required before data can be utilized. This processing may range from hand entries to real-time conversion of instrument voltages to physical units. Raw data from these systems will be communicated by various means (i.e. mail, telephone, radio and satellite transmission, microwave, and the Internet) to centers for data assembly and quality control.

Data management “begins” with the output from the primary data assembly centers and the establishment of common standards and protocols to support (1) metadata; (2) data discovery and on-line browse (the ability to assess the character of data using common Web browsers); (3) data transport; and (4) secure, long-term archives. Data management “ends” with the delivery of data and data products in forms specified by user groups, including text forecasts, maps of ocean variables and coastal features, materials for educational curricula, and time series showing trends useful for resource managers.

The development of DMS for the GCN and regional coastal ocean observing systems will be facilitated by the formation of a Data Management Working Group (DMWG) under the auspices of a global body of GRAs (Chapter 2). In collaboration with the IODE and the JCOMM Data Management Programme, the DMWG will formulate guidelines for system development, promote the establishment of standards and protocols, define metrics and encourage pilot projects.

Action 4.1: The GRAs as a group (e.g. the GOOS Regional Forum) should establish a data management working group (DMWG) to implement actions such as those recommended below.

4.2 Establishing Common Standards and Protocols

4.2.1 Metadata

Metadata are critical for all DMS functions (data discovery, transport, and archival). Variable names, units, location in time-space (where and when measurements were made) are referred to as "use metadata." Descriptions of measurement and analysis techniques and information on calibration and validation are referred to a "descriptive metadata." For each variable-specific and instrument-specific type of data, it will be necessary to specify both according to internationally accepted standards.

Action 4.2: The DMWG, in collaboration with national GOOS Programmes and ocean data centers, the JCOMM-IODE Expert Team on Data Management Practices, the Terrestrial Environmental Monitoring Sites (TEMS) of GTOS, and international research programmes (e.g. IGBP and SCOR), should (1) determine metadata content and format standards, (2) agree on the initial organizations that should participate in metadata management for the GCN, (3) develop tools and procedures in support of metadata providers (i.e. develop or adopt procedures and tools to aid the design, generation, verification, and maintenance of metadata), (4) ensure they are applied to relevant historical data and to data streams generated by the GCN and regional coastal ocean observing systems, (5) establish a metadata catalogue for the coastal module (to enable data discovery), and (6) develop tools to modify metadata appropriate to the corresponding data.

4.2.2 Data Discovery

The capacity must be developed to allow users with varying technical capabilities and requirements to search, discover and acquire data easily and in a timely manner. Data discovery includes both the location of data sets which have been processed and archived, and the identification of the source of real time data which can be accessed on line. Data discovery will initially be implemented as a process of locating data by searching the coastal GOOS metadata catalogue. DMS data discovery capabilities will complement and extend search capabilities of existing commercial Web search engines such as Google and Yahoo.

Currently, metadata records for marine data are often managed separately from the data themselves. As a practical matter, initial solutions to data discovery for GOOS should build on this architecture. However, this creates two significant challenges: (1) ensuring the validity over time of the links between metadata records and points of data access (see data transport) and (2) ensuring that changes to data sets are reflected in the corresponding metadata. This practice should not be continued for the non-physical common variables. For these, the new operational variables, metadata records and data should be managed together.

On-line browse capability provides a uniform means to inspect and make comparisons among GOOS data sets, and the DMS subsystem must provide a seamless transition from data discovery to on-line browsing and data transport. This can be achieved by using the DMS data transport protocols for accessing data.

Action 4.3: The DMWG should work with the appropriate bodies (e.g. national ocean data centers, JCOMM-IODE Expert Team on Data Management Practices, IODE's ODIN Programme) to determine what search and browse capabilities are needed and to establish a standard machine-to-machine interface (the data location service) that enables the seamless transition from data discovery to access.

4.2.3 Data Transport

Web services provide a standardized means for computer systems to request data and data processing from one another enabling the DMS to link independent systems. They are reusable software components based on the eXtensible Markup Language (XML). Web services use the communications protocol of the World Wide Web (HTTP, Hyper Text Transfer Protocol) and are accessed through Universal Resource Locators (URLs) that begin with http://.

Data transport on the Web is done via protocols such as File Transfer Protocol (FTP), Hypertext Transfer Protocol (HTTP), and Simple Mail Transfer Protocol (SMTP).

These protocols are supported on most computers and operating systems, and all of them will be used to move various types of data over the network. However, there is no uniform syntactic[25] or semantic[26] information that is guaranteed for data communications using these protocols and, therefore, no guarantee of interoperability among computer applications. This is the function to be fulfilled by the DMS web services standards. The uniformity provided by DMS web services standards will permit all components involved in data transport to be interoperable at the machine level, i.e. data can be moved from one data center or computer another and retain complete syntactic and semantic information without human intervention.

Action 4.4: In collaboration with the JCOMM-IODE Expert Team on Data Management Practices, the DMWG should work with national ocean data centers to develop web services standards and a comprehensive data model (for data to be moved into for transport between server and client) for the coastal module. To initiate this process, the DMWG should inventory data management solutions currently in use by data providers; identify existing and new applications (within the framework of the six societal goals of GOOS) that should be supported; determine requirements for delivery of formatted subsets to users; and develop middleware solutions for requesting and receiving data and metadata over the Internet, translating data from existing data management systems into an ocean data access protocol[27], and ingesting data from the protocol into existing and new data management systems.

25 The syntax (structure) of the data set including the atomic data types in the data set (binary, ASCII, real, etc.), the dimensionality of the data set (e.g., a 100x200x25x10 element array), and the relationship between variables in the data set.

26 The semantics (description) of the data including the meaning of variables (e.g., P is phytoplankton biomass), units used to express variables, descriptions of methods, and special value flags (e.g., a value of -1 means missing data).

27 The goal is to provide the means by which end users, whoever they may be, may access immediately whatever data they require in a form they can use while using applications they already possess and are familiar with. Several solutions exist for this, but none are universally accepted. A broadly tested and accepted data access protocol within the oceanographic community is the OpeNDAP (Open Source Project for Network Data Access Protocol). This data access protocol uses a discipline-neutral approach to packaging data for transport. Discipline neutrality is a key element of the data transport protocol for an integrated observing system that is intended to serve large volumes of data for a broad diversity of multidisciplinary variables, e.g., 4-dimensional geospatial grids, time series, vertical profiles and the abundance and distribution of biological species. The protocol ensures that the structure, numeric values, and metadata are preserved between server and client.

The capacity for timely data dissemination not only depends on rapid data input to and output from primary data assembly and modelling centers, it depends on obtaining agreements among countries and programmes to release data (including sensitive data, e.g. fisheries statistics) and for data providers to honor those agreements. This will require special capacity building and training as well as bi- and multi-lateral agreement among participating countries. The problems of reluctance to exchange real time data between operational agencies from different countries, and the failure to release data which scientists may wish to protect for reasons of prior publication, have hindered the development of operational oceanography repeatedly during the last ten years. If coastal GOOS is to provide the socio-economic benefits demanded of it, these problems must be confronted directly and solved. These problems have been referred to many times before, but the continued difficulty in obtaining a solution means that investment in operational services may be postponed yet again, with consequent damage to the environment and risk to human life and health.

Action 4.5: GSSC should work with the I-GOOS and the GRAs to promote conformance to the IOC Data Policy (http://ioc.unesco.org/goos/GOOSdm_final.pdf) and the establishment and execution of international agreements for timely data exchange among GRAs and participating nations.

4.2.4 Archival

Data archives receive and provide access to both real-time and delayed mode data and metadata. Initially, existing archival facilities (e.g. national ocean data centers) should provide these capabilities. Operating principles, requirements for additional centers, and coordination among facilities should be defined early in the development of the DMS. High priorities include (1) identifying all critical data streams and existing data archives; (2) formulating plans for involving existing archives in the coastal module; and (3) establishing mechanisms to ensure that all valuable data are sent to officially designated archives and that an exact copy is received, and (4) establishing mechanisms to detect and correct failures rapidly (using automated backups and expert oversight to check the integrity of data streams).

BOX 4.1. BIOLOGICAL DATA CONSIDERATIONS

Managing biological data has special challenges that have been neglected in the past. Special considerations must be given to metadata. For example, a basic unit for biological data is species. New species are discovered and named every day. Names of recognized species are often changed, especially for microbial species. Thus, the hierarchical tree of evolutionary relationships among species and associated nomenclature are constantly being revised. Such systems require name translators that give currently recognized names, synonymous names and common names. The taxonomic authority for each major group of organisms maintains the accepted species list with oversight provide by one or more of groups including the Global Biodiversity Information Facility (GBIF), Catalogue of Life, Species 2000 of the Integrated Taxonomic Information System (ITIS), and the Ocean Biogeographic Information System (OBIS). Protocols for using DNA sequences as "bar codes of life" have been proposed as an aid to taxonomic identification.

At this time, many physical variables have designated archives at national and international levels, while most of the non-physical variables do not. Most physical variables presently managed by operational agencies, such as sea ice, sea surface temperature, and surface waves, are archived by specialist groups within the operational community. For each variable it will be necessary to identify regional, global and long-term archival centers. The roles and responsibilities of each center must be defined and procedures for designating official GOOS centers and for discontinuing GOOS functions in the event that a designated center wishes to do so. To qualify as an archive center, a data center must be able to manage multiple copies of data and metadata, create and verify metadata, and frequently check data integrity.

Standards and protocols developed by metadata management and data transport activities will be an integral part of the network of data archive centers. In the mature DMS, data and metadata should be received and redistributed through DMS transport mechanisms in standardized formats. This will eliminate many of the delays and difficulties of non-standard and diverse methods that have burdened this process in the past. Evolution to this state must be phased so that current data services are not interrupted and users can make a smooth transition.

Action 4.6: The DMWG should conduct or oversee the following activities:

- Assess current archival holdings and access methods for data on the common variables;
- Prioritize data sets based on users' needs;
- Categorize data sets for the common variables as irreplaceable, replaceable, perishable, and virtual as a means to determine data set storage strategy and retention periods;
- Recruit archival centers for the coastal GOOS archival network and form partnerships;
- Develop and archive critical metadata;
- Prepare and formally adopt policies for contributing data and using data;
- Establish guidelines for data providers that include the archival and access policy, metadata and data discovery standards and recommended procedures to develop metadata easily;
- Define the human and machine data discovery interfaces;
- Develop procedures for receiving and broadcasting more data in real time;
- Establish a protocol to report and resolve data and data flow problems efficiently;
- Verify data security requirements for irreplaceable data sets; and
- Promote pilot projects to demonstrate the capacity of archive centers to support data discovery and transport using DMS standards and protocols.

4.3 National, Regional and Global Data Organizations

The coastal module of GOOS will function as a hierarchy of observations from global to regional and national scales through the establishment of a decentralized infrastructure in which the participants have clearly defined roles and responsibilities for each of its elements (Figure 4.2). A wide range of data types is already managed at the national and regional or sub-regional level within

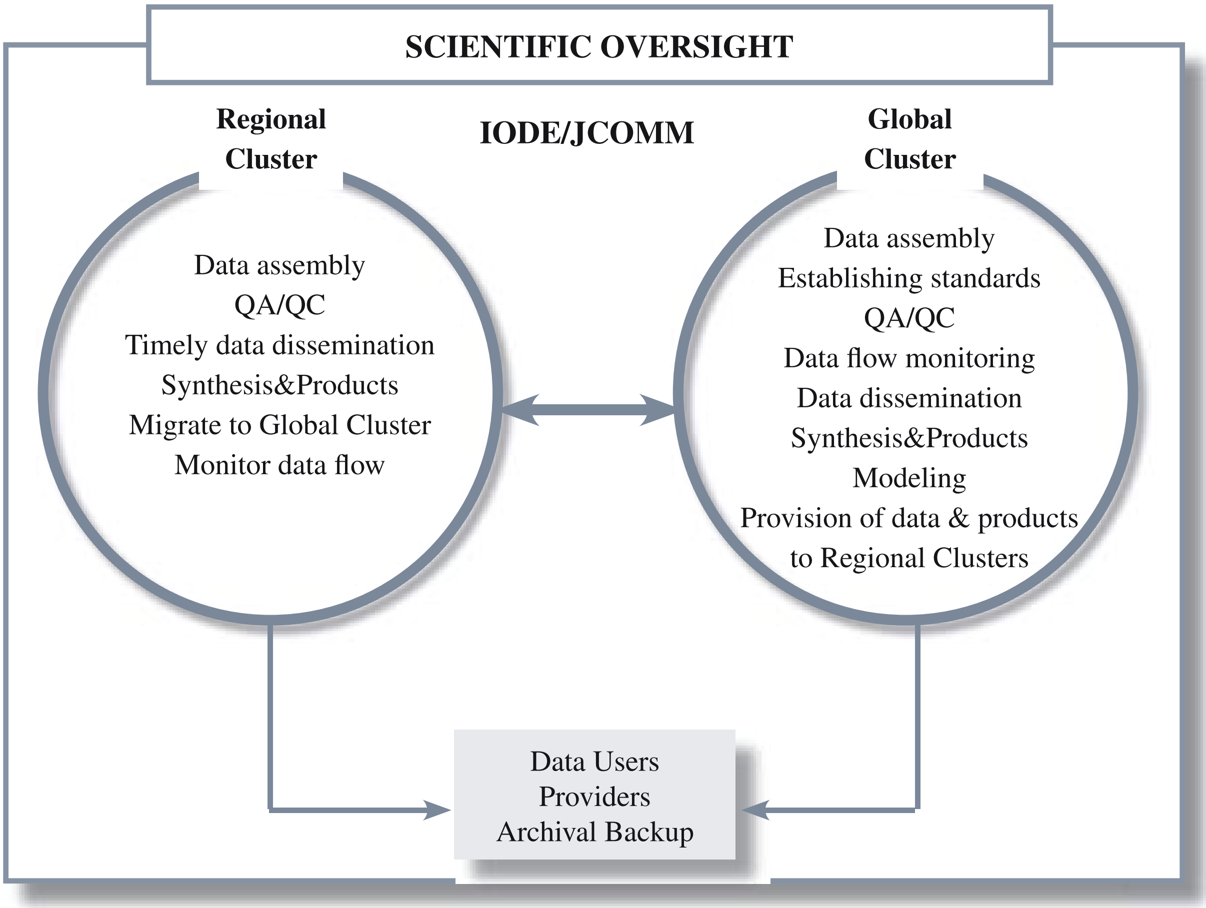


Figure 4.2. The coastal module of GOOS must function on national/regional to global scales so the communications and data management subsystem must also have this functionality. In regions where national centers exist, Regional "Clusters" may include one or more national centers as needed. Where national centers do not exist, a Regional Cluster may be established in lieu of the establishment of national centers. It should be emphasized that, although the JCOMM-IODE enterprise is shown here as the oversight body for implementing the DMS for the coastal module, it is far from clear that this is the appropriate mechanism. JCOMM currently has no mechanism to recognize implementation through GRAs or regional clusters.

the GRAs such as NEAR GOOS, EuroGOOS, and US-IOOS. Much of the data will continue to enter the system and be processed initially at the national level where the delivery of data and products can be tuned to the needs of local users. In many areas, clustering of national centers regionally will provide efficiencies of scale and allow each GRA to take advantage of the diverse capabilities provided by countries in the region (including data assimilation by regional models). In addition, where national centers do not exist, the development of multi-national, regional data centers may be the most cost-effective means of managing data. National centers and regional clusters will manage data from both regional coastal ocean observing systems and the GCN.

The regional clusters should be involved in both the formulation and application of internationally accepted standards and provide functionality that cannot by applied cost-effectively at the national level. Regional clusters will also provide a means for importing data from the GCN and from other regions. It is also possible that policies for exchange of data over and above that provided by IOC Data Policy can be negotiated regionally. Principally for the common variables, the global clusters will provide a final level of aggregation where well tested global data communication, processing and management tools can be brought to bear.

Action 4.7: In collaboration with national ocean data centers and the IODE, the DMWG should promote the establishment of regional and global clusters as needed.

Action 4.8: In collaboration with the GOOS-JCOMM Ocean Information Technology (OIT) pilot project and the JCOMM-IODE Expert Team on Data Management Practices, the DMWG should establish an oversight mechanism for developing an integrating DMS that builds on existing capabilities, includes non-physical variables, and enables interoperability among GRAs, the global ocean-climate observing system (GOOS/GCOS), the Global Terrestrial Observing System (GTOS), and ocean research programmes (e.g. those sponsored by the IBGP and SCOR). This activity should include the following:

- Identify gaps in the terms of existence of data centers and the capabilities of existing centers, and devise solutions;
- Establish regional and global clusters with clear roles and responsibilities (Figure 4.2);
- Formulate and implement rules for data and information exchange;
- Establish mechanisms for data and information exchange with remote sensing centers (Chapter 3) to ensure timely access to data streams and derived products as needed for both regional applications and the calibration and validation of satellite-based observations;
- Establish mechanisms for data and information exchange with data centers for terrestrial and atmospheric observations; and
- Specify metrics to evaluate and improve the data management subsystems in terms of timely access of users to diverse data from many sources.

4.4 Challenges, Current Capabilities and Plans for Improvement

Establishing the recommended DMS faces many challenges, not the least of which are the following:

(1) A centralized management structure for oversight and coordinated development of a global data management network for non-physical data must be established through existing bodies (e.g. JCOMM, the GOOS Regional Forum), through the establishment of new bodies, or a combination of both.

(2) The DMS will be a distributed system in which data resides and is managed at many different organizations on national, regional and global scales.

(3) The diversity of data and metadata to be managed is very large. Variables are multidisciplinary and measurements are unevenly distributed in time and space. Classes of data include large volumes of data from remote and in situ sensing, satellite and drifter tracks, concentration and distribution of a diversity of chemical species, abundance and distribution of a diversity of biological species, modeled data model outputs, etc.

Though challenging, the technical requirements for (2) and (3) can be addressed through an internationally coordinated approach to software engineering with guidance and input from user groups (specifying requirements for products and services) and the science community (defining requirements and evaluating characteristics of data streams). Emerging management structures that address (1) are summarized in section 4.4.1.

4.4.1 JCOMM, IODE and the OIT

The International Oceanographic Data and Information Exchange (IODE) Programme of the IOC and the Data Management Program area of the JCOMM are cooperating closely. The Expert Team on Data Management Practices (ETDMP) is a joint JCOMM-IODE venture and the IODE capacity building activities (Chapter 6) are contributing to JCOMM. The ETDMP has agreed to work on three pilot projects during its initial intersessional period:

1. metadata management;
2. data assembly, quality control and quality assurance; and
3. development of end-to-end data management.

The ETDMP also agreed to work closely with the GOOS-JCOMM Ocean Information Technology (OIT) Pilot Project which has priorities overlapping those of the ETDMP. The OIT Pilot Project objectives are aimed at (i) improved telemetry; (ii) metadata management; (iii) data assembly, data set integrity, quality control; (iv) data circulation and transport; (v) archives and archaeology; (vi) applications and user interfaces; (vii) capacity enhancement and training; and (viii) governance, oversight and metrics. It is expected that the IODE Project Office (located in Belgium), will be a key facility in the implementation of the ETDMP and OIT projects (as well as being a specialized data and information management training facility).

Although these efforts do not include the non-physical variables (which account for most of the diversity of

GOOS observations) and JCOMM is not organized to address issues of regional development, they are breaking new ground that will be of critical importance to the development of the fully integrated DMS. However, the extent to which the infrastructure provide by JCOMM and IODE (both with a focus on global development) can be adapted to meet the needs of the coastal module remains to be seen.

Action 4.9: The DMWG should work with the IODE and JCOMM Data Management Programme area to assess the capacity of the JCOMM-IODE infrastructure to oversee the implementation of the DMS for the coastal common variables of the GCN.

4.4.2 The Ocean Biogeographic Information System (OBIS)

OBIS, the information component of the Census of Marine Life, is a rapidly developing international infrastructure for archiving and serving biological data. It provides access to data content, information infrastructure and informatics tools (maps, visualizations and products from models) through an on-line, dynamic, global 4-D (three space-dimensions and the time dimension) atlas of biogeographic information. Through "open access" via the Web, OBIS provides (1) taxonomically and geographically resolved atlas on marine life and ocean environment; (2) data from museums, fisheries and ecological studies; (3) data from all ocean environments (seabed to plankton and coastal to deep sea); (4) interoperability with other databases; (5) access to physical oceanographic data at regional and global scales; (6) software tools for acquiring new data, checking species names, mapping, modelling and biogeographic analysis. The atlas will be used to reveal interesting spatial and temporal patterns, generate new hypotheses about global marine ecosystems and guide future field expeditions. The on-line, digital atlas developed by OBIS is an important new product that will be critical to achieving the goals of sustaining living marine resources and healthy marine ecosystems.

OBIS is an Associate Member of the Global Biodiversity Information Facility (GBIF) and plans to work closely with the developing Global Ocean Observing System on data management and analysis issues. A major goal for the next 2-3 years is to establish an international network of national and regional nodes with common data access through the OBIS Portal[28].

4.4.3 U.S. Data Management and Communications (DMAC) Programme

Under the auspices of the Ocean.US enterprise, a long-term plan for the Data Management and Communications (DMAC) subsystem of the U.S. Integrated Ocean Observing System (IOOS, the U.S. contribution to GOOS) has been prepared, including governance mechanisms and detailed cost estimates to implement and maintain this subsystem[29]. This plan creates a virtual system by providing a framework for interoperability among independent, distributed and heterogeneous data management programmes and activities. It builds on existing data management activities and best practices, and lays the foundation for transitioning these capabilities to a truly integrated, yet highly distributed network using a common data communications infrastructure. The plan describes the proposed architecture for the DMAC subsystem; provides a technical focus on interoperable data delivery, access and archival; and proposes a detailed development time line with cost estimates projected over 10 years.

Action 4.10: The DMWG should monitor the development of OBIS and the U.S. DMAC subsystem for lessons learned, to integrate OBIS into the DMS infrastructure, and to determine which aspects of the U.S. effort can be scaled up to help build the global infrastructure for the DMS of the coastal module of GOOS.

28 http://www.iobis.org
29 http://dmac.ocean.us/dacsc/imp_plan.jsp

5. Implementing the Modelling and Analysis Subsystem

The coastal module of GOOS will efficiently link observations (Chapter 3) to applications through integrated data management (Chapter 4) and modelling. Apart from serving raw data, all of the products generated by the coastal module will come from models of various kinds. Given that GOOS is 'user-driven', its success ultimately depends on an effective modelling and analysis subsystem.

The term "model" is used here to include simple rules of thumb (e.g. for converting biological-indicators measured using Rapid Assessment of Marine Pollution (RAMP) – into measures of public health risk), algorithms for converting measurements into meaningful quantities (e.g. empirical schemes – algorithms – for converting ocean colour into chlorophyll a concentration and primary production), geographic information systems, and numerical models (e.g. physically-based numerical models that can forecast three-dimensional velocity, temperature and salinity fields, with associated nutrient concentrations and plankton fields) (IOC, 2003, Chapter 5).

For the most part, models are mathematical tools for analyzing, synthesizing and testing our understanding of the dynamics of complex systems through retrospective and predictive calculations. Models are needed to develop and enhance understanding, quantify descriptions of processes, synthesize and consolidate knowledge, establish interactions between theory and observations, develop predictive capabilities, and simulate scenarios of past and future developments (Fennel and Neumann, 2004). The function of operational modelling in GOOS is similar to the long-established processes of numerical weather prediction carried out by meteorological offices. Models have been used operationally for several years to forecast tides, sea ice, storm surges, wave height, currents, and a few other variables, notably in coastal and shelf environments.

This chapter presents an implementation strategy for modelling and analysis subsystems on both regional and global scales. Section 5.1 recommends the establishment of community modelling networks as the primary mechanism for model development, and section 5.2 recommends actions to facilitate and coordinate modelling and analysis activities within and among regions and globally.

The development of regional modelling and analysis subsystems, and their integration into a global system, will be enabled by the formation of a Modelling and Analysis Working Group (MAWG) under the auspices of the GRAs. In collaboration with the GRAs, the MAWG should formulate guidelines for developing the modelling and analysis subsystem, promote the establishment of common standards, define metrics and encourage pilot projects. This section recommends an action plan for the MAWG.

Action 5.1: The GRAs as a group (e.g. the GOOS Regional Forum) should establish a modelling and analysis working group (MAWG) to implement actions such as those recommended below.

5.1 Community-Based Modelling

Measurements are given added value by further analysis in a structured way, including data assimilation into dynamic models. Models are used to analyze and synthesize data generated from measurements (both in situ and remotely sensed observations) to (i) provide estimates of past and present distributions of variables and associated errors at a finer spatial and temporal resolution than the original observations; (ii) initialize and update models for improved predictions and estimates of uncertainty (IOC, 2003, Chapter 5), (iii) combine variables into parameters indicating states or characteristics which have not actually been measured directly; and (iv) develop, test and validate new model software and design. Models are the basis for the majority of products delivered to users

Model outputs include spatial representations of past (hindcasts), present (nowcasts) and future (forecasts) states of the coastal ocean. In addition to being valuable in themselves, model outputs are often used as the basis of risk analyses, decisions to issue alerts, and other services. Modelling capabilities vary among regions. For example, EuroGOOS has developed sophisticated operational models that routinely generate and disseminate products for users including forecasts of waves, tides, storms surges and surface currents. In other regions, such capabilities do not exist at all. Routine coastal modelling now is conducted in many regions of the globe, including within the NEAR-GOOS, off the Australian coast, in the Mediterranean Sea, and in areas off the USA.

5.1.1 Community Modelling Networks (CMNs)

In order to fully utilize coastal measurements, exploit the best existing operational models, build the modelling and analysis subsystem, and generate products, Community Modelling Networks (CMNs) are needed. CMNs should involve research programmes such as LOICZ, GLOBEC, GEOHAB and IMBER; Large Marine Ecosystem Programmes; national GOOS programmes, GRAs, and other bodies as appropriate. The formation of CMNs will lead to the following positive results:

- Provide a common voice when specifying requirements for offshore boundary conditions from deep ocean models (OOPC), atmospheric forcing fields (JCOMM), terrestrial inputs (GTOS), and satellite products (satellite developers and operators);
- Define generally accepted, standard measures of model performance and user satisfaction (i.e. internal and external metrics);
- Share modelling expertise and development of community software (models, and assimilation, visualization and coupling code) thereby avoiding duplication of effort. Note that the typical time for a model to reach operational status is of order 10 years and the required resources are usually beyond those of any one organization. Similarly the development of robust code to assimilate some of the new data streams (e.g. HF radar measurements of surface currents, surface colour, in situ measurements from AUVs) is challenging and will require the efforts of a many experts;
- Share computer resources; and
- Accelerate development of modelling and analysis subsystems for new GRAs and capacity building (through, for example, exchange of personnel, training courses, summer schools and workshops).

Action 5.2: The MAWG should work with GRAs, LOICZ, GLOBEC, GEOHAB, IMBER, Large Marine Ecosystem Programmes, and other bodies as appropriate to encourage and guide the development of CMNs focused on regional needs, technical problems and products.

5.1.2 Community Modelling, Assimilation and Visualization Software

No single model can satisfy all user needs. The range of applications, and local differences in coastal ocean conditions, are simply too varied. In fact it can be argued that a wide range of coastal models is essential for meaningful model assessment and the generation of realistic envelopes of model predictions that properly allow for model uncertainty. Community software for a wide range of models will be essential if such inter-comparisons and ensemble forecasting is to be undertaken.

A strong case can be made for the development of free, robust, readily available software that is documented with version control, quality assured, maintained and upgraded by permanent teams of professional software developers, i.e. community software (Hallberg et al., 2004). There are many examples of community models for the physical state of the ocean (Box 5.1). Community software also exists for other applications (e.g. Fishery Stock Assessment, Box 5.2 and ECOPATH with ECOSIM for ecosystem modelling). Some biological models are widely used (e.g. the nutrient-phytoplankton-zooplankton model of Fasham et al., 1990), although often software is not readily available and/or well-documented and/or maintained. EuroGOOS published an analysis of modelling and bio-ecological observations in operational oceanography (Fischer et al., 2000). In addition to model code, there is also a need for community software that includes schemes for assimilating data (e.g. HF radar estimates of surface currents and waves, in situ measurements from gliders and AUVs), helping to optimize the design of observing systems, for visualizing outputs of models and data analysis activities, and for coupling different kinds of models (e.g. physical and ecosystem models) and data assimilation modules.

There are at least two ways that the MAWG could help both new and established GRAs with community modelling: (i) prepare and periodically up-to-date an inventory of community models, assimilation and visualization software, and (ii) encourage the development of new community software, particularly for non-physical products. This could be achieved through the activities of CMNs.

Action 5.3: The MAWG should work with community modelling networks to promote access to (through a web-based inventory) and development of freely available and well-documented models and software for data assimilation and visualization. Particular attention should be paid to the development of community software used to generate nonphysical products (e.g. forecasts of changes in ecosystem states) and of generic assimilation software for biological data.

BOX 5.1. COMMUNITY OCEAN CIRCULATION MODELS

The World Wide Web provides access to information on many ocean circulation models ranging from primitive equation to quasi-geostrophic, from regional to global, and from single- to multi-processor. A sampling of such models is given below.

- Bergen Ocean Model – A 3-dimensional hydrodynamic, multi-purpose model for coastal and shelf seas that resolves mesoscale and seasonal scale processes and is coupled to biological, resuspension and contaminant models. The mathematical basis for the model represents the fields of velocity, pressure, density, salinity and temperature as governed by momentum, continuity, and conservation equations. The model applies finite differences on a staggered grid with a vertical sigma-coordinate representation. (www.mi.uib.no/BOM/).
- Hybrid Coordinate Ocean Model – An isopycnal model in the open, stratified ocean that smoothly converts to a terrain-following coordinate in shallow coastal regions and to z-level coordinates in the mixed layer or unstratified seas. (http://oceanmodeling.rsmas.miami.edu/hycom/)
- Modular Ocean Model – A primitive equation, general circulation model last updated in 1996. (www.gfdl.noaa.gov/~fms/pubrel/j/mom4/doc/mom4_manual.html)
- Ocean Parallelise Model – A primitive equation model for both regional and open ocean circulation. It is intended to be a flexible tool for studying the ocean and its interactions with other components of the earth climate system. (www.lodyc.jussieu.fr/opa)
- Princeton Ocean Model – A sigma coordinate, free surface, primitive equation model that includes a turbulence sub-model. The model has been used to model circulation of estuaries, coastal regions and the open ocean. (http://www.aos.princeton.edu/WWWPUBLIC/htdocs.pom/)
- Regional Ocean Modelling System – A free-surface, hydrostatic, primitive equation model that uses stretched, terrain-following coordinates in the vertical and orthogonal curvilinear coordinates in the horizontal. (http://marine.rutgers.edu/po/index.php?model=roms)
- Terrain-following Ocean Modelling System – An activity to develop, evaluate, test and provide support for developing terrain-following (sigma) ocean circulation models. The web site provides useful resources for the ocean modelling community including supporting analysis codes, data assimilation, and updates on the future modelling system currently under development. (www.aos.princeton.edu/WWWPUBLIC/htdocs.pom/TOMS.htm)

BOX 5.2. COMMUNITY SOFTWARE FOR FISHERY STOCK ASSESSMENT

The need for standardized software tools for evaluating the status of fishery resources and to predict the effects of alternative management actions has led to the development of a number of community models. Models are used both to identify the common state variables and to project future states of the system (IOC, 2003, Chapter 5). The models employed can be classified into those that provide hindcasts and nowcasts for resource populations (for example, various forms of sequential population analysis), forecasting and projection models, and those that are used to estimate Biological Reference Points – targets and limits to exploitation – for fishery resources. A representative source location for software to meet these needs can be found at the website for the International Council for Exploration of the Sea[30]. An inventory and brief description of some of the individual software packages is provided below.

ADAPT A combination of traditional virtual population analysis and statistical procedures to estimate model parameters from tuning data.

AMCI A flexible assessment model combining information from various sources.

FISHLAB A set of fisheries tools in the form of Excel add-ins and functions as well as routines that can be called from Visual Basic. Standard assessment methods are provided as well as routines to allow the evaluation of management under uncertainty.

ICA A statistical alternative to virtual population analysis.

MLA Marine Laboratory in Aberdeen. Programs for medium-term projections.

MSFPY A multi-fleet deterministic short term and long-term projection program

MTAC Takes the single-species advice for each species in the fishery as a starting point, then attempts to resolve these into consistent catch or effort advice using fleet-disaggregated catch forecasts in combination with explicitly stated management priorities for each stock.

Pasoft Precautionary Approach software which can calculate various biological reference points

VPA Virtual Population Analysis. The Lowestoft suite of VPA programs, like XSA and Seperable VPA

Other software compilations for fishery stock assessment have been made available over the World Wide Web through the Food and Agriculture Organization of the United Nations[31] and other groups.

30 http://www.ices.dk/datacentre/software.asp
31 http://www.fao.org/fi/statist/fisoft/fisat/index.htm

Action 5.4: Pilot projects should be initiated to accelerate the development of community models and metrics related to ecosystem forecasting, including ecosystem-based management of fisheries and water quality. Projects should build on or contribute to current efforts such as those associated with Large Marine Ecosystem Programmes and with regional coastal ocean observing systems (e.g. the Mediterranean Forecasting System, the Marine Environment and Security for the European Area (MERSEA) Programme, or the Gulf of Maine Ocean Observing System).

5.2 Developing and Improving Regional Modelling Capabilities

This section recommends a procedure for developing new operational models and improving existing ones. These advances will benefit both research and the operational capabilities of the modelling and analysis subsystems for regional coastal ocean observing systems. The process should be linked to that described in Chapter 3 for the development of measurement subsystems for regional coastal ocean observing systems, and it should be repeated periodically.

Step 1: Establish CMNs to promote model development (including the incorporation of uncertainty into models to make more useful, probabilistic predictions) and testing via pilot projects. Objectives are to determine capabilities in the region and set research priorities for improving existing operational models and developing new models. Engaging user groups in the process of assessing operational models against data and information requirements should be a high priority from the start. In order to make this assessment realistic the users consulted should be drawn from the community of experts concerned with data assimilation, model code development, and value-added organizations who use the output from models to create new products.

- Identify and engage users to specify data and information needs. The Users' Forum recommended in Chapter 3 to specify observing subsystem requirements should be expanded to include identification of modelling needs and the specification of requirements for model outputs and associated errors by involving the appropriate community of experts
- Inventory and assess existing modelling capabilities. Before proceeding with a new modelling or analysis activity, assess current modelling capabilities and their data requirements regionally and globally; classify models in terms of their stage of development from research to operational (Chapter 1, Section 1.5); and identify gaps that exist in modelling and analysis capabilities.
- Specify data and information requirements. Begin the process described in Chapter 3, 3.1 to determine if model requirements for observations are met.
- Compare and select models. In many cases there will be more than one model or method of analysis that can be applied to a particular problem. There might also be community and commercial software available (see section 5.2.1) that will greatly enhance modelling and analysis and circumvent the need to develop software from scratch. CMNs should be used to promote model development and comparative analyses through pilot projects within and among regions. This will accelerate the development of operational modelling capabilities.

Step 2: Implement pre-operational projects to evaluate model outputs in terms of their usefulness to users.

- Assess model performance. Once a model or method of analysis is being used routinely to generate results, the ability of the model to achieve its stated objectives must be assessed. Analysis and modelling results must be compared with standardized measures that allow developers and users to determine if model results are consistent both internally (section 5.2.3) and with other modelling studies (section 5.2.4).
- Evaluate products. When modelling or analysis is producing products that address the stated objectives, the product usefulness and appropriateness need to be evaluated by the users and clients. This could result in changes to the model or the analysis approach, or it could cause the objectives to be revised. GSSC will help with this step by providing a set of standardized external metrics that will measure user satisfaction (section 5.2.4).
- Enhance: The end products from modelling and analysis should be enhanced in a number of ways. These might include, for example, technical enhancements that increase the speed and efficiency at which products are delivered, improvements to user interfaces, or improvements to the underlying model and analysis approach.

Step 3: Begin operational use and periodic performance evaluations (Chapter 8).

5.2.1 Inventory of Coastal Models

An inventory of coastal models and their characteristics that are updated periodically will be useful to nations and GRAs interested in establishing modelling subsystems. Such an inventory will also be useful to individual researchers and the users of model products. Conducting the inventory will be a non-trivial task and must be carried out by groups of experts working with members of the MAWG.

In addition to listing the models and corresponding web sites (URLs), the usefulness of the inventory will be enhanced by including independent assessments of the predictive skill of the models and their operational status (i.e. research and development, pilot, pre-operational, or operational). Examples of model applications (published papers, practical applications, operational use) and plans for model enhancements also will be useful.

The range of coastal models is very wide and it will be necessary to inventory classes of models in a sequential way perhaps starting with the physically-based models. The classes could be based on applications.[32] Useful commercial software has been developed for many applications and these should be included in the inventory. The

32 Applications include, for example, forecasting harmful algal blooms, assessing the status of living marine resources, ecosystem-based assessments of the sustainability of fish stocks, forecasting the three dimensional physical state of the coastal ocean, estimating chlorophyll-a from remotely-sensed ocean colour.

IOC has begun developing an internet-based resource on ocean remote sensing sensors, data, education, and ocean models.[33] This website should be expanded to include the inventory described above.

Action 5.5: The MAWG should work with the research community (through programmes such as LOICZ, GLOBEC, GEOHAB, and IMBER), the Large Marine Ecosystem Programme, with the JCOMM Services Program Area, and with regional and national operational agencies, to develop and maintain an up-to-date inventory of coastal models organized by application. The MAWG should also recommend measures of model skill and operational status and ensure the inventories are readily available via the web. Commercial and non-commercial models should be included in the inventory.

5.2.2 Data Needed for Coastal Models Falling Outside the Scope of GSSC

In addition to measurements from regional coastal ocean observing systems and the GCN (Chapter 3), coastal modellers need access to data sets that provide atmospheric forcing fields (e.g. wind and air pressure), land-based inputs (river flows and associated inputs of nutrients, sediments and contaminants), and open boundary conditions that can be provided by deep ocean models (IOC, 2003, Chapter 5). High-resolution and accurate bathymetries and, in some instances surficial sediments and coastal orography, are also of great importance to coastal modellers. The availability of such data, which are not currently among the common variables (and their real-time access in some cases), will be a challenge for some regions and will require capacity building (Chapter 6) of both expertise and communication networks (Chapter 4). Therefore, an inventory of data types and sources with web links to them should be developed and updated to enable rapid access (e.g. 'one stop shopping') for coastal modellers needing data that are not served by the GCN or regional coastal ocean observing systems. This will require collaboration with a number of groups, including JCOMM for oceanography and marine meteorology variables, WMO for atmospheric products, OOPC for open boundary conditions, GTOS for terrestrial inputs, and the IGOS Coastal Theme Team for remotely sensed data.

Action 5.6: The MAWG should establish routine and sustained exchanges of information and requirements with JCOMM, OOPC, GTOS, and the IGOS Coastal Theme Team and maintain an up-to-date inventory of the additional data sets required by coastal modellers. The MAWG should also facilitate the development of data transfer links as needed. A pilot project could be initiated to identify and resolve issues related to real-time data flow for models in a developing region, e.g. MILAC (Chapter 7).

5.2.3 Model Validation and Inter-Comparison: Internal Metrics

A set of measures must be defined to measure unambiguously the quality, internal consistency and skill of model predictions. Such 'internal metrics' are essential for meaningful model comparison exercises, quantifying model performance, accelerating model improvement and developing more useful and reliable products.

The GOOS/OOPC (through the GODAE pilot project) has been developing a set of internal metrics for open ocean forecasting. They have found it useful to define classes of metrics based on (i) standard grids, levels and integrals thereof (for model-model inter comparison), (ii) observation locations and transects (for model-observation comparison), (iii) forecast fields and higher-order assimilation statistics (to assess the model's interpolative and prediction skill). The experience of OOPC will be very useful to MAWG as it starts to develop internal metrics for coastal ocean applications. Following the lead of deep ocean and tidal modellers, it may also be worthwhile defining standard test cases for some classes of model thereby allowing straightforward and quantitative comparison of models.

Action 5.7: The MAWG should work with community modelling networks to define internal metrics that will measure the quality, internal consistency and skill of the main classes of coastal models. The MAWG could also consider defining standard test cases. The group should build on the experience gained by other groups who have already developed similar measures for other types of models (e.g. OOPC/GODAE for deep ocean models).

33 http://ioc.unesco.org/goos/Remote_sensg/index.html

5.2.4 Quality Control and Assurance and User Satisfaction: External Metrics

The output of coastal models must be quality-controlled before distribution to users. Many methodologies exist to assess numerical weather predictions and new methodologies are being developed to assess deep ocean model forecasts. Operational agencies in many countries have been providing forecasts of sea state physical parameters to offshore engineering companies, oil and gas producers and their sub-contractors, and to insurance and registration agencies. The liability for mistakes in these conditions are considerable, and the model accuracy and errors must be understood and conveyed to the customer. Quality assurance and quality control methodologies should be developed by Community Modelling Networks (see 5.2.6) in collaboration with the MAWG for approval by the sponsoring organizations of GOOS and JCOMM.

A set of 'external' metrics is needed to assess user satisfaction with the products generated by the coastal models. Such metrics will promote meaningful user feedback to the Community Modelling Network and global modellers, and thereby encourage the development of more relevant products. In general one can anticipate that external metrics will be harder to define than internal metrics and will require close collaboration with the user community. In some cases the metrics may be semi-quantitative (e.g. measures of user satisfaction, impact).

In addition to the timely dissemination of products to users, it is important to emphasize that a mechanism for receiving and responding to user feedback should be included in the design of operational systems.

Action 5.8: The MAWG should work with GRAs, Large Marine Ecosystem Programmes, and other bodies as appropriate to define a set of external metrics that will facilitate quality control and quality assurance and measure user confidence in, and satisfaction with, coastal model products.

6. Developing and Improving Capacity

A fully integrated GOOS that addresses all six societal goals can be achieved only by improving coastal observing and reporting capabilities globally. Thus, capacity building, especially in the developing world, is a high priority for implementing the coastal module and will be a major focus of GSSC. Capacity building is needed on two related fronts: (1) enabling nations and GRAs in different stages of economic development to establish coastal ocean observing systems with the related infrastructure and to benefit from data and information provided by GOOS and (2) developing new technologies and models through research that can be used to improve the operational capabilities of regional coastal ocean observing systems and the GCN. To these ends, participating nations must recognize the need for long-term, continuous commitments to building and sustaining national and regional capacity world wide through the following:

- Develop diverse approaches that include a broad range of activities from training courses to the installation of observing system infrastructure with sustained training programmes;
- Establish mechanisms that enable scientists, operational environmental agencies, engineers, socio-economists, and users to work closely together (learning by doing, teaching the teachers) in the execution of projects, programmes, and partnerships;
- Tailor programmes to specific national and regional needs as determined by the recipient countries and GRAs;
- Ensure that recipient nations and GRAs contribute to their own development;
- Enable timely delivery of data and information to recipient nations and regions;
- Through research and development, close the gap between capabilities for near real-time detection of physical and biogeochemical variables;
- Develop partnerships among governments, international organizations, private sectors, NGO's, technical experts and donors to finance and build capacity; and
- Increase national and international support through public and political awareness programmes that highlight the need for and potential of integrated and sustained ocean observations and predictions.

Key issues related to these activities have been identified by JCOMM and GOOS.[34] GSSC is expected to work with the GOOS/JCOMM Capacity Building Programmes and the GRAs to (1) set priorities for capacity building in each participating country and GRA, (2) plan and promote capacity building activities (training, building infrastructure, outreach to the public and government agencies) for measuring and processing (data management and analysis) non-physical variables, and (3) promote sustained investments to support these activities.

34 The project should be closely related to requirements of user sectors based on national or regional surveys; (ii) the project should build as much as possible on existing facilities and capabilities in the nation or region; (iii) the project should be nationally or regionally owned and promoted; (iv) the potential for a joint project with industry might be explored, particularly in the context of possible industry interest in emerging markets; (v) the project should be presented as an integrated whole, but with multiple components and uses, which would allow presentation to, and potential funding by, a number of donor agencies; (vi) dialogue between recipient countries, capacity providers, and potential donors should begin as early as possible in the project development process; and (vii) the project should be structured and focused with regard to potential donor objectives, including justification of the project aims and requirements in terms of those donor objectives.

A high priority is to initiate cooperative projects with GRAs that have focused, attainable objectives and will leave a legacy of sustained observations, data management, and/or analysis systems serving the regional common need. To the extent that this process is driven by stakeholders from the targeted region or country, has commitments from participating governments to sustain the observing systems once established, and is guided by partnership between providers and recipients, regional approaches will be more cost-effective than attempting to build capacity on a global scale from the beginning.

Action 6.1: The GRAs as a group (e.g. the GOOS Regional Forum) should establish a capacity building working group (CBWG) to ensure that local and regional needs are met by national and international capacity building efforts and to implement actions such as those recommended below.

6.1. Capacity Building in the Developing World

Capacity building is the key to the implementation of COOP and great attention needs to be given to this activity especially in the Developing world. Partnerships between developed and developing nations (as illustrated in Box 6.1) need to be arranged and streams of continuing funded need to be identified.

Action 6.2: The CBWG should advise the GOOS-JCOMM Capacity Building programme on the establishment of protocols for nations and GRAs to implement, operate and improve regional coastal ocean observing systems based on their own priorities.

6.1.1 Procedures for improving capacity

It is essential to develop mechanisms for identifying deficiencies in the ability to contribute to or benefit from the coastal module of GOOS, and then to create mechanisms to remedy them, and promote implementation.

BOX 6.1. PARTNERSHIP BETWEEN THE UNIVERSITY OF GOTHENBURG (SWEDEN) AND EAST AFRICAN MARITIME INSTITUTIONS

A promising means of capacity building is to promote partnerships between institutions in developing and developed countries to enhance scientific, technical and analytical capabilities and sustain a strong and continuing relationship. A good example of this is the partnership between the Department of Oceanography at Gothenburg University in Sweden and the East African maritime countries during 1992 – 1998. Promoted by the Swedish International Development Agency (SIDA), a comprehensive two-year MS programme in physical oceanography was launched in 1992. The programme consisted of intensive lectures at the Department of Oceanography, Gothenburg University for periods of three months each year. In between, the participants carried out fieldwork and thesis writing in their respective home countries. All participants were employed at a marine institution at home, either at a university or at the local Fishery Board. Courses were conducted in 1992, 1995 and 1998. Out of 20 participants, 16 finished and obtained their diplomas in Gothenburg. Of those who finished, six were from Kenya, three from Mozambique and two from Tanzania. The other students were from outside East Africa, mainly Sri Lanka. Some of the graduates were accepted for PhD studies within the Regional Program. Institutional contacts that were established are considered to be of major importance. In Kenya, all six participants are active at the Kenya Marine and Fisheries Research Institute (The Fishery Board) in Mombassa. Others are at UEM in Maputo and IMS and TAFIRI of Tanzania. So far, none of the graduates have left their home countries. The key factor here is continuous contacts through research and efforts to start up local education programmes in the recipient countries. In Sri Lanka, the University of Peradenyia is, for the second year running an MS course with ten participants. A similar course is planned to start at UEM from next year. With financial support, it should be possible to initiate graduate coursework also at other universities within the region.

First, using the guidelines recommended in Chapter 3 (section 3.1, Annex II), each region should prioritize data and information requirements based on socioeconomic needs (perhaps by sectors, e.g. tourism or fisheries). Then, existing infrastructure and skills should be assessed to determine gaps or deficiencies in the capacity to meet those requirements. These may include inadequate infrastructure for observing (platforms, instruments, data transmission) and managing data, trained personnel (technicians, scientists, managers, etc.), and funding for sustained observations. Agencies responsible for safety at sea, coastal flood defenses, fisheries regulation, public health etc., are not always those with a strong component of science or research. The strengthening of infrastructure and training often needs to be focused on these agencies, as well as in improving scientific capability. Throughout this process, GRAs should collaborate with other GRAs to compare experiences and learn from each other. The next step is to identify an appropriate capacity building programme or entity with the expertise and willingness to work with the region to build the needed capacity. For capacity building to be effective the anticipated benefits must match the expectations of the donor. Then, the provider and recipient must work with a facilitator (e.g. Partnership for Observation of the Global Oceans (POGO)) to develop plans that meet the requirements of all three partners (recipient, provider, and facilitator).

Pilot projects are of critical importance in this process.

Action 6.3: The CBWG should work with GRAs to design and implement pilot projects that will enable capacity building to establish sustained coastal ocean observing systems worldwide, especially in those regions that lack the resources to develop such systems.

Action 6.4: The GOOS-JCOMM Capacity Building Programme should establish centres of technical support at existing institutions that will provide advice and have the ability to send technicians to the recipient country or GRA to facilitate the deployment of new instruments and troubleshoot problems with existing infrastructure. This will serve as a common facility to underpin all GRAs (or the GCN). For example, the University of Hawaii has a 3-person technical team that services large set of tide gauges in the Pacific. The funding initially should be viewed as lasting for approximately 10 years, with the possibility of evolving to a self funded "community technical team."

It is important to develop training programmes that target measurement of as many of the common variables as possible, supplemented with those needed for regional enhancements (e.g. detection of ciguatera in reef areas). Such programmes should develop easy-to-apply and practical protocols for key products. Development of custom-made training courses for coastal observing system products is one way of achieving this. An example of this is the POGO/SCOR courses on ocean colour that are held annually in South America.[35]

Because of the modular structure of GOOS, the GRAs and national GOOS programmes will be the primary vehicles for capacity building. Thus, it is critical that these bodies continuously evaluate the needs for maintaining a cost-effective technical workforce and engage government agencies, universities and private sectors in providing and applying data and information from GOOS and in securing sustained support for these activities.

6.1.2 Attracting funding for capacity building

Funding for most capacity building programs in oceanography come at present from organizations such as IOC, UNEP, World Bank/GEF, POGO, philanthropic foundations and nations through bilateral and multilateral agreements. All of these resources must be used and more developed. One approach would be to encourage investments in capacity building from revenues derived from the marketing of GOOS products or from economies achieved through the use of data and information from coastal ocean observing systems. For example, even a small fraction of the millions of dollars saved by timely forecast of extreme events like tropical cyclones could go a long way in strengthening capacity within a region prone to these impacts. It is necessary to identify other potential users of coastal products from sectors, such as tourism, fishing, maritime transport, and prospectors in coastal areas and to convince them of the need to contribute to capacity building to improve their bottom line and the quality of services offered to them. The objective is to increase funding from user groups

35 http://ocean-partners.org/fellowshipb.html

while sustaining investments made by conventional funding organizations.

Capacity building is also needed in the infrastructure, communications, instrument maintenance, and data management within national operational agencies. This type of support could come from equivalent operational agencies in developed countries, or through their international bodies. This would also take some of the funding strain off the science research budgets.

Several examples for the "user pays" concept already exist. Notable among them are Ducks Unlimited[36], a non-profit organization that raises funds for habitat protection. The Galapagos Islands collect revenues from tourists and use them for environmental protection[37]. Some countries tax sport fishing and other related activities to support ecosystem-based monitoring and protection. Tourism, fishing and diving at the Turneff Atoll in the Caribbean (Belize) are taxed this way. Turneff Flatts commits 1% of the revenue to organizations promoting conservation and sustain coastal marine habitats such as the Turneff Atoll[38]. Also some countries charge fees for access to state and national parks to pay for environmental protection. For example, the Australian Government imposes a reef tax of $ 4 Australian per person per day which goes towards research and protection of the Great Barrier Reef[39].

Given that economies made are equivalent to funds generated, existing training programs need to be reviewed to make them more effective in helping to build coastal GOOS. For example, many nations or institutions conduct regular in-house or intra-country training programs on various marine subjects. Alignment of the curriculum of these courses to address capacity building needs of coastal GOOS could alleviate the need for, and hence additional expenditures on, separate capacity building activities.

NGOs should be asked to help identify sources of funds. For example, NGO's such as the Surfrider Foundation[40] are likely to be interested in more accurate and timely information on beach, water quality, and wave conditions. An initial conference with global NGOs could be organized to develop a strategy for continuing dialogue, outreach and support. A resolution of the time frame of interest is important as CB is a long-term process and the NGO needs tend to be more immediate.

Many marine commercial activities such shipping, tourism, or offshore oil and gas have national and international trade associations. These bodies organize conferences, exhibitions, and lobby for their common interests. In all such cases an efficient operational service such as Coastal GOOS would improve their productivity, reduce accidents and loss of life or property, and make it easier to comply with regulations. Such bodies should be approached for capacity building support in the countries where they operate.

Action 6.5: GSSC should lobby international donors (including the GEF) to fund partnerships between developing and developed nations to establish the GOOS infrastructure. (As an example, the GEF funding would cut across many LMEs and/or GRA regions, making it bigger than just one LME).

6.1.3 Regional Tool Kits for Capacity Building

Toolkits are important as resources of self-teaching, support for operational activities and interactions with user communities. Many toolkits pertinent partly or wholly to the Coastal Module of GOOS are already available. The capacity building initiatives can specifically benefit from toolkits that are custom made for their use, such as Ocean Teacher[41]. Annex II of this document provides a set of tools that can be used to determine priorities within regions based on socioeconomic needs. The Integrated Strategic Design Plan for the Coastal Ocean Observations Module of GOOS provides a tool kit for determining variables to be measured based on scientific requirements[5].

The three volumes of the IOC Manual on sea level measurement and interpretation are perhaps the first set of comprehensive tools designed for use in coastal ocean observations. The IOC published the first volume in 1985 and the third volume in 2002. The 2002 volume provides updated material with a specific focus on enhancing capacity in sea level related activities for use by coastal GOOS and GLOSS. By providing extensive accounts of tide gauges and measurements in various parts

36 http://www.ducks.org
37 http://www.galapagos.org/about.html
38 http://www.tflats.com/fishing.html
39 http://www.aph.gov.au
40 http://www.surfrider.org/
41 http://ioc.unesco.org/oceanteacher/

BOX 6.2. A TOOL KIT APPROACH TO BUILDING CAPACITY – RAPID ASSESSMENT OF MARINE POLLUTION (RAMP) RAPID ASSESSMENT OF SOCIO-ECONOMIC INDICATORS (RASE)

Overview – The use and dissemination of Rapid Assessment Methodologies (RAMs) in the form of "tool kits" is a cost-effective means for improving operational capabilities for assessing the health of ecosystems and living marine resources and linking these assessments to socio-economic indicators. Adoption of RAMs may prove particularly important as a capacity building tool.

The Rapid Assessment of Marine Pollution (RAMP) and Rapid Assessment of Socio-Economic indicators (RASE) pilot project is intended to provide sensitive rapid assessments of contamination from discharges of sewage and chemical pollutants, as well as of physical stresses associated with land reclamation and development of coastal areas for tourism and industrial activities. The plan is to test this methodology in the Caribbean region after a capacity building exercise.

Products – Conduct a two year survey of RAMP variables in the Caribbean as a model for regional environmental assessment and develop the programme into a fully operational system in 2 years.

Project Description – RAMP has been designed to test and provide easy-to-use, inexpensive chemical and biological markers that can be used to assess pollution and improve environmental management. A RAMP pilot project was initiated in Brazil in 1997. RAMP's immunoassay-based tests provide an inexpensive, rapid and highly selective means of measuring specific chemical compounds and have been used to diagnose medical conditions for many years.
Specifics of RAMP can be found in the Strategic Design Plan for the Coastal module (IOC, 2003). In this capacity building exercise scientists will be trained providing they agree to include RAMP methodology in their own monitoring programmes. The Workshop will be held in Cave Hill Campus, University of the West Indies. The parameters tested will be: Acetlycholinesterase inhibition, lysosomal neutral red retention, metallothionein, spontaneous cytotoxicity and use of Elisa's to determine concentrations of contaminants.

Partners – National University of Mexico, University of the West Indies, University of North Carolina, University of Plymouth, Oceans Conservancy, University of Massachusetts-Boston as well as 10 other Caribbean laboratories. Participants will be trained in these specific methods for a one week workshop and then will incorporate these measurements into their own monitoring programmes. PAH, PCB's, organochlorine and organophosphorous pesticides, selected herbicides and fungicides have all been identified as relevant environmental contaminants/pollutants. Biomarkers used in the RAMP programme are simple to use, inexpensive and reliable. They provide a means of detecting deterioration in the condition of biota from contaminated sites. The data will be housed centrally at the National University of Mexico however all participants will compare the RAMP technology with the monitoring assessment presently underway. After 2 years, participants in this programme will be routinely using RAMP systems in the region.

of the world, this document (IOC Manuals and Guides No. 14) provides a synthesis of merits of the different technologies and paves the way for a unified approach that is critical to the success of the Coastal Module of GOOS. This manual comprehensively satisfies several of the GOOS requirements such as data acquisition, transmission, documentation of the process and exchange of data procedures and products. The manual also has a section on training and courses already held. This appears to be the "model" toolkit.

At a local level many aspects of capacity building can and should be started with training literature that already exists. As coastal GOOS grows, and especially as the GCN approaches fully operational status, a series of toolkits will be needed with the same global standardization as the IOC sea level manual.

Action 6.6: The CBWG should identify, develop and make available toolkits for building capacity for all three subsystems (observations, data management and modelling). Access to existing data streams should be a high priority, e.g. through CEOS, the space agencies should be asked to provide data for GOOS variables in a timely fashion through a user-friendly web site.

6.1.4 Inventory of current capacity building programmes

Although GOOS capacity building has been a priority for sometime, successes have been limited. This may reflect a lack of coordination and focus among the many capacity programmes in existence. To begin the process of coordinating and focusing capacity building activities relevant to GOOS, an inventory of these programmes and their programmatic priorities is needed. The review below is not comprehensive, but sets the stage for such an inventory and subsequent analysis.

Capacity building efforts are supported by intergovernmental organizations, international organizations, international NGOs, regional indigenous organizations, bilateral donor communities, commercial trade associations, and the private sector. Some exist in various programmes within the UN system, including, for example, those of UNEP, IOC/TEMA[42], and WMO[43]. Programmes occur regularly through universities and private institutions[44]. There are also many regional training programmes; the POGO[45] has begun capacity building with the aim of improving links between Northern and Southern Hemisphere organizations. The Train-Sea-Coast programme of the UN provides specific training for scientists and Environmental Managers, to name a few. This programme[46] is an inter-country cooperative training network composed of training/education centres in developing countries, countries in transition and developed countries. It aims at strengthening the capabilities of institutions and individuals having responsibilities in the field of coastal and ocean management. It is part of the UN TRAIN-X Network comprised of eight training programmes implemented by the UN organizations in different fields of specialization. Courses from Integrated Coastal Zone Management to Coastal Ocean Ecosystems have been developed and delivered.

Unfortunately, almost all training programmes in existence today have limited resources. Therefore, priorities must be established in terms of who they train (targeted groups) and what they are trained to do (high pay off locally). Successful appeals to funding agencies can only be possible if a strong case is made that will benefit the quality of life and coastal environment (livelihood, ecological security, health, marine safety). Priorities should be set to enhance an existing regional system or to develop a new GOOS pilot project with sustained capacity building as a major component. GSSC, in collaboration with GRAs, should work with the JCOMM/GOOS Capacity Building panel to set these priorities.

Action 6.7: GSSC, in collaboration with the GRAs, JCOMM and other capacity building organizations, should inventory existing capacity building efforts relevant to coastal ocean observations and their applications, review them and recommend a way forward that makes more effective use of their collective capacity building resources. This may include the identification of common gaps in tertiary-level education and training relevant to GOOS capacity building and the promotion of mechanisms to improve long-term capacity building.

6.2 Improving Operational Capabilities of the Coastal Module through Research

The coastal module of GOOS will require continued development of sensors, platforms, techniques, standards and reference materials, software and personal capital (trained researchers and engineers). As feasible, metadata in agreed format should be incorporated in new instrument design so that resulting measurement information includes the metadata. Capacity building in research and development of sensors, platforms and instrument design are as essential as with observational needs. Developed countries have the technological advantage in this respect and funding agencies like the Global Environment Facility (GEF) should be asked to provide support to them in developing instrumentation capacity through partnerships with developing nations. This could also take the form of capacity building in technical manpower like creation of a pool of travelling technicians to support sea-level measurements through

42 http://ioc.unesco.org/tema/iocGrants.htm
43 http://www.wmo.ch/web/etr/etrplink.html
44 http://www.bbsr.edu, http://www.bigelow.org/, http://www.mbl.edu/
45 http://www.ocean-partners.com
46 http://www.un.org/Depts/los/tsc_new/TSCindex.htm

BOX 6.3. REMOTE SENSING RESOURCE KIT

IOC has developed an internet based resource kit on ocean remote sensing sensors, remote sensing data, educational remote sensing material and ocean model software that may be of use in developing national and regional GOOS products (http://ioc.unesco.org/goos/Remote_sensg/index.html).

Among the resources is the UNESCO Bilko computer learning package in remote sensing that was originally developed under the leadership of Coastal Seas and Small Islands Programme but for which IOC now has resumed responsibility. The UNESCO Bilko project was initiated in 1987 under UNESCO's then Marine Sciences Training and Education Programme to develop training capability in coastal and marine remote sensing through a series of computer-based learning modules. Using a specially commissioned educational image-processing software package (Bilko) which was designed to operate on personal computers, the project has provided seven modules of computer-based lessons to over 500 marine science laboratories and educational establishments to about 600 individual users in over 70 countries around the world.

Each module is a self-contained package of the image processing software (Bilko), an introductory tutorial on how to use the software, lessons on the applications of remote sensing to oceanography and coastal management, satellite and airborne remotely sensed images to accompany the lessons.

The original objective of the project was to facilitate "hands-on" training in coastal and marine remote sensing for those traditionally excluded from such training by the high cost of commercial image-processing software, need for expensive computer equipment to run that software, difficulty of acquiring remotely sensed images for teaching purposes, long learning-curves required to master complex commercial software, and need to teach large numbers of students at the same time.

Some of these constraints have eased significantly since 1987 but collectively they still prevent access to such training in much of the world. The worldwide success of the Bilko project demonstrates the widespread demand for training in countries both with limited and advanced remote sensing capabilities.

As the project progresses, a global network of users is being developed with many of these users themselves becoming authors of lessons in subsequent modules. Such lessons have now been published from scientists in over 15 countries around the world.

servicing, maintenance and calibration of tide gauge hardware as well as provision of training to local staff.

One area where emphasis should be directed immediately is that of remote sensing. Proxies for biogeochemical parameters can be developed in many regional areas such as nitrate in upwelling areas and this could be developed into a global database. Also international groups such as SCOR should be encouraged to continue the development of new technologies for measurement of biological parameters (e.g. acoustics for determining zooplankton biomass) in the coastal zone that can be transferred to operational systems in nations and regions.

Acquisition of costly instruments does not necessarily mean improved data delivery, since these instruments often require a high level of technical skill for their maintenance and operation. Such sophistication may be unwarranted for some variables, and instead the instruments need to be made less expensive and more robust so that they can facilitate rapid data delivery. Techniques should be made simpler and easier in order to transfer technology. Nations should be encouraged to develop simple and easy methods that deliver information required by all countries and regions. Donor aid agencies should be encouraged to support the development of such methods and instrumentation appropriate to them.

Action 6.8: GSSC should serve as an advocacy group to direct these points to the attention of donor agencies through the JCOMM-GOOS CB Task Team for Resources.

BOX 6.4. TRAINING THROUGH RESEARCH (HTTP://IOC.UNESCO.ORG/TTR/GENINFO.HTML)

In operation since 1990, the Training-through-Research (TTR) programme combines the advantages of formal training for undergraduate and postgraduate students. The annual TTR cycle of activities includes:

- preparation of a cruise by the Executive and Scientific Committees under the TTR programme;
- the TTR cruise, with (when possible) a mid-cruise workshop and/or field excursion(s) for the participants and invited scientists;
- preliminary data processing, preparation and publication of scientific reports;
- a post-cruise conference to present and discuss the results of on-going analysis and interpretation of data, and to co-ordinate with other regional studies;
- preparation of scientific publications.

During 1991-2001, eleven major TTR cruises were conducted in the Mediterranean and Black Seas and in the northeastern Atlantic. Nine post-cruise conferences were held. A number of other field exercises (including smaller cruises), group and individual training activities, and presentation and publication of the research results were carried out. About 500 scientists and students from some 25 countries have participated in the cruises, mostly from around the North Atlantic, Black Sea and Mediterranean regions but some also from Latin America, the Middle East, and Southeast Asia. About one thousand people have been involved in TTR. It is open to all interested in making break-through research and gaining new experience through training in multidisciplinary science.

7. Developing the Coastal Module through Pilot Projects

Current operational capabilities of the GOOS are most advanced for those goals that require meteorological and physical oceanographic data (safe and efficient marine operations, forecasting extreme weather and associated phenomena such as storm surge flooding) and least advanced for those goals that require chemical, biological and ecological data. Operational services for physical variables already exist at the local and regional level for coastal regions in Europe, USA, Japan, SE Asia, Australia, and in offshore oil and gas sectors globally. Developing a coastal module of GOOS that provides data and information needed to achieve all six societal goals will require research and efficient use of new technologies and knowledge to improve operational capabilities of the coastal module. Pilot projects are critical to this process.

As described in the Strategic Design Plan for the Coastal Module (IOC, 2003), a pilot project is an organized, planned set of activities with focused objectives designed to repeatedly test, over a range of conditions, techniques and approaches that show promise as potential elements of the operational system. Pilot projects have a defined schedule of finite duration. Their purpose is to illuminate weaknesses, provide opportunities to address those weaknesses, permit a better understanding of how capabilities may be applied, and gain community acceptance of new techniques (from measurements to models). Proposed projects must specify (1) how successful completion will contribute to the development of the GOOS and benefit potential user groups; (2) objectives and milestones that can be achieved within a specified, finite period (e.g. less than 5 years); and (3) partners and procedures to be used to achieve the projects objectives.

Pilot projects may target specific elements of the GOOS (sensors, platforms, models, etc.) or the development of product-driven, end-to-end capabilities (improve an existing product or produce a new product). In many, if not most cases, pilot projects will be developed within a national or regional setting and, if successful, be adopted by other regions and/or scaled up for global deployment.

Pilot projects have important roles to play in developing operational capabilities both regionally and globally. To these ends, a set of pilot projects is proposed below that the GSSC may wish to consider promoting. Projects are labelled as “unfunded” if they have yet to be developed and funded and as “funded” if they are currently (2004) active and funded at some level.

Action 7.1: GSSC should review the pilot projects recommended herein; assess those that have been funded to determine their potential for incorporation into the GCN (or adopted by other regions); and identify those that should be promoted for funding as coastal GOOS pilot projects.

7.1 Building Capacity in the Developing World

7.1.1 QUIJOTE (Quickly Integrated Joint Observing Team) – Funded

Overview – QUIJOTE is a linking project, strengthening the capability of regional agencies, institutions and scientists in order to deploy an operational monitoring system in the South-Western Atlantic (Brazil, Uruguay and Argentina) that will provide data and information needed to achieve the six societal goals of the GOOS (http://www.cem.ufpr.br/fisica/quijote.htm).

Products – On line data on tides, sea state, and storm surge forecasts for the Southwestern Atlantic.

Project Description – The regional QUIJOTE Pilot project aims to serve as a linking system to strengthen marine sciences in the South-western Atlantic Ocean with specific focus on operational oceanography in the coastal zone. The main goal is to monitor, protect and forecast states of the coastal oceans of Argentina, Uruguay and Brazil. The observing system includes both meteorological and oceanographic sensors, and forecast services (e.g. surges and waves) are fully operational. The observing and forecasting system are being improved by increasing the density of observations (add sampling sites in the Amazon basin) and by increasing computing power for forecasting.

The project has four initial modules

- Beach-watch: monitoring beach erosion and its correlation with meteorological forcing in the South-Western coast of Atlantic Ocean.
- Estuarine-ocean connectivity: Bi-national agreement between Argentina and Brazil to monitor and exchange data on the condition of their estuaries and evaluate the effects of changes in ocean and riverine end members.
- Redsur network: establish a coastal information network on all the GOOS operational categories. The main product is an up to date news on coastal issues.
- Storm surge forecast system: forecast of the storm surge with a lead of 8 to 10 hours.

Partners and implementation mechanisms – Institutions in Argentina, Uruguay and Brazil. In Brazil, the group is growing with support from the national Millennium initiative which is establishing a permanent coastal observing network, including coastal met-ocean stations and real-time telemetry and display for the entire Brazilian coast, from the Amazon to the Uruguayan border. To complete the network, support for QUIJOTE Argentina and Uruguay is being sought.

7.1.2 Marine Impacts on Lowland Agriculture and Coastal Resources (MILAC) – Unfunded

Given the recent history of storm surge flooding and studies that suggest tropical cyclones may become more intense with global warming, there is an immediate need to improve the forecasting of storm surge flooding in low lying flood plains, especially in the tropics and subtropics, e.g. the Bay of Bengal. At the same time, advances in technology and modelling capabilities have made possible the establishment of prediction systems that can be implemented fairly rapidly with moderate levels of financing.

MILAC aims to enable nations and regions susceptible to tropical cyclones to predict (hindcast, nowcast and forecast) wind and wave fields and associated spatial and temporal extent of storm surge flooding. The emphasis on hindcasting or forecasting (and nowcasting) will be decided on the basis of a pre-study to assess existing resources and the socio-economic capacity of the nation or region. The initial system will be established over three years by building on existing resources of the nation or region. This will be developed into a more comprehensive, cost-effective system as additional resources become available. The form and modes of delivery of products and services will be determined through an agreement with natural disaster reduction (NDR) and mitigation bodies the region.

Products – There are 3 major products: (1) a socio-economic analysis of the impacts of storm surges on lowland agriculture and coastal resources, giving guidance to the next ‘product’; (2) a short term forecasting system in support of decision making i.e. provision of population evacuation, alternatively a hindcast/climatological study of historical events giving guidance to future planning of agriculture and land use, and (3) an interaction mechanism with ‘the society at large’, in particular the public and mechanisms for mitigation of natural disasters.

Project Description – MILAC can be installed in a GRA or country with a 3 year pilot project with the first year focusing on the establishment of an interim management organization, an analysis of existing capacity and socio-economic capabilities, and implementation of a baseline system consisting of freeware numerical models for hindcasting and/or forecasting to be tested and validated. The second year will build on year-1 by investing in required ocean observing networks to improve hindcasting and/or forecasting. System performance, including socio-economic impacts of MILAC, will be evaluated in the third year. Results of this evaluation will be used to improve the system and prepare for sustained operations.

Partners and implementation mechanisms – The MILAC system will develop in a regional to national framework with inter-regional and global coordination occurring through collaboration of GTOS, JCOMM, GLOSS, the WMO Commissions for Agricultural Meteorology and Hydrology, the Tropical Cyclone Programme, and entities within the International Natural Disaster Reduction (INDR). Inter-regional and global coordination is intended to ensure interoperability (e.g. timely exchange of data, knowledge and technologies among regions) and to provide assistance as requested and where possible. The partners would work together to facilitate coordination and promote funding from international sources. At the regional level, a "champion" nation would take the operational lead as set forth in a multi-lateral agreement that defines responsibilities of participating nations within the context of a business plan for MILAC development and financing. GRAs could provide the framework for this in those regions where they have been established.

7.1.3 Building End-to-End Capacity for Coastal GOOS (ANTARES) – Funded

The coastal waters of South America are important to global community in several ways. They are home to the largest tropical rainforest in the world, support a major global fisheries associated with the Peruvian upwelling, have a dramatic influence on the global climate when the intensity of coastal currents along the western coastal margins vary (El Niño) and are, in the recent years, also sites of oil and natural gas production (http://antares.ws). In South America the need to have a sustained coastal observing system, through which the nations would pool resources and sharing products, is of paramount importance. The goal is to establish an integrated network of in situ and remote sensing stations around the continent. This network would be called ANTARES.

Products – The initial products include an inventory of existing operational activities and their products and a reliable, spatially and temporally consistent series of images that show the state of coastal ecosystems around South America (temporal resolution – 1 week; spatial resolution 1 – 50 km pixels).

Project description – The long-term objective is to establish an operational observing system that provides the data and information needed to detect and understand the impacts of climate change and human activities on coastal ecosystems of South America through regional coordination and to provide an effective vehicle for training and capacity building for professionals in the region. Immediate objectives are to establish a South America ANTARES user forum, prepare initial designs with priorities for implementation, establish a data and information management system (data centres have already been identified in Argentina, Brazil, Chile and Venezuela), and develop community-based modelling activities (sharing of model codes and outputs, compare and validate models).

Partners – The initial partners include institutes in Argentina, Brazil, Chile and Venezuela. The goal is to involve institutes from all South American countries.

7.1.4 Global Patterns and Trends in Public Health, Socio-Economic and Resource Indicators – Unfunded

Overview – There are many indicators that currently exist (primarily as national indicators) and that can be used to document temporal trends and map "hot spots" in the domains of public health (e.g. the World Health Organization's Global Atlas of Infectious Diseases: http://globalatlas.who.int/GlobalAtlas), the environment (e.g. the Global Terrestrial Observing System's Terrestrial Ecosystem Monitoring Sites: http://www.fao.org/gtos/tems; the Census of Marine Life's Ocean Biogeographic Information System: http://www.coml.org/descrip/obis.htm), socio-economics (e.g. the World Resources Institute's Earthtrends: http://earthtrends.wri.org/) and living marine resources (e.g. the Sea Around Us Project: http://www.seaaroundus.org/). The use and usefulness of some of these indicators could be substantially enhanced on regional or global scales if they can be analyzed across disciplines. To achieve this, common standards and protocols will be needed for both inter-comparisons and for scaling up locally or nationally specific indicators to be indicative of regional and global patterns.

Furthermore, given the large number of indicators that have been developed and the need for a relatively small set of internationally accepted indicators that meet established common standards, high priority should be given to developing a short list of high priority indicators (Chapter 1).

Many of the data required to calculate these indicators are available through existing data portals, but they are not available in one place (for "one stop shopping") or in compatible formats for use in GIS, or statistical and risk analyses.

Products – An integrated data management and visualization system for a selected set of indicators representing the following broad categories:

- Global burden of disease (e.g. reported cases of cholera in specified years)
- Land use and land cover (e.g. distribution of human settlements at the coast)
- Human population density (e.g. persons per unit area in coastal zones)
- Socio-economics (e.g. role of fish in protein supply per region per year)
- Fisheries (e.g. fisheries landings of piscivorous fish by region and year)
- Aquaculture (e.g. extent of aquaculture production per region and year)
- Biodiversity (e.g. species richness by region and decade)

Description (objectives and duration) – This partnership project should collate information on available global indicator data sets relevant to the six societal objectives of GOOS. An initial, small, tractable set of indicators should be identified, reflecting the phenomena of interest. The project should co-ordinate the development of software to allow the data to be plotted on common global or regional maps, and facilitate the adoption of data formats that ease this process. The expected duration of an initial pilot phase is 3-5 years, with the likelihood of subsequent activities.

Partners and implementation mechanism – In this pilot project, a close co-operation is required among groups that maintain and update existing databases and meta-databases (e.g. Global Terrestrial Observing System, World Health Organization, Food and Agricultural Organization, Census of Marine Life, Sea Around Us Project, World Resources Institute, United Nations Development Programme). A forum should be established to identify an initial set of indicators from different disciplines, which together will address the societal objectives of GOOS. Once the indicator set has been identified, a technical group should collaborate on developing and/or enhancing the software required for visualization, and the associated preferred data formats.

7.1.5 SeagrassNet – Funded

Objective – Develop a better understanding of the status and trends of seagrass ecosystems worldwide. Monitoring of seagrass habitat around the world to develop a long-term comparable data set assessing baseline conditions and habitat change (http://www.SeagrassNet.org)

Products – Comprehensive reports on the status of seagrass beds and trends in changes, deduced by synchronous and repeated sampling of selected seagrass habitats and environmental parameters.

Project Description – SeagrassNet, a global Seagrass Monitoring Network, was established during the 3rd International Seagrass Biology Workshop in 1998 (Manila, Philippines) to function as the primary mechanism for serving the data and information needs of the World Seagrass Association (WSA) to promote research and provide advice to management agencies and the public on the protection and restoration of seagrass communities (Green and Short 2003). Objectives are to (1) develop an observing and reporting system to assess the status of seagrass ecosystems worldwide; (2) facilitate data and information exchange among scientists; (3) develop models to predict the effects of global climate change and human activities on seagrass ecosystems; and (4) enhance training and education and disseminate information on seagrass beds, their importance as essential fish habitat, their ecological significance, and their contribution to the well-being of human coastal populations. Quarterly monitoring of seagrass beds and environmental parameters from selected sites with a web-reporting database.

Partners – The programme is funded by the David and Lucille Packard Foundation, the Oak Foundation, Inter-American Institute for Global Change Research (IAI), IUCN, and NOAA. Collaborating countries include Australia, Belize, Brazil, Federated States of Micronesia, Fiji, Indonesia, Malaysia, Mexico, Palau, Papua New Guinea, Philippines, Tanzania, USA, and Vietnam.

7.2 Improving Operational Capabilities

7.2.1 Global Coastal Surface Wind Fields – Unfunded

Overview – Surface winds associated with large weather systems are modified in the coastal zone by land topography, land-sea differences in the turbulent surface fluxes and radiative heating conditions. Given the coastal surface wind is a major driving force of coastal currents and wind waves, it follows that high-resolution coastal wind fields are essential for many applications envisioned by the Coastal Ocean Observations Module. Real-time dissemination of accurate coastal surface winds will contribute to maritime safety and mitigation of natural hazards in the coastal zone. The goal of this project is to improve our ability to obtain coastal marine surface winds for any coastal region of interest. Research and development will be carried out on combining in situ wind measurements, satellite-based data (surface vector winds from scatterometers, scalar winds from altimeters, microwave radiometer and SAR), land-based HF radar data with high-resolution atmospheric models.

Products – Three products will be generated by this pilot project:

- High resolution surface vector wind fields (1 km, hourly) for coastal regions.
- Demonstration of improved regional research and applications using the coastal surface wind products.
- Methodologies to produce and improve the coastal wind products.

Description – The project will examine and characterize surface wind fields; develop methodologies to obtain the high-resolution coastal winds with high-resolution numerical atmospheric models using in situ measurements, scatterometry, and HF radar; validate high-resolution surface wind products; and enable research to develop products that require nowcasts and forecasts of surface wind fields, e.g. search and rescue, nowcasts and forecasts of oil spill and HAB trajectories.

Partners and implementation mechanism – The partners will be JCOMM, The Observing System Research and Predictability Experiment (THORPEX) (Global Atmospheric Research Programme) and the regional Numerical Weather Prediction (NWP) community. Given that the applications and services based on high-resolution surface winds are useful for maritime safety and mitigation of natural hazards, the implementation mechanism should be involve local weather services, coast guard agencies and local governments.

7.2.2 Mapping Surface Coastal Currents Using HF Radar – New

Overview – High-frequency (HF) radar has the potential to provide extremely useful, remotely sensed maps of near-surface (1 m) currents that cover the nearshore to the outer continental shelf (200 km). This pilot project aims to monitor surface currents from the nearshore to the outer continental shelf. The product will be half hourly vector maps of the upper coastal ocean (1 meter) water mass with a horizontal resolution of the order of 1 km. The maps will be accessible via the web in agreed-upon formats. In additional estimates of the subsurface flow, and forecasts will be made using 3D coastal circulation models.

This project could be combined with the surface vector winds project above to become a Coastal Data Assimilation Experiment (CODAE) to assess the value of integrating data streams from space-based sensors (altimetry, scatterometry, AVHRR, ocean colour), in situ sensors (ADCPs), and HF radar to provide improved, high resolution, real-time maps of 3-dimensional current fields.

Products – Vector maps of the near surface flow of the coastal ocean will reveal tidal currents, eddies and “jets” as well as major the mean, background flow. All flow components can contribute to the dispersion of materials and biota and thus the surface flows estimates will be of great interest to a wide range of users. By assimilating the near surface current observations into 3D ocean models may be possible to (i) extrapolate the horizontal currents to greater depths, and (ii) improve the initial conditions required by the model for forecasts. There is a wide range of potential users of better nowcasts and forecasts of 3D flow fields on the continental shelf including port and coastal authorities, coast guard, fisheries regulation bodies and pollution mitigation agencies.

Project description – The project will seek cooperation with ongoing developments of HF radars for surface current monitoring including efforts in the US, Europe and other regions. The project will help promote the use of HF technology in coastal countries for which the technology has great potential, along with other ground based radar techniques such as nautical radars for wave/current detection. This pilot project will integrate the measurement, modelling and analysis, and data management subsystems, both within and between regions.

Partners and implementation mechanisms – For this pilot project to succeed, a close cooperation is required with the manufacturers of HF and radar systems. Given these sensors have been in use in limited areas for some time, their validation is now possible. Implementation mechanisms must involve coast guards and coastal authorities. Major users of such a system would be the offshore oil and gas industry.

7.2.3 Improved Coastal Sea Surface Temperature Fields – Unfunded

Overview – In order to develop a regional ocean observing system in the WESTPAC NEAR-GOOS region, high-resolution cloud-free quality-controlled daily SST products are desired by the application users as well as the regional ocean science community. The Ocean Remote Sensing Programme (ORSP) was structured as one of the WESTPAC science programmes at the WESTPAC-V in August 2002, and the New Generation Sea Surface Temperature Project became its first project. Its goal is to develop/generate new SST products responding to the regional requirements through intensive scientific researches of remote sensing technology, air-sea interface dynamics and oceanic variability. Better combination of remote sensing measurements and regional in situ observations are needed to be investigated to achieve sustainable generation of the new SST products.

Products – The regional cloud-free, gridded, digital, quality-controlled new SST product should have (1) greater spatial resolution (1 km) and (2) greater temporal resolution (6 hours) for the NEAR-GOOS region and the southern/northern WESTPAC region.

Project description – During 2003-2004, three meetings were held for the project planning, inviting the project members from China, Korea, Russia, Taiwan, and Japan. The project has been introduced in several NEAR-GOOS meetings to make collaboration mechanisms between the two regional programmes (http://www.ocean.caos.tohoku.ac.jp/~sst/ngsstp/index.html). User requirements of the high-resolution regional SST product and its potential users and applications are already listed. It is recognized by the project members that the regional high-resolution SST products need to deal with the diurnal SST variations explicitly. High-resolution SST retrieval problems (atmospheric correction, cloud/ice detection, validation etc), infrared and microwave SST merging methods, SST diurnal variations, and use of the in situ SST data needs to be studied by using regional in situ and remote sensing data. The members agreed to establish a regional SST data server for methodology development and new SST product generation.

Partners – The project is now active. The regional SST server for FTP dissemination of SST products from the IR sensors of locally received operational satellites is established at the Tohoku University for research & development of the high-resolution SST products. The members use the NEARGOOS server to access the regional in situ SSTs. In order to investigate characteristics of the near-coast SSTs, the members search regional observational buoys measuring SST time series. The NOAA-HRPT network which exchanges the satellite information in real-time through FTP is now formed through the collaboration of regional local stations. Demonstration real-time generation of lower-resolution new SST product is carried out merging the locally received IR SSTs and the microwave SSTs of R&D satellite (http://www.ocean.caos.tohoku.ac.jp/~merge/sstbinary/actvalbm.cgi?eng=1). Research/development of the high-resolution SSTs (1km and 6-hourly) will be carried out in 2004, and its real-time generation will be in 2005.

7.2.4 Global Methods for Developing, Evaluating and Improving Ocean Colour Products in the Coastal Zone – Unfunded

Overview – Temporal and spatial patterns in surface chlorophyll a fields are central to describing variability in coastal ecosystems, not only as measures of phytoplankton biomass, but also as input to models of primary productivity, ecosystem-based management of coastal water quality (e.g. eutrophication) and fisheries, and coastal compartments in the global carbon budget. Spatially synoptic assessments of phytoplankton on the scales of coastal marine and estuarine ecosystems are possible only from remote sensing of ocean colour. Although aircraft can be used for this purpose in small ecosystems such as the northern Adriatic, Chesapeake Bay, and the Seto Inland Sea, satellite remote sensing is required for larger systems such as Large Marine Ecosystem.

Ocean colour is responsive to concentrations of chlorophyll and other phytoplankton pigments, coloured dissolved organic matter (CDOM), and suspended sediments. In principle, concentrations of these constituents can be estimated from satellite-based measurements of ocean colour. However, in practice, the optical complexity of most coastal waters and problems in removing the effects of land and the atmosphere from the signal detected from space lead to substantial uncertainties in estimates.

Despite these difficulties, ocean colour algorithms have been developed and successfully used to translate ocean colour into useful products in some coastal systems, e.g. upwelling regions of eastern boundary currents, Mediterranean and Adriatic Seas, Gulf of Mexico. However, these are specific to particular regions and are not sufficiently robust for global applications. Moreover, it is currently impossible to evaluate their quality globally or to merge these products over many regions because of the lack of inter-comparability among regional algorithms and data used for validation.

Generally, data products are developed and their uncertainties are quantified through comparison of in situ data with satellite observations processed with algorithms or other analytical procedures. For delivery of ocean colour data-products on global scales of known quality, standard procedures must be established for developing, evaluating and improving ocean colour algorithms for translating ocean colour into useful products, e.g. comparable estimates of surface fields of chlorophyll a, CDOM, turbidity, and water clarity from different regions. Once this is done, satellite-based measurements of ocean colour can be used to monitor changes in these important variables on regional to global scales.

Products – Toolkits for using in situ data and satellite observations to develop and determine the quality of regional ocean colour data products in coastal waters. These include standards and protocols for collecting and processing data, and procedures for parameterising several types of regional algorithm, developed by and shared among the ocean colour community. The results will be a suite of calibrated and validated regional algorithms for coastal ocean colour data products, each evaluated quantitatively and comparable globally. These algorithms can then be used to produce spatially synoptic fields of chlorophyll a, CDOM, turbidity, and water clarity with associated estimates of uncertainty. The data can be applied to models of primary productivity and descriptions of temporal and spatial variability of phytoplankton biomass. Availability of several versions of the same data product, with estimates of error, will be very useful in modelling and management.

Description – This 10 year project will improve ocean colour algorithms in coastal waters; develop standardized ocean colour products with known uncertainty; develop regional ocean colour algorithms which are intercomparable; merge the products of these algorithms to estimate fields on regional to global scales, e.g. determine global patterns by synthesizing chlorophyll a fields generated for different areas using different algorithms; and determine inter annual variations of phytoplankton productivity in the coastal ocean on regional and global scales.

Partners – Partners include the IGOS, JCOMM, IOCCG, and the GMES Service element on remote sensing.

7.2.5 Global Storm Surges and Flooding Risk – Unfunded

Overview – Coastal flooding is an ever present threat to many low-lying, coastal regions. Recent predictions of an acceleration in the rate of rise of global sea level, and the possibility of climate change, have led to increased societal concern about more severe flooding over the coming century. Storm surge models are now run operationally for many coastal regions and they can provide very useful short term forecasts (lead times of hours to days) of coastal flooding. The models can also be run in hindcast mode in order to reconstruct surge variability over recent decades, leading to a better understanding of changes in flooding risk and also the estimation of flooding risk for regions with no sea level observations. In principle surge models can also be driven by climate change scenarios in order to assess how flooding risk may change over the next century.

The main objective of this project would be to construct a storm surge modelling system with global coverage that can provide short-term forecasts and decadal-scale hindcasts, and also be used for climate change scenarios. The development of such a system would also provide a good opportunity for capacity building and allow the surge modelling community to clearly define the required accuracy and resolution of coastal wind and air pressure forecasts and reanalyses. A community-based modelling approach will be employed (Chapter 5, Section 5.1).

Products – Five products will be generated by this pilot project:

- Short term (hours to days) forecasts of storm surges for the global coastal ocean.
- Reanalyses of surge variability for the global coastal ocean based on the best available wind and air pressure reanalyses for recent decades.
- Quality control of real-time and archived coastal sea level observations (including data from GLOSS stations).
- Spatial maps and trends in flooding risk over recent decades, and validation against return periods calculated from hourly coastal tide gauge data.
- Projections of flooding risk over the next century under plausible global sea level rise scenarios.

Description – The first step in the design of the pilot project will be to establish a community modelling network (CMN, Chapter 5, Section 5.1) to bring together a team of surge modellers representing the major national surge forecasting groups. The objective would be to promote the development of local capacity and the capability to do ensemble modelling. Particular attention will have to be paid to a number of issues including (i) the computing resources required for the storage, data management, visualization and dissemination of model output, (ii) predicting tides (iii) methods for estimating spatial maps and trends of flooding risk based on decadal hindcasts and climate change scenarios, (iv) capacity building through the exchange of personnel, and possibility the development of regional models for new regions using common, shared code, (v) the requirements for next generation coastal wind and air pressure reanalyses and forecasts, (vi) methods for dealing with hurricanes which are difficult to forecast.

(It is important to note that the feasibility of running a relatively high resolution global coastal forecast system in operational mode is not in doubt. Such systems already exist [www7320.nrlssc.navy.mil/global_ncom/] and is presently run daily with a horizontal resolution of 1/8 degree).

Partners and implementation mechanism – The partners will include GSSC, JCOMM, GLOSS, Coastal GTOS, national and international meteorological agencies, the NWP community.

7.2.6 Coupling Shelf and Deep Ocean Models – Unfunded

Overview – There is ample evidence from in situ and satellite observations that conditions on the continental shelf can be significantly affected by changes in the state of the adjacent deep ocean. For example, it is well known that physical conditions on the narrow shelves of the west coasts of North and South America can be influenced by coastal trapped waves that are generated in remote, tropical regions. On the much wider shelves of the eastern U.S. and Canada, eddies generated by an unstable Gulf Stream have been observed to entrain water and biological organisms from the outer shelf. The working hypothesis underlying this set of pilot projects is that an increase in our ability to predict changes in the adjacent deep ocean will increase our ability to forecast conditions on continental shelves.

Over the last 10 years there has been a significant improvement in the predictive capability of deep ocean models. This can be traced back to better observations (particularly surface properties from satellite borne sensors and temperature-salinity profiles from Argo floats), better models, and the development of effective schemes for assimilating data. Building on these advances, the OOPC has undertaken a pilot project to demonstrate the feasibility of operational forecasting of the deep ocean. The Global Ocean Data Assimilation Experiment (GODAE) is using all available ocean data and sophisticated models to generate ocean analyses and model assimilation estimates. The forecasts emerging from GODAE prototype systems range from regional and global short-range ocean forecasts to high-fidelity estimates of ocean climate. In addition to generating products, GODAE has also established the GODAE Common which is designed to facilitate the exchange of data, products, servers and the accumulated knowledge base.

Pilot projects are proposed for the coastal module to quantify the increase in predictability of physical and biogeochemical conditions on the shelf that result from using open boundary conditions generated by deep ocean forecast systems such as those being developed by GODAE. It will be advantageous to conduct pilot projects in contrasting regions (e.g. narrow versus wide shelves, eastern versus western boundaries of ocean basins). It will also be important to supplement the shelf modelling with an active shelf observation program in order to evaluate the accuracy of the forecasts. In parallel with the pilot projects, a joint GSSC/OOPC-GODAE working group could be formed to exchange modelling, assimilation, and coupling expertise and to examine the limits to predictability (e.g. how much do shelf modellers really gain in forecast skill by including offshore boundary conditions from the present generation of deep ocean models, and what can we expect over the next 5 years? What metrics should be used to assess forecast skill on the shelf for physical and nonphysical variables?). The same group could also build on the idea of the GODAE Common and promote the development of community modelling and assimilation software for coupled models.

Products – Extended forecasts (e.g. lead times of tens of days) of conditions on the continental shelves along with standardized measures of forecast skill for physical and selected biogeochemical variables.

Project description – Suggested pilot project locations include the following:

- Gulf on Maine on the east coat of the US and Canada
- Northwest European shelf, building on existing physical and biogeochemical modelling efforts
- Mediterranean, building on the Mediterranean Forecasting System
- Indian Ocean with a focus on the utility of coastal sea level
- West coast of South America

Partners and implementation mechanisms – For this pilot project to succeed, close cooperation will be needed between the coastal and deep ocean modellers. It will be essential for the MAWG to work closely with JCOMM, OOPC, and the GODAE modellers for the duration of GODAE. Additional partners will depend on where pilot projects are conducted.

8. Performance Evaluation

The GOOS Coastal Module is being implemented in a series of overlapping phases, with some components well advanced in some regions, and others requiring major investment in capacity, or new research. As the system develops it will be increasingly important to achieve high levels of standardization and to know what procedures and devices are producing the best results. Measurably successful trials in one region can then be used in another in a standard way. This is particularly important for the development of the GCN.

Successful implementation and sustained development of the observing system in the medium to long-term will require systematic and rigorous procedures for periodic and routine performance evaluations of operational status and socio-economic benefits of the data and information provided by GOOS. Activity and program performance indicators (metrics) are needed that are grounded in the GOOS design principles and based on the six societal goals (Chapter 1) and the actions recommended herein.

8.1 Indicators of Performance

Many performance indicators are measures of bureaucratic activity (e.g. staff size, number of reports issued and meetings held, etc.). Here we focus on two categories of performance metrics: (i) how well the system is functioning and (ii) the realization of benefits. System function should be assessed in term of the following:

- **Interoperability** – adoption and development of common standards and protocols and their use for the GCN and by GRAs;
- **Data flows** – continuity, timeliness, quality, diversity, and integration of data flows from observations to products; and
- **Improved operational capabilities** – development of new operational capabilities for observations (including data telemetry), data management, and modelling as a consequence of capacity building (geographic expansion of operational capacity) and research (new technologies and scientific understanding).

Benefits of new or improved data and information provided by the observing system should be assessed in terms of the following:

- **Products** – the number of new or improved products traceable to the coastal module;
- **User groups** – the number of groups that use these products;
- **Achieving the six societal goals** – use of data and information provided by the system to meet the requirements and conditions of international conventions and agreements; and
- **Cost/benefit analyses** – measure the cost of the system against socio-economic benefits.

8.2 Phased Implementation of Performance Evaluations

The usefulness of performance indicators will change as the system develops over time. Evaluation of the GCN in its early stages of development should focus on how well the system is managed and coordinated, how well capacity building needs of GRAs are identified and addressed, how efficiently data and information are made available internationally, and the extent to which the data and information meet the needs of GRAs and nations. As the coastal module develops, evaluations should be expanded to include assessments of research and pilot projects and the efficiency by which new technologies and understanding are used to improve operational capabilities, how well the system addresses the six societal goals, and the diversity of groups that benefit from the provision of coastal data and information.

- During the formative years of the coastal module (2005 – 2015), the strategic implementation plan should be updated periodically (e.g. every five years) to include implementation and quantitative indicators of performance. These should be used to correct problems and improve operational capacity as well as to measure the benefits of new data and information.

As the observing system continues to develop, performance metrics will be needed for user satisfaction, cost-effectiveness (cost of the observing system against socio-economic benefits), and for assessing how the observing system has improved capacity to achieve all six societal goals. Such assessments will be needed for both the GCN and regional coastal ocean observing systems.

Action 8.1: The CBWG should develop performance indicators for four key, cross-cutting activities that are critical to establishing an end-to-end, user driven global observing system for the coastal ocean:

- international coordination and collaboration in implementing the GCN (interoperability);
- capacity building in terms of the effectiveness with which regional and national priorities for developing all three subsystems are identified and addressed;
- development of operational capacity by the GRAs as a group; and
- development and use of socio-economic indicators that measure the effectiveness of more rapid detection and timely predictions of the phenomena of interest in terms of sustainable uses of the oceans and resources they support.

8.3 Immediate Actions Needed to Evaluate the Performance of Subsystems

8.3.1 Observing Subsystem

In Situ Sensing, Measurements and Sampling

The development and application of new technologies for more rapid detection of changes in physical, chemical and biological properties and processes is critical to the development of the fully integrated observing system.

Action 8.2: The GSSC, in collaboration with the MWG, should establish procedures for periodically assessing and updating the common variables and sampling programs for the GCN, and for identifying priority research activities needed to improve operational observing capabilities.

Interoperability depends in part on the comparability of measurements of the common variables among nations and regions.

Action 8.3: The MWG should promote and coordinate intercalibration activities (e.g. workshops, comparison of results from measurements of reference material among laboratories globally) among GRAs and national and global programmes to improve and evaluate measurements of the common variables.

Action 8.4: The GSSC, in collaboration with the MWG, should identify existing standards and protocols (e.g. Annex IV), and develop ones as needed, for measuring the common variables recommended for use by data providers.

In evaluating the GCN attention should be paid to identifying observing programmes where some or all of the common variable measurements can be transitioned to operational status. The criteria for this transition will include:

- The standards and protocols that have been specified for the measurement are being met
- Data are quality controlled and managed in compliance with GOOS data management standards and protocols;

- There is dedicated staff responsible for acquisition and quality control of data on a routine and continued basis, with routine data distribution.

Action 8.5: The GSSC, in collaboration with the MWG, should track progress in the development of new operational capabilities, standards and protocols for measuring the common variables and promote their incorporation into operational observing systems (GCN, regional coastal ocean observing systems).

Remote Sensing

A major objective of remote sensing is to provide data of known quality to users of data and information on coastal marine and estuarine environments. To this end, there is an immediate need to develop and apply performance indicators for evaluating techniques, sensors, algorithms and data management specifically for coastal waters.

Action 8.6: The GSSC should promote implementation of the IGOS Coastal Theme.

Action 8.7: The MWG should work with the IGOS Coastal Theme Team and the JCOMM Satellite Requirements Task Team to prepare an adequacy report on satellite-remote sensing (sea surface temperature, altimetry, scatterometry, SAR and ocean colour for coastal waters), airborne remotes sensing (shore-line mapping), and land-based remote sensing (surface current mapping with HF radar). This should build on the Coastal Theme, and adequacy should be assessed in terms of spatial and temporal resolution, measurement uncertainty, product quality, data format and timeliness of delivery.

Experience over the past decade has demonstrated that space-based observations are most useful when used in conjunction with complementary in situ data for calibration and validation as well as for the generation of products that integrate remote and in situ sensing to improve field estimates (fused products). For calibration and validation, in situ measurements of the GCN should be used to improve algorithms and satellite-derived ocean parameters for regional applications.

Action 8.8: The GSSC should regularly review the quality and utility of satellite products and recommend procedures for improving them (including algorithms) and developing new satellite-based remote sensing capabilities.

8.3.2 Data Management Subsystem

Establishing procedures to monitor, evaluate and improve the performance of the DMS is fundamental to the success of the initial observing system and its evolution. Performance metrics must be developed and implemented to assess the timeliness, continuity and quality of all data streams at each stage of data delivery from measurements to data telemetry in terms of user requirements.

Action 8.9: The DMWG should develop and promote the use of performance indicators to assess timeliness and continuity of data delivery, interoperability (development and use of common standards and protocols) and data exchange among regions and nations (bi-lateral and multi-lateral agreements for data exchange and their implementation).

8.3.3 Modelling and Data Analysis

As the observing system becomes functional in terms of data integration and the provision of products and services, the performance of the observing system can be evaluated by assessing its ability to deliver products to end-users.

A number of key products, such as storm surge predictions, assessment of shoreline erosion, water quality models, real-time oil spill transport models, can be identified by GRAs and national GOOS programmes. For each product, regional experts could then assess gaps in the observing (time-space resolution, variables measured, techniques used or available) and modelling subsystems.

Action 8.10: The GSSC should work with the GRAs to develop procedures for conducting product-specific, impact-feasibility procedures for assessing current operational capabilities of the observing system and identify research priorities for improving them (where impact is measured in terms of the ability to produce the product or improve an existing product and feasibility is measured in terms of both the availability of techniques and their cost).

ANNEX I
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ANNEX II

Tool Kit for Prioritizing Socio-Economic Variables

COOP has designed and used a protocol for identifying common variables to be measured by the GCN (IOC, 2003). The protocol provides a quasi-objective technique for selecting the common variables[47] and may be used by nations and GRAs to help determine their priorities for the GCN and for developing their own regional coastal ocean observing systems. The objective is to identify the minimum number of variables that must be measured to detect and predict changes that are important to the maximum number of user groups. The purpose here is to extend this approach to include socio-economic variables that can be used to link changes in marine and estuarine systems to terrestrial systems where people live. This is the focus of the IGOS Coastal Theme (http://ioc.unesco.org/igospartners/coastal.htm), i.e. observing requirements across the land-sea boundary needed to relate changes in marine and estuarine systems to socio-economic systems and the efficacy of environmental policies.

1. Identifying and Ranking Socio-Economic Variables

This process, is similar to the process used to identify the common (environmental) variables for the GCN. It begins with listing user groups, socio-economic phenomena of interest and associated socio-economic variables.

User groups (Table II.1) – This master list is the same as that used to rank environmental variables for consideration as common variables for the GCN. That this master list is the same for environmental and socio-economic variables and for regional observing system and the GCN reflect in integrated nature of the GOOS user-driven approach.

47 http://www.phys.ocean.dal.ca/~lukeman/COOP/

Tables II.2-II.5 summarize the procedure used for identifying the common environmental variables for the GCN[5] with examples of variable categories (Table II.3b) that were not considered for the GCN because the precise variable to be measured changes from region to region.

Phenomenon of Socio-Economic Interest (Table II.6) – These are equivalent to the environmental phenomena of interest identified by in the Strategic Design Plan for the Coastal Ocean Observations Module of GOOS[5]. Here, four primary issues of importance are used to describe fifteen phenomenon (PSE 1-15).

Socio-Economic Variables (Table II.7) – This list represents the work of several international groups of experts and was developed by COOP, refined by a team of experts, and vetted by the Coastal Panel of the Global Terrestrial Observing System (C-GTOS). Its purpose of the list is to test the protocol for ranking socio-economic variables.

2. Ranking Socio-Economic Variables

The exercise described below was conducted to determine if the protocol used to prioritize variables to be measured by the GCN could also be used to prioritize socio-economic variables. The results presented here should be viewed as illustrative of the approach and as representing the views of the expert panel that conducted the test. The results are not meant to be relevant to any given region or country. Results for a specific region with a well defined set of priorities for data and information linking changes in coastal waters to socio-economic impacts are likely to be different. However, the results strongly suggests that this approach can be of substantial value for understanding socio-economic linkages to coastal environmental change and in building a richer, more integrated and sustained observing system.

Figure II.1 provides an illustration of two reporting products describing the weighted rankings of the 32 socio-economic variables. In the top figure the variables are aligned along a weighted scale with the most highly ranked variable (V4 – Employment in Industry Sectors) located in the top left corner and the variable holding the least value (V17 – Pesticide Use in Watersheds) located at the end of the continuum ending the bottom right. The figure titled "Unclustered but Ranked by User Interest", provides a different view of variable value by user. It places higher ranked variables on the left of the figure and uses colour to denote the level of user interest. Here, red (with dark red representing highest) and orange convey higher interest while greens and blues convey less interest (with dark blue representing lowest). This representation should be viewed as a graphic

SECTOR	CODE	USER GROUP
Commercial	U1	Shipping
	U2	Marine energy and mineral extraction
	U3	Insurance and re-insurance
	U4	Coastal engineers
	U5	Fishers (commercial, recreational, artisanal)
	U6	Agriculture
	U7	Aquaculture
	U8	Hotel - restaurant industry
	U9	Consulting companies
Government	U10	Fisheries management
	U11	Search and rescue
	U12	Port authorities and services
	U13	Weather services
	U14	Government agencies responsible for environmental regulation (pollution issues)
	U15	Freshwater management/damming
	U16	Public health authorities
	U17	National security (including navies)
	U18	Wastewater management
	U19	Integrated coastal management
Public / NGO	U20	Emergency response agencies
	U21	Ecotourism, Tourism
	U22	Conservation and amenity (including environmental NGOs)
	U23	Consumers of seafood
	U24	Recreational swimming
	U25	Recreational boating

Table II.1. This list of user groups is intended to be a reasonable sampling of the spectrum of user groups that are likely to benefit from the Coastal Module. The relative number of users from each sector influences the result; users are listed by sector to illustrate the balance that was chosen for this ranking.

representation of the strength of user interest for individual socio-economic variables. Table II.8 provides a simple ranking of the variables.

An algorithm was used to cluster user interest in the variables based on this ranking process (Figure II.2). If the user interest clustered in ways that was intuitive, one can argue that the exercise succeeded in establishing initial value (at least) of the approach. The five clusters of users in Figure II.2 can be viewed as those holding similar interest in the variable ranking. In effect, this clustering provides a reporting product that identifies groups of users with similar interests in the relative importance of the variables.

Again, it must be emphasized that this exercise demonstrates a tool for nations or GRAs to help rank socio-economic variables. The analysis above is only an example of how it may be used.

ISSUE OF IMPORTANCE	CODE	PHENOMENON OF INTEREST
Marine Services and Public Safety	P1	Sea state
	P2	Coastal flooding
	P3	Surface currents
	P4	Rising sea level
	P5	Changes in shoreline and shallow water bathymetry
Public Health	P6	Chemical contamination of seafood
	P7	Human pathogens in water and shellfish
Status (Health) of Marine and Estuarine Ecosystems	P8	Habitat modification and loss
	P9	Eutrophication / oxygen depletion
	P10	Changes in species diversity
	P11	Biological responses to contaminants (pollution)
	P12	Harmful algal events
	P13	Invasive species
	P14	Water clarity
	P15	Disease and mass mortalities in marine organisms
	P16	Chemical contamination of the environment (includes oil spills)

Table II.2. Phenomena of interest. The Coastal Module should provide observations that can be used to detect or predict the occurrence of or changes in these phenomena.

CODE	VARIABLE TO DETECT OR PREDICT CHANGE	CODE	VARIABLE TO DETECT OR PREDICT CHANGE
V1	Attenuation of solar radiation	V19	Particulate organic C and N
V2	Changes in bathymetry	V20	pH
V3	Benthic biomass	V21	Phytoplankton biomass (chlorophyll)
V4	Benthic species diversity	V22	Phytoplankton species diversity > 20 µm
V5	Biological oxygen demand	V23	Primary production
V6	Neutral red assay	V24	Salinity
V7	Cytochrome p450 (biomarker; e.g., oil)	V25	Sea level
V8	Cholinesterase (biomarker; pesticides)	V26	Sediment grain size, organic content
V9	Metallothionein (biomarker; trace metals)	V27	Changes in shoreline position
V10	Currents, and current profiles	V28	Surface waves, direction, spectrum
V11	Dissolved inorganic nutrients (N, P, Si)	V29	Total organic C and N
V12	Dissolved oxygen	V30	Total suspended solids
V13	Eh in sediment	V31	Water temperature
V14	Faecal indicators	V32	Zooplankton biomass
V15	Fisheries: landings and effort	V33	Zooplankton species diversity
V16	Nekton biomass	V34	Coloured dissolved organic matter - CDOM
V17	Incident solar radiation	V35	Seabird abundance
V18	Nekton species diversity	V36	Seabird diversity

Table II.3a. Variables for detecting or predicting the occurrence of or changes in the phenomena of interest. These are properties or rates that can be measured with known precision or accuracy and which could potentially be included in the global coastal system.

Artificial radionuclides	Metal toxins in sea food
Bio-assays of contaminant effects	Metals/organometals
Biogenic toxins in sea food	Nekton species
Coastline geomorphology	Optical properties of surface waters
Extent of biologically structured habitat	PAHs
Fisheries: Recruitment rates for exploitable species	Petroleum hydrocarbons
Fisheries: By-catch	Pharmaceuticals
Fisheries: Diet of exploitable fish species	Phytoplankton species
Fisheries: Fishing effort	POPs
Fisheries: Landings by species	Sea ice
Fisheries: Locations and frequency of habitat disturbance	Sediment chemical composition
Fisheries: Size spectrum of exploitable populations	Strandings and mass mortalities
Fisheries: Spawning stock biomass of exploitable populations	Suspended plastics and plastics/liter on seashore
Human pathogens	Tar balls on the seashore
Macrobenthic species	Toxins in humans
Marine mammals/birds species	Zooplankton species
Meiobenthic species	Zooplankton biomass

Table II.3b. Examples of variables for regional and national systems. These variables are essential to detecting and predicting change, but they would not be defined in the same way throughout the global system and might not be relevant globally (e.g., sea ice). Lists of variables such as this could be reviewed and considered in the design of regional elements of Coastal GOOS at the regional level.

CATEGORY	CODE	PREDICTION
Coastal marine services	M1	Storm surges
	M2	Waves
	M3	Currents
	M4	Coastal erosion
Ecosystem health & relation to human health	M5	Risk assessment: seafood consumption
	M6	Risk assessment: direct contact
	M7	Chemical contamination of seafood
	M8	Habitat modification / loss
	M9	HABs - population dynamics
	M10	Anoxia / hypoxia
	M11	Invasive species
	M12	Pollution effects - population
	M13	Water quality model
Living marine resources	M14	Capture fishery production/sustainability
	M15	Aquaculture production/sustainability - finfish
	M16	Aquaculture production/sustainability - shellfish
	M17	Fisheries: Sequential population analysis
	M18	Fisheries: Community dynamics
	M19	Fisheries: Ecosystem dynamics

Table II.4. The representative list of predictive models used in the ranking procedure.

	P1 Sea State	P2 Flooding	P3 Currents	P4 Sea Level	P19 Living Marine Resources
U1, Shipping	2	0	2	2	0
U2, Energy	2	1	2	2	1
U3, Insurance	2	2	1	1	0
U4, Coastal Engineers	2	2	1	2	1
U28, Scientists	2	2	2	2	2
TOTAL	**10**	**7**	**8**	**9**	**4**

Table II.5. Weighting of phenomena of interest by user group. This truncated example (see Tables II.1 and II.2 for full listings) shows how phenomena of interest are scored according to user groups interested in them (2 for direct interest, 1 for significant but indirect or partial interest). The scores presented here and in the following three matrices are for illustration and are somewhat arbitrary. Responses of panellists were used to generate rankings.

Issue of Importance: Biophysical Dynamics		
PSE1	Land Use/Land Cover	Changes to land use and land cover composition and pattern within the coastal watershed.
PSE2	Physical Alteration	The built environment within the coastal flood zone, including marine transportation infrastructure, flood protection and other forms of direct alteration of the coastal zone
PSE3	Changes to Coastal Habitat	Biologically driven habitat lost/gained within the coastal watershed
Issue of Importance: Economic Value and Environmentally Induced Costs		
PSE4	Economic Equity and Distributional Effects	The distribution of income and wealth within the coastal zone
PSE5	Industrial Structure and Composition	The nature, structure and rate of change in industry located in or reliant upon the coastal watershed system
PSE6	Community Infrastructure	The nature and scale of public and private infrastructure within the coastal zone
PSE7	Environmental Damage Costs	Total costs for environmental damage, including management, mitigation, enforcement, restoration and other associated costs
Issue of Importance: Human/Resource Use and Health Risks		
PSE8	Exploitation of Living Resources	The nature, location and scale of living resource exploitation
PSE9	Exploitation of Non-Living Resources	The nature, location and scale of non-living resource exploitation
PSE10	Tourism and Other Non-Consumptive Uses	The level and trends in coastal tourism and other recreational/non-consumptive activities
PSE11	Marine-Sourced Public Health	The various marine risk vectors influencing human health
Issue of Importance: Population Dynamics and Cultural Values		
PSE12	Coastal Population Dynamics	Human population, growth and distribution within the coastal zone
PSE13	Cultural Integrity and Stability	The cultural, economic and social stability of coastal communities
PSE14	Coastal Aesthetic Quality	The non-use quality/value in the coastal zone
PSE15	User Conflict	The nature, level and severity of user conflicts in the coastal zone or driven by coastal resource issues

Table II.6. Phenomenon of Socio-Economic Interest.

V1	Resident Population
V2	Population Density
V3	Land Use/Land CoverPatterns/Composition
V4	Employment in Industry Sectors
V5	% Population with Potable Water
V6	% Population with Internet Access
V7	Change in User Conflict
V8	Property Values
V9	Income/wealth Distribution
V10	% Altered Coast
V11	Public Access Points/km of coastline
V12	% water dependent use industry/coastal industry
V13	Value Manufactured Products From Coastal Habitats
V14	Non-Use Values of Coastal Habitat (Bequest/Existence/Option)
V15	% Population Served by Wastewater
V16	Fertilizer Use in Watershed
V17	Pesticide Use in Watershed
V18	Energy Production (% of National Production)
V19	Level/Value of Commercial Fish Landings by Harvest Area
V20	Artisanal Fishing Effort
V21	Number/Value of Recreational Fishing Days
V22	Seafood Consumption Patterns
V23	Seafood International Trade Value/Quantity/Terms & Direction
V24	Number of Tourists (% of National)
V25	Number/Attendance at Recreational Bathing Beaches
V26	Number of Shipping Vessels Entering/Transiting Coastal Waters
V27	Aquaculture – Total Hectares
V28	Value Change in Seafood Due to Chemical Contamination
V29	Value Change in Seafood Due to Pathogenic/Toxic Contamination
V30	Number of Beach Closings
V31	Cost of Invasive Species
V32	Groundwater Extraction

Table II.7. Short list of candidate socio-economic variables.

1.	Employment in Industry Sectors
2.	% water dependent use industry/coastal industry
3.	Resident Population
4.	Land Use/Land Cover Patterns/Composition
5.	Number of Beach Closings
6.	Population Density
7.	Artisanal Fishing Effort
8.	% Altered Coast
9.	Level/Value of Commercial Fish Landings by Harvest Area
10.	% Population Served by Wastewater
11.	Value Manufactured Products from Coastal Habitats
12.	Public Access Points/km of coastline
13.	Change in User Conflict
14.	% Population with Potable Water
15.	Number of Shipping Vessels Entering/Transiting Coastal Waters
16.	Number/Attendance at Recreational Bathing Beaches
17.	Property Values
18.	Non-Use Values of Coastal Habitat (Bequest/Existence/Option)
19.	Aquaculture - Total Hectares
20.	Value Change in Seafood Due to Pathogenic/Toxic Contamination
21.	Value Change in Seafood Due to Chemical Contamination
22.	% Population with Internet Access
23.	Number of Tourists (% of National)
24.	Income/wealth Distribution
25.	Groundwater Extraction
26.	Energy Production (% of National Production)
27.	Cost of Invasive Species
28.	Number/Value of Recreational Fishing Days
29.	Seafood Consumption Patterns
30.	Seafood International Trade Value/Quantity/Terms & Direction
31.	Fertilizer Use in Watershed
32.	Pesticide Use in Watershed

Table II.8. Simple Numeric Ranking of Socio-Economic Indicators Resulting from the Initial Expert Group Exercise.

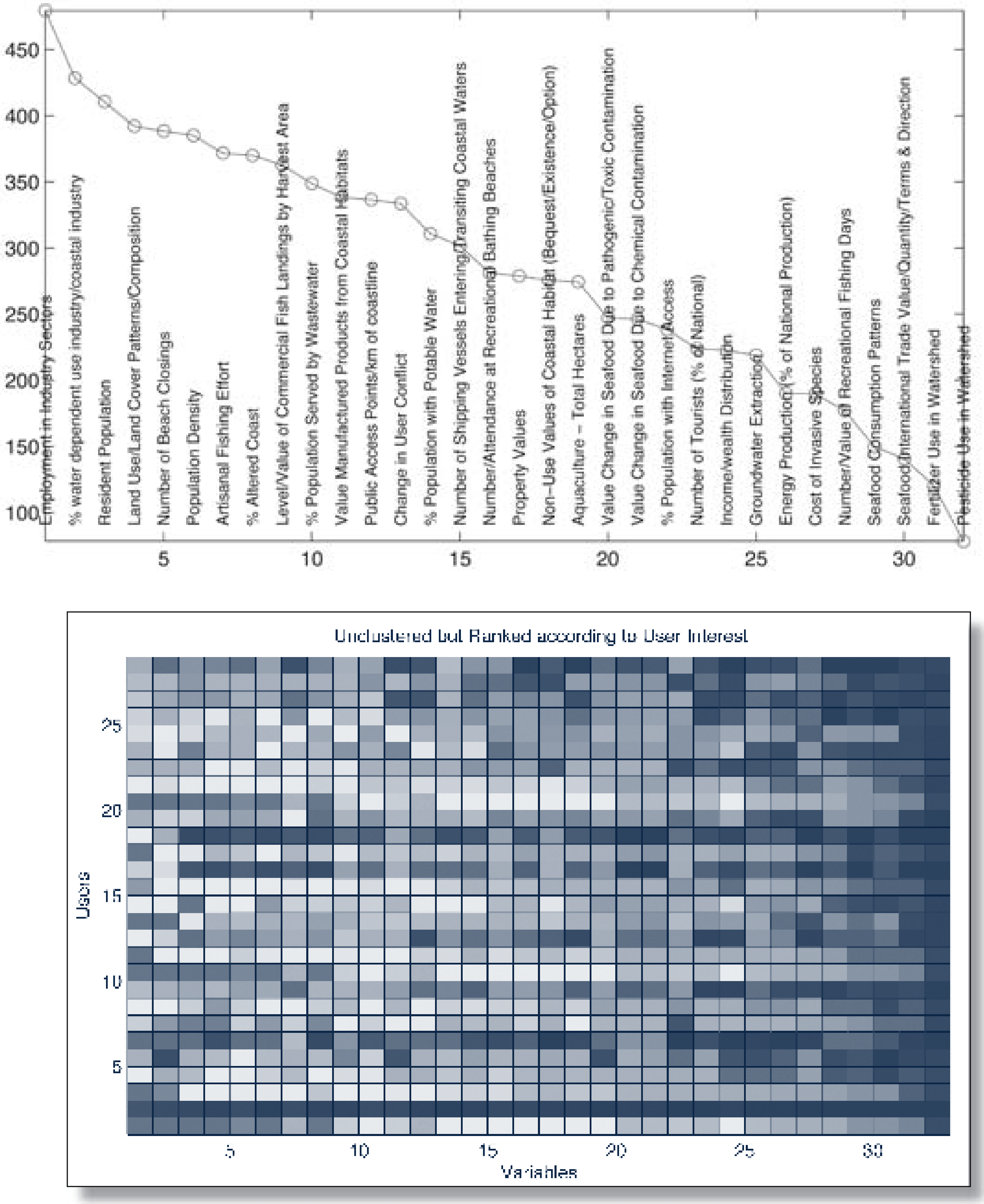

Figure II.1. Ranking of socio-economic indicators resulting from initial expert group exercise.

(For a color version of this figure please see inside of back cover)

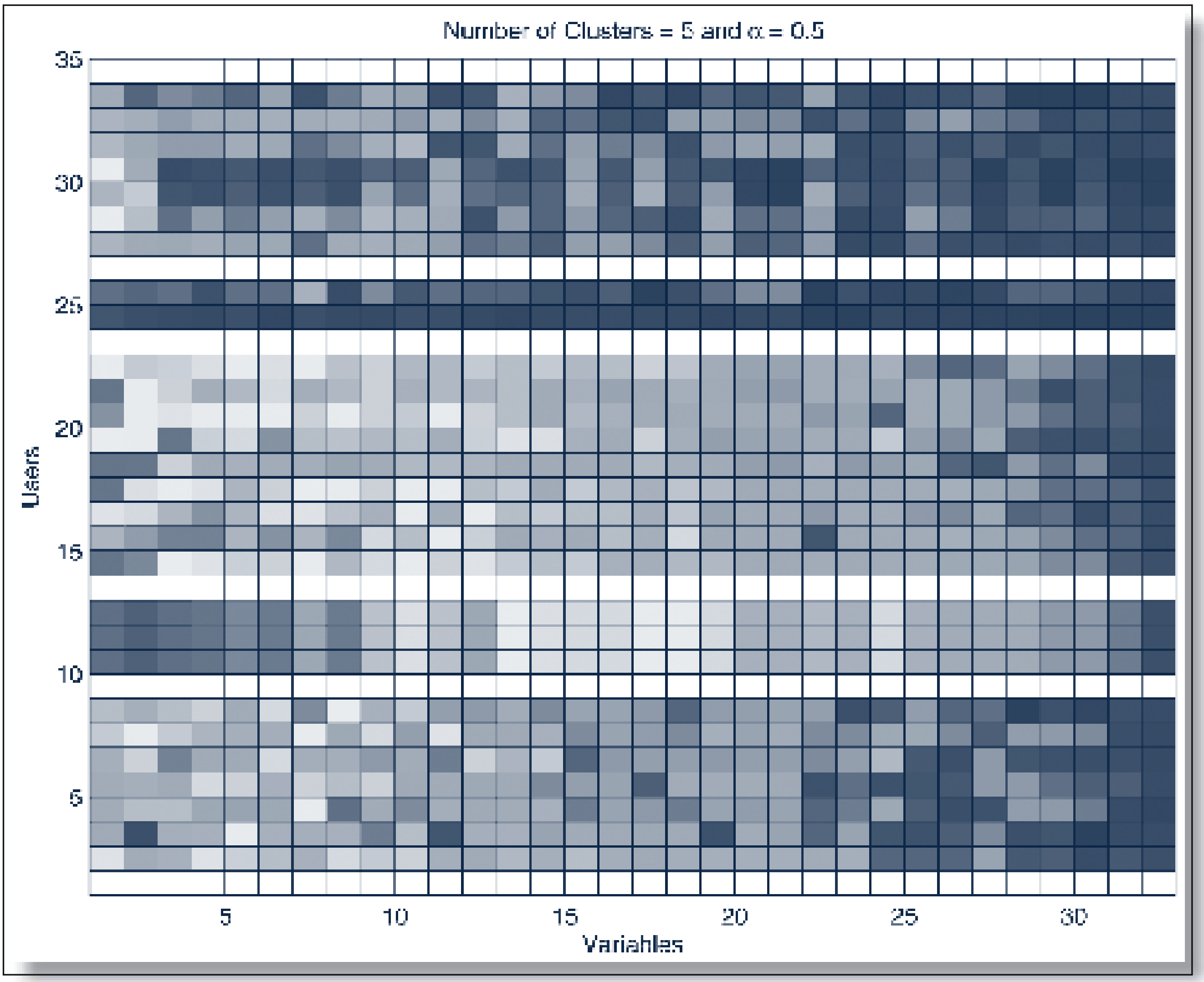

Figure II.2. Stakeholder groups with significant affinity interests in indicator ranking from initial expert group.

Group 1: Shipping, Insurance and Re-insurance, Coastal engineers, Search and rescue, Weather services, National security (including navies), Emergency response agencies

Group 2: Consumers of seafood, Educators

Group 3: Hotel–restaurant industry, Port authorities and services, Government agencies responsible for environmental regulation, Freshwater management/damming, Public health authorities, Wastewater management, Ecotourism, Tourism, Conservation and amenity (including environmental NGOs), News media

Group 4: Consulting companies, Integrated coastal management, Scientific community

Group 5: Marine energy and mineral extraction, Fishers (commercial, recreational, artisanal), Agriculture, Aquaculture, Fisheries management, Recreational swimming, Recreational boating

(For a color version of this figure please see inside of back cover)

ANNEX III

GOOS Regional Policy

(http://ioc.unesco.org/goos/docs/GOOS_reg_pol.pdf)

1. Purpose

Establishing and improving the GOOS are critically dependent on the coordinated development of GOOS Regional Alliances (GRAs) that contribute to and benefit from the global system. GRAs are created to facilitate sustained ocean monitoring to meet regional and national priorities. They require interagency collaboration and an internationally accepted policy. The activity and cooperation of GRAs is especially important to the development of the coastal module of GOOS.

2. Qualifications

GRAs are formed by agreement between participating countries, national organizations, and/or international bodies (Regional monitoring networks, Regional Fishery Bodies, Regional Seas Conventions, etc.). Membership should be chosen to best serve the data and information needs of organizations that use, depend on, or are responsible for the management of the marine environment and its resources in the region.

To be recognized as a part of the GOOS, a GRA must conform to the GOOS principles, policies and practices that are established and endorsed inter-governmentally by the IOC, WMO or UNEP from time to time.

To the extent that the geographic range and activities of a GRA overlap with those of other GRAs, the GRAs involved must establish agreements to ensure effective use of resources to the benefit of all.

Each GRA is expected to benefit from and contribute to the activities of the GOOS Regional Forum established by the Intergovernmental Committee for GOOS (I-GOOS).

3. Approval

The compliance of the activity of an organization requesting recognition as GRA with the GOOS principles must be reviewed by the GOOS Steering Committee (GSSC) and endorsed by the Intergovernmental Committee for GOOS (I-GOOS), upon evaluation of issues of inter-governmental cooperation, sponsorship or endorsement. The I-GOOS will inform the executive body of the GRA concerned about the evaluation. Where improvements, changes or actions are recommended to secure recognition, these shall be negotiated through the GOOS Project Office. After its endorsement by the I-GOOS, the case for each GRA will be submitted for the approval of the General Assembly or the Executive Council of the IOC.

Proposals to be recognized as a GRA must include the following:

- Evidence that a management structure is in place that can deliver an integrated and sustained system by linking, enhancing and supplementing existing infrastructure and expertise in the region.

- Provision of an acceptable business plan that has been endorsed by stakeholders (data providers and users) from the region and describes the procedures by which the observing system will be established, developed, and sustained. This must include procedures for quality assurance, conformance to internationally accepted standards and protocols for measurements, data management, and communications.

4. Accountability

To ensure that there is a single forum where GOOS activities can be considered in their entirety, all recognized GRAs are expected to: (i) be active members of the GOOS Regional Forum, (ii) be represented at meetings of the I-GOOS, (iii) provide periodic reports on their activities to I-GOOS. Reports should include among other things (a) analyses of the extent to which GOOS Principles have been implemented, and (b) information about the provision of data and information in forms and at rates required by user groups, about data quality, and about the continuity of data streams.

A GRA may be dropped from the GOOS based on the recommendation of I-GOOS and approval by the General Assembly or Executive Council of the IOC.

ANNEX IV
Methods, Standards and Inter-calibration

As GOOS is implemented it is essential that guidelines are provided on best practice in collection of data. Methods on sampling, analysis and data management need to be standardized or calibrated at least on a regional basis. In the past both IOC and UNEP provided guidance through Manuals and Guides and Reference methods documents. Through the IOC GIPME program the Group of Experts on Methods and Intercalibration (GEMSI) provided expertise in these areas specifically with contamination issues. The Group of Experts on the Effect of Pollutants (GEEP) provided biological effects information and the Group of Experts on Standards and Reference Materials (GESREM) provided input to the development of reference materials for marine science. Since the end of GIPME these groups have not been active and therefore there is no international body providing integration in this way. In order for GOOS to be successful there will have to be commitment to a similar expert group to GESREM to maintain a dialog in this area and provide integration with the GRAs and the various Capacity Building groups.

There are places where information on Methods for coastal GOOS variables can be found, however the sources exist in a diverse range of places, from books to academic peer-reviewed journals to various web sites. It is recommended that once measurements are deemed operational in a region that methods used are logged and recorded on a web site at the IOC. The description and guidelines for measurements of the variables which comprise the Global Coastal Network can be found in the Integrated Strategic Design Plan for the Coastal Observations Module of GOOS in Annex V (GOOS Report No. 125, IOC) and on the web at (http://ioc.unesco.org/goos/docs/GOOS_125_COOP_Plan.pdf)

For some of the core variables such as nutrients, salinity etc. the most up to date measurements can be found as part of the Bermuda Atlantic Time-series Study (BATS). The protocols for 20 methods are outlined (http://gyre.bbsr.edu/methods_index.html). It should be noted that many of these measurements are calibrated for low levels found in the open ocean but these are standard methods based on methods described by Grasshoff et al (1983), Parsons et al (1992) and Strickland and Parsons (1972).

Methods for specific measurements can be found in the open literature however there exists literature in the International Intergovernmental agencies for regions to receive guidance. Primarily regional associations will have to develop protocols within areas of interest and through Capacity Building programs. These can be shared and become resources for each region. The GOOS Regional Forum can provide a vehicle to spread the techniques from GRA to GRA.

It is important to recognize that standard protocols are not essential between regions. Regions will have different needs, different resources and require different detail. The disparity between regions can be partially solved by the use of Certified Reference Materials which will allow for different methods to be used but calibrated with known material. Standards are also going to be a problem as they are expensive and presently most standards are supplied by supply houses where the costs do not fit within the budget of lesser developed countries. To this end, it important that the developed countries play a role in developing relatively simple and easier to use and calibrated methods for use in the Developing Nations (see Chapter 6). The international funding bodies as well as National funding agencies need to be encouraged to provide support for such activities.

Specific methods for GRAs' requirements will be dealt with as the Implementation Plan is updated.

ANNEX V
Satellite Requirements for the Coastal Module of GOOS

The coastal module of GOOS requires satellite observations with high spatial, temporal and spectral resolution and rapid access to data streams and products. Establishing and improving the GOOS coastal module are critically dependent on the coordinated development of GOOS Regional Alliances (GRAs) that contribute to and benefit from the global observing system, e.g. satellite-based remote sensing.

1. IOC Strategy For Remote Sensing

The increasing population of the world's coastal zones imposes new challenges on society to manage the finite marine resources of the planet in a sustainable and environmentally responsible manner. For the oceans in particular, the challenge to humankind of observing the oceans, understanding them, and transferring knowledge and information about them into management processes is very demanding. Many of the countries of the world do not yet have the resources to enable them to routinely and systematically collect from their coastal seas and Exclusive Economic Zones the observations at high resolution that are required on the one hand for fully effective ocean management in the pursuit of sustainable development, and on the other hand for the improvement of weather and climate forecasting.

Recalling the World Summit on Sustainable Development Implementation Plan for widespread use of remote sensing from space as a tool for sustainable development, IOC member states need to make best use of satellite data and to make remote sensing a new focus for IOC's capacity building efforts. Developing countries evidently need to make best use of the data from the satellites that overfly their waters day after day for the integrated coastal area management.

2. Satellite Requirements

2.1 IOC-CEOS Requirements

The IOC, UNEP, WMO and ICSU sponsored Global Ocean Observing Programme has been designed as (1) a global ocean module concerned primarily with detecting and predicting changes in the ocean-climate system and improving marine services (led by the Ocean Observations Panel for Climate: OOPC) and as (2) a coastal module concerned with the effects of large scale changes in the ocean-climate system and of human activities on coastal ecosystems, as well as improving marine services (led by the Coastal Ocean Observations Panel: COOP). The present satellite data requirements for the GOOS are summarized in Table VI.1.

Most of users of the satellite-derived information on the oceans are in the coastal seas. Establishing and improving the GOOS are critically dependent on the coordinated development of GOOS Regional Alliances (GRAs) that contribute to and benefit from the global observing system, e.g. the satellite remote sensing. GRAs are formed by agreement between participating countries, national organizations, and/or international bodies (Regional monitoring networks, Regional Fishery Bodies, Regional Sea Conventions, etc.). The activity and cooperation of GRAs are especially important to the development of the coastal module of GOOS.

2.2 IGOS Coastal Theme Requirements

The satellite requirements developed by the IGOS Coastal Theme are provided in Table 3.1.

USE	"REQUIREMENT"	"HOR RES"	"HR MIN"	"OBS CYCLE"	"OC MIN"	"DELAY OF AVAILABILITY"	"DA MIN"	"ACC - RMS"	"AC MIN"
GOOS Climate - large scale	Ocean chlorophyll	25 km	100 km	1 d	3 d	1 d	3 d	0.1 % (Max)	0.5 % (Max)
GOOS Climate - large scale	Ocean dynamic topography	100 km	300 km	10 d	30 d	10 d	30 d	2 cm	5 cm
GOOS Climate - large scale	Ocean salinity	200 km	500 km	10 d	30 d	10 d	30 d	0.1 psu	1 psu
GOOS Climate - large scale	Sea surface bulk temperature	10 km	300 km	6 h	720 h	6 h	720 h	0.1 K	1 K
GOOS Climate - large scale	Sea-ice cover	10 km	100 km	1 d	6 d	0.125 d	1 d	2 % (Max)	10 % (Max)
GOOS Climate - large scale	Wind speed over sea surface (horizontal)	25 km	100 km	24 h	168 h	24 h	168 h	1 m/s	2 m/s
GOOS Climate - large scale	Wind vector over sea surface (horizontal)	25 km	100 km	24 h	168 h	24 h	168 h	1 m/s	2 m/s
GOOS Climate - mesoscale	Ocean dynamic topography	25 km	100 km	7 d	30 d	2 d	15 d	2 cm	10 cm
GOOS Surface	Dominant wave direction	10 km	30 km	1 h	6 h	2 h	4 h	10 degrees	20 degrees
GOOS Surface	Dominant wave period	10 km	30 km	1 h	6 h	2 h	4 h	0.5 s	1 s
GOOS Surface	Sea surface bulk temperature	1 km	10 km	6 h	12 h	2 h	4 h	0.1 K	2 K
GOOS Surface	Sea-ice thickness	25 km	100 km	1 d	6 d	1 d	6 d	50 cm	100 cm
JGOOS-III	Geoid	250 km	500 km	240 mo	360 mo	12 y	24 y	2 cm	5 cm
Marine biology (coastal water)	Aerosol (total column) size	1 km	10 km	24 h	48 h	3 h	7 h	0.1 µm	1 µm
Marine biology (coastal water)	Ocean chlorophyll	1 km	5 km	1 d	3 d	3 d	7 d	5 % (Max)	20 % (Max)
Marine biology (coastal water)	Photosynthetically Active Radiation (PAR)	1 km	5 km	0.04 d	1 d	3 d	7 d	5 % (Max)	20 % (Max)
Marine biology (coastal water)	Sea surface bulk temperature	1 km	5 km	24 h	48 h	3 h	7 h	0.1 K	0.5 K
Marine biology (open ocean)	Aerosol (total column) size	4 km	50 km	24 h	48 h	3 h	7 h	0.1 µm	1 µm
Marine biology (open ocean)	Air pressure over sea surface	50 km	100 km	24 h	48 h	3 h	7 h	10 hPa	15 hPa
Marine biology (open ocean)	Ocean chlorophyll	10 km	50 km	1 d	3 d	3 d	7 d	0.1 % (Max)	0.5 % (Max)
Marine biology (open ocean)	Ocean yellow substance absorbance	1 km	5 km	1 d	2 d	3 d	7 d	5 % (Max)	20 % (Max)
Marine biology (open ocean)	Ozone profile - Total column	50 km	200 km	24 h	48 h	3 h	7 h	10 DU	20 DU
Marine biology (open ocean)	Photosynthetically Active Radiation (PAR)	10 km	50 km	0.04 d	1 d	3 d	7 d	5 % (Max)	20 % (Max)
Marine biology (open ocean)	Sea surface bulk temperature	10 km	50 km	24 h	48 h	3 h	7 h	0.1 K	0.5 K
Marine biology (open ocean)	Specific humidity profile - Total column	Missing	Missing	24 h	Missing	3 h	7 h	Missing	Missing
Marine biology (open ocean)	Wind vector over sea surface (horizontal)	4 km	50 km	24 h	48 h	3 h	7 h	2 m/s	5 m/s

Table VI.1. IOC satellite requirements as submitted to the CEOS/WMO database.

ANNEX VI
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ANNEX VII
Acronyms

ACI	Atmospheric Circulation Index
ADCP	Acoustic Doppler Current Profiler
ADM	Alternative Dissemination Method
AERP	Atmospheric Research and Environment Programme (WMO)
AUV	Autonomous Underwater Vehicle
AVHRR	Advanced Very High Resolution Radiometer
BATS	Bermuda Atlantic Time-series Study Atlantic Time-series Study
BOOS	Baltic Operational Oceanographic System
CASI	Compact Airborne Spectrometry Instrument
CBWG	Capacity building working group
CDOM	Coloured Dissolved Organic Matter
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites (WMO)
C-GTOS	Coastal Panel of the Global Terrestrial Observing System (FAO)
CITES	Convention on International Trade in Endangered Species
CMNs	Community Modelling Networks
CNES	Centre National d'Etudes Spatiales (France)
CODAE	COastal Data Assimilation Experiment
COOP	Coastal Ocean Observations Panel (GOOS)
CPR	Continuous Plankton Recorder
CPWG	CaPacity building Working Group
CZCS	Coastal Zone Color Scanner (NASA)
DMAC	Data Management and Communications Programme (US GOOS)
DMS	Data Management Subsystem
DMWG	Data Management Working Group
DPSIR	Driver-Pressure-State-Impact-Response
DSC	Digital Switched Calling
EDIOS	European Directory of the Instrumental Observing System
ENSO	El Niño Southern Oscillation
ETDMP	Expert Team on Data Management Practices (IODE)
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization of the United Nations
FTP	File Transfer Protocol
GBIF	Global Biodiversity Information Facility
GCN	Global Coastal Network
GCOS	Global Climate Observing System
GCRMN	Global Coral Reef Monitoring Network
GEEP	Group of Experts on the Effect of Pollutants
GEF	Global Environment Facility
GEMSI	Group of Experts on Methods and Intercalibration
GEO	Group on Earth Observations
GEOHAB	Global Ecology of Harmful Algal Blooms
GEOSS	Global Earth Observing System of Systems
GESREM	Group of Experts on Standards and Reference Materials
GIPME	Global Investigation of Pollution in the Marine Environment
GLOBEC	Global Ocean Ecosystem Dynamics
GLOSS	Global Sea Level Observing System (JCOMM)
GMES	Global Monitoring for Environment and Security

GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GRA	GOOS Regional Alliance
GRAND	GOOS Regional Alliances Networking Development
GCRMN	Global Coral Reef Monitoring Network
GRSCs	GRA Remote Sensing Centers
GSSC	GOOS Scientific Steering Committee
GTOS	Global Terrestrial Observing System Global
HABs	Harmful Algal Blooms
HF	High Frequency
HTTP	Hypertext Transfer Protocol
IAI	Inter-American Institute for Global Change Research
ICES	International Council for the Exploitation of the Sea
IGBP	International Geosphere – Biosphere Programme
IGOS	Integrated Global Observing Strategy
I-GOOS	Intergovernmental Committee for the Global Ocean Observing System (IOC-WMO-UNEP)
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research (IGBP)
IMO	International Maritime Organization
ISDR	International Strategy for Disaster Reduction (UN)
IOC	Intergovernmental Oceanographic Commission
IOCCG	International Ocean Colour Coordinating Group
IODE	International Oceanographic Data and Information Exchange (IOC)
IOOS	Integrated Ocean Observing System (US)
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature (and Natural Resources)
IWCO	Independent World Commission on the Oceans
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology (IOC-WMO)
LEO	Low Earth Orbit
LIDAR	LIght Detection And Ranging technologies
LOICZ	Land-Ocean Interaction in the Coastal Zone (IGBP)
LOS	Line-Of-Sight
LTER	Long-Term Ecosystem Research network
MAWG	Modelling and Analysis Working Group
MERSEA	Marine Environment and Security for the European Area
MF	Medium Frequency
MILAC	Marine Impacts on Lowland Agriculture and Coastal Resources
MWG	Measurements Working Group
NAO	North Atlantic Oscillation
NDR	Natural Disaster Reduction
NEARGOOS	North East Asia Regional GOOS
NGO	Non-governmental Organization
NGSST-P	New Generation Sea Surface Temperature Project
NOAA	National Oceanic and Atmospheric Administration (USA)
NOOS	North Sea Operational Observing System
NRC	National Research Council (Canada/USA)
NWP	Numerical Weather Prediction
OBIS	Ocean Biogeographical Information Systems
OIT	Ocean Information Technology
OOPC	Ocean Observations Panel for Climate (GCOS-GOOS-WCRP)
OpeNDAP	Open Source Project for Network Data Access Protocol
ORSP	Ocean Remote Sensing Programme
OTH	Over-The-Horizon
PAR	Photosynthetically Active Radiation
PDO	Pacific Decadal Oscillation
PICES	North Pacific Marine Science Organization
PTWS	Pacific Tsunami Warning System
QA	Quality Analysis
QC	Quality Control
QUIJOTE	QUickly Integrated Joint Observing TEam
RAM	Rapid Assessment Methodology
RAMP	Rapid Assessment of Marine Pollution
RASE	Rapid Assessment of Socio-economic indicators
RCOOS	Regional Coastal Ocean Observing System

RIS	Regime Indicator Series
SCOR	Scientific Committee on Oceanic Research
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SIDA	Swedish International Development Agency
SMTP	Simple Mail Transfer Protocol
SOLAS	Safety of Life at Sea
TABS	Texas Automated Buoy System
TEMS	Terrestrial Ecosystem Monitoring Sites
TGLO	Texas General Land Office
THORPEX	The Observing System Research and Predictability Experiment (WMO-AREP-WWRP)
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
URL	Universal Resource Locator
VHF	Very High Frequency
WCMC	World Conservation Monitoring Centre (UNEP)
WCRP	World Climate Research Programme
WESTPAC	IOC Sub-Commission for the Western Pacific
WG	Working Group
WiFi	Wireless Fidelity
WMO	World Meteorological Organization
WSA	World Seagrass Association
WWW	World Weather Watch
XML	eXtensible Markup Language

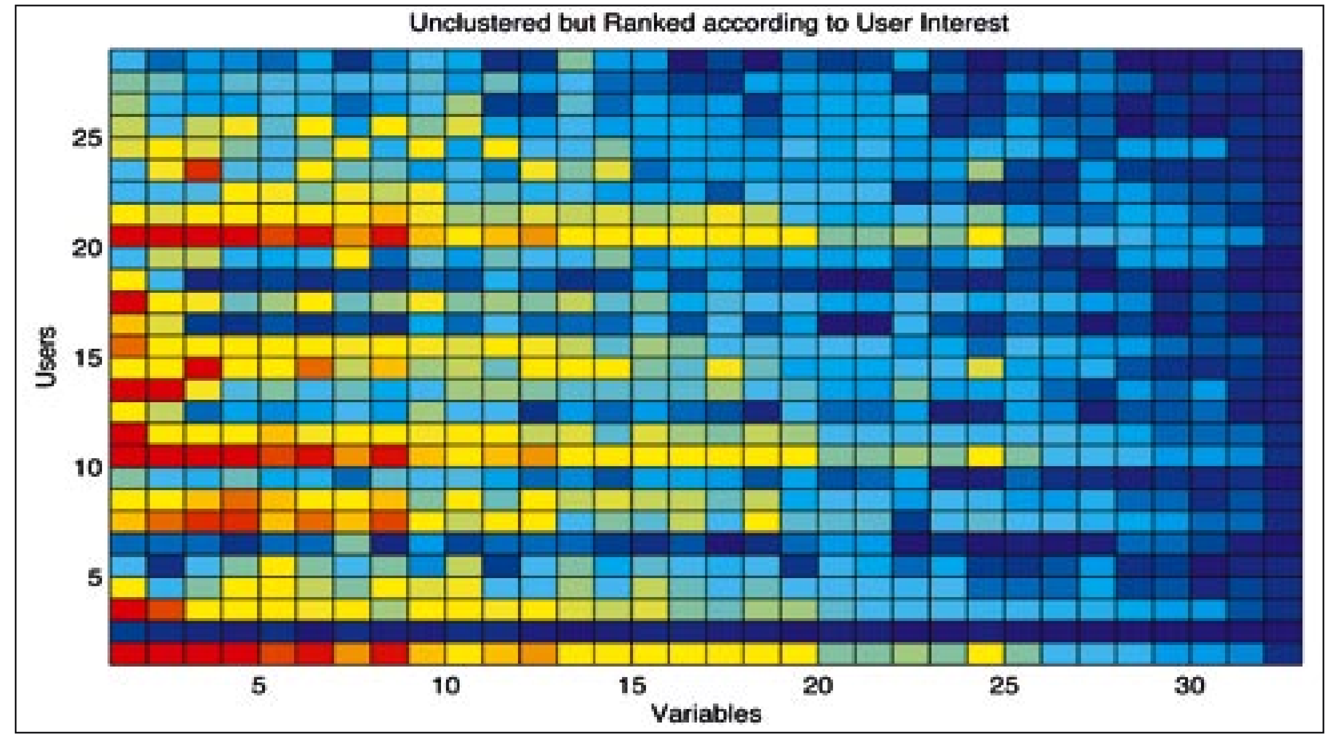

Figure II.1. Ranking of socio-economic indicators resulting from initial expert group exercise.

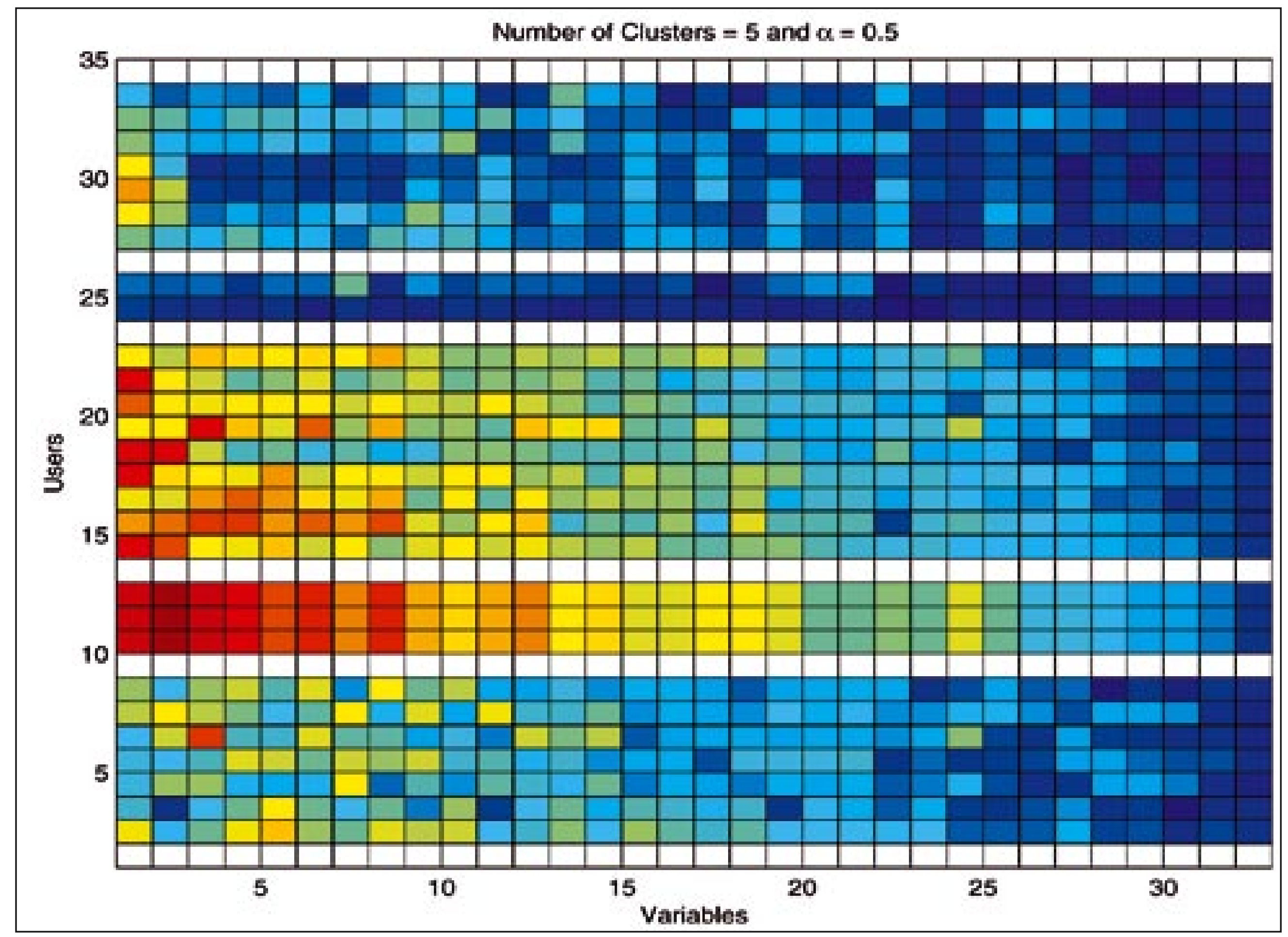

Figure II.2. Stakeholder groups with significant affinity interests in indicator ranking from initial expert group.

Group 1:	Shipping, Insurance and Re-insurance, Coastal engineers, Search and rescue, Weather services, National security (including navies), Emergency response agencies
Group 2:	Consumers of seafood, Educators
Group 3:	Hotel–restaurant industry, Port authorities and services, Government agencies responsible for environmental regulation, Freshwater management/damming, Public health authorities, Wastewater management, Ecotourism, Tourism, Conservation and amenity (including environmental NGOs), News media
Group 4:	Consulting companies, Integrated coastal management, Scientific community
Group 5:	Marine energy and mineral extraction, Fishers (commercial, recreational, artisanal), Agriculture, Aquaculture, Fisheries management, Recreational swimming, Recreational boating