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The Case for IOCARIBE-GOOS: A Strategic Plan

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ABSTRACT

This document sets out a Strategic Plan for the development of a Regional Ocean and Coastal Observing System in the wider Caribbean region including the Gulf of Mexico. This system will be a regional component of the Global Ocean Observing System (GOOS). It will be managed by the IOC's Regional Sub-commission for the Caribbean and Adjacent Regions (IOCARIBE), and will be called IOCARIBE-GOOS. The Strategic Plan was endorsed by the Member States of IOCARIBE meeting in their 7th session (Veracruz, 25 - 28 February 2002).

Its implementation will be the responsibility of a Steering Committee for IOCARIBE-GOOS, which will produce an Implementation Plan and oversee the implementation process on behalf of IOCARIBE.

* Translated into French and Spanish. Annexes remain in English only.

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EXECUTIVE SUMMARY

This document sets out a Strategic Plan for the development of a Regional Ocean and Coastal Observing System in the Wider Caribbean region, including the Gulf of Mexico. This system will be a regional component of the Global Ocean Observing System (GOOS). It will be managed by the IOC's Regional Sub-Commission for the Caribbean and Adjacent Regions (IOCARIBE), and will be called IOCARIBE-GOOS. IOCARIBE-GOOS will be a basic source of information, services and products to support sustainable social and economic development, welfare, and safety, through systematic observations and associated research on coasts and seas in the IOCARIBE region. The system will be operational in nature and designed to yield products and services that meet the needs of users (managers, decision-makers, policy-makers, industry, the public, and the scientific community). It will provide information on the past, present and future state of the marine and coastal environment, on marine ecosystems and biodiversity, and on weather and climate variability. It will also be a tool for integrated management of the coastal zone. International cooperation and capacity building are essential to the effective operation of the system and to enable potential users to benefit from it.

The Strategic Plan comprises nine sections. Chapter 1 defines the concept of IOCARIBE-GOOS by describing the objectives, principles and development of GOOS, and explaining the importance of developing the GOOS concept at the regional level. By sharing observations about a common sea area, countries will benefit from improvements in the range and quality of ocean, weather and climate information and forecasts. Chapter 2 focuses on the needs of the user community as the main drivers for developing a regional observing system, and takes a preliminary look at costs and benefits, including the development of products as a response to user requirements. Chapter 3 explains how GOOS is being designed at the global level, and defines key roles for the IOCARIBE-GOOS Steering Committee in the development of the regional observing system. The system will comprise 4 basic elements: the observational network, the communications and data management subsystem, the modelling and applications subsystem, and a cross-cutting training and capacity building programme. Chapter 4 sets out the various steps to be taken in converting the Strategic Plan into an Implementation Plan. A key initial objective is the implementation of an Initial Observing System for the region, including the design of one or more concept-demonstration projects. Chapter 5 discusses what is required in the way of a data and information management system to ensure that observational data are collected, stored and analysed in the most appropriate ways to generate a stream of useful products in near-real time for the benefit of the user community. Chapter 6 spells out the regional requirement for building the capacity of all countries in the region to participate in, contribute to, and benefit from GOOS according to their respective needs and abilities. Chapter 7 offers advice on how the developments desired could and should be supported at the national and regional level. Chapter 8 explores what resources are currently available, and what may be needed for the future, from government, or from industry and commerce, to ensure the successful implementation of a regional GOOS. Finally, Chapter 9 sets out what is needed to ensure the coordination needed at the national, regional and global levels to guarantee the success of this new venture.

An essential requirement to take these developments forward is the creation of a Steering Committee for IOCARIBE-GOOS, which should comprise operational experts in oceanography, meteorology, and fields related to fisheries and/or environmental management. Bearing in mind the importance of that body, which will convert this Strategic Plan into an Implementation Plan, and then oversee the implementation process, we focus here on the main tasks that the Steering Committee has to carry out.

The Steering Committee must:

1. Carry out a survey among the marine-related communities of the participating IOCARIBE Member States (i) to construct an appropriate set of user scenarios, and (ii) to determine what end-products and services are required by the user community;

2. Evaluate the costs and benefits of implementing IOCARIBE-GOOS for discrete user sectors (e.g. tourism, offshore industry, fishing);

3. Develop an inventory of existing activities relevant to IOCARIBE-GOOS including: (i) operational systems and programmes; (ii) organizations; (iii) scientific programmes; (iv) services and products; (v) commercial interests; and (vi) training and capacity building;

4. Devise an Implementation Plan that meets both the advice from the GOOS advisory panels and the needs of the region;

5. Establish an integrated Initial Observing System building on existing national and sub-national level observing systems;

6. Identify key gaps in the existing observing systems, and make plans to fill them;

7. Prepare an engineering and design analysis to integrate the various existing and planned ocean observations and provide for the future adaptability of the system;

8. Develop and implement concept-demonstration projects that will contribute to the long-term health and stability of IOCARIBE-GOOS, beginning by organizing a regional workshop on concept-demonstration projects;

9. Organize data management among the IOCARIBE-GOOS Initial Observing System elements, to improve data collection, storage, exchange and dissemination, building on existing structures, and exploiting the proposed Ocean Data and Information Network for the Caribbean and South America (ODINCARSA);

10. Establish an appropriate capacity building programme, building initially on existing and planned capacity building activities;

11. Work to ensure not only the effectiveness and efficiency of the observing system, but also its sustainability for the long term;

12. Ensure that GOOS design principles and principles of involvement are maintained within IOCARIBE-GOOS activities;

13. Encourage the development of National GOOS Coordinating Committees and appropriate national GOOS focal points in IOCARIBE Member States;

14. Take full advantage of the creation of JCOMM to bring together meteorologists and oceanographers to design IOCARIBE-GOOS in such a way as to extract the maximum benefit from JCOMM as an implementation mechanism for GOOS;

15. Develop appropriate synergies with global programmes having activities in the region;

16. Hold a regional applications-oriented science conference (like the biennial Operational Oceanography conferences of EuroGOOS or the science conferences of WESTPAC), to bring the community together behind the development of IOCARIBE-GOOS;

17. Develop the case for establishing and funding an Administrative Officer to supply the Secretariat support required for implementing IOCARIBE-GOOS;

18. Solicit external funding (with the secretariats of IOCARIBE and IOC) from potential sponsors to implement aspects of the work programme;

19. Coordinate with the GOOS Steering Committee Advisory Panels on scientific and technical developments;

20. Develop appropriate marketing and communications strategies including a web site and newsletter for IOCARIBE-GOOS.

1. THE DEFINITION OF IOCARIBE-GOOS

1.1 INTRODUCTION

The World Ocean plays a major role in a large number of processes occurring at the surface of the earth. It influences the human environment and in turn is impacted by human pressure. However, despite more than a century of detailed scientific study, until recently there was no internationally coordinated system to observe the ocean continuously and systematically on a global scale, to define the common elements of regional marine environmental problems or to provide data and products on which collective national response can be built, and on which the traditional and new marine-related industries can be advanced responsibly and cost-effectively.

The United Nations Convention on the Law of the Sea (UNCLOS), in defining the Exclusive Economic Zone, gave coastal states the right to use and the obligation to protect and manage their resources within at least 200 miles of their coasts. The United Nations Conference on Environment and Development (UNCED), through the conventions on biodiversity and climate change and through the publication of Agenda 21, committed countries to develop integrated management programmes for the sustainable use of the environment and the development of a global monitoring system. More recently, the awareness of policy makers and the public was raised further through the United Nation's International Year of the Ocean (1998), the report of the Independent World Commission on the Oceans, the UN CSD-7, and other initiatives calling for increased attention to global ocean governance.

Since the end of the nineteen-eighties, the international marine scientific community has been working on the theoretical conception and practical implementation of a Global Ocean Observing System (GOOS). This system is intended to be similar to the World Weather Watch that underpins weather forecasting worldwide, but in addition will allow forecasting of the ocean environment in general. It will also contribute to the understanding and forecasting of climate change at the global scale. Public awareness of global environmental decline, development in the technology of low cost observing systems, advances in numerical modelling, including biological processes, and rapid progress in the electronic communication of information all contribute to make GOOS feasible now as a tool to underpin the decision-making needed for cost-effective sustainable development, environmental management, and the protection of life and property. GOOS is therefore envisaged as an important investment in the future of the planet. What is needed to implement it is political will of the member states.

Apart from the "common good" benefits of GOOS, many commercial and industrial activities can gain advantage from access to more comprehensive and reliable "operational" data and information on the marine and coastal environment. The active involvement and support of such non-government interests would both widen the scope of GOOS and strengthen its funding base.

GOOS is being implemented at both global and regional scales. Here we make the case for the regional component of GOOS for the wider Caribbean region that comes under the responsibility of the Regional Sub-commission of the Intergovernmental Oceanographic Commission (IOC) for the Caribbean and Adjacent Regions (IOCARIBE).

The design, implementation and development of an observation system at global or regional scale requires not only an appropriate human and material capacity, but also strong organizations and institutional arrangements at national and international levels. It must capitalize on existing coordinating structures, and on the capacity and willingness of individuals, institutions and states to develop strong cooperative relationships and mutual assistance.

A change is also called for in institutional approaches, recognizing that a modern appreciation of the marine environment calls for an integrated approach to ocean and coastal issues. The further development of marine scientific research, and the establishment of marine and coastal services having wide geographical and thematic coverage, are largely beyond the full reach of any single nation. Today, ocean and coastal scientific research and services increasingly depend on international cooperation as well as on national and regional capacity.

GOOS was initially devised by the Intergovernmental Oceanographic Commission (IOC) of UNESCO in 1989. It was subsequently endorsed by the Intergovernmental Panel on Climate Change (IPCC) and by the Second World Climate Conference, in 1990, as the means of providing the oceanographic data needed for the Global Climate Observing System (GCOS). Formal initiation of the Global Ocean Observing System (GOOS) was approved by Resolution XVI-8 of the XVI Assembly of the IOC in Paris, in March 1991. The GOOS was also endorsed by the United Nations Summit Conference on Environment and Development that took place in Rio de Janeiro in 1992, with GOOS being called for in Agenda 21, as a tool for marine environmental management. Subsequently the various sessions of the Conference of the Parties to the UN Convention on Climate Change have called for the maintenance, and where necessary, the expansion of ocean observations, especially in support of climate monitoring. The Second International Conference on Oceanography (Lisbon, November 1994) also gave high priority to the establishment of an operational system for global ocean observations. The conference recognized the need to create and to strengthen the scientific capacity of developing countries, so as to enable them to fully participate in international oceanographic programmes that were consistent with their national priorities and aspirations.

In this context, the establishment of a Regional Ocean and Coastal Observing System in the Wider Caribbean region, including the Gulf of Mexico is particularly important. The region has many states and cultures, all sharing the sea as a common heritage. The sea unites them. The sea provides them with basic resources. And the sea affects them, by modulating both weather and climate. Much is to be gained by sharing information about this shared sea are. Thus marine observations, forecasts, and other products and services dealing with the Caribbean and Gulf of Mexico marine and coastal environment, are important strategic elements for the sustainable development of the Region.

Bearing this in mind, the IOC Sub-commission for the Caribbean and Adjacent Regions decided at its 6th session in April 1999 to establish and develop the regional component of the Global Ocean Observing System, IOCARIBE-GOOS.

1.2 THE GLOBAL OCEAN OBSERVING SYSTEM

The Global Ocean Observing System (GOOS) is co-sponsored by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the World Meteorological Organization (WMO), and the United Nations Environment Programme (UNEP), together with scientific guidance from the International Council of Science (ICSU).

The development and implementation of GOOS at global or regional levels follow a specific Mission and are designed to meet a set of Goals, Objectives and Principles, set out below as taken from the GOOS Strategic Plan (GOOS Report No. 41, IOC, Paris, 1998).

1.2.1 The Mission

To use long-term, multi-disciplinary, operational oceanographic monitoring of seas and oceans as the basis for:

(i) Enabling the use of ocean data in creating and disseminating reliable assessments and predictions of the present and future state of these environments in support of their health and sustainable use and,

(ii) Contributing to prediction of climate change and variability, for the benefit of a wide range of users. This will,

(iii) Guide the directions of scientific and technical research, development and training in the various disciplines of oceanography that will in turn facilitate the development and management of the system.

1.2.2 The Goals

- To serve the marine data and information needs of humanity for the efficient, safe, rational and responsible use and protection of the marine environment, and for climate prediction and coastal management, especially in matters requiring information beyond that which individual national observation systems can efficiently provide, and which enable smaller and less-developed nations to participate and gain benefit;

- To establish an international system to provide the required coordination and sharing of data and products that otherwise would not be possible.

1.2.3 The Objectives

- To specify in terms of space, time, quality and other relevant factors, the marine observational data needed on a continuing basis to meet the common and identifiable requirements of the world community of users of the oceanic environment and ocean knowledge;

- To develop and implement an internationally coordinated strategy for the gathering or acquisition and the archiving of these data and synthesising them for common use and practical application;

- To facilitate the development of uses and products of these data, and encourage and widen their application in the sustainable use and protection of the marine environment;

- To facilitate means by which less developed nations can increase their capacity to contribute, acquire and use marine data;

- To coordinate GOOS activities and ensure their integration with other global observation and environmental management strategies.

1.2.4 The Principles

The Design Principles define the overall principles that determine the design of the system and provide a guide for what the design should include and exclude. The Principles of Involvement are a guide to the conditions that should determine participation in the system, and the elements that determine those conditions. These Principles have been adopted to guide the design and implementation of GOOS. Nothing within them should be interpreted as contravening or conflicting with the rules and regulations of the sponsoring organizations or the individual rights of Member States.

1.2.4.1 Design Principles

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

D2. The design assumes that contributions to the GOOS are long term and systematic.

D3. The design will be reviewed regularly.

D4. The design allows for flexibility of technique.

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

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

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

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

D9. The design takes into account quality assurance procedures.

1.2.4.2 Principles of Involvement

P1. Contributions to the GOOS will be compliant with plans developed and agreed on the basis of the above design principles.

P2. Contributions will be compliant with a defined GOOS data policy.

P3. Contributions should reflect an intent for sustained observations.

P4. Standards of quality will apply to GOOS contributions.

P5. Implementation will be effected using existing national and international systems and organizations where appropriate.

P6. Implementation will be incremental and progressive, whilst bearing in mind the long-term goals.

P7. Participation in the GOOS implies an undertaking to help less-developed countries to participate and benefit.

P8. Participants will have full autonomy in the management of their contributions.

P9. Contributing nations and organizations will reserve the right to determine and limit their contributions to the GOOS.

P10. Use of the GOOS 'label' implies conformity with the relevant principles of the GOOS.

Behind the rationale for GOOS is the conviction that the benefits of a planned and coordinated system that delivers useable information, understanding and prediction of the marine environment and of its effect on climate will outweigh the costs of its operation by a large factor. GOOS implementation priorities will be set by focussing on what data and data products the "users" of the world seas and oceans most need to perform their function effectively and responsibly, and on the needs of "users" on land who are or may be impacted by the ocean or by its effect on climate change. Scientific research is promoted through GOOS as a critical link, being the vehicle by which value is added to data, and as a "user".

GOOS is envisioned to resemble the global meteorological observation and prediction network, supported by national governments and implemented through the contributions of national agencies, organizations and industries, with the assistance of national and international data management and distribution bodies.

The implementation of GOOS will depend almost entirely upon the cooperative participation of national marine observing and research agencies, industries and non-government organizations. To support this participation and to ensure the resources needed for its success, governments need to become well informed about GOOS and committed to the concept. For this commitment to be made, GOOS must build upon already functioning systems and elements and must be able, without delay, to demonstrate tangible benefits over these individual efforts.

GOOS will include diverse marine observations many of which have not been systematically or routinely assembled before. Nevertheless, maximum use will be made of existing systems and organizations, and encouragement will be given for these to modify and enhance their activity to include observations and products contributing to a coordinated GOOS plan.

The implementation of GOOS will be very largely dependent upon the commitments made by the participating nations to support the observational systems through their national observing agencies, and by providing infrastructural elements such as data centres and distribution networks, scientific and technical research, development and installation. Much of the implementation will be accomplished using regional alliances, but a global approach will be needed to address the ocean's role in the climate system.

Training and the facilitation of participation by less-developed countries will be a responsibility shared between nations and the sponsors.

Support for planning and international coordination required for the design and implementation of GOOS is apportioned between the GOOS sponsoring organizations, IOC, WMO, UNEP and ICSU, and supplemented through them by financial, manpower and in-kind contributions from nations with an interest in its success.

GOOS constitutes the oceanic component of the Global Climate Observing System (GCOS), and the marine coastal component of the Global Terrestrial Observing System (GTOS).

1.3 THE REGIONAL OCEAN AND COASTAL OBSERVING SYSTEM

The IOC Sub-commission for the Caribbean and Adjacent Regions (IOCARIBE) is a unifier of efforts and purposes, and provides a stimulus to develop marine sciences and services in the region. Its fundamental goals are based on international cooperation in marine sciences, services and capacity building in order to promote and facilitate the development of high priority marine and coastal scientific and service programmes. It has contributed to remarkable advances in marine sciences and services in the Caribbean and the Gulf of Mexico region. The platform built by IOCARIBE's efforts in the past constitutes the basis for the establishment and development of a regional observing system of the ocean and coasts. That is why the 6th session of IOCARIBE (Costa Rica, April 1999) approved the establishment of a regional ocean observing system (Recommendation SC-IOCARIBE-VI.1), a decision later endorsed by Resolution XX.14 of the 20th IOC Assembly in Paris, in June 1999. The Sub-commission agreed that this regional component of the Global Ocean Observing System (GOOS) would be called IOCARIBE-GOOS. IOCARIBE-GOOS would promote the technical implementation of GOOS in the Greater Caribbean Region, at appropriate time and space scales as required, so as to satisfy the economic, social and environmental needs of the region's coastal and island states.

To take IOCARIBE-GOOS forward, the 6th session of the Sub-commission approved the establishment of a Steering Committee consisting of representatives from Member States, assisted by a Joint *ad hoc* Advisory Group consisting of not more than ten participants that would within the time-frame of two years:

a) prepare an inventory of what is already being done in the region;
b) assess the regional and national requirements for setting up the IOCARIBE-GOOS component;
c) develop links with existing relevant organizations, programmes and projects;
d) prepare a-10 year strategic plan for the development of IOCARIBE-GOOS; and
e) consider mechanisms for gradual and appropriate implementation of pilot-projects to take part in IOCARIBE-GOOS and identify funding sources.

Prior to the 7th session of the Sub-commission, at which it was expected that the Steering Group would be formed, the *ad hoc* Advisory Group met four times (Caracas, 3-5 November 1999; La Havana, 29 November-1 December, 2000; Miami, April 1-5, 2001; and Veracruz, February 21-23, 2002). At the Havana meeting the above terms of reference were modified slightly to:

a) prepare an inventory of what is already being done in the region;
b) draft and distribute guidelines for national participation in IOCARIBE-GOOS;
c) develop links with existing relevant organizations, programmes and projects in the region;
d) provide a draft IOCARIBE-GOOS Strategic Plan for review by the future IOCARIBE-GOOS Steering Committee (this subsumes (e) from the previous Terms of Reference).

The objectives of the Regional System will be the same as those of the global system, modified by inclusion of a set of specific objectives that will satisfy the fundamental needs and priorities for the sustainable development of the states of the region. Top priority areas (as determined by the IOCARIBE Users and the GOOS Capacity Building Workshop, Costa Rica, 1999, GOOS Report No. 84) for the conception and implementation of IOCARIBE-GOOS would be:

Tourism	Fisheries	Agriculture	Storm Surges
Coastal populations	Maritime safety	Marine pollution	Marine Biological Diversity
Storms and hurricanes	Weather forecasts	Tsunamis	

1.4 IOCARIBE-GOOS: DEFINITION OF THE OCEAN AND COASTAL OBSERVING SYSTEM IN THE CARIBBEAN AND THE GULF OF MEXICO

The establishment of IOCARIBE-GOOS will require an intense process of capacity building, and the development of strong scientific, technological, organizational, and structural capacities by all participants independently of their level of development. The development of the system requires not only the making and processing of observations, but also developing the ability of potential users to use the knowledge acquired.

The establishment and development of the regional ocean and coastal observing system must be based on the marine sciences and services developed with the help of the Sub-commission.

The Steering Committee for IOCARIBE-GOOS must define, establish, promote and develop:

(i) The scientific conception;
(ii) Assessments of national and regional capacities and needs;
(iii) Strategic design, planning and implementation;

These must be developed at appropriate time and space scales, as required to satisfy the regional economic, social and environmental needs of all coastal and island states.

IOCARIBE-GOOS shall be organized to facilitate the full participation of interested countries and their institutions. Developing countries should be actively involved in the process of conception, planning and implementation, to ensure that IOCRIBE-GOOS meets their strategic needs and priorities. In doing this, the following guidelines should be borne in mind:

- To define the priorities that should be addressed, bearing in mind the available resources;
- To conceive and to execute the scientific and services programmes in harmony and correspondence with common national priorities;
- To ensure appropriate capacity building in terms of human, material and institutional resources;
- To establish the necessary mechanisms to enable national and institutional activities and programmes to become contributions to the international programmes;
- To improve coordination and conciliation of interests among related governmental and non-governmental organisms and international mechanisms;
- To develop the widest coordination, association and cooperation spirit among all states participating in the programme, in order to facilitate the achievement of the most cost-effective Regional Capacity;
- To ensure a plan of systematic actions that guarantees the continuity of the programme, starting from a clear and precise definition of the concrete objectives that are pursued at short, medium and long-term, including their systematic evaluation.

The countries of the Caribbean and the Gulf of Mexico need IOCARIBE-GOOS as a fundamental tool to support the development of tourism and sustainable exploitation of the marine environment. Tourism is an important economic activity that is extremely sensitive to environmental factors, because it depends on the quality and health of environmental resources, and on the wisdom with they have been managed. Through monitoring the quality of the marine environment IOCARIBE-GOOS will provide a tool for the integrated management of the coastal zone, from which tourism will benefit.

High quality weather forecasting is also strategically important for the Region, not only because many of the region's economic activities depend on the weather and climate, but also because extreme meteorological events can seriously damage life and property as well as degrading the environment. IOCARIBE-GOOS should improve the flow of ocean data required to improve weather and climate forecasts and so help to reduce the risks of human and/or economic losses due to weather and climatic events. Improved forecasts would also help to improve the design and development of systems for coastal protection.

Good science is fundamental to the establishment and implementation of IOCARIBE-GOOS.

Bearing the above background in mind, IOCARIBE-GOOS can be defined as follows:

DEFINITION

" IOCARIBE-GOOS is a basic source of information, services and products to support sustainable social and economic development, welfare, and safety, through systematic observations and associated research on coasts and seas in the IOCARIBE region. The system is operational in nature and designed to yield products and services that meet the needs of users. It provides information on the past, present and future state of the marine and coastal environment, on marine ecosystems and biodiversity, and on weather and climate variability. It is also a tool for integrated management of the coastal zone. International cooperation and capacity building are essential to the effective operation of the system and to enable potential users to benefit from it."

This definition is consistent and complementary with the general definition given by the Plan and Principles for the Global Ocean Observing System.

2. ASSESSMENT OF NEEDS AND PRODUCTS

2.1 A FOCUS ON USER NEEDS

To support a new regional undertaking of the scale and complexity of IOCARIBE-GOOS, a clear focus must be placed on what the 'user' community (defined as broadly as possible) needs by way of marine information, and priorities must be placed upon the data and products derived from them in terms of what quantifiable benefits can be delivered to these users.

The user community for operational oceanographic data is broad. Users need data and products not only for offshore and coastal activities, but also to provide the basis for weather and climate forecasts used to plan supplies of water, food and energy (Table 1).

Table 1: The User Community

- Government agencies, regulators, public health, certification agencies;
- Environmental management, wildlife protection, amenities, marine parks;
- Operating agencies, services, safety, navigation, ports, pilotage, search, rescue;
- Small companies; fish farming; trawler skippers, hotel owners, recreation managers;
- Large companies, offshore oil and gas, survey companies, shipping lines, fisheries, dredging, construction;
- The single user, tourist, yachtsman, surfer, fisherman, scuba diver;
- Scientific researchers in public and private institutions.

Applications will extend to fisheries, climate prediction, public health, safety at sea, coastal protection (e.g., sea-walls, groins, soft-engineering solutions), recreation and tourism, wildlife conservation, weather forecasting, shipping, port operations, agriculture and the management of water and energy supplies. These applications take place increasingly in the context of Integrated Coastal Area Management (ICAM). IOCARIBE-GOOS will be a tool for ICAM.

In the case of the wider Caribbean region much of the sea area now belongs to the Exclusive Economic Zone (EEZ) of one nation or another. Responsibility for an EEZ implies knowledge about its state as the basis for the sustainable management of its resources. IOCARIBE-GOOS will be a tool for EEZ management.

Users want information about the kinds of public concerns listed in Table 2. Many of these concerns are the responsibility of government agencies whose job is to meet statutory national and international obligations. These 'public good' issues are the major motors for the development of operational oceanography.

Table 2: Regional Concerns About Coasts, Seas and Oceans

- Climate variability including El Niño and other oscillations;
- Sea-level rise caused by global warming;
- Frequency and intensity of hurricanes and storm surges;
- Pollution and its effects on water quality and public health;
- Oil spills and other marine accidents;
- Dumping and waste disposal;
- Loss of amenities due to coastal development and urbanisation;
- Coastal and beach erosion;
- Loss of coastal ecosystems and fragile habitats;
- Degradation of coral reefs and mangrove forests;
- Nutrient run-off leading to eutrophication;
- Toxic algal blooms;
- Invasive species;
- Exhaustion of fish stocks;
- Decreasing biodiversity;
- The need to conserve Wildlife;
- Mass mortalities of and damage to marine mammals;
- Safety of passenger and cargo ships, ferries and offshore operators;
- Tsunami warnings.

2.1.1 Management as a Key User

In addition to enhancing knowledge and understanding of coastal and oceanic processes and validating and verifying predictive models, coastal and open ocean observations are needed to determine the status of specific coastal and marine areas and resources, to detect changes and trends, to provide early warning of future problems, to provide real-time observations to guide routine and emergency operations, and to evaluate the efficacy of coastal and open ocean management strategies and policies.

Management is the critical link that converts information derived from ocean and coastal observations, into actions. Managers of coastal and marine resources (fish, oil and gas), areas (marine protected areas; wetlands etc), and activities (shipping, waste disposal etc) should be seen as key users of IOCARIBE-GOOS products and services. Their requirements should be addressed in the design and implementation of IOCARIBE-GOOS. Both public and private sector management institutions at all levels may also be a source of funds for some IOCARIBE-GOOS products and services.

2.1.2 The Science Community as a User

The scientific community plays a very important part in designing the observation and forecasting system so that it can meet the needs of the wider community. In addition, scientific research is critical to improving the range and accuracy of observations and forecasts made through GOOS.

On the other hand the scientific community itself is a potential beneficiary from the establishment of GOOS. Currently marine scientists have to plan their work largely in the dark, lacking the benefit long experienced by meteorologists of having access ahead of time to comprehensive data fields displaying the state of the marine environment and providing a context for the design of experiments. Provision of data fields by GOOS will improve the research environment. Similarly the collection of data over long time periods will establish the basis for research on long term changes, such as the decadal scale shifts caused by phenomena like the North Atlantic Oscillation or the Tropical Atlantic Dipole, with their likely effects on the Caribbean ecosystem and associated fisheries. GOOS activities also provide an essential basis for educating and training new generations of students.

2.1.3 Nations as Users

All coastal nations collect and use some marine environmental information, even though the amount and range of what is collected may be small. Some do so through regional or wider international agreements as well as at the national level. Where many nations share a common sea area, as in the Wider Caribbean, there is merit in pooling information so as to get the best possible view of how the ocean is behaving, because the water that washes one island’s shores today will wash another’s tomorrow. As in other such common sea areas, there is a need for IOCARIBE Member States not only to know about local conditions, but also to know what is happening further a field, for example in the circulation of the adjacent Atlantic, and in the El Niño-Southern Oscillation patterns of the equatorial Pacific, both of which can transmit their effects to the Wider Caribbean region. IOCARIBE-GOOS recognizes that even though the Wider Caribbean may seem to be self-contained, in fact it is influenced by events in the wider ocean. IOCARIBE-GOOS will improve local products by accessing a wide range of regional and local information.

The degree to which different nations may wish to become involved in IOCARIBE-GOOS will depend ultimately on the extent to which they can be satisfied as users, and the extent to which they can see that the benefits significantly outweigh the costs. Their involvement may vary to some extent with size. In the Wider Caribbean there are very substantial differences between the large states and the small island states, leading to different competencies for operational oceanography. About 75% of the population lies in the larger islands and surrounding continental areas. The rest lie mostly in numerous small island developing states that have very little capacity for operational oceanography. They may only be able to participate in and contribute to GOOS to a rather limited extent. It is the larger, wealthier countries that have the potential to collect information for the greater good of the Wider Caribbean community, enabling the smaller nations to benefit through free and open access to essential data. Achieving this exchange and the ensuing benefits will require barriers to be overcome in cultures, languages, political systems and economies, as well as in scientific competencies and capacities. The way forward to collaboration is expected to lie in the recognition of major issues that are trans-boundary in nature. Below we offer some general examples of needs and products in which large benefit is implied for small investment. Achieving the benefits requires liaison between different countries and even between different agencies within individual countries, as well as between international and intergovernmental agencies, working towards the common goal of a multi-purpose IOCARIBE-GOOS.

2.1.4 International Conventions and Assessments as Users

One clear need for systematic observations is in support of international and regional conventions and action plans, such as the Cartagena Convention and its Protocols. Caribbean governments need data on which to meet their obligations under the conventions, and information on the state of the environment, resources and processes to which the conventions and action plans are directed. Only reliable observations over time can demonstrate if the measures taken under the conventions are effective. IOCARIBE-GOOS will liase closely with the relevant global and regional convention bodies such as the Cartagena Convention, in the design of observing systems, so as to be a tool for the achievement of the objectives of the Convention.

There also will be a continuing ocean data requirement in support of assessments of the state of the marine and coastal environment. Assessments in progress include the next GESAMP State of the Marine Environment report in 2002, a prior assessment of land-based activities affecting the marine environment under the Global Plan of Action, a Global International Waters Assessment planned by the World Bank's Global Environmental Facility (GEF), and the Millennium Assessment. IOCARIBE-GOOS should explore with bodies planning these assessments how their data requirements can be supported at the Caribbean level.

Indicators and indices, like those for environmental health, are a form of information increasingly being called for by the Commission on Sustainable Development and in other *fora*, to assist decision-makers in identifying problems and trends, measuring progress, and evaluating the effectiveness of management measures. IOCARIBE-GOOS should contribute to the design of appropriate indicators for the Caribbean, and should help to provide the regular flow of reliable data from which such indicators and indices can be calculated.

2.2 PRODUCTS IN RESPONSE TO USER'S NEEDS

Operational Oceanography is concerned with observing the present state of the sea to provide accurate nowcasts and forecasts of its behaviour for the benefit of a wide range of users. This means observing and forecasting not only the behaviour of the physical system (waves, tides, currents, winds and so on), but also that of the chemical and biological components (nutrients, pollutants, plankton, fish, etc.). The information must be presented in the form of products useful to the different parts of the user community and tailored to meet their requirements. In essence, IOCARIBE-GOOS should work as an end-to-end system in which the users define their requirements, products are devised to meet those requirements, the observations and the processing required to produce those products are defined, and, finally, the observational network is put in place to create the observations needed. As a start, then, the system designers should work either with stated user requirements, and/or with scenarios that define arrays of possible user requirements. Such scenarios are helpful in discussions with users who are not sure what they want, but who have a feeling they need something better than they have at present.

GOOS user surveys elsewhere have shown that many users need the same basic information. Those interested in fish, for example, or pollutant trajectories, all rely, as do weather forecasters, on the basic physical information. The key parameters required include: near-surface air temperature and pressure; surface winds; humidity and precipitation; short- and long-wave incident, reflected and emitted radiation; sea-level; surface sea water temperature and salinity; waves and currents; bathymetry; turbidity and sediment type; nutrients; phytoplankton pigments and colour of the ocean. Other marine variables (physical, geochemical or biological) can be added as locally feasible and convenient.

Observations and forecasts will be used to provide products for a variety of purposes, for example for numerical weather prediction, to improve the safety and efficiency of marine operations; to monitor and predict climatic variability; to preserve and restore healthy marine ecosystems and manage living marine resources for sustainable use; to help to mitigate the effects of natural coastal hazards; and to monitor the supply and effect of pollutants and their effects on water quality.

Although at present the supply of information products is dominated by observations of physical parameters such as waves, tides, currents, temperature and salinity, with the oil and gas and shipping sectors as major customers, over the next decade the supply is expected to respond to growing calls for environmental information, and to include more environmental measurements and forecasts for people managing coastal zones and monitoring pollution. Improvements in all kinds of product supply will depend on improvements in several areas: (a) numerical modelling and simulation of oceans and shelf seas and ecosystems; (b) increases in data acquisition, management and assimilation into models; and (c) improved understanding of the ocean's role in climate variability and the relationship of fisheries to ecosystems.

We are likely to see, for example, increases in:

(i) monitoring of pollution by assessing its biological effects on specific organisms (Customers include: local authorities, tourism, fisheries, aquaculture);
(ii) monitoring eutrophication by *in situ* chemical analysis, or by changes in phytoplankton mass or species (Customers: local authorities);
(iii) monitoring changes in coastal communities, by observing benthic communities by optical methods (video etc) (Customers: local authorities, tourism, fisheries);
(iv) monitoring development of harmful algal blooms through refined observation of harmful algae (optical-fluorometric identification) and forecasting of their occurrence (Customers: aquaculture, fisheries agencies, aquaculture, tourism, health authorities).

In future, given the huge advances in computing power in recent years, many more products will be produced by coastal managers and others using numerical models. These can now be run on desktop PCs to simulate the way the ocean works and to forecast how it may change in response to external forcing. The application of numerical models is now an essential part of the toolkit of the manager of ocean or coastal zone operations. Switching to model-based generation of products will greatly improve the performance of local operational oceanographic services, by enabling redesign of the sampling strategy for observations, which may cut costs by requiring fewer observations than before. Numerical models, can convert original non-synoptic meteorological, *in situ* oceanographic data and data from satellites into richly textured fields of synoptic information, including the probable locations of fronts, the simulation of eddy fields, water levels, and the likely locations of currents and other important structural features of the water column. This approach can help developing countries to manage their coastal zones in a sustainable way. Regional scale models can provide local managers with the boundary conditions they need for the operation of local-scale models.

Improved products will likely require the further instrumentation of ships. The Caribbean region needs (and lacks) both a comprehensive Voluntary Observing Ships (VOS) programme collecting marine meteorological data, and a Ship of Opportunity programme (SOOP) to collect subsurface date. Both meteorological and subsurface data could be collected from the same voluntary observing ships (which are usually commercial vessels on transit, and could include ferries). Advice on these developments should be obtained from the new Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), which calls for national meteorological agencies and oceanographic agencies to work closely together to improve observing networks and associated products and services. Improved bathymetric maps are needed, especially on continental shelves and along coastlines, because the modelling of circulation, waves, tides, tsunamis and storm surges is critically dependent on the shape of the bottom topography used in numerical models.

In order to determine what products are needed (and hence what observations to make), what is required is a comprehensive analysis of what users need in the way of products. In the absence of specific requests from the user community, User Scenarios can be used to demonstrate (i) possible practical reasons for needing particular kinds of ocean information, and (ii) some of the ways in which the information can be provided. At the very least this will help to stimulate thinking about what is really needed. Examples of possible scenarios are given in Annex I. **As the basis for determining what observations are needed, and where, the Steering Committee should carry out a survey among the marine-related communities of the participating IOCARIBE Member States (i) to construct an appropriate set of user scenarios, and (ii) to determine what end-products and services are required by the user community**.

2.3 COSTS AND BENEFITS (THE VALUE OF AN IOCARIBE-GOOS)

Several major examples of trans-boundary issues requiring a Caribbean-wide observing and forecasting system can be given.

Hurricanes and severe storms have a tremendous region-wide impact, as we have been reminded recently by Hurricane Mitch (October 1998). It is worth noting that both the intensity and geographic locations of hurricanes are subject to long-term change. During El Niño events, for example, there are fewer major hurricanes along the eastern seaboard of the USA or in the Caribbean. However, it is also apparent that there is some relation between hurricanes and the North Atlantic Oscillation, which may explain why in the earlier part of the twentieth century there were more major hurricanes in the Caribbean than there were in the later part of that period. With the strengthening of the North Atlantic Oscillation it is possible that more hurricanes will make landfall in the Caribbean. Since the early part of the century coastal populations have massively increased in this region. We also know now that major storms can jump to hurricane status by picking up heat from patches of warm water or warm currents. There seems to be good reason therefore to collect more offshore information about sea surface temperature and the depth to the thermocline (i.e. the thickness of the warm water layer) in relation to possible storm tracks so as to improve hurricane forecasting. Considerable savings in life and property may be expected to result from a small investment. One immediate result of Hurricane Mitch is the installation, with the help of NOAA funding, of 6 tide gauges and meteorological monitoring stations in the coastal zones of El Salvador, Guatemala, Honduras and Nicaragua, under the RONMAC Project. However, this does not address the need to find out more about sea surface temperature and the thickness of the thermocline, which requires a combination of satellite data on the sea surface, and subsurface temperature monitoring from ships of opportunity (including ferries).

Major El Niño events in recent years have caused billions of dollars worth of damage worldwide and numbers of deaths**. Improvements in El Niño forecasts** based on ocean data, as well as furthering the understanding of how El Niño affects Caribbean climate, will help to mitigate these effects by facilitating planning.

Tourism is the largest global industry, and a major source of income to many countries in and around the Caribbean. It has been labelled as “the first priority” for the Presidents of those countries that are Members of the Association of Caribbean States, in the Declaration of Santo Domingo (Dominican Republic, April 1999). **Degradation of the marine and coastal environment** of the Caribbean is recognized as a critical problem, as was manifest for example (i) at the meeting of the UNEP Special Committee on the Protection of the Environment and Caribbean Sea (Caracas, November 1996), and (ii) in UNEP’s recent third Global Environmental Outlook (GEO-3). The meeting recognized that international collaboration was essential to solving this problem, through concrete national actions taken within a regionally agreed framework, which is what IOCARIBE-GOOS is all about. The goal is rational use of natural resources. Control measures demand increased understanding of ocean and ecological processes, and long-term observation programmes. Any observations or forecasts that contribute to maximizing environmental health (e.g. clean bathing water and beaches; healthy coral reefs) and to minimizing disturbance (from extreme environmental events) will improve the cost-effectiveness of the tourist industry and have a beneficial effect on tax revenues and local incomes.

Several countries in the wider Caribbean region (Venezuela, Mexico, USA, Colombia, and Trinidad and Tobago) are engaged in the offshore extraction of oil and gas. All activities associated with oil and gas exploration, production, transportation and distribution are subject to **hazardous environmental conditions, especially storms, high waves and strong currents**. Any improvements in the ability to forecast changes in these conditions, and especially the occurrence of extreme events, will lead to less down time and hence improved efficiency and cost savings. Given the size of the industry, the returns in tax revenue are likely to be considerable.

The region is geologically active and subject to tsunamis. IOCARIBE-GOOS provides a mechanism to assess the requirements of a **tsunami warning service** for the region, in partnership with other appropriate organizations.

Finally, recognizing the reliance of the region on living marine resources for food, and the economic importance of artisanal and commercial fisheries, we note that forecasts of oceanographic variables and conditions would allow more efficient fishing, and that GOOS will be a tool to support the ecosystem-based approach to **fisheries management**.

To encourage investment in an IOCARIBE-GOOS, estimates are required of the costs and benefits of implementing such a system. The benefits of GOOS occur in different economic and social forms: improved commercial cash profits; reduction of commercial risk and uncertainty, improved management of the environment; reduction in pollution; early warning of developing environmental problems; the assessment of the effectiveness of ameliorative action; public good benefits such as improved health and reduction of natural hazards, and long term benefits such as climate prediction and protection of biodiversity. The economic characteristics of these benefits are not immediately comparable, and some are very difficult to quantify on any scale.

International estimates suggest that marine-based industries and services may benefit from GOOS to the extent of 1-2% of their revenue. To this should be added the intangible benefits from environmental protection and amenity, and the terrestrial benefits to agriculture and water and energy management, as well as the potentially enormous benefit from the reliable prediction of climate variability and climate change.

Better estimates of the potential benefits to the Caribbean region countries from an IOCARIBE-GOOS are needed at many scales, and should be derived carefully, using standardised methodology, and consistent assumptions. The assessment of costs and benefits has to start at the national level, through governments assessing the potential value of operational forecasts and data products. Each industry and service sector has different requirements for specialised data products, and it is important to study at least a representative sample of user groups to find exactly what they need. The results of these studies can be extended by analogy to similar industries, or to other countries with similar environments and economic conditions, or be amalgamated regionally.

As the basis for a regional evaluation of the costs and benefits of implementing IOCARIBE-GOOS, it is recommended that the Steering Group assign a working group to pull together available national statistics on costs and benefits of operational oceanography for discrete user sectors (e.g. tourism, offshore industry, fishing).

3. THE DESIGN OF IOCARIBE-GOOS

3.1 INTRODUCTION

Guiding the overall **design** of GOOS are **principles** that determine the essential and distinguishing characteristics of GOOS; these are specifically listed in Chapter 1, and they will similarly serve as the basis for the design of IOCARIBE-GOOS. The overall design of GOOS is now being undertaken through two panels, the Ocean Observation Panel for Climate (OOPC), considering observations in the open ocean and those relevant to weather and climate; and the Coastal Ocean Observations Panel (COOP), which considers all aspects of coastal seas. The types of issues dealt with by COOP are thought by most IOCARIBE Member States to be the more tangible and immediately relevant priorities for themselves and the region. The coastal GOOS design being developed by COOP is intended to be a sustained and integrated observing system that makes more effective use of existing infrastructure and resources to detect and predict the causes and consequences of changes in coastal ecosystems for the benefit of human populations. COOP addresses the concerns formerly described in the GOOS modules for Health of the Oceans, Living Marine Resources, and Coastal GOOS. While the COOP programmes are clearly most relevant to the needs of regional users, OOPC ocean and climate-related activities would also be part of an IOCARIBE-GOOS. Because the individual coastal systems are strongly linked to regional scale phenomena – the Atlantic western boundary current system, coastal upwellings, and trade winds – there is a need for larger scale measurements. Many elements of the global observing system will be collecting data throughout the region, e.g., volunteer observing ships, drifting buoys, ARGO floats, and of course satellite-borne sensors. Taken together as a subset of the global system, these will provide the basis for the region-wide analyses and modelling necessary for understanding the larger space and time scale phenomena that impact the region as a whole. In fact, because of this natural connectivity, the semi-enclosed nature of the region, and its relatively easily defined boundary conditions, the IOCARIBE region would be well suited to a regional scale observation/modelling effort.

National and Regional GOOS Programmes are the primary means for continued development of the design plan, implementation, and regional customisation. **It will be the responsibility of the IOCARIBE-GOOS Steering Committee (IGSC), through appropriate planning documents, planning and oversight committees, meetings, and forums to ensure that GOOS design principles and principles of involvement are maintained within IOCARIBE-GOOS activities**. The regional GOOS must apply GOOS design principles – as they have been interpreted and recommended by the COOP and OOPC panels – to the user defined regional priorities. For IOCARIBE-GOOS, this will include:

- **Promoting the implementation of GOOS-COOP within IOCARIBE states;**
- **Providing guidance for national GOOS-COOP programmes to address regional priorities;**
- **Developing regional centres for data management and exchange;**
- **Promoting development of regional scale analyses, models, and forecasts;**
- **Contributing to and extracting regional data from OOPC activities in the region.**

As stated in the COOP design framework, the purpose of the coastal ocean observing system is to detect and predict the causes and consequences of changes in coastal ecosystems. Physical processes structure marine ecosystems, and variations in biological and chemical properties are related through a hierarchy of physical-chemical-biological interactions that govern their status and effect changes. This underscores the importance of modelling and suggests that there is a common set of core variables that, if measured with sufficient resolution over long enough periods and large enough areas, will serve many needs e.g., from forecasting changes in water depth and sea state on short time scales to predicting the environmental consequences of human activities and climate change on longer time scales. IOCARIBE-GOOS will be a regional network for the measurement of a common set of core variables that is enhanced to address those issues that are of greatest concern of participating countries. The system requires timely access to both data and information products, integrated to provide useful information in a timely fashion to multiple user groups. Timely exchange of data is essential to provide the regional context in which all local problems are nested. The coastal observing system will be a regional scale network for measuring and analysing a common set of core variables that is locally customized to address issues of greatest concern to participating countries. Both detection and prediction depend on effective linkages between measurement, data communication, and analysis. This will require a managed end-to-end system with the following elements:

- The observing subsystem (networks of platforms, sensors, sampling devices, and measurement techniques) to measure the required variables on the required time and space scales to detect and predict changes in coastal indicators;
- The communications network and data management subsystem (telemetry, protocols and standards for quality assurance and control, data dissemination and exchange, archival, user access);
- The modelling and applications subsystem (data assimilation, synthesis and analysis; procedures for translating data into products); and
- Capacity building and training.

These four elements are consistent with the JCOMM organizational structure, which can be seen as a useful model for the general IOCARIBE-GOOS management structure.

3.2 THE OBSERVING SUBSYSTEM

This is the measurement front end of the end-to-end, user-driven observing system. It consists of the infrastructure required to measure core variables and transmit data to the communications network and data management subsystem. Basic variables to be observed must be determined using regional user surveys and the results of similar Coastal GOOS and EuroGOOS studies. Measurements of core variables in four dimensions are required for both detection and prediction. To these ends, the observing subsystem will consist of an integrated mix of samplers, sensors and platforms required to measure core variables with sufficient spatial coverage and temporal resolution to detect changes in 4 dimensions and to communicate data in a timely fashion. Thus, emphasis is placed on methods that provide high resolution, synoptic time series measurements (autonomous *in situ* sensing of multiple variables simultaneously and continuously in the vertical dimension), spatially synoptic measurements (remote sensing of surface distributions of a limited set of variables simultaneously over large areas), and near real time data telemetry (from sensors that make instantaneous measurements and generate electronic or acoustic signals). Based on COOP design principles, the regional observing subsystem is organized into 6 related and mutually dependent categories:

- Coastal Observing Network for the Near Shore (CONNS);
- Regional Network of Coastal Tide Gauges;
- Fixed Platforms, Moorings and Drifters;
- Ships of Opportunity and Voluntary Observing Ships;
- Remote Sensing from Satellites and Aircraft; and
- Remote Sensing from Land-based Platforms.

Elements from each of these categories are presently in place in the IOCARIBE region; examples are discussed in Chapter 4. These elements of the observing subsystem provide a hierarchy of measurements of multiple variables that must be judiciously merged in such a way as to provide more comprehensive and timely detection and prediction of environment changes than would otherwise be possible. Successful integration of these elements is an important aspect of the value added nature of the observing system.

It will be up to the IOCARIBE-GOOS Steering Committee to work with Member States to devise an implementation plan that meets the advice from the GOOS advisory panels on the one hand, and the needs of the region on the other hand.

A significant investment in research will be needed to develop the required technologies and analytical tools. Governments will need to develop mechanisms by which new knowledge and technologies can be used to improve the observing system in a timely fashion. Existing observing systems (e.g., GLOSS/CPACC/RONMAC sea level measurement systems, GCRMN, CARICOMP, the global network of meteorological buoys, SOOP, VOS, Seakeepers) may require enhancements to measure more oceanographic properties at additional locations and at higher frequencies. In general, the frequency and spatial resolution of observations must increase with decreasing distance from the coastline and with decreasing depth, especially in the proximity of urban centres and major river discharges.

The challenge of developing cost-effective sampling schemes underscores the importance of the interaction between measurements and modelling. As coupled physical-biological-chemical models and data assimilation techniques are developed and become more effective, it will be possible to use model-based sampling simulations to determine (i) optimal combinations of variables to measure and (ii) the optimal time and space scales for measurements to be made. In addition, the relationships between regional scale models and higher resolution, more complex coastal models must be explored and pushed forward. For these purposes, research-oriented enhancements to existing systems must be encouraged, supported, and implemented.

It is important to emphasize that all aspects of the observing subsystem cannot be based solely on autonomous *in situ* and remote sensing. For the purposes of continuity and integration, the initial system must incorporate variables that cannot be measured and communicated in real time. Autonomous *in situ* sensors have been developed for some core variables (e.g., dissolved inorganic nutrients, phytoplankton pigments, and dissolved oxygen), and it is likely that some of these will soon be operational (routine, guaranteed data stream). Perhaps the greatest challenge is the detection of the full spectrum of biological species that inhabit coastal ecosystems. Changes in species composition, distribution and abundance are of fundamental importance to water quality, living resources, and the aesthetic beauty of coastal ecosystems; and regional enhancements of the observing system are likely to incorporate such measurements. Current methods of identification for most species (the exceptions being birds, marine mammals, turtles, and gelatinous zooplankton) rely on *in situ* sampling and subsequent laboratory analyses that can be laborious and time consuming. Although the use of molecular probes for sensing microbial species *in situ* is on the horizon, and acoustic techniques are being used to monitor some fish populations remotely, some necessary and significant observing systems will rely on sampling and microscopic analysis for the foreseeable future.

Many observing system components are already active in the region, as described in chapter 4. **The IOCARIBE-GOOS design plan should include an Initial Observing System (IOS).** The IOS should be established using GOOS design principles and include existing observation systems and appropriate elements of the Communications Network and Data Management Subsystem as described in Chapter 6. **The IOCARIBE-GOOS design plan should also take note of and work with existing national and sub-national level integrated observing systems**. These can serve as components of and templates for the regional system. In particular the U.S. has plans for a national U.S. Integrated Observing System. There are also well-organized U.S. regional integrated observing systems along the Atlantic coast (SECOOS) and Florida/Gulf of Mexico coast (SURA/SCOOP) that include the IOCARIBE region. The IOS and these existing systems will provide the foundation and learning experience necessary for the full regional observing system by expansion of existing systems and addition of new systems through pilot programmes.

In order to demonstrate how different aspects of IOCARIBE-GOOS would work to benefit users in the region, as well as set up preliminary components and operational mechanisms for the regional system, a certain number of concept-demonstration projects will be needed. Examples of possible pilot projects are discussed in chapter 4.

3.3 THE COMMUNICATIONS NETWORK AND DATA MANAGEMENT SUBSYSTEM

The Communications Network and Data Management Subsystem is the subject of Chapter 5.

3.4 THE MODELLING AND APPLICATIONS SUBSYSTEM

Data assimilation and modelling are critical components of the observing system, and observing and modelling coastal ecosystems must be treated as mutually dependent, complementary processes. Real-time data from remote and *in situ* sensors will be particularly valuable in this regard. Data telemeter from these sources can be used:

- for assimilation and more accurate estimates of the distributions of state variables;
- to develop, test and validate models; and
- to initialise models for improved forecasts of coastal environmental conditions and, ultimately, changes in ecosystem health and living resources.

A mix of modelling approaches (statistical, theoretical, empirical) will be required to produce realistic, multi-dimensional views of change based on data from multiple sources. Two approaches are commonly used in coastal modelling to increase resolution in areas of greatest interest and to address the problem of scale-dependent variability: finite element modelling and nesting of finite difference models. A number of issues must be faced when using either approach (e.g., computational efficiency for finite element models and allowing for true two-way interaction with nested, finite difference models), and these issues will become increasingly difficult as more comprehensive ecosystem (coupled physical-chemical-biological) models are developed. As these problems are solved, the distinction between the coastal and regional scale components of GOOS will blur.

Modelling the physics and meteorology of coastal ecosystems has matured to the point that there are now a number of operational systems that provide useful forecasts of state variables such as water depth (sea level), waves, and currents. Although advances are being made in modelling ecosystem processes related to ecosystem health and the sustainability of living resources, much improvement must be made before such models are useful for making predictions for the purposes of environmental science let alone being of use for operational forecasting.

Another problem of immediate concern is the development and application of data assimilation techniques that require knowledge of coastal marine and estuarine processes, statistics and numerical modelling. Currently, there is a global shortage of individuals with this combination of expertise in oceanography and ecology that must be addressed as this is a serious impediment to the development of operational coastal oceanography, particularly for those indicators that require ecosystem models to predict.

3.5 TRAINING AND CAPACITY BUILDING

Training and capacity building requirements must be integrated in to the design plan to guarantee system sustainability and maximize user effectiveness; this is discussed in detail in Chapter 6. Regional organizations focused on non-observational GOOS activities like capacity building, education, and training must also be considered and included in IOCARIBE-GOOS planning.

4. IMPLEMENTATION

4.1 INTRODUCTION

This chapter recommends actions required to implement an integrated and sustained observation system adapted to the marine environment of the Wider Caribbean Region. It submits a scheme to develop an Implementation Plan, focusing on future steps and how to best proceed.

A guiding principle of the implementation is that it will follow the ‘end-to-end concept’, meaning that there will be a known or definable pathway of connection between each initial measurement and the end uses to which it (or information derived from it) is applied. IOCARIBE-GOOS will be initially implemented as an assembly of the contributions of data, resources, effort and products of existing and proposed national and international observing systems and (in some cases) experiments and satellite missions. Only parts of these systems will contribute to GOOS. However, for those parts the implementation must encourage participation, the selective enhancement and refinement of observations and the alignment of their quality and relevance to follow an accepted GOOS philosophy and design, and to comply with defined GOOS criteria.

It must be recognized at the onset that many of the measurements required for a fully integrated, multi-disciplinary observing system are not operational, that much work is needed to determine those products that are most useful, and that capabilities and resources vary enormously among nations. These realities underscore the need for enabling research and capacity building, and it is expected that the coastal and regional components of GOOS will develop along two tracks:

- Building an initial regional network through the incorporation of existing operational elements; and
- Implementation of concept-demonstration projects that (i) demonstrate the utility and cost-effectiveness of the GOOS end-to-end, user-driven approach and (ii) contribute to the development of the regional network and local GOOS implementation.

It will be important for the Implementation Plan to recognize that at present many of the observations included in GOOS come from observing systems put in place by researchers, and serve both research interests and operational requirements. The Argo project is a case in point. In that context, much of GOOS today is quasi-operational. Over time, it is expected that the operating costs of the elements of the system that are essential for operational purposes will be picked up by operational agencies, as has happened with the Tropical Atmosphere Ocean array of buoys that monitor El Niño events in the equatorial Pacific.

The complete ocean observing system will evolve as a result of interaction among three different groups. One group consists of the users who will define the needs for specific observations within the context of the overall goals of the system. The users may range from scientists to academic and commercial developers of data products to farmers and fishermen. The second group consists of the technical experts who design and run the systems for collecting observations of the ocean. They respond to the users by developing a system that can meet their needs. The third group is the researchers that provide knowledge to bridge gaps between the user needs and the capabilities of the data collections systems. In this context, the researchers develop technology and applications in support of the ocean observing system. Other researchers, whose work is enabled by data from the system, belong in-group one, although individual researchers may participate in both kinds of research activity.

The idea is to create a process in which the whole will be greater than the sum of the parts, through sustained regional commitment to a common purpose. This effort will involve building partnerships between different government agencies, and between government and non-government agencies within individual countries, and between different countries, to create appropriate observing sub-systems, data access and information management activities, programme management activities, and funding. The model to be followed is that of the World Weather Watch (WWW), which is one of the great success stories of international collaboration in global observations and communications. In fact, GOOS includes the marine component of the WWW. The WWW is essentially a coordinated aggregation of meteorological facilities and observations controlled by the member nations of the WMO. The WWW concentration on coordinating observations, communications, and data access to all participants has had an overwhelmingly positive impact on short- and medium-range weather forecasting and on meteorological research.

IOCARIBE-GOOS will not reach its potential without appropriate state-of-the-art technology. Recent technological developments have significantly improved ocean-observing systems. Within the region, satellites, drifting and fixed buoys, cables, autonomous vehicles and state-of-the-art ships each collect a variety of oceanographic data, but by themselves these observations are not comprehensive enough. Important gaps exist in coastal, open-ocean, and seafloor data sets, which are poorly integrated.

IOCARIBE-GOOS may have to rely heavily on satellite-borne technology to monitor the ocean's surface. It will require surface measurements *in situ* to calibrate and validate satellite observations. It will also require appropriate suites of measurements from the subsurface, made by fixed and drifting buoys, and other advanced technologies, some of them presently being developed, such as autonomous underwater vehicles and acoustic thermometry. Advances in technology will be required not only for measurements but also for instance in communication from instruments by telemetry or satellite, and in anti-fouling techniques to keep sensors working for long periods unattended.

By improving the coordination of data collection, storage formats, and dissemination processes at the national and international levels, a regional ocean observing system would provide more complete real-time information on ocean and coastal conditions for a full range of users.

4.2 THE KEY COMPONENTS OF IMPLEMENTATION

As mentioned in chapter 3, four key components are critical to the success of the IOCARIBE-GOOS system: (i) observational subsystems; (ii) a communications network; (iii) a data management subsystem; and (iv) training and capacity building. Some of the building blocks already exist, but the complete system structure, the network for providing access among the data-providers and users, and the system for managing the data generated in both real-time and delayed-mode have yet to be developed. The final structure will result from a phased implementation approach starting with integration of major existing programmes and networks in all components. The essential technical elements will include:

For observations: Satellites, dedicated ships and ships of opportunity, buoys, profiling floats, traditional and advanced *in situ* sensors, fixed arrays, and other elements as appropriate.

For communications: Various networks to form an adequate structure that is managed so that, as part of its operating procedures, it manages the development standards and protocols as well as the overall communication system operations and provides information on data quality. This network will hold the entire observational system linking together data providers and users, observations subsystems, centres of data, and data archives.

For data management (see chapter 5 for details): A federation of specialized data and information management centres organized for processing and distributing specific observational data in real -or near-real-time, as well as delayed-mode (including material samples) shore processing facilities, all of which will enhance existing national and regional capabilities. A management system that builds on existing facilities and is responsible for the long-term cataloguing, maintenance and storage of data and metadata, final quality assurance, and data rescue and migration (transfer of data from one storage medium to another as technology advances). This will include a data archive system (partly or wholly centralized) to ensure archival preservation and backup.

For capacity building: Appropriate efforts to enable all Member States to contribute to and benefit from IOCARIBE-GOOS. This will require the development of a substantial training, education, mutual assistance and technology transfer programme to enable all the IOCARIBE Member States to participate in the interpretation and application of the resulting data, end-products and information (see chapter 6 for details).

Three important cross-cutting issues are applicable to each of these four system components:

(i) A technology, products and applications programme that ensures development of appropriate new technologies and products (through direct or indirect means). This programme will require interaction among technical designers, researchers and operational users;

(ii) A research programme that makes available the results of long-term observations to improve understanding of ocean processes, provides the foundation for further advances in technology, and demonstrates the practical utility of the system;

(iii) An education and outreach programme that makes the data available to the public, schools, and media in real- or near-real-time for teaching and public awareness.

4.3 IMPLEMENTATION

A key element of the implementation plan should be to capitalize on the past and present research efforts and ongoing operational activities of various academic, state and private sector organizations, in such a way as to provide sustained observations of the ocean, with outputs that are easily accessible for creating forecasts and products essential to the regional economy, to the management of marine resources, and to ensuring public health and safety.

The IOCARIBE-GOOS observing system should be implemented through three overlapping phases:

(i) The Implementation Planning phase;
(ii) The Initial Observing System phase;
(iii) The Assessment and Improvement phase.

4.3.1 The Implementation Planning Phase

This phase began with the formation of the *ad hoc* Advisory Group for IOCARIBE-GOOS, which has produced the first draft of the Strategic Plan for IOCARIBE-GOOS (in the form of the present document). It will be up to the Regional Sub-commission to create the Steering Committee to draft the Implementation Plan, and to begin implementation.

An initial requirement of the Steering Committee is the development of an inventory of:

- existing operational systems and programmes both at the international and national levels with relevance to IOCARIBE-GOOS;
- existing organizations with potential interest in IOCARIBE-GOOS;
- existing and proposed scientific programmes with relation to IOCARIBE-GOOS;
- existing services and products with potential interest to IOCARIBE-GOOS;
- commercial interests; and
- training and capacity building.

This work has been started by a consultant (Ms Gletys Guardia-Montoya) working under the supervision of *ad hoc* Advisory Group co-chairman Doug Wilson, and funded by the IOC.

The key to a successful system will be an adequate Implementation Plan, based on input from the users, the researchers, and the operators, that will assess the cost-effective engineering trade-offs, monitor the efficiency, and provide the technology roadmaps for the entire system. The system must be capable of facilitating the connections between the research and operational parts of the entire system, enabling smooth, effective transitions of technology. **The Steering Committee should prepare an engineering and design analysis to integrate the various existing and planned ocean observations and provide for the future adaptability of the system**.

4.3.2 The Initial Observing System Phase

Recognizing the scope and objectives of the Implementation Plan, **the Steering Committee should create an Initial Observing System by building upon pre-existing observing systems**, each of which will continue to serve the previous users. As shown below, there is a good number of such systems to start with.

Many activities capable of becoming part of the implementation are already fully or near-operational (in the sense of having a structure and funding for continued operations and a back-up plan) through national observing systems, international organizations and bodies or through large-scale scientific programmes. The most common deficiency is lack of adequate geographical coverage. The prior existence of these components considerably reduces the risks and costs associated with their incorporation in the Initial Observing System. But they do need to be used effectively in an integrated way to deliver the tangible benefits expected from GOOS implementation. **The Steering Committee should then identify key gaps in the existing observing systems, and make plans to fill them**.

4.3.2.1 Examples of Existing Observing Subsystems

Because the IOCARIBE region is largely enclosed except for a dozen or so significantly deep and wide island passages and straits, it is well situated for observations around its boundaries. **Coastal tide gauges** provide the longest existing time series. Presently, there is a large existing array of coastal tide gauges, a many of which operate in a real-time telemetry mode, operated as part of the RONMAC, GLOSS and CPACC programmes. Many of these telemeter sea level gauges are being fitted with other ocean and atmospheric sensors to take advantage of their real-time capability.

There are also a number of telemeter **coastal meteorological stations** and several meteorological buoys in the northern Gulf of Mexico. These are part of a substantial U.S. Gulf of Mexico regional system. Other U.S. fixed buoy observing systems exist on the West Florida Shelf and the Florida Keys, and Cuba and the U.S. are planning installations in Cuban coastal waters. Meteorological Doppler radars, automated meteorological weather stations, and radio-sonde stations are being located on the coasts and islands of Venezuela under the national VENEHMET programme.

Coral Reef monitoring systems of varying degrees of complexity and real-time capability are provided by GCRMN, CARICOMP, and national organizations.

Satellites provide visual and IR imagery at varying resolutions, as well as ocean colour, sea surface height, and scatterometer wind information. Capability for downloading images exists at several centres in the region, including Mexico, Costa Rica, Venezuela, Puerto Rico, and several cooperating institutions in the U.S.

The distribution of ports and passages around the region, including the Panama Canal, make it ideal for observations by **Volunteer Observing Ships** (VOS) engaged in both shipping and holiday cruises; such programmes exist in the U.S. and Cuba and are being planned in other countries. Besides XBT and weather measurements from SOOP ships transiting the region, there is a RCCL cruise ship instrumented by NOAA and UM/RSMAS that makes weekly transits from Miami to St. Thomas, USVI making upper ocean measurements, including currents, and atmospheric and marine boundary layer measurements. The new International Seakeepers programme also provides data collection and transmission equipment to private vessels in the Caribbean.

Quasi-operational observing systems include the **submarine telephone cable** between West Palm Beach, Florida and Settlement Point, Bahamas that has monitored the transport of the Florida Current in near-real time for several decades, and a newly established monitoring cable across the Grenada Passage (between Grenada and Trinidad and Tobago). Cable-derived transport data provide important boundary conditions for regional numerical models.

Compact **skywave radar** systems will be available use for exploratory monitoring of surface currents in the Caribbean Sea; new advances in this technology may make permanent placement and operational implementation of these systems feasible.

During 1998-2000, over 150 WOCE **drifting floats** were deployed in the eastern Caribbean Sea and in the Panama-Colombia Gyre as a contribution to the International Year-of-the-Ocean (IYO) programme, showing the potential value of a continuing programme. These activities all involve collaborations between researchers and operational entities.

Additionally, there are a number of **ongoing research** projects that are producing noteworthy time series. For example, the Antilles Current and DWBC region east of the Bahamas has been monitored in an exploratory fashion with current meter moorings and floats over the past decade to design a simplified monitoring strategy. Similarly, the flows through various passages have been sampled repeatedly over the past several years to determine the mean, seasonal, and other components of transport, and to lay the scientific foundations for the design of an efficient monitoring strategy. A multi-year, multidisciplinary study of the physics and biogeochemistry in the Cariaco Trench off Venezuela is continuing with time series from moored instrumentation integrated with Sea WIFS color imagery. The University of Puerto Rico at Mayaguez has sampled a biogeochemical time series station in the north eastern Caribbean off Puerto Rico monthly from a research vessel for several years. The Colombian Navy conducts periodic CTD surveys over the western Caribbean. Flow through the Yucatan Straits is under investigation with moored and shipboard instrumentation by Mexican and Cuban investigators. Although these existing efforts do not completely meet the basic observational approach of IOCARIBE-GOOS (long-term, systematic, routine observations), some of them could form the nucleus of regional-scale integrated observing sub-systems of IOCARIBE-GOOS.

Several larger institutions in the U.S. and Mexico are conducting regional scale numerical modelling. The U.S. Navy layered ocean model (NLOM) assimilates altimetry and SST and produces IOCARIBE region analyses and up to 30-day forecasts of SST and surface height and currents. Unfortunately this model does not at present extend to the continental shelf. Newer versions of this and the MICOM/HYCOM models will extend to the coast and assimilate other data types, as part of the international Global Ocean Data Assimilation Experiment (GODAE). The possibility of a similar regional “ODAE” is considered as an IOCARIBE Pilot Programme. Other localized coastal regions in the area have their own research models, but there are few coastal forecast numerical models. Models also exist that utilize observational data and forecast specific events like coral bleaching (CHAMPS). Considerable work remains to be done in this area.

4.3.2.2 Other Initial Observing System Considerations

This phase of implementation will depend upon commitments made by the participating Member States through their state and private agencies and research institutions, by providing facilities in the form of observation platforms, specialized centres and distribution networks.

Improvements to existing observing programmes that can be accomplished now should move forward without waiting for the full design and engineering analysis. Expansion in space and time of moored, cabled, and drifting arrays, opportunities for increased shipboard monitoring and satellite coverage, and incorporation of improved technology should proceed. In addition, changes or enhancements to existing programmes that eliminate redundancy or improve the efficiency of those efforts should be allowed to move forward. These short-term investments will ultimately result in a better overall system.

The use of new technology and the efficient deployment of existing technology are key elements in the design of GOOS, and for this reason IOCARIBE-GOOS should look at those devices which seem to have the greatest promise in routine operations and long-term monitoring.

To ensure the right technologies are in place, surveys are needed in member countries to assess what is currently available and what is needed, as basis for justifying the appropriate expenditure on technology acquisition or development for IOCARIBE-GOOS.

Two important features that must be developed to support the Initial Observing System are: (i) the distributed network of data and data archives; and (ii) the development of standards and protocols for the data. **To support development of the Initial Observing System, the Steering Group should work towards improving data collection, storage, exchange and dissemination, planning to build on the pre-existing structures such as National Oceanographic Data Centres put in place through the IOC’s IODE programme and related activities**. Data issues are considered in further detail in chapter 5.

Aside from data issues the Implementation Plan must state what communications systems will be used to exchange data and disseminate results. These systems will include the WMO's Global Telecommunications System (GTS), and the Internet, as appropriate.

Although the first steps to achieving the overall observing system will largely involve the integration and extension of existing programmes into the operational stage, the system will need to integrate new technology. As an example, the measurement of biological, geophysical, and chemical parameters will require new sensors and extensive ship resources. If these needs are filled, the system will be better able to collect synoptic observations from distributed observing platforms and achieve a multidisciplinary characterization of the ocean environment to serve different users.

It is important to document the present infrastructure; develop an approved set of requirements to be addressed in a realistic, time-phased, affordable manner; and establish the appropriate organizational, user adviser, technology transfer, and operations management plans with the necessary documentation and agreements.

4.3.3 Concept-Demonstration Projects

Organized, planned sets of activities with focused objectives, defined schedules, and a finite life time can produce results that significantly enhance the global ocean observing system in general and the regional observing system in particular. These 'concept-demonstration projects', also known as pilot or pre-operational projects, though limited in scope and small in scale, are critical for the evolution of the system. They might involve a demonstration that a new technology can be successfully used in an operational fashion, that an existing data collection effort can be scaled up in time or space, or that several smaller efforts can be successfully integrated into a larger programme on a regional or basin scale. Some possible demonstration projects that have been discussed are:

(i) *Development of a Regional Circulation Model*:

Remotely sensed data (e.g., altimetric measurement of sea surface height), surface drifter data, SST, and other data from the region might be integrated into numerical models to provide regional circulation products that would set the boundary conditions for local area models of various kinds. Regional circulation controls the flow into coastal zones and through marine protected areas, and controls the spread of fish larvae, and pollutants. The Global Ocean Data Assimilation Experiment (GODAE) (and supporting observational programmes like ARGO) is a pilot project for international GOOS; a similar programme could be undertaken in the IOCARIBE region. A regional 'ODAE' would require bringing regional-scale modelling capability up to the present standard of global ocean modelling.

(ii) *Bridging the Scales between Coastal and Offshore Observing Systems*

New technologies are being increasingly applied to improve monitoring of coastal ocean systems. For example, consider a typical coastal system consisting of near shore resources (coral reefs, spawning areas, habitats) in the vicinity of land-based sources. Coastal observing systems can monitor conditions quite well at both locations, often providing data in very nearly real time. It is rare, however, that these coastal systems are self-contained; invariably, forcing from mesoscale or larger-scale offshore features is an important determinant of conditions in the coastal zone. Considering that an important goal of coastal monitoring is forecasting, and that the larger scales are often more deterministic and better modelled, there is a real need to bridge the coastal and offshore observing scales to contribute to the generation of useful products from the coastal observing investment. This pilot programme would merge observations from a well-instrumented coastal region, a coastal model, and a regional model, to develop tools and methodology for coastal zone forecasting. It would take place at one or two selected locations with the goal of exporting the operational system to other locations within the region. This system would provide the basis for an Integrated Coastal Area Management (ICAM) system.

(iii) *Pollution*

The Health of the Ocean (HOTO) strategic design plan contains generic advice on topics that might be included in a Caribbean pilot project focused on pollution. This might address among other things: harmful algal blooms; pesticides; oil spills; eutrophication. The group agreed that it would be wise to focus on one particular topic, not all of these. Such a project might in addition provide a capacity building vehicle for expanding the use of the RAMP approach to indicate changes in environmental health. The project might also be designed to provide indicators of human health (e.g. in areas of pesticide runoff). It was further agreed that a HOTO pilot project might be sub-regional rather than region-wide.

(iv) *Capacity Building in Remote Sensing*

All IOCARIBE states are over-flown by a number of satellites measuring a broad range of ocean attributes. Much of this data is not currently easily obtainable by these states, and even if it were, they might not all have people trained to make effective use of it. Space agencies are interested in seeing wider use of their products, and individual nations are interested in obtaining access to potentially useful data from their waters. Both of these needs might be satisfied through a comprehensive programme of training in the interpretation and application of remotely sensed data. In addition it would be useful to assess the means of distribution of satellite data in the region to see if it could be improved through the establishment of more ground stations.

(v) *Coastal Erosion*

A pilot project on this topic could prove useful to planners. Information is required on the real and potential incidence of erosional events. A forecasting ability is desirable and might be achievable through the application of local area models (perhaps bought off the shelf). Monitoring and forecasting of winds, waves and sea level is desirable.

(vi) *IOCARIBE-GOOS Participation in existing or planned regional pilot projects*

Examples include the proposed Large Marine Ecosystem study, the Water Level Observation Network for Latin America (RONMAC) programme, and the successful CPACC and CARICOMP programmes.

(vii) *Ecosystems, Fisheries and Aquaculture*

Following the example of ICES in the North Sea, a concept-demonstration project could be developed to examine how GOOS approaches may be used in the Caribbean as a tool to improve the ecosystem-based management of fisheries.

An important task of the Steering Committee will be developing and implementing concept-demonstration projects that will contribute to the long-term health and stability of IOCARIBE-GOOS; this work should begin immediately with responsible planning and oversight, as the potential success of IOCARIBE-GOOS will likely be judged by the success of these projects.

4.3.4 Assessment and Improvement

Continued assessment and improvement in individual aspects in the entire system is essential for the appropriate performance of the system and its individual components, which should be reviewed regularly to ensure that each is working efficiently and effectively, the level of redundancy in the system is appropriate and able to meet the needs of what is likely to be a growing community of users. Assessment will involve among other things the use of metrics to evaluate the performance of different elements within the system.

The Steering Committee should work to ensure not only the effectiveness and efficiency of the observing system, but also its sustainability for the long term.

5. DATA AND INFORMATION MANAGEMENT

5.1 INTRODUCTION

Access to the data, information and products that result from observational activities is critical to GOOS at all scales. To ensure success, **the IOCARIBE-GOOS Steering Committee should form a Data and Information Management (DIM) committee to organize data management among the IOCARIBE-GOOS Initial Observing System elements, and to develop an appropriate strategy for system growth and product utilization**. The primary purpose of this chapter is to provide guidance for that committee.

Data collected by IOCARIBE-GOOS should be physically located on a network distributed throughout the region that will be accessible from anywhere. The long-term maintenance and storage of the information generated by the sustained observations will require the establishment of data archives built on existing archival systems. The archives will need space, computing power, and staff to process and maintain the data that will be sent there for storage, as well as to respond to requests from the observing and user communities to retrieve the data.

Effective data management can be achieved only with the development and application of standards that are agreed to and followed rigorously by the collectors of the data so that the products developed from the data for the users are reliable. The criteria for real-time or near-real-time data may be different from those used to calibrate and validate the delayed-mode data so standards for both types of data will be needed.

Compilation, quality assurance, and dissemination will be the primary tasks of the IOCARIBE-GOOS data management system. Assimilation of the data for use in developing operational products such as predictive models will be an important step. In order to facilitate this process, IOCARIBE-GOOS should work closely with ongoing and future data assimilation efforts like the Global Ocean Data Assimilation Experiment (GODAE).

The Steering Committee should work with IODE and the Data Management Group of JCOMM to capitalize on their existing regional and national data and information management structures, such as the IODE's National Ocean Data Centres, and IODE's proposed Ocean Data and Information Network for the Caribbean and South America (ODINCARSA).

5.2 THE IOCARIBE-GOOS DATA AND INFORMATION MANAGEMENT STRATEGY AND PLAN

Although the mechanisms for managing GOOS data and information have yet to be agreed upon in detail, certain standard principles have been developed and accepted. The IGSC should take note of the document "*The Global Ocean Observing System Data and Information Management Strategy and Plan*", which outlines basic design information, guiding principles, typical responsibilities for data and information centres, and a strategy to be used by the scientific and technical panels and data managers in planning the development and implementation of GOOS data and information systems. In keeping with the evolving GOOS data network and products, this is a web-based document presently available at http://ioc.unesco.org/goos. It is worth noting highlights of that document and suggesting how they can be utilized by the IOCARIBE GOOS DIM Committee.

This document provides guidelines for analysing the data and information management requirements of observing systems, and uses the guidelines to determine DIM requirements and characteristics of numerous typical GOOS applications for the benefit of managers of similar systems. The IOCARIBE-GOOS DIM committee should undertake a similar analysis of existing and proposed regional and national level systems as one of their first tasks.

The document also summarizes common characteristics of the end-to-end DIM systems that will be required by GOOS, and suggests GOOS DIM guidelines as follows:

- Systems will be planned and directed. They will deliver data sets and products to specific users for specific purposes; pre-planned and operational as opposed to opportunistic.
- Systems will have an operational component.
- Systems will make extensive use of electronic networking.
- Systems (and centres) will produce products for Users and for Managers.
- There will be Internet (www) access to Data and Products.
- Databases will be continuously managed.
- There will be scientific participation in data management operations.
- There will be scientific quality control of data.
- There will be standards for metadata.
- Historical data sets will be considered and subject to GOOS data management principles; this implies a consideration of data archaeology.
- Management of the large fields generated by satellite imaging and numerical models must be considered and implemented.
- DIM responsibilities should be assigned to centres on an end-to-end management basis.

As discussed in other chapters of The Case for IOCARIBE-GOOS, early tasks of the IOCARIBE GOOS Steering Committee will be the recognition of an Initial Observing system and the planning and implementation of Pilot Projects. These must be supported by appropriate Data and Information Management systems, conceived and maintained utilizing designated guidelines. The GOOS Data and Information Management Strategy and Plan contains specific guidelines for Initial Observing Systems for *in situ* data and for satellite data; additionally, numerical model output should be considered. Incorporation of these three major data systems and their Data and Information Management structures into the IOS and pilot projects would lay the proper foundation for expansion of IOCARIBE-GOOS.

The IOCARIBE-GOOS Data and Information Management Committee must address issues of data access and data sharing consistent with existing GOOS guidelines. They should consider establishing a Data Coordinator to oversee Data and Information Management plan development and implementation, and to facilitate data flow, sharing, and access issues. The Data Coordinator would be responsible for coordinating with GOOS science panels and technical advisory groups. They would also be the focal point for coordination by the IOCARIBE-GOOS Data and Information Management Committee with other international data collection and management entities (JCOMM, IODE, GCOS, CLIVAR, etc.).

Finally, the IOCARIBE region should be a model for development of Capacity Building programmes to collect, distribute, and above all, interpret and utilize the data and analyses produced by IOCARIBE-GOOS.

5.3 IMPLEMENTING THE DATA AND INFORMATION MANAGEMENT PLAN

Implementing the IOCARIBE-GOOS Data and Information Management Plan will require (at least):

(i) A distributed network of national and programme-specific databases

The IOCARIBE-GOOS data and information system will make best use of all existing facilities, which will be linked through a network of local and regional data centres. The primary source of most IOCARIBE-GOOS data will be the national organizations and region-wide programmes that have agreed to commit a part of their data gathering and data-related activity to the regional observing system framework. Designated 'Local Data Centres' will be expected to make their short-term archives and products of relevant data accessible to IOCARIBE-GOOS, both directly and by submission to regional Data Centres. As several of the proposed activities are already the responsibility of existing research or operational centres, the initial data management emphasis of IOCARIBE-GOOS will be on coordination, integration and stimulation of these national and local level activities, the encouragement of expansion or enhancements and compliance with GOOS designs and standards of timeliness and quality as defined in GOOS documents. Timely data distribution is an important prerequisite for real-time operational oceanography. The system recognizes that not all ocean data will be GOOS data. Data will be acceptable for GOOS if they adhere to the GOOS data policy and standards, are long-term, systematic, and relevant to the overall objectives. The IOCARIBE-GOOS data management system will be a major means of facilitating participation of smaller countries and agencies that would have difficulty in implementing their own distribution infrastructure.

(ii) IOCARIBE-GOOS Regional Data and Information Centre(s)

Ultimately, IOCARIBE-GOOS will want to concentrate data and information management services at one or two regional centres. Given the available resources, it is understood that these functions may initially be filled by volunteer members and subcommittees of the steering group for coordination and assessment, and by existing data centres for data management services. The capacity building element should include as a goal wider local distribution of these capabilities, however. All IOCARIBE-GOOS data centres will work closely with international GOOS data centres and national and world ODC's.

(iii) Technical Advisory Groups (TAGs) to set detailed guidelines, standards, and protocols

The GOOS Data and Information Management Plan proposes that informal groupings (TAGs) of data-gathering experts from the participating agencies, are convened on an as-needed basis, in order to reach consensus in: (a) defining the detailed guidelines for data and meta-data of various types in terms of format and protocol, standards, distribution, etc; (b) addressing technical questions concerning data gathering and distribution methodology; and (c) providing a conduit of feedback to the GOOS design and implementation process on the above matters.

The IOCARIBE-GOOS Data and Information Management committee should be the intermediary group that passes information between these TAGs and data providers and users within the region. **The IOCARIBE-GOOS Steering committee should ensure that regional representatives are on Data and Information Management Technical Advisory Groups, when appropriate, or that a regional representative is appointed as a liaison to each group to serve the local observing GOOS community**.

(iv) Capacity building

Initial capacity building for Data and Information Management will build on the existing or planned initiatives of IODE (e.g. ocean teacher) and JCOMM.

6. TRAINING AND CAPACITY BUILDING

6.1 INTRODUCTION

Given the reality that many of the member states within IOCARIBE-GOOS do not have the resources, technologies and expertise to develop local or regional observing systems without some assistance, capacity building must be an early priority. This is one of the greatest challenges to the implementation of IOCARIBE-GOOS. **As a matter of priority, the Steering Committee should establish an appropriate capacity building programme, building initially on existing and planned capacity building activities**.

The goal of capacity building is to enable all the member states of IOCARIBE-GOOS to contribute to and benefit from the observing system. Achieving this goal will require partnerships between donors and recipients. Capacity building will generally involve a mix of activities from technology transfer (observing, communications network and data management, and modelling and product development subsystems), and training, to public outreach activities intended to educate the public, donor organizations, government agencies, and other user groups on the problems that should be tailored national/regional needs and cultures and should include, where possible, active community participation and awareness building (from government agencies and private enterprise to NGO's and volunteers). In order to ensure successful capacity building, a sustained commitment will be required by the IOCARIBE-GOOS members. Participating member states and donor organizations must recognize the need to maintain capacity once it has been built.

Science plays a key role in development, as demonstrated in the World Science Reports of UNESCO and many recent studies of the World Bank. However, solving society's needs requires not only capacity for making observations, but also the capacity to analyse the data, generate forecasts and other products and to communicate the results to the public, managers and policy makers. This implies the need not only to build the capacity of the suppliers to supply what is required, but also the capacity of the users to use the products intelligently in support of management, policy, or decision making.

Sound advice from indigenous experts is essential for policy. To develop local expertise requires a series of successive and interlinked approaches, including science education, the training of technicians, a knowledge of, and framework for, integrated management, research ability, and an operating ocean service system that is fully integrated into a global network.

6.2 THE PROCESS

Developing and strengthening marine research and observational capacity involves human resources, the necessary institutions, and a framework that supports and sustains the observational system. These components must form an integrated network, but the implementation is difficult, because of the complexity of jurisdictions within and amongst nations and the variations in ability and capacity. Because of the large differences between countries, IOCARIBE-GOOS capacity building activities must be tailor-made to the specific needs of a country. A number of overall conclusions can be drawn about marine capacity building:

- It is a long-term process;
- There should be a clear definition of the priorities that could be addressed bearing in mind the available resources;
- The involvement of the recipient government is crucial;
- The conception and execution of scientific and services programmes should be in perfect harmony and correspondence with common national priorities;

- Necessary mechanisms should be established in order to facilitate national and institutional activities and programmes contributing to the international programmes;
- Appropriate capacity building in terms of human, material and institutional resources must be ensured;
- For building an indigenous capacity, the active involvement of the community in the recipient countries is an absolute necessity;
- Partners in developing countries are the most effective and persistent advocates for marine science and technology. Capacity building activities can vary from a single training course to the installation of a complete environmental monitoring system;
- The best instruments for capacity building are activities in which scientists, engineers, socio-economists, and users work closely together (learning by doing, teaching the teachers) in the execution of projects, programmes, and partnerships;
- Governments, international organizations, the private sector, and donors should join forces in capacity building. In this regard, substantial interaction is also needed between the science foundations and donor organizations, because most donor organizations are unsure of marine issues;
- There must be a plan of systematic actions that guarantee the continuity of the programme, starting from a clear and precise definition of the concrete objectives that are pursued at short, medium and long terms, including their systematic evaluation;
- Creation of awareness in the minds of the public and policy makers is essential for raising national and international support; and
- Finally, all participants must recognize the need to sustain capacity once it has been built.

The first GOOS User's Forum identified areas in which enhancement of the capacity of developing countries to participate, contribute and benefit in regional GOOS. These areas are applicable to developing countries of the Wider Caribbean and must be taken into account. They are:

(i) **Technical capacity** which includes technology transfer, where technology means processes as well as equipment; and the deployment of equipment and training in its use; and provision for the continued operation of the equipment and its maintenance after installation;

(ii) **Human capacity** which includes a full range of education training programmes utilizing the INTERNET where possible. Emphasis should be placed on training in modelling which provides a means of adding value to data;

(iii) **Organizational capacity** which involves strengthening or adapting present institutions as well as networking. It should involve the development of Centres of Excellence, which could be regional or national centres of education, training or operations covering all of marine science or focusing on particular aspects of it;

(iv) **Processes** which should be taken to mean the development of regional or national capacities through participation in the research or operation process. Ideally regional projects should be long term, for example, the 8-year long CARIPOL project which deals with oil pollution in the Caribbean;

(v) **Partnerships** developed with the marine capacity building programmes of UNEP and WMO;

(vi) **Best practice** which could be passed on through either the GOOS User's Forum or the GOOS Web page and through networking of national and regional GOOS bodies.

6.3 THE ROLE OF THE IOC

The IOC has an important advisory, coordinating, and facilitating role to play in supporting the creation and strengthening of national mechanisms. It has established regional subsidiary bodies that should assist in making national efforts more sustainable and effective and that should provide mechanisms to stimulate capacity building for IOCARIBE-GOOS and other IOC programmes, as appropriate.

The IOC regional bodies formulate and agree on cooperative regional projects built on national actions and addressing identified national and regional needs and priorities. They aim at regional pooling of resources and joint capacity building, and draw upon the global programmes of the IOC, for expertise, results, and advice.

The IOC Training, Education and Mutual Assistance in marine sciences (TEMA) capacity building programme is central to the overall IOC role and supports the capacity building efforts that are focused within the programmes of the Commission. A strong TEMA policy, acceptable to Member States, is desirable to help ensure that the capacity building process is linked to existing and planned national and regional programmes, thereby enhancing the success rate of capacity building activities. The IOC acts as a link with potential donor agencies, although it has limited success to-date, and cooperates with regional intergovernmental subsidiary bodies and with the analogous mechanisms of sister organizations such as WMO, UNEP, UNDP and ICSU.

Funding is mostly found from a combination of the IOC funds and contributions from Member States. More substantial sources of support must be found from donor agencies (including the private sector) and from other appropriate and creative means.

It is imperative that IOCARIBE-GOOS institutes principles and a programme to develop national capabilities in marine sciences and services. This programme for the building of capacity would involve a wide range of activities, depending on the starting capacity (level of ability) of the nation concerned. The activities would fall under the general headings of training, education, and mutual assistance; and within the IOC they would be managed through the TEMA Programme.

The first steps in building capacity are raising awareness of the activities involved, the benefits that may accrue from participation, and the likely costs.

Donor countries stand to benefit from their investment in the capacity of developing countries because it will lead to a broad development of IOCARIBE-GOOS, from which all countries will benefit.

6.4 IOCARIBE-GOOS CAPACITY BUILDING OBJECTIVES

In relation to IOCARIBE-GOOS, three partners should carry out capacity building:

(i) The IOCARIBE-GOOS organization with its sponsors;
(ii) Recipients or local, national or regional beneficiaries of the activities; and
(iii) National or international donor agencies, the private sector or countries.

In the Organization for Economic Co-operation and Development (OECD) countries, the existing infrastructure will underpin many of IOCARIBE-GOOS activities. This is not true of many other countries, where the necessary infrastructure is only partly or poorly developed.

Strategies should be implemented to meet these basic objectives:

- To develop and maintain a minimum scientific capability to support, participate in, and take advantage of IOCARIBE-GOOS related activities, including among others coastal zone and fishery resource management;
- To raise understanding of the importance of *in situ* and space-based observations of the ocean in seeking solutions to socio-economic problems;
- To educate the public and politicians regarding the socio-economic benefits of, and fundamental dependence on, an ocean observing system;
- To raise the ability of countries to contribute to and benefit from global observing systems;
- To promote excellence in education and training to take full advantage of the existing regional capabilities, utilizing the additional technical support of some specific UNESCO programs (e.g. BILKO Project for training in satellite coastal and marine oceanography).

There must be a long-term investment in developing infrastructure for receiving, processing, and interpreting data from ocean and space-based sources. This investment should be optimised by training in the use of such facilities and in the provision of services and products.

Special efforts should be made to create and sustain baseline networks of high quality surface-based stations or sections in a wide range of climates. Many of these are likely to be required in the coastal waters and the EEZ of countries requiring assistance.

6.5 IOCARIBE-GOOS CAPACITY BUILDING: APPROACHES

6.5.1 Cooperation

Effective IOCARIBE-GOOS capacity building is a long-term process, which starts with the potential users and their needs. An important instrument is partnerships between member countries, those possessing and those requiring advanced marine capacity. The partnerships may involve bi-lateral or multi-lateral relationships. An underlying objective is that the interests and commitments of all partners must be considered prior to undertaking any activity.

IOCARIBE-GOOS capacity building activities should be harmonized to the extent possible with those of other entities, including organizations and states interested in the region (e.g. CPACC). A major part of the financial support must come from agencies/states located in, or interested in supporting, the region.

6.5.2 Hardware and Maintenance

Responding to requests for the provision of hardware, whether instruments for observation or computer systems for analysis, is always difficult. IOCARIBE-GOOS itself has no access to such equipment and demands would usually be expensive. A brokerage service bringing requirements for equipment and inventories of surpluses would seem to be a novel and worthwhile idea. It must always be remembered however, that successful equipment transfer must include the ability of the recipient to operate and maintain the equipment and access to replacement parts.

6.5.3 The National and Regional Approach

An important part of capacity building is the national and regional approach outlined in Chapter 7.

7. NATIONAL AND REGIONAL DEVELOPMENT

7.1 NATIONAL GOOS DEVELOPMENT

The IOCARIBE Member States are diverse, ranging from highly developed countries, such as the USA, to very small island developing states, like those in the Eastern Caribbean. Similarly, their involvement in GOOS at a national level is diverse, ranging from the highly organized and very extensive USA national contribution to GOOS, to little or no knowledge of the need to develop a national GOOS. As a result, any discussion on the development of GOOS at a national level must in the first instance be generic.

The implementation of GOOS at the national level will depend upon the participation of the national meteorological and marine observing agencies as well as research organizations, industries (who are potential GOOS product users) and non-government organizations. Some of these organizations will be users of GOOS data and products; others will be suppliers; and some may be both users and suppliers.

The development of an inventory recognizes that the regional system has to build on national activities and requirements. Ideally, the governments of the IOCARIBE Member States should be encouraged to commit part of their national observational effort to a coordinated and integrated IOCARIBE-GOOS plan, and to sustaining that commitment on an on-going basis. **The Steering Committee needs to encourage the development of National GOOS Coordinating Committees and appropriate national focal contacts in each of the IOCARIBE Member States**.

As noted in chapter 8, national governments will be required to make commitments to support the participation of appropriate agencies and organizations in GOOS, and to ensure the resources needed for its success at the national level. This will require that each government is informed about GOOS, the benefit to be derived from implementing a National GOOS, and the need for their commitment to its success. In order to make these commitments, the governments must be convinced that GOOS will build on already existing and functional systems at the national and regional levels. They must also be convinced of the need to add to existing observations, for example where it appears necessary to fill gaps in geographical coverage, or in the supply of needed services. Further, governments must be convinced that GOOS will provide, through its regional network, the institutional strengthening and training required by the less developed countries of the region.

National development will be dependent to varying degrees on capacity building.

It is recommended by the IOC through GOOS publications that individual countries should be encouraged to develop national groups to promote the development of GOOS. This could be done by establishing National GOOS Coordinating Committees (NGCCs) to develop and strengthen the effectiveness of the national institutional infrastructures in support of operational oceanography and marine meteorology. This would stimulate the development of GOOS on a national and regional basis. Some nations already have such committees, which in some instances are outgrowths of or subcommittees to National Oceanographic Committees. There is no reason why a NGCC should not be part of a National Oceanographic Committee, provided that provision is made for the bringing together in the NGCC of all the potential stakeholders, both suppliers and users, including academia, all relevant branches of government, commerce and industry.

NGCCs will be expected to consult with governments to develop plans to address the following requirements to:

- determine user needs and specify the data and products required to satisfy those needs;
- identify and work to improve existing national capabilities, including human skills and available technology;
- identify gaps in those capabilities, including inadequacies in present observing and data management systems, and work to correct them, focussing (a) on training and practical assistance related to meeting users' needs in the coastal zone and elsewhere, and (b) on formulating plans to fill gaps;
- pay special attention to exploring the opportunities offered by the increasing number and variety of observations of the coastal zone and open ocean from space satellites;
- apply, within a regional context, the training possibilities of the BILKO Project on the use of satellite, air-borne and *in situ* data in the study of coastal and marine processes;
- promote communications between marine scientists and meteorologists on the one hand, and between them and coastal managers and other potential users of GOOS data and information on the other hand, through the development of national, regional and global electronic networking;
- promote the design and implementation of regionally coordinated strategies for data acquisition, integration, synthesis and dissemination of products to improve coastal zone assessment, the assessment of other environments, and the forecasting and prediction of environmental change;
- develop regional pilot projects to demonstrate the usefulness of the GOOS system in the coastal zones and surrounding oceans, and encourage participation in ongoing GOOS pilot projects;
- evaluate costs and benefits as the basis for persuading governments, donor agencies and the private sector to support a data acquisition programme and associated capacity building;
- promote GOOS development and expansion through appropriate communication.

The *Ad Hoc* Advisory Group for IOCARIBE-GOOS felt that in addition to these generic requirements, the National GOOS Coordinating Committees should fulfil the following duties:

- To define the national priorities that could be addressed, bearing in mind the available resources;
- To conceive and execute the scientific and services programmes in harmony and correspondence with common national priorities;
- To ensure appropriate capacity building in terms of human, material and institutional resources;
- To establish the mechanisms necessary to facilitate national and institutional activities and programmes becoming contributions to international programmes;
- To ensure better and greater coordination and conciliation of interests among related governmental and non-governmental organisms and international mechanisms;
- To develop the widest coordination, association and cooperation among all national institutions and organizations participating in the programme, in order to facilitate the achievement of a real national capacity;
- To ensure a plan of systematic actions that guarantees the continuity of the programme, starting from a clear and precise definition of the concrete objectives to be pursued at short, medium and long-terms, including their systematic evaluation.

In some IOCARIBE Member States, the national organizations that could be grouped into NGCCs need to be strengthened. Additionally they must agree to share the responsibilities of establishing a national GOOS.

7.2 NATIONAL USER NEEDS

The NGCCs must determine national GOOS user needs by requiring their members, who are the stakeholders who stand to benefit from the development of GOOS products, that is, both suppliers and users, to take part in an initial survey or workshop to find out (i) what products and services are required; (ii) who are the existing and potential generators of the products and services; and (iii) what management and planning institutions could integrate the information derived and convert it into actions. NGCCs should make clear to all the benefits that are likely to accrue to different sectors, including for instance: fisheries, climate prediction, public health, safety at sea, coastal protection, recreational activities, tourism, wildlife conservation, shipping and port operations, agriculture, and oil and gas exploration and production.

Among other things, GOOS is a tool that nations can use to meet their obligations under the United Nations Convention on the Law of the Sea (UNCLOS), which requires each coastal state to be responsible for managing its marine environment. The large number of countries which border the Caribbean Sea results in almost the entire marine environment of the Caribbean falling within one exclusive economic zone or another. This results in the management of these areas falling under national jurisdictions. Effective management of each of these national regions demands regional cooperation, as the waters washing one coast today will wash another tomorrow.

While all GOOS products and services will have economic and social benefits, some of these may be difficult to quantify. Benefits can take the form of improved commercial cash profits; reduction of commercial risk and uncertainty; improved management of the environment; public good benefit such as improved health and reduction of the adverse impacts of natural hazards; and long term benefits such as climate prediction and protection of biodiversity.

Based on the user needs and specific data and products identified to satisfy the needs, the NGCCs, particularly in developing countries, will have to identify institutional strengthening requirements in terms of national capabilities, including training and technology needs. In the IOCARIBE region, the filling of gaps identified in the capabilities, particularly inadequacies in present observing and data management systems, should be addressed by bilateral arrangements between the developing and developed countries of the region. These bilateral arrangements would be expected to provide the training and practical assistance required. Alternatively, the NGCCs could seek the assistance of international organizations to address training and technology gaps.

At the national level, the primary source of GOOS data will be from the organizations within the country, which are prepared to commit a part of their data gathering and data utilisation activities to the GOOS system in conformity with GOOS Principles. This will require adherence to certain standards, methodology, data and information management specifications, which have been established by the GOOS planning bodies.

7.3 REGIONAL GOOS DEVELOPMENT

7.3.1 General

Regional cooperation increases programme visibility and can emphasize the importance of collective local priorities. Regional development of GOOS requires that the IOCARIBE Member States combine resources to focus on a specific set of agreed objectives for the collective benefit. Regional frameworks can also increase the effectiveness of scarce resources and the efficiency of the local observing, research, data management and prediction network. Establishing funding support for regional centres (i.e. University of the West Indies and Institute of Marine Affairs) that included the training, maintenance and replacement abilities to support national systems will help to build capacity. Regional organizations already having operational responsibilities can provide IOCARIBE-GOOS with essential access to staff, support systems, communications, data facilities, and other infrastructure, particularly in areas lacking such capabilities. Regional cooperation can create appropriate and presently lacking institutional arrangements to ensure that all Member States have access to GOOS outputs. Regional planning for IOCARIBE-GOOS must take into account the extreme diversity between Member States in the IOCARIBE region.

Several initiatives that are GOOS-like in character and/or scope have already been developed in the Wider Caribbean Region, and are subscribed to by the governments of many of the IOCARIBE Member States (see below). These initiatives can provide guidance as to how IOCARIBE-GOOS might best be developed to meet regional development needs. IOCARIBE-GOOS should take note of these initiatives and build on them. IOCARIBE-GOOS can use the commitment of the governments to these regional initiatives to show how the formation of IOCARIBE-GOOS and the generation of GOOS products can contribute to the successful implementation of these initiatives.

7.3.2 Association of Caribbean States (ACS) Initiatives

In April 1999, the Association of Caribbean States (ACS) Heads of States and Governments Meeting in Santo Domingo formulated a declaration calling for the establishment of a sustainable tourism zone of the Caribbean. The declaration stressed that the Caribbean Sea is a common heritage of the region, both for the role it has played historically, as well as for its potential to serve as a unifying element in the development of the region. The declaration called for the collective abilities of the people to be mobilised to develop and exploit regional resources in a sustainable manner and in harmony with the environment, so as to improve the quality of life of present and future generations. The declaration recognized that tourism is a strategic industry contributing to the development of all Member States. It also indicates that benefits will accrue through taking an integrated approach to protecting biodiversity and the environment of the region.

The declaration provides IOCARIE-GOOS with advice on IOCARIBE what the governments consider important to the region. **The Steering Committee should determine what products are needed to support the concept of developing the sustainable tourism zone advocated by the ACS, and should also note that the ACS countries ranked sustainable fisheries management as the second priority area for the region**.

7.3.3 Regional UNEP Initiatives

The Strategic Plan for GOOS requires among other things that systematic observations be made in support of international and regional conventions and action plans. Governments need data and information in order to meet their obligations under the conventions. The conferences of the parties, the secretariats, and the subsidiary scientific and technical bodies of the conventions need information on the state of the environment, the resources and the processes to which the conventions and action plans are directed. Reliable observations collected over substantial time are needed to demonstrate if the measures taken under the conventions are effective. The IOCARIBE-GOOS Implementation Plan must indicate how GOOS observations may be used to assist the States in meeting the needs of the various conventions.

In particular it will be necessary for IOCARIBE-GOOS to meet the needs of the Caribbean Environment Programme of UNEP's Regional Seas Programme, which is designed to meet the needs of the Cartagena Convention ("The Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region") and its three protocols: (i) on cooperation in combating oil spills in the Wider Caribbean Region; (ii) on Specially Protected Areas and Wildlife; and (iii) on the prevention, reduction, and control of marine pollution from land-based sources and activities.

7.3.4 Regional WMO/JCOMM Initiatives

The recent formation of JCOMM, which held its first meeting in June 2001, calls for increased collaboration between the meteorological and oceanographic communities worldwide, among other things to improve weather and climate forecasting and associated services for users of the marine environment and for coastal communities ad activities. The Steering Group for IOCARIBE-GOOS must take full advantage of the creation of JCOMM (i) to bring together meteorologists and oceanographers to design IOCARIBE-GOOS in such a way as to extract the maximum benefit from JCOMM as an implementation mechanism for GOOS, and to contribute to the success of JCOMM activities for the benefit of the wider community, (ii) to encourage the National GOOS Coordinating Committees to strengthen links between meteorologists and oceanographers at the national level to ensure the success of both JCOMM and GOOS.

8. RESOURCES

8.1 INTRODUCTION

The design, implementation and management of IOCARIBE-GOOS will require the long-term commitment of substantial resources. Existing international, regional and national agencies mechanisms should be used to the extent possible. Ultimately IOCARIBE-GOOS will be carried out and funded largely by the IOCARIBE Member States, assisted as appropriate by international funding in response to specific proposals, and by observations made by space agencies.

8.2 SEEKING NATIONAL COMMITMENTS

National commitments to IOCARIBE-GOOS are needed at three levels:

(i) A commitment to make available for exchange data that is presently being collected as part of national programmes, and that has region-wide use (this would include what is already being exchanged through the World Weather Watch, plus other items not yet exchanged);

(ii) A commitment to create national data gathering and management systems that are compliant with GOOS Principles, and to contribute the data from those systems to GOOS;

(iii) A commitment to specifically support those observations of GOOS that are regional and/or global in nature, for example a network of stations needed for observations of global climate or global sea level, or some similar ocean property (these would form a subset of a more dense coastal observing network).

Even though commitments will always be made for programmes that are primarily in the national interest, they can be fully accepted as contributing to GOOS provided the data are made available and the measurements accord with the Principles, guidelines and standards established by GOOS. The benefit will arise from the reciprocal access to regional and/or global information which may be applied to the solution of local problems.

National meetings of potential stakeholders are needed to generate commitments, to prioritise activities within GOOS, to create inventories of what is available and what is required, and to identify areas where capacity building and external funding are needed. It will be useful for the managers of national GOOS activities to develop close relationships with all potential suppliers of oceanographic and marine meteorological data, including, for example, port managers (for sea-level data), and navies.

8.3 REGIONAL ORGANIZATIONS IN SUPPORT OF GOOS

The implementation of IOCARIBE-GOOS will depend not only on investment in GOOS at the national level, but also on investment in the region in related IOC programmes, such as IODE, HAB, GLOSS and the DBPC, and in JCOMM activities. **The Steering Committee will need to be in direct contact with global programmes having activities in the region, and also with the space agencies, to develop apropriate synergies**.

Development will also depend on capitalising on existing regional resources, including structures, such as the distributed centres of excellence of the University of the West Indies. National inventories (see 10.2, above) should be amalgamated into regional inventories, showing for each Member State whether or not, and to what extent it makes beach observations; oceanographic observations; marine meteorological observations; coastal meteorological observations; sea-level observations; biological observations; fisheries observations; pollution observations; chemical observations; bathymetric observations; remote sensing observations from aircraft; and remote sensing observations from space. Inventories should also indicate what resources are available in terms of trained personnel (graduate and non-graduate), research ships, ships of opportunity, small boats for coastal or estuarine work, and so on.

Development will be crucially dependent on the creation of appropriate regional networks as a resource. The nucleus for these already exists in many cases. As a model for the development of a regional network, a good example is given in the successful proposal by MedGOOS to the European Commission for funding for a Mediterranean network to Assess and upgrade Monitoring and forecasting Activity (MAMA) in the region. MAMA is divided into several discrete work packages each with a discrete set of deliverables. The packages include: (i) project integration and co-ordination; (ii) stocktaking and identification of the present situation; (iii) scientific assessment of the adequacy of existing ocean observing systems; (iv) capacity building; (v) numerical model development and application; (vi) a prototype data and information management system; (vii) establishing the MAMA Internet site as the basis for communication, and building a directory on operational forecasting; (viii) an awareness campaign to sensitise potential stakeholders; (ix) determining user need and disseminating products.

The Steering Committee should hold a regional applications-oriented science conference (for example like the biennial EuroGOOS Operational Oceanography conferences or like the biennial WESTPAC science conferences), to bring the community together behind the development of IOCARIBE-GOOS.

Support will be supplied to IOCARIBE-GOOS from the GOOS Project Office and the IOC and IOCARIBE Secretariats, as appropriate, bearing in mind the small budget and limited manpower available for this purpose.

8.4 SUPPORT FROM INDUSTRY AND COMMERCE

If the case is well made that industry and commerce will be direct beneficiaries of IOCARIBE-GOOS outputs, then industry and commerce may well be persuaded to make some additional investment in the development of specific parts of IOCARIBE-GOOS. However, it needs to be borne in mind that over most of the world, industry and commerce see investment in observing systems as a national 'public good' responsibility that provides them with outputs that they can adapt or tailor for their own commercial purposes.

The Steering Committee and National GOOS Coordinating Committees should explore the possibility that industry and commerce may be able to invest in some aspect of the observing system, or contribute to it some of their own observations. Particular attention should be paid to the oil and gas industry, fisheries, tourism and construction for example.

One argument that may attract support from the oceanographic service industry supplying the commercial sector with information is that the growth of IOCARIBE-GOOS will provide the basis for the creation of advanced commercial services and products that are beyond the present capabilities of the industry.

8.5 CAPACITY BUILDING

Resources will be needed not just to build the IOCARIBE-GOOS system, but also to build and sustain a regional capacity building programme. Here it is essential that partnerships must be forged between the donor organizations and/or countries and the recipient organizations and/or countries. It may be the former that can supply the financial assistance, expertise or technology, but it is the latter that must set up the programme framework and establish its priorities. In many countries there will be a requirement for assistance in the initial planning process and to ensure linkages, because local benefits cannot be optimised without adequate attention being paid to the interaction with the local, regional and global systems.

Donor agencies will respond positively to collective regional requests and to programmes that promise national and regional commitments. Expertise must be sought to prepare quality proposals that will have an optimum chance of being received and funded. It is recognized that the process of preparing a proposal itself needs financial support.

Donor funds should be used to assist and accelerate the participation of developing countries. However without a commitment by the receiving government, programmes will be as transient as the funding source, and without a framework to channel funds into the programme, and to the desired priorities, each source of funding will risk duplication or fragmentation.

9. ENSURING EFFECTIVE COORDINATION

9.1 INTRODUCTION

Given that the IOC is the lead agency for the development of GOOS worldwide, the responsibility for ensuring the effective coordination required for the development of a regional GOOS for the Wider Caribbean must inevitably be taken by IOCARIBE, the regional Sub-Commission of the IOC. The Regional Sub Commission is an intergovernmental subsidiary body of the IOC, and as such is responsible for the promotion, development and coordination of the marine scientific research programmes, the ocean services, and related activities, including Training, Education and Mutual Assistance (TEMA) in the region. In agreement with IOCARIBE's Terms of Reference, the development of IOCARIBE-GOOS would take place in close coordination with the appropriate IOC programme office, in this case the GOOS Project Office, through which coordination would be assured with the appropriate technical bodies within and related to the GOOS structure, and to the Intergovernmental Committee for GOOS, and through that to the GOOS sponsors, including the IOC Assembly.

The main elements of the Sub-Commission's structure that can be called upon to support effective coordination include the Member States themselves, the ongoing Programmes and Projects that may be related to GOOS (such as the national ocean data centres and training activities of the IODE programme, and the training associated with the Harmful Algal Bloom programme), and the regional Secretariat in

Cartagena, Colombia, which should host the IOCARIBE-GOOS secretariat, at least initially. Member States contributions to coordination include the National Focal Points, national institutions and national and regional experts, as well as National Oceanographic Committees and National GOOS Coordinating Committees (which may be the same thing in some instances). At a higher level are the governing bodies and officers of the Sub-Commission. This network element allows for interaction between these entities and other organizations in the region.

Of twenty-eight independent states in the region, including France, the Netherlands and the United Kingdom with their territories and departments, twenty-one are members of IOCARIBE, but not all are active members. The Member States are diverse in terms of size, wealth, ethnic make up, language and politics. They have many issues in common, the most important of which is the shared use of the Caribbean Sea, Gulf of Mexico and adjacent regions.

The Report on IOCARIBE Evaluation (IOC/INF-1043, September 1996) indicated that based on data available, questionnaires and a number of interviews, the large and medium sized states (Columbia, Cuba, Mexico, USA and Venezuela), which represent three quarters of the region's population, had been actively involved in and profited the most from IOCARIBE. Many smaller states had either not participated, or their participation had been minimal; consequently they had not benefited from the IOCARIBE process. The Steering Committee should develop a plan of action to ensure, to the extent possible, the participation of all Member States in IOCARIBE-GOOS.

9.2 COORDINATION MECHANISMS

Regional coordination of IOCARIBE-GOOS will be the responsibility of the Regional Sub-commission (IOCARIBE), acting through the Steering Committee for IOCARIBE-GOOS. **The Steering Committee will report to IOCARIBE**.

Coordination of IOCARIBE-GOOS activities nationally will be the responsibility of the National GOOS Co-ordinating Committees (NGCCs).

Noting the example of other regional GOOS bodies, it is evident that for IOCARIBE-GOOS to be fully effective it will need to be served by a full time Administrative Officer. The Administrative Officer should be located in the IOCARIBE Secretariat, so as to capitalize on the resources already available there.

The IOCARIBE-GOOS Administrative Officer should have appropriate flexibility and autonomy so as to be able to stimulate and respond to regional initiatives and fulfil the expectations of Member States. **The Steering Committee should develop the case for establishing and funding the Administrative Officer for IOCARIBE-GOOS**. In the absence of the Administrative Officer the responsibility for serving the needs of the Steering Committee must fall on the shoulders of the IOCARIBE Secretary, who has many other duties to perform.

The Steering Committee should carry out its intersessional work programme through a small Executive Committee of 'Officers' assisted by the Administrative Officer.

The Steering Committee will liase with Intergovernmental Committee for GOOS [represented intersessionally by the GOOS Project Office (GPO)] regarding issues where intergovernmental or international action will facilitate the development of IOCARIBE-GOOS.

The Steering Committee, the Administrative officer, and the Director of the GPO should liase on aspects of soliciting funding from potential sponsoring agencies.

The Steering Committee should liase with the GOOS Steering Committee on scientific and technical developments to ensure that they follow the advice of the GOOS Advisory Panels.

The Steering Committee should develop a marketing and communications strategy, including a web site and newsletter for IOCARIBE-GOOS, to assist in promoting the concept and to provide effective external communications. These should be managed by the Administrative Officer.

Each NGCC should have its own web page on (or accessible through) the IOCARIBE-GOOS web site. National web pages should list the activities of the NGCC, plus the GOOS products, users and suppliers in each country. The web page and newsletter could be used for purposes of mutual assistance, for example to solicit help in solving problems, in coping with training requirements for personnel, or in accessing equipment from other NGCCs in the region.

A system could be developed within IOCARIBE-GOOS, in which countries which have already established a national GOOS could assist countries which have not yet established a national GOOS. The system would have to be coordinated by the Steering Committee and the Administrative Officer. This would assist the establishment of observing systems, the development of products, and the exchange of data and information in accordance with GOOS Principles.

ANNEX I

PRELIMINARY (NON-EXHAUSTIVE) LIST OF USER SCENARIOS

Scenario 1:

Local coastline water level variations, seasonally, annually, and in storms or tsunamis

To improve its local flood defences, a coastal zone management group needs to know how water levels may vary along a particular stretch of coast, especially in storms, both seasonally and from year to year. Much the same information will be required by the local managers of ports and harbours, not only for flood defence but also for predicting and controlling access to loading and unloading. Water levels may vary because of tides, changes in sea level caused by climate change, surges caused by storms, or changes in wave height, for instance, all of which may be independent, but which may be combined, and all of which can be monitored, modelled, and predicted.

Products and service solutions can be obtained from tide gauges, satellite altimetry, and tsunami-watch programmes, for example.

Scenario 2:

Impact on coastal circulation systems from changes in the open ocean circulation

Port managers need information about circulation in support of safe navigation and environmental protection in harbours and their surrounding or approach areas. Coastal circulation is partly forced by the circulation in the outside open ocean basin, partly by tidal effects, local topography and hydrographical conditions. Pollution emergency response systems similarly depend on a good knowledge of local circulation, and their design should be based on climatological information on the variability of this circulation.

Products and service solutions can be obtained from national or commercial meteorological or oceanographic agencies providing coastal warnings, observations, weather charts, sea-level and sea state and swell forecasts.

ANNEX II

LIST OF ACRONYMS

ACS	Association of Caribbean States
CARICOMP	Caribbean Coastal Marine Productivity Programme
CARIPOL	Caribbean Pollution Monitoring Programme (IOCARIBE)
CHAMPS	Coral Health and Monitoring Programme (NOAA)
CLIVAR	Climate Variability and Predictability (WCRP)
CONNS	Coastal Observing Network for the Near Shore
COOP	Coastal Ocean Observations Panel
CPACC	Caribbean Planning for Adaptation to Climate Change
DIM	Data and Information Management
EEZ	Exclusive Economic Zone
EuroGOOS	European GOOS
GCOS	Global Climate Observing System
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environmental Facility
GEO	Global Environmental Outlook
GESAMP	Group of Experts on the Scientific Aspects of Marine Environment Protection (IMO-FAO-UNESCO/IOC-WMO-WHO-IAEA-UN-UNEP)
GLOSS	Global Sea-level Observing System
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GPO	GOOS Project Office
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunications System
HAB	Harmful Algal Bloom
HOTO	Health of the Ocean
ICAM	Integrated Coastal Area Management
ICES	International Council for the Exploration of the Sea [CIEM]
ICSU	International Council of Science
IGSC	IOCARIBE-GOOS Steering Committee
IOC	Intergovernmental Oceanographic Commission
IOCARIBE	IOC's Regional Sub-Commission for the Caribbean and Adjacent Regions
IODE	International Oceanographic Data and Information Exchange (IOC)
IOS	Initial Observing System
IPCC	Intergovernmental Panel on Climate Change
IYO	International Year-of-the-Ocean
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
MAMA	Mediterranean network to Assess and upgrade Monitoring and forecasting Activity (in the region)
MedGOOS	Mediterranean regional GOOS
MICOM/HYCOM	Miami Isopynic Co-ordinate Ocean Model/Hybrid Co-ordinate Ocean Model
NGCC	National GOOS Coordinating Committee
NGO	Non-Governmental Organization (ONG)
NLOM	Navy layered ocean model
NOAA	National Oceanic and Atmospheric Administration (USA)
ODAE	Ocean Data Assimilation Experiment
ODINCARSA	Ocean Data and Information Network for the Caribbean and South America
OECD	Organization for Economic Co-operation and Development
OOPC	Ocean Observation Panel for Climate
RAMP	Rapid Assessment of Marine Pollution (HOTO)
RCCL	Royal Caribbean Cruise Line
RONMAC	Red de Observacion del Nivel del Mar para America Central [Water Level Observation Network for Latin America (NOAA and partners)]
ROTHR	Relocatable Over-the-Horizon Radar
SEA-COOS	South-East Atlantic Coastal Observing System
SOOP	Ship of Opportunity programme
SURA/SCOOP	Southeastern Universities Research Association (USA)/SURA Coastal Ocean Observing Programme

TAG	Technical Advisory Groups
TEMA	Training, Education and Mutual Assistance in marine sciences
UM/RSMAS	University of Miami/Rosenstiel School of Marine and Atmospheric Science
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VENEHMET	“Programa de Modernización del Sistema de Medición y Pronóstico Hidrometeorológico Nacional” (Venezuela)
VOS	Voluntary Observing Ships
WESTPAC	IOC Sub-commission for the Western Pacific
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment (WCRP)
WWW	World Weather Watch
XBT	Expendable Bathythermograph