Intergovernmental Oceanographic Commission

Workshop Report No. 45

# IOCARIBE Workshop on Physical Oceanography and Climate

Cartagena, Colombia, 19-22 August 1986

Unesco

# IOC Workshop Reports No. 45

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| No. | Title | Publishing Body | Languages |
|---|---|---|---|
| 1 | CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand 24-29 September 1973 UNDP (CCOP), 138 pp. | Office of the Project Manager UNDP/CCOP c/o ESCAP Sala Santitham Bangkok 2, Thailand | English |
| 2 | CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (Unesco Technical Paper in Marine Sciences, No. 20). | Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France | English (out of stock) Spanish (out of stock) |
| 3 | Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean, Monte Carlo, 9-14 September 1974. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish (out of stock) |
| 4 | Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974. | FAO Via delle Terme di Caracalla 00100 Rome, Italy | English (out of stock) Spanish (out of stock) |
| 5 | IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, Kingston, Jamaica, 17-22 February 1975. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English (out of stock) Spanish |
| 6 | Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, 1-6 September 1975. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 7 | Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/Unesco/EAC, Nairobi, Kenya, 25 March-2 April 1976. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish Russian |
| 8 | Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters, Penang, 7-13 April 1976. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English (out of stock) |
| 9 | IOC/CMG/SCOR Second International Workshop on Marine Geoscience, Mauritius, 9-13 August 1976. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish Russian |
| 10 | IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring, Monaco, 14-18 June 1976. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish (out of stock) Russian |
| 11 | Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain Trinidad, 13-17 December 1976. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English Spanish (out of stock) |
| 11 Suppl. | Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain, Trinidad, 13-17 December 1976. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English Spanish |
| 12 | Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, Fort-de-France, Martinique 28 November-2 December 1977. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish |
| 13 | Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area, Port of Spain, Trinidad, 16-18 January 1978. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English Spanish |
| 14 | IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas, Abidjan, Ivory Coast, 2-9 May 1978. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French |
| 15 | CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific, Santiago de Chile, 6-10 November 1978. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English (out of stock) |
| 16 | Workshop on the Western Pacific, Tokyo, 19-20 February 1979. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Russian |
| 17 | Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS), Moscow, 9-11 April 1979. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 17 Suppl. | Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System, Moscow, 2-6 April 1979. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 18 | IOC/Unesco Workshop on Syllabus for Training Marine Technicians, Miami, 22-26 May 1978 (Unesco reports in marine sciences, No. 4) | Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France | English (out of stock) French Spanish (out of stock) Russian |
| 19 | IOC Workshop on Marine Science Syllabus for Secondary Schools, Llantwit Major, Wales, U.K., 5-9 June 1978 (Unesco reports in marine sciences, No. 5). | Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish Russian Arabic |
| 20 | Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources, Bandung, Indonesia, 17-21 October 1978. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 21 | Second IDOE Symposium on Turbulence in the Ocean, Liège, Belgium, 7-18 May 1979. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish Russian |
| 22 | Third IOC/WMO Workshop on Marine Pollution Monitoring, New Delhi, 11-15 February 1980. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish Russian |
| 23 | WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific, Tokyo, 27-31 March 1980. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English Russian |
| 24 | WESTPAC Workshop on Coastal Transport of Pollutants, Tokyo, 27-31 March 1980. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English (out of stock) |
| 25 | Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, Bermuda, 11-26 January 1980. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English (superseded by IOC Technical Series No. 22) |
| 26 | IOC Workshop on Coastal Area Management in the Caribbean Region, Mexico City, 24 September-5 October 1979. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English Spanish |
| 27 | CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Nouméa, New Caledonia, 9-15 October 1980. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 28 | FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes Lima, 20 April-5 May 1980. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 29 | WESTPAC Workshop on Marine biological methodology Tokyo, 9-14 February 1981. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 30 | International Workshop on Marine Pollution in the South-West Atlantic Montevideo, 10-14 November 1980. | IOC, Unesco Place de Fontenoy, 75700 Paris, France | English (out of stock) Spanish |
| 31 | Third International Workshop on Marine Geoscience Heidelberg, 19-24 July 1982 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish |
| 32 | UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime Paris, 27 September - 1 October 1982. | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish |

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**Intergovernmental Oceanographic Commission**

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# IOCARIBE Workshop on Physical Oceanography and Climate

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# TABLE OF CONTENTS

ANNEXES

1. OPENING

The IOCARIBE Workshop on Physical Oceanography and Climate was opened at 09:30 hours, 19 August 1986, by the Chairman of the IOC Sub-Commission for the Caribbean Sea and Adjacent Regions (IOCARIBE)(x), Capt. Rafael Steer-Ruiz, at the site of the Centro de Investigaciones Oceanográficas e Hidrográficas, Cartagena, Colombia. Capt. Steer-Ruiz in welcoming the participants, pointed out that the Workshop was the first activity organized after the recent designation of the Senior Assistant Secretary for IOCARIBE and the installation of the regional secretariat. He also elaborated on some of the on-going and planned activities of the Sub-Commission.

2. ADMINISTRATIVE ARRANGEMENTS AND CONDUCT OF THE WORKSHOP

Dr. F. Robles, IOC Senior Assistant Secretary for IOCARIBE, briefly informed about relevant global programmes of the IOC, such as CCCO and oceanic components of the TOGA and WOCE exercises of the World Climate Research Programme (WCRP). He pointed out that the IOC Intergovernmental mechanism for the oceanic component of the WCRP is the Programme Group for Ocean Processes and Climate (IOC/PG-OPC) established in March 1985. He also outlined the general working procedures for the meeting.

The Agenda is enclosed in Annex I.

The List of Participants if enclosed in Annex II.

3. ELECTION OF OFFICERS FOR THE WORKSHOP

Capt. R. Steer-Ruiz was proposed as Chairman for the Session. This proposal was unanimously accepted by the participants.

Dr. G. Maul and MSc. R. Aparicio-Castro were proposed as Vice-Chairman and as Rapporteur, respectively. These proposals were likewise unanimously accepted by the participants.

4. OVERVIEW PAPERS ON WATER MASSES AND CIRCULATION IN THE CARIBBEAN SEA AND ADJACENT REGIONS

The following overview papers were presented to cover the subject of this agenda item:

- Water Masses and Circulation of the Caribbean Sea, by Dr. G. Maul.
- Water Masses and Circulation of the Gulf of Mexico, by Dr. A. Gallegos
- Coastal Dynamics, by Dr. M. Hernández-Avila

Abstracts of these presentations are enclosed in Annex III.

(x) A List of Acronyms and Abbreviations is provided in Annex V.

## 5. REPORTS OF INVITED EXPERTS ON THE STATUS OF PHYSICAL OCEANOGRAPHY IN THE CARIBBEAN REGION IN THEIR RESPECTIVE COUNTRIES

Scientists attending the Workshop from the following Member States of IOCARIBE introduced presentations on ongoing physical oceanography (and climate) activities in their respective countries:

Colombia, Costa Rica, Cuba, Jamaica, Mexico, Puerto Rico, Trinidad & Tobago, United States and Venezuela.

Abstracts of these presentations are incorporated in Annex III.

Dr. G. Cambers, who was unable to attend, addressed to the Workshop relevant positions papers describing the situation for Barbados and Grenada. These papers are also enclosed in Annex III.

## 6. SCOPE OF THE MEETING

In covering introductory topics suggested by the provisional programme as possible themes for project proposals, some elements for regional project outlines in Sea Level and Climate (Dr. G. Maul), Hydrography and Bathymetry (Dr. A. Gallegos) and Coastal Hydrodynamics (Dr. Hernández-Avila) were introduced to the Workshop's consideration. The general view expressed by many participants was that large scale regional projects would be viable only if they, at the same time, would explicitly encompass smaller scale activities related to immediate needs of the countries concerned. To further elaborate these ideas and without prejudicing an overall integral approach, the Workshop formed two working groups, one focussing on regional scientific problems on sea level and climate and the other on coastal hydrodynamics aspects. The initial inputs of the deliberation of the two groups were later on incorporated in single programme proposal (See 7 below).

## 7. AN IOCARIBE PROGRAMME IN SEA LEVEL/WEATHER MONITORING OF THE CARIBBEAN SEA AND ADJACENT REGIONS (CSAR)

### 7.1 INTRODUCTION

The Caribbean Sea - Gulf of Mexico - Bahamas region (CSAR) is a semi-enclosed sea which plays a fundamental role in the circulation of the North Atlantic Ocean. It is a region rich in temporal and spatial scales of variability in the motion of its water, and is directly influenced by the runoff of the three largest rivers in North and South America. Complexity of near surface oceanic phenomena is a nested hierarchy of: Gulf Stream System formation and dissipation (eddy) dynamics; mesoscale and coastal scale upwelling; near-shore currents, waves, and transport including beach erosion; estuarine circulation; and sea level variability from tidal to interannual scales.

### 7.2 GENERAL OBJECTIVES

Central to each of these nested problems is the need to know the basin scale upper layer circulation because of the unique geography in CSAR. Circulation on the narrow continental and/or island shelves is strongly influenced by fluctuations of the deep water currents; similarly littoral and estuarine circulation is strongly influenced by the shelf currents, coastal winds and waves. The physical understanding of coastal circulation dynamics is not possible without direct knowledge of the offshore variability, which provides the boundary conditions necessary to any inshore modelling.

Recognizing that the interest of many IOCARIBE Member States is primarily in the economic and applied aspects of shelf and coastal processes, it has been determined that a sea level project is basic and essential to the achievement of this goal. All efforts should therefore be initially concentrated on the successful implementation and completion of a coastal (open sea) sea level/weather monitoring system in the CSAR. It is also recognized at the outset that individual member states have highly specialized needs which should be vigorously addressed through TEMA, with the goal of applying the sea level/weather data, and other ancillary information, to these specialized needs.

As a model for this project, the successful CARIPOL approach was adopted. CARIPOL is characterized by two aspects: simplicity of expectations; and strong emphasis on training and mutual assistance. To accomplish aspect one, it is proposed to establish an improved network of stations each to record sea level, sea surface temperature and salinity, wave spectra, wind velocity, barometric pressure, precipitation, insolation and relative humidity. To accomplish aspect two, it is proposed to organize and co-ordinate workshops and expert consultations so as to provide Member States with equipment, training, and spare parts to contribute to a decade-long (minimum ) programme in CSAR critical measurements for physical oceanography, coastal dynamics and climate research.

7.2.1 Theoretical Framework

To put these observations into a physical framework, the most direct means of estimating basin-scale upper layer circulation is through a regional real-time, reporting coastal sea level/weather station network.

To first order, the surface current in deep water are geostrophically adjusted. This implies that sea level station pairs can measure the mean surface current velocity between them from the relationship

$$fv = g \frac{dH}{dX} \qquad (1)$$

where f is the Coriolis parameter ($f = 1{,}4544 \times 10^{-4}$ sine latitude), v is the surface current velocity, g is the acceleration of gravity, dH is the difference in sea level between two stations, and dX is the horizontal distance between the two stations. Equation (1) describes the physical basis of a linear model for nowcasting CSAR surface currents from a network of coastal sea-level/weather stations using routine WMO reporting procedures.

7.2.2 A practical example

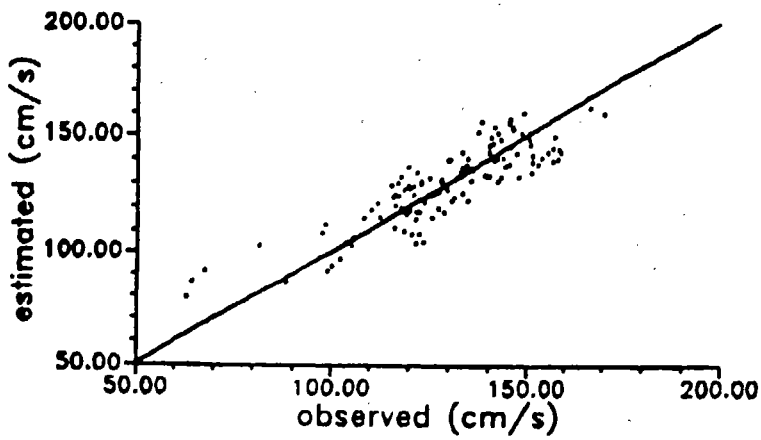
Figure 1 shows examples of estimating both surface currents and total volume transport through the Straits of Florida using sea level and weather data. In this example, almost all of the signal in dH is at the Florida side of the Straits. The linear equation

$$v = C_o + C_1 \times HBSL + C_2 \times BP + C_3 \times EW^2 + C_4 \times NW^2 + C_5 \times AT \qquad (2)$$

produces root mean squared errors in velocity of less than $\pm$ 10 cm/sec., and less that $\pm$ 1.5 x $10^6$ $m^3$/sec in volume transport. The terms $C_o$ ..... $C_5$ are empirical constants determined from linear least-squares modelling of daily averages of Haulover Beach (Florida) sea level (HBSL), atmospheric barometric pressure (BP), East wind (EW) and North wind (NW) squared components, and air temperature (AT) against repeated in situ determination of speed and transport from hydrography and/or direct observations. Equation (2) is readily determined by standard statistical techniques using a personal computer or calculator.

A sea level model of near surface CSAR currents is only a first order approximation to the complex circulation that exists. It is however a powerful constraint as a surface boundary condition on more complicated numerical models which are ultimately necessary for increased physical understanding. Additionally, a coastal sea-level/weather station network provides measurements of climate variability such as changes in rainfall patterns and oceanic upwelling that affect the living and non-living resources of the IOCARIBE Member States.

Fig. 1 Gulf Stream Speed from HBSL




Gulf Stream Transport from HBSL

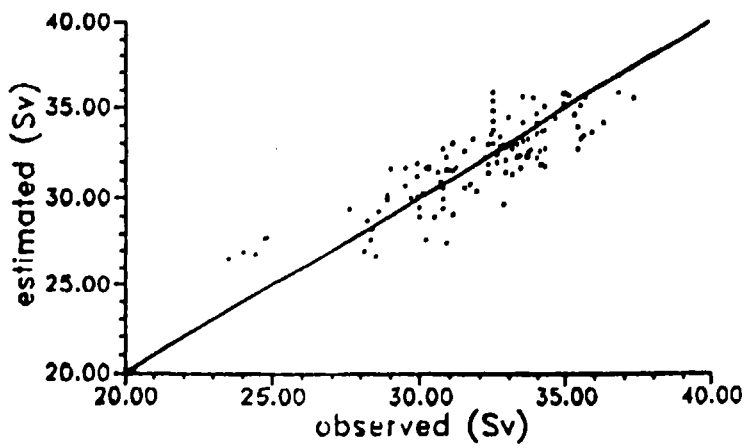


Figure 1: The upper panel shows the results of using Equation 2 to estimate mean surface currents in the Straits of Florida; r.m.s. erros is ± 10 cm/sec. The lower panel is a similar result for volume transport (in sverdrups; 1 Sv = $10^6$ $m^3$/sec) in the Florida current; r.m.s. error is ± 1.5 x $10^6$ $m^3$/sec. Approximately 120 independent in situ observations are used to determine the empirical constants.

7.3 SPECIFIC OBJECTIVES

(i) Establish a network of IOC/WMO reporting coastal (open sea) sea-level/weather stations for long term measurement against which changes in the CSAR marine environment may be judged.

(ii) Participate in the global understanding of climate changes as an IOC contribution to the WCRP (TOGA, WOCE and OOSDP) with the specific objective of improvided long-range forecasts for IOCARIBE Member States.

(iii) Investigate the causes of sea-level fluctuation and contribute to predicting future changes.

(iv) Use sea level as a measure of the intensity of heat content or thermocline topography especially in the CSAR where density structure can be approximated by a two-layer system.

(v) Implement nowcasting surface currents and volume transport in a linear CSAR box model.

(vi) Initiate and conduct a vigorous and progressive TEMA programme in sea-level/weather observations, analysis methodology (including remote sensing and numerical modelling), employing the generated data to be applied to coastal dynamics processes research, taylored to the needs of individual Member States.

(vii) Improve professional expertise for scientists from Member States by active participation in data analysis and interpretation, and publication of results in referred journals.

7.4 DATA ACQUISITION

(i) Sea-level/weather station requirements

Definition of a sea-level/weather station

In defining a sea-level/weather station, no specification of the design of equipment is made, only that the measurements meet accepted standards of hydrographic and weather services. Most important in the siting of each station is that it should be exposed to the open sea as close to deep water as possible. Long piers are usually prime candidate structures for these stations. It is preferred that the meteorological site be co-located with the oceanographic site, but in no case greater that 3 km away. Each station will measure the following: sea level, sea and air temperature, salinity, spectrum of surface waves, wind velocity, relative humidity, precipitation and insolation. Data will be digitized and transmitted via the WMO communication network (GTS) at each synoptic hour, using standard codes.

Tentative list of additional and existing stations required

The following list was prepared by the experts attending the Workshop, including locations at countries not represented in the venue. The list is therefore not final and serves general information purposes only.

(a) Countries with experts attending the Workshop:

| | New | Existing |
|---|---|---|
| Colombia (4) | | |
| | Puerto Bolivar | |
| | Cartagena | |
| | San Andrés | |
| | Serranilla Island | |
| Costa Rica (1) | | |
| | Puerto Limón | |
| Cuba (5) | | |
| | Punta Maisi | Cabo San Antonio |
| | Cabo Cruz | Siboney |
| | Pinos Island | Gibara |
| | Cayo Sabinal | |
| | Cayo Francés | |
| Jamaica (5) | | |
| | Port Antonio | Port Royal (Kingston) |
| | Montego Bay | |
| | Savannah La Mar | |
| | Pedro Cays | |
| | Morant Key | |
| Mexico (1) | | |
| | Isla Mujeres or Puerto Morelos | Tuxpán |
| | | Veracruz |
| | | Campeche |
| | | Progreso |
| | | Tampico |
| Trinidad & Tobago | | |
| | Toco | Chaguaramas |
| | Crown Pt. | |
| | Charlotteville | |
| | Icacos Pt. | |
| United States and Puerto Rico (2) | | |
| | Isla Mona | Miami |
| | St. Croix | Lake Worth |
| | | Key West |
| | | San Juan |
| | | Mayaguëz |

Venezuela (3)

| New | Existing |
|---|---|
| Isla de las Aves | La Guaira |
| La Orchila | Carupano |
| Puerto Cabello | |

(b) Countries with no experts represented at the Workshop (In general, one station by country)

| New | Existing |
|---|---|
| Bahamas (2) | |
| Great Isaac | Cat Cay |
| Great Abaco Is. | Settlement Point |
| Barbados | |
| Grenada | |
| St. Vincent | |
| St. Lucia | |
| Martinique | |
| Guadaloupe | |
| Dominican Republic | |
| Haiti | |
| Grand Cayman | |
| Honduras (Swan Island) | |

Total number of suggested new stations = 37

In addition, the Workshop stressed the need for many existing stations, to examine the re-establishment of corresponding bench-marks, by periodic levelling of these marks, and the eventual re-habilitation of tide gauges out of operation.

(ii) Hydrographic measurements

Measurement of surface current velocity and volume transport between two sea-level stations requires, according to equation (2), the determination of the six constants (calibration for each pair of stations). The only way this can be accomplished is through the estimation of speed and volume transport normal to the line joining the pair of sea level stations. Such estimations are determined on the basis of repeated hydrographic transects and Eulerian and/or Lagrangian measuring techniques to estimate sub-surface and surface layer advection between pairs of sea-level stations.

To start the production of surface current and volume transport now-casts in CSAR, it is proposed to calibrate the following pairs of sea-level stations:

TABLE 1

| | | |
|---|---|---|
| 1. | Puerto Morelos, Mexico | Cabo San Antonio, Cuba |
| 2. | Habana, Cuba | Key West, USA |
| 3. | Caleta de Carapachibe, Cuba | Grand Cayman, Cayman Is. |
| 4. | Swan Island | Grand Cayman, Cayman Is. |
| 5. | Cabo Cruz, Cuba | Montego Bay, Jamaica |
| 6. | Punta Maisi, Cuba | Morant Key, Jamaica |
| 7. | Navassa, Haiti | Morant Key, Jamaica |
| 8. | Punta Maisi, Cuba | Cop du Mole, St. Nicholas, Haiti |
| 9. | Serranilla, Colombia | I. Swan, Honduras |
| 10. | San Andrés Isla, Colombia | I. Swan, Honduras |
| 11. | San Andrés Isla, Colombia | Puerto Limon, Costa Rica |
| 12. | San Andrés Isla, Colombia | Puerto Bolivar, Colombia |
| 13. | Morant Key, Jamaica | Puerto Bolivar, Colombia |
| 14. | I. Saona, Punta Cana (Rep. Dom.) | I. Mona, Puerto Rico |
| 15. | Cabo Rojo, Puerto Rico | I. Mona, Puerto Rico |
| 16. | San Juan, Puerto Rico | Frederiksted, St. Croix |
| 17. | Basse Terre, Guadaloupe | Frederiksted, St. Croix |
| 18. | Basse Terre, Guadaloupe | Rosseau, Dominica |
| 19. | Fort de France, Martinique | Rosseau, Dominica |
| 20. | Fort de France, Martinique | Port Castries, St. Lucia |
| 21. | Kingston, St. Vincent | Port Castries, St Lucia |
| 22. | St. Georges, Grenada | Charlotteville, Tobago |
| 23. | Frederiksted, St. Croix | Cumana, Venezuela |
| 24. | Puerto Colon, Panama | Kingston, Jamaica |
| 25. | Banco Pedro, Jamaica | Kingston, Jamaica |
| 26. | Banco Pedro, Jamaica | Serranilla, Colombia |
| 27. | Savannah La Mar, Jamaica | Banco Pedro, Jamaica |
| 28. | Charlotteville, Tobago | Bridgetown, Barbados |
| 29. | Toco, Trinidad | Crown Point, Tobago |
| 30. | G. Cayman, Cayman Island | Cabo Cruz, Cuba |
| 31. | St. Croix, USA | La Orchila, Venezuela |

Figure 2: shows the proposed pairs of sea-level stations to be used for the purpose of sea surface and volume now casts.

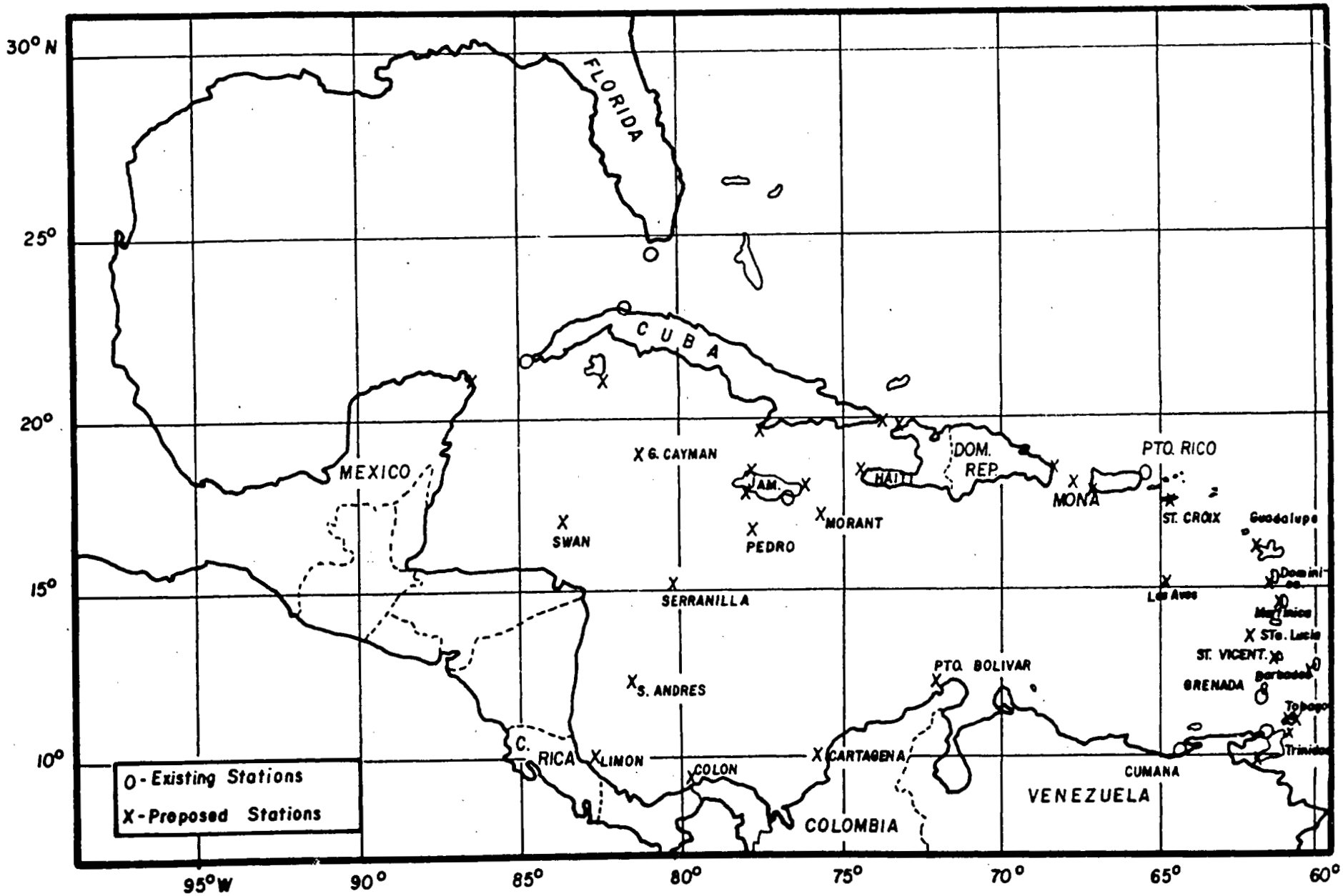



Fig. 2 Proposed pairs of Sea-Level Stations to be used for the purpose of Sea Surface and Volume Nowcasts (see text).

The following station pairs are proposed to be calibrated through sections performed by research vessels of the three countries listed:

| Station Pairs | Proposed Responsible IOCARIBE Member State | Proposed Vessel |
|---|---|---|
| 1-8, 30 | Mexico | R/V "Justo Sierra" |
| 9-13, 24-27 | Colombia | R/V "Providencia"/R/V'MARPELO' |
| 14-23, 28-29, 31 | U.S.A. | R/V "Researcher" |

Invitations will be extended to interested physical oceanographers from IOCARIBE Member States to participate in the cruises that will be carried on to calibrate the pairs of stations listed in Table 1. It is requested that IOC, through the IOCARIBE Sub-Commission, covers the necessary expenses in transportation and/or per diem of invited participants.

(iii) Remote sensing by satellite

Substantial benefits to both the basin-scale and local-scale aspects of the programme can be realized through use of satellite remote sensing (aircraft remote sensing is held in abeyance because of prohibitive costs). Due to the facilities requirements for individualized image processing, the thrust will be utilization and interpretation of existing standard products such as sea-surface temperature from the MCSST files, ocean color from NESDIS CZCS transparencies, near shore and coastal land/sea interaction using LANDSAT data from EROS and SPOT from CNES and satellite altimetry and sea state from GEOSAT. Specialized image processing on a limited scale will be provided by the University of Puerto Rico, who will also provide the facilities for training of interested scientists. In the longer view, this IOC programme will be proposed as an integral part of the USA/France effort in satellite altimetry (TOPEX/POSEIDON) and the NASA effort in surface winds measurements from NSCAT. The lead responsibility for obtaining and sharing altimeter and scattermeter data will be NOAA/AOML.

(iv) Ship-of-opportunity programme

This CSAR programme in sea level studies will benefit from the IGOSS ship-of-opportunity programme. Contact will be made with the IGOSS co-ordinator to determine the XBT lines now planned for the CSAR, and communicated to the IGOSS co-ordinator from possible expansion of ship-of-opportunity observations.

(v) Lagrangian Drifters

To supplement the system of sea-level/weather stations, hydrography, satellite data, and ship-of-opportunity observations, satellite tracked Lagrangian Drifters will be deployed. A proposal to accomplish this is being made by scientists from the Research Triangle Institute (USA) to a U.S. funding agency. Member States in the vicinity of the several launching

sites (Grenada Passage, Anegada Passage and Windward Passage) would cooperate by providing assembly facilities and a launching vessel at approximately 3-month intervals. Processed data will be provided to all Member States and cooperative studies conducted by interested individuals.

(vi) Subregional study

In the South-West subregion of the Caribbean Sea, (including waters of Colombia, Panama and Costa Rica), hydrographic measurements will be carried out, in order to supplement and calibrate data from the sea-level/ weather stations that will be installed in this area. These studies should be designed in such a manner that will allow the description and knowledge of the mesoscale circulation in the subregion, eddies regime and interannual variability. All to be matched to the large scale circulation of the Caribbean and to smaller scale coastal dynamics.

To this end, a work programme will be elaborated by the interested countries. An initial draft will be submitted by Colombia to Panama and Costa Rica in order to initiate this exercise.

Besides hydrographic data, additional measurements may be considered, such as drifters, data buoys and remote sensing parameters, according to specific questions.

It is also considered most important in the content of the studies described, that training and education components should be included at every stage.

## 7.5 SAMPLING SCHEME

The Workshop decided that the sampling plan should be developed as part of the operation plan of the programme. However, some basic requirements were advanced, such as the need for seasonal periodicity, for the sampling scheme, including the oceanographic cruises concerned and the need of hourly measurements for the sea-level/weather stations to be averaged at two weeks intervals.

## 7.6 FACILITIES AVAILABLE AND NEEDED

The following two tables summarize the available and required facilities (for countries with experts attending the Workshop), in relationship to main parameters/human resources, needed to carry out the proposed programme. The list must be considered only as a first approximation to the stated facilities. In addition, the existing facilities of many Member States may need to be upgraded.

TABLE 2

AVAILABLE FACILITIES

| Country | Sea Level (Stations) | Weather Param. (Stations) | Water Column | Remote Sensing | Ocean Expertise |
|---|---|---|---|---|---|
| Colombia | No | Yes (2) | Yes | No | Yes |
| Costa Rica | No | No | No | No | Yes |
| Cuba | Yes (3) | Yes | Yes | No | Yes |
| Jamaica | Yes (2) | Yes (8) | No | No | Limited |
| Mexico | Yes | Yes | Yes | No | Yes |
| Trinidad & Tobago | No | Yes | No | No | Yes, yet limited |
| U.S.A. | Yes (5) | Yes (5) | Yes | Yes | Yes |
| Venezuela | No | Yes | Yes | No | Yes |

Note: Number in parenthesis gives the number of corresponding stations (when known).

TABLE 3

NEEDED FACILITIES

| Country | Sea Level (Stations) | Weather Param. (Stations) | Water Column | Remote Sensing | Ocean Expertise |
|---|---|---|---|---|---|
| Colombia | 4 | 2 | No | Yes | Yes |
| Costa Rica | 1 | 1 | Yes | Yes | Yes |
| Cuba | 5 | 3 | Yes | Yes | No |
| Jamaica | 5 | 2 | Yes | Yes | Yes |
| Mexico | Yes | Yes | No | Yes | No |
| Trinidad & Tobago | 4 | 3 | Yes | Yes | Yes |
| U.S.A. | 2 | 2 | No | No | No |
| Venezuela | 3 | 3 | Yes | Yes | Yes |

## 7.7 TIMETABLE (Tentative)

The following matrix depicts a tentative time framework for main decisions/activities needed to develop the proposed programme, which is recommended to last for a period of at least one decade.

| Item | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| IOCARIBE endorsement | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— |
| IOC Assembly Approval | | X | | | | | | | | |
| Expert Consultation | X | X | X | X | X | X | X | X | X | X |
| Experimental Design | | —— | | | | | | | | |
| Installation of Stations | | ——— | ——— | ——— | | | | | | |
| Operational Programme | | | | — — — | ——— | ——— | ——— | ——— | ——— | ——— |
| Hydrographic cruises | | | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— |
| Remote Sensing: | | | | | | | | | | |
| Operational | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— |
| NSCAT | | | | | ——— | ——— | ——— | ——— | ——— | ——— |
| TOPEX/POSEIDON | | | | | | ——— | ——— | ——— | ——— | ——— |
| GEOSAT | | ——— | ——— | ——— | | | | | | |
| Reports | | X | X | X | X | X | X | X | X | X |
| Modelling | — — — | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— | ——— |
| Training | | ——— | ——— | ——— | — | — | — | — | — | — |

8. COMMUNICATION AND DATA EXCHANGE

The Workshop requested all participating Member States to be encouraged to follow as far as possible the co-ordination lead of the IOC Sub-Commission's Office, and to establish if possible a SCIENCENET (Ocean) terminal in a local marine science center. Most routine written communications and data exchange would be accomplished via this network.

The use of the IODE/IGOSS data formats and systems is also strongly endorsed.

9. BIBLIOGRAPHY ON PHYSICAL OCEANOGRAPHY

The Workshop considered that future information exchange among Member States of IOCARIBE may be substantially improved if a bank of bibliographic references on regional physical oceanography is available. In this context, it is recommended that through each one of the participants in the Workshop, a local search of scientific articles and thesis on Physical Oceanography be attempted (English and/or Spanish).

This information will be centralized at the AOML and a selected bibliography will be published.

10. TEMA SUPPORT

There was consensus among the Workshop participants that the training aspects of the proposed programme should be strongly stressed. It was expressed that training is a necessity, without which there will be no real benefit for the participants, especially those from developing countries.

The Director of the Department of Marine Sciences (DMS), of the University of Puerto Rico, being one of the participants, offered the facilities of the Department to conduct needed training courses directly related to the objectives of the programme. This offer included use of available expertise, instrumentation, accommodation, free of charge. It was determined that the most appropriate time to conduct courses would be during the summer period.

The Workshop also recommended that IOCARIBE Member States should look into the possibility of required assistance through IOC, in providing resident experts that can offer training in specific countries for extended periods of time, particularly in aspects related to the proposed regional exercise.

11. REGIONAL GROUP OF EXPERTS

The Workshop strongly recommended to IOC the formation of a regional Group of Experts charged with the follow up of the proposed activities including the implementation of the programme, when approved.

12. ADOPTION OF THE SUMMARY REPORT

The Workshop adopted the Summary Report of the Session.

13. CLOSURE

In closing the Workshop the Chairman thanked all participants for the intensive and fruitful deliberations leading to a concrete proposal for an IOCARIBE Programme in Sea-level/Weather Monitoring. Several participants voiced their satisfaction for the work accomplished and the way the Session was conducted by the Chairman, Vice-Chairman and the Secretariat. They also commended the good facilities and atmosphere provided for the Workshop by the CIOH.

The Workshop was closed at 16.30 hrs., 22 August 1986.

# ANNEX I

## AGENDA

1. OPENING
2. ADMINISTRATIVE ARRANGEMENTS AND CONDUCT OF THE WORKSHOP
3. ELECTION OF OFFICERS FOR THE WORKSHOP
4. OVERVIEW PAPERS ON WATER MASSES AND CIRCULATION IN THE CARIBBEAN SEA AND ADJACENT REGIONS
5. REPORTS OF INVITED EXPERTS ON THE STATUS OF PHYSICAL OCEANOGRAPHY IN THE CARIBBEAN REGION IN THEIR RESPECTIVE COUNTRIES
6. SCOPE OF THE MEETING
7. AN IOCARIBE PROGRAMME IN SEA-LEVEL/WEATHER MONITORING OF THE CARIBBEAN SEA AND ADJACENT REGIONS (CSAR)
   - 7.1 Introduction
   - 7.2 General Objectives
   - 7.3 Specific Objectives
   - 7.4 Data Acquisition
   - 7.5 Sampling Scheme
   - 7.6 Facilities available and needed
   - 7.7 Timetable (Tentative)
8. COMMUNICATION AND DATA EXCHANGE
9. BIBLIOGRAPHY ON PHYSICAL OCEANOGRAPHY
10. TEMA SUPPORT
11. REGIONAL GROUP OF EXPERTS
12. ADOPTION OF THE SUMMARY REPORT
13. CLOSURE

# ANNEX II

## LIST OF PARTICIPANTS

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# ANNEX III

## ABSTRACTS OF OVERVIEW PAPERS ON WATER MASSES AND CIRCULATION IN THE CARIBBEAN SEA AND ADJACENT REGIONS

### 1. WATER MASSES AND CIRCULATION OF THE CARIBBEAN SEA

Dr. G.A. Maul, US Dept. of Commerce, NOAA/AOML, Miami, USA

Geography of the Caribbean Basin is that of semi-enclosed sea with numerous passages of varying sill depth for the inflow/outflow of its surface and deep waters. Meteorologically, the Caribbean is dominated by variability in the ITCZ - Trade Wind system, resulting in wind stress often in excess of 2 dynes/$cm^2$, and variations in precipitation from 100 mm/year to 2000 mm/year along the South American coast. Sea surface temperatures average 25-26°C in winter to 28-29°C in summer and has an annual cycle of 0.4°C at 100 m/depth. Sea surface salinity averages 35-36‰ in winter to 33-36‰ in summer with evidence of both precipitation and runoff significantly affecting the variability.

Sill depth of most passages is less than 2000 m. which effectively prevents North Atlantic Deep Water from entering the basin; temperatures below 2000 m. in the Caribbean Sea are characterized by extremely small variability about 3.8°C, resulting in a deep barotropic fluid. T-S correlations are dominated by the 36.5‰ maximum at 22°C, which characterizes the Subtropical Under Water(SUW), and by the 34.9‰ minimum at 7°C, characteristic of Antartic Intermediate Water. Geostrophic velocities in the SUW are typical of surface velocities because of depths of less than 200 m. in the SUW core. Average geostrophicflow shows a broad Caribbean Current which is strongest in the Southern half of the basin, but forming into the intense Yucatan Current where surface speeds often exceed 200 cm/sec. Most of the speeds are less than 10 cm/sec. below 1000 m. depth.

Volume transport into the Caribbean Sea appears to come mostly through the Grenada, St. Vincent and St. Lucia passages in the Lesser Antilles (about 20 x $10^6$ $m^3$/sec total), with the other 10 x $10^6$ $m^3$/sec. of the total of 30, from the Windward Passage. There appears to be a great deal of uncertainty in the mean values, and current meter moorings have shown substantial evidence of deep counter flows in many passages. Further evidence of substantial variability is seen in Lagrangian Drifter tracks; the most notable variability is that of mesoscale eddies throughout the region. The flow, however, is dominated by a strong annual cycle which is in phase with the Trade Wind stress, and affects the Gulf Stream System from the Central Caribbean Sea to the offing of Cape Hatteras (35ºN). Associated with the annual volume transport and current speed cycle is a substantial heat flux variability of greater than 0.25 x $10^{15}$ Watts.

Flow in the Yucatan Strait is clearly that of a major western boundary current. The annual cycle of surface speed is in phase with the Caribbean Current and can be reasonably observed by sea level differences between Mexico and Cuba. Current direction in the Strait below 1000 m

is often observed to be towards the south as inferred by geostrophy, silicate distributions, and current meter observations. With respect to the latter, flow at the sill has been observed for three years to be southerly at an average speed of 2 cm/sec., but is seen to have bursts in excess of 10 cm/sec. for durations of a month or longer.

Numerical modelling at the CSAR is a rapidly evolving science, and five models are prominent: Oxford University, Florida State University, Geophysical Fluid Dynamics Lab (NOAA), and two of different resolutions at the Navy Ocean Research and Development Activity. Model results show the need for higher spatial resolution models with realistic bottom topography. Results from such calculations show realistic amplitude and phase for the annual transport signal, but do not resolve adequately the mesoscale eddies. Higher spatial resolution sub-regional scale models show complicated pycnocline height anomaly that is representative of westward advecting cyclonic/anticyclonic eddy pairs similar to those observed by Lagrangian Drifters. Future direction of modelling research, in addition, to improved resolution, must be towards ingesting a variety of ship-of-opportunity, sea-level/weather, satellite, and other in situ data, so as to provide realistic simulations as offshore boundary conditions for island-scale models, and as input to global efforts by the oceanographic community.

## 2. WATER MASSES AND CIRCULATION OF THE GULF OF MEXICO

Dr. A. Gallegos, ICML, UNAM, México D.F., Mexico

The Gulf of México (GM) is an energy source region primarily exporting energy via evaporation. The processes whereby the GM gains energy are absorption of solar radiation and energy input from ocean currents. The GM connects with the Caribbean Sea through the Yucatan Strait (sill depth 2000 m.) and with the western north Atlantic via the Straits of Florida (sill depth 800 m.). The surface area of the GM is about $1.7 \times 10^6$ $Km^2$, has an average depth of 1500 m. and contains $2.6 \times 10^6$ $Km^3$ of seawater (if the continental shelf areas are excluded, the average depth of the GM basin increases to 3000 m.).

Hydrographic reports of the GM were published since 1898; most of the early work relates the observed littoral drift to the offshore and deep circulation. It was not until 1935 that the first sound descriptions of the water masses and their motion within the GM started to merge. The present day accepted picture of the regional oceanography of the GM follows:

(i) Waters below 1500 m. are nearly uniform in the horizontal with an almost neutral vertical stability index. Temperature and salinity values range between 4.00 to 4.15°C and 34.964 to 34.976, respectively. Such values imply that their source is in the Cayman Sea basin, which in turn is intermittently supplied with Deep Western North Atlantic Water through the Windward Passage where the sill depth, one of the deepest passages to the Caribbean Sea, is close to 1600 m.

(ii) Waters above 1500 m. are well stratified and approximately uniform in the horizontal. Remnant subantarctic Intermediate Water occupies a 300 m. thick layer throughout the GM at an average depth of 700 m. This watermass shows as a salinity minimum which is clearly eroded from its entrance value, 34.86 at the Yucatan Strait, to a value of 34.89 in the southwestern GM. This suggests a longer residence time of this watermass in the southwest region.

(iii) A salinity maximum (36.75) core at an average depth of 150 m. in the middle of the Yucatán Strait and a few tens of metres shallower or deeper within the GM, specifies the Subtropical Underwater, whose origin is traced to the surface salinity maximum in the North Atlantic (20-25°N, 30-50°W). Compared to the values at the Yucatán and Florida Straits, the salinity maximum values in the southwestern GM are lower.

(iv) The description and understanding of the water masses and circulation in the surface layer of the GM is far from being completed. Nevertheless, sea surface temperature and surface salinity help to demarcate: a) seasonal variations, b) river discharge effects, c) intense local energy interchange events at the ocean-atmosphere interphase, d) shelf and oceanic waters and e) Loop Current waters from GM resident waters.

The historical mean dynamic topography of the GM and the space-time averages of surface and subsurface velocity measurements indicate that the circulation is dominated by the Loop Current in the central and eastern Gulf while the circulation in the west is driven equally by the curl of the wind stress and by the eddies that regularly separate from the Loop Current. This current is maintained by the Yucatán Current which imports surface and sub-surface water into the GM at an average rate of 30 Sverdrups. The flow continues into the central GM where it loops east and southward (thus its name) and exits through the Straits of Florida to continue along the USA east coast as the Florida Current.

A sequence of events, starting with the intensification of the wind over the Caribbean Sea, finally induces flow instabilities in the Yucatán and Loop Currents that force the generation and eventual separation of an eddy that moves slowly (2 cm/s) to the west and dissipates against the shelf slope off Tamaulipas (Mexico) and Texas (USA). This situation repeats once every 10 to 16 months. Typical scales of these anticyclonic eddies are 360 Km. in diameter, the same as the north-south length scale of the anticyclonic circulation usually observed in the central and north western GM.

Most of the water that enters the GM through the Yucatan Strait exists through the Straits of Florida. Calculations show that about 10% of the imported water stays in the GM, incorporated by intense mixing, while an equivalent volume of resident GM water entrains the eastern GM circulation and flows to the western north Atlantic.

Recently, a 3-year long time series of velocity measurements near sill depth in the Yucatán Strait clearly indicated a persistent southward flow, 2 cm/s on average with few month-long bursts up to 10 cm/s. The observed outflow seems to contradict the historical T-S geographical variation from the Yucatán Strait to the south-western GM (erosion of salinity minimum). The topographical constraint imposed by the sill depth difference between the Florida and Yucatán Straits (1200 m.) is a controlling factor in the sill depth inflow-outflow condition through the Yucatán Strait. The observed outflow could be restricted to the thickness of the local boundary bottom layer, in which case this volume transport would not be significant considering the volume transport over the whole water column along the strait.

Budget studies of the GM show that there is a net import of thermal energy via ocean currents. The excess is given to the atmosphere mostly in the form of latent heat (evaporation). Estimates of the water balance of the GM indicate that river runoff compensates the evaporation minus precipitation term. Since the GM is a net evaporation basin, this last term is positive. Any unbalance between net evaporation and river runoff is compensated accordingly by net volume inflow or outflow.

The tide in the north Atlantic induces tidal currents in the Straits of Florida and Yucatán. The dynamic effect of such currents, in addition to the tide within the GM, have been the focus of several studies. A few controversial aspects remain unexplained and require more tidal observations in appropriate locations to attack the problems yet unsolved.

Analytical models have been developed and laboratory model experiments were carried out successfully and contributed, in their time, to the understanding of the basic dynamics of the GM circulation. Nevertheless, increasing computer facilities concentrated and promoted the development of numerical models of the GM. Starting with single layer - barotropic models and progressing to multi layer - baroclinic models, simulation of the GM circulation has improved substantially. However, finer time-space resolution and more realistic boundary conditions should be used in order to assess the importance of mesoscale processes in the redistribution and dissipation of energy throughout the GM system.

The systematic observation and measurement of oceanographic and meteorological variables in the GM region is a necessary condition towards a better understanding of the physical processes that occur in a wide spectrum of space-time scales, selectively associated to particular and important applied problems such as: a) contaminants, waste, thermal and oil pollution, b) surface circulation nowcasting, c) precipitation and hurricane track forecasts, d) energy budget studies, particularly heat flux, e) ocean climate and f) determination of forcing functions and realistic boundary conditions for numerical modelling and coastal processes studies.

3. COASTAL DYNAMICS

Dr. M.L. Hernández-Avila, Dept. of Marine Sciences,
University of Puerto Rico, Mayagüez, Puerto Rico, USA

The importance of coastal dynamics research is evident. Coastal management and development, with its engineering and socio-economic practical implications, is of great concern to all nations as they extend their boundaries into the Exclusive Economic Zones (EEZ). Coastal processes determining cause-and-effect influences, extend and are essential in the search and exploitation of submarine mineral resources; in the prediction of storm surges; in planning of tourism-recreational aspects; in coastal structure designs and construction; in possible energy-power generation by wave forces, tides and temperature discharges; in oceanic transportation and in the planning, development and management of fisheries.

Significant progress has been made in the past two or three decades through empirical and theoretical research of coastal dynamic processes. The evidence lies in the amount of funds allocated for such research and the extensive publication of research reports in the scientific literature. Still, fundamental knowledge of various aspects of the dynamic processes involved and their interactions are not yet well understood. There are many unknowns, many macro and micro physical processes which need clarification, verification and re-evaluation. Concerted research efforts should be undertaken to increase our knowledge of those unknown factors which are of critical applied importance. Precise and intensive investigations are needed in:

(i) Macro and micro circulation studies to understand the influence of physical forces on biological processes, i.e. larval transport and distribution, habitats selection and enhancement, determination of upwelling regions and nutrient transport, among others.

(ii) Effects of drastic and significant variations in salinity, density and temperature not only in the coastal zone, but also in estuarine environments.

(iii) Boundary energy-trapping, especially around island coasts.

(iv) Wave energy/power distribution and its consequences along coastlines.

(v) Transport mechanisms for waste-sewage dispersal and diffusion as well as for sediment distribution.

(vi) Storm surge predictions, effects and extended flooding on coastlines.

(vii) Effects of submarine topography on water circulation and subsequent influences on sediment transport, distribution, deposition and erosion.

(viii) Development of modern methodologies for data analyses, computer simulations and numerical modelling of sediment transport and nearshore circulation patterns.

(ix) Development of methodologies for remote sensing and ground-truth measurements with electronic sensors to monitor coastal parameters and for wave-wind climate predictions and spectral analyses.

(x) Specific research on the effects of coastal edge waves, wind stresses, internal waves, seiches, sea level changes on beaches, tidal current velocities and variability, river runoff, reef dynamics, wave set-up and run-up, radiation stresses, and design construction effects of coastal structures.

Knowledge of coastal zone dynamic processes interaction is critical for developing the practical and responsible planning criteria essential to the proper utilization, conservation and management of coastal resources. Developing countries should be specifically interested in the results of this applied research.

# ANNEX IV

## REPORTS OF INVITED EXPERTS ON THE STATUS OF PHYSICAL OCEANOGRAPHY IN THE CARIBBEAN REGION IN THEIR RESPECTIVE COUNTRIES

### COLOMBIA

Lic. C. Andrade, Centro de Investigaciones
Oceanográficas e Hidrográficas, Cartagena, Colombia

Physical oceanography in Colombia is directed by the "Plan Nacional de Desarrollo de las Ciencias y Tecnologías del Mar", which establishes the priorities of investigations for the Caribbean Sea.

The "Centro de Investigaciones Oceanográficas e Hidrográficas" (CIOH) is the institute which mainly develops physical oceanographic investigation; the "Instituto de Hidrología, Metereología y Adecuación de Tierras" (HIMAT) is in charge of obtaining and handling weather stations and the "Comisión Colombiana de Oceanografía" is the body which coordinates the different actions of the "Plan Nacional".

With relation to the facilities available, there are two oceanographic ships with similar capacities to carry out investigations in physical oceanography; however, one is more specialized in geophysics and the other in fisheries exploration. Other conventional instrumentation to perform measurements at the sea as well as more advanced instruments such as CTD's, current meters, wave and tide meters, and continuous register recorders, are also available.

So far, 9 oceanographic cruises have been carried out in different parts of the Colombian Caribbean area, and at present a proposal is being studied to make investigations in conjunction with Costa Rica and Panama, to study the dynamics of the Southwest Caribbean Sea.

Colombia has the capacity to process oceanographic information and is connected through the IODE system, to the NODC, which is the responsible data center for IOCARIBE region.

There are some weather stations on the Colombian coastline, which depends from the HIMAT, at Rioacha, Barranquilla, Cartagena, Santa Marta, Turbo and the San Andrés Islands. At present, there are no sea level stations that could be listed in this report.

## COSTA RICA

M.Sc. C.L. Brenes Rodriguez, Oceanografía Física,
Universidad Nacional Campus "Omar Dengo", Heredia, Costa Rica

In Costa Rica, the only group of physical oceanographers exists at the "Universidad Nacional" and is attached to the Physics Department. Other institutions involved in oceanographic activities are the "Universidad de Costa Rica", the "Instituto Geográfico Nacional", the "Dirección General de Obras Portuarias" and the "Instituto Meteorológico Nacional". The Physical Oceanography section has basic equipment and instruments needed to make studies on the physical properties of sea water, currents, tides (in the Pacific Ocean), mainly in coastal areas.

At present the Physical Oceanography Section is working in estuarine environments and in the consolidation of a National Program of Tides and Sea Level which will permit the monitoring and prediction of these two parameters on both coasts. Interest in doing studies in coastal dynamics is great, as it is not known much about this research area. Physical oceanography in Costa Rica is just starting to develop and should be strongly reinforced from its bases: human resources and equipment.

## CUBA

Lic. P. Rodríguez Portal, Instituto de Oceanología
Academia de Ciencias de Cuba, La Habana, Cuba

Cuba is working in a long term oceanographic investigation plan to know its Exclusive Economic Zone waters, including the coastal ones. Cuba is also aware of the important role that the sea plays over climate. For these reasons, Cuba is very much interested in participating in local as well as in regional or worldwide investigation projects which contribute in one way or another to solve the above-mentioned problems.

Cuba has two oceanographic stations more than ten years old, two boats not fully equipped, but with bottles and thermometers to make samples down to 1000 m. and electronic current meters, a coastal meteorological station network, and potentially enough human resources to actively participate in plans derived from this Workshop. However to make this collaboration more productive, it is needed to raise the scientific level of the scientists involved to create a software system adequate to process information and to obtain some equipment (e.g. two CTDs; two satellites navigation systems; and three tidal stations).

JAMAICA

Dr. M. Hendry, Geology Dept., University of West Indies,
Kingston, Jamaica

Jamaica does not have a substantial background of physical oceanographic research. There are, however, a number of agencies and institutes who are interested in the results of physical oceanographic investigations, some of whom are also involved, at various levels, in research and data collection.

Research interests that require inputs from physical oceanography are diverse, and include dispersal and transport of planktonic larvae, wetland and harbour effluent, oil and toxic waste; coastal erosion and nearshore dynamics; hydrographic data for study of thermocline stability and upwelling, and T/S effects on fish growth and distribution; sea level studies; storm surge prediction and risk mapping of flood-prone areas.

Efforts are being made to upgrade facilities and expertise in oceanographic research, mainly at the University of the West Indies, where a Marine Science Unit has been established to co-ordinate future marine research, and which has access to a number of facilities and instruments, including a C.T.S.D., autoanalyser, mainframe and microcomputers. Our capability at present is strongly linked to counter-part expertise provided by Dalhousie University on a coastal zone project, though graduate training is underway. The appointment of a physical oceanography graduate at the research level is crucial to future research, as are the provision of sea going capability and upgraded sampling equipment. Elsewhere, the Survey Department has a bathymetric mapping capability that requires upgrading though computers for data logging, and the Meteorological Office has an extensive network of coastal/marine weather stations. Improved maintenance of the two existing tide gauges, plus installation of new instruments is also desirable. Development of remote sensing capability is also foreseen as a major requirement in future research efforts.

MEXICO

Dr. A. Gallegos, ICML, UNAM, México D.F., Mexico

1. PRESENT INFRASTRUCTURE ON PHYSICAL OCEANOGRAPHY

Institutions and basic activity:

- Dirección General de Oceanografía of the Secretaría de Marina:

  Hydrographic work in the Gulf of México.

- Instituto de Investigaciones Eléctricas:

  Hydrography in the shelf and slope water of the western Gulf of México.

- Instituto de Ciencias del Mar y Limnología of the Universidad Nacional Autónoma de México:

  a) Hydrography in the Yucatán Strait and Campeche bank to determine transports and study upwelling processes

  b) Studies of fronts at the months of rivers and coastal lagoons.

  c) Numerical modelling of the Gulf of México.

2. FACILITIES

a) Oceanographic ship - R/V 'Justo Sierra'

   Length: 50 m.

   Width: 14 m.

   Displacement: 1050 tons

   Autonomy: 30 days or 10,000 kms.

   Scientific team: 21 persons

b) Ships 'Mariana Matamoros' and 'Dragaminas 20', adapted for hydrographic work.

c) Ships 'Humboldt' and 'Onyuko' for fisheries research

d) Coastal laboratories at Ciudad del Carmen, Campeche and Puerto Morelos, Q. Roo.

## 3. INFRASTRUCTURE FOR OCEANOGRAPHIC DATA PROCESSING

Each institution has its own data handling system. At the "Instituto de Ciencias del Mar y Limnología" there is a PDP-11 "Ditigal" mini-computer similar to the one installed in the R/V "Justo Sierra". Necessary software has been developed locally.

## 4. SEA LEVEL AND WEATHER STATIONS

The Instituto de Geofísica of the Universidad Nacional Autónoma houses the Servicio Mareográfico, which maintains the following sea-level stations:

| Place | Date installed | Type of record |
|---|---|---|
| Tampico | Jan. 1952 | Digital |
| Tuxpán | Nov. 1957 | Analog (Paper) |
| Veracruz | Oct. 1952 | Analog (Paper) |
| Alvarado | Nov. 1954 | Analog (Paper) |
| Coatzacoalcos | Jan. 1952 | Analog (Paper) |
| Cd. del Carmen | Jun. 1956 | Analog (Paper) |
| Progreso | Jul. 1952 | Analog (Paper) |
| Chetumal | Mar. 1985 | Digital |

Several governmental agencies operate weather stations at airports and major coastal cities.

## PUERTO RICO

Dr. M.L. Hernández-Avila, Dept. of Marine Sciences
University of Puerto Rico, Mayagüez, Puerto Rico, USA

In reference to the main purpose of the IOCARIBE Workshop on Physical Oceanography and Climate, the two representatives of the USA complement each other. Both represent institutions interested on the physical processes of the Caribbean. The Atlantic Oceanic and Meteorological Laboratory (AOML) of NOAA in Miami is mainly concerned with deep sea oceanography with respect to sea-level variations and coastal climatological processes. The Department of Marine Sciences (DMS), University of Puerto Rico (UPR), Mayaguez Campus, specifically addresses and performs research on coastal dynamic processes from a scientific but also applied point of view.

The DMS-UPR is conducting research in coastal dynamics, chemical oceanography and coastal engineering problems: storm surge prediction, pollution, estuarine circulation, internal waves and seiches; physical oceanographic research in support of biological and fisheries development studies and remote sensing, imaging and numerical modelling of physical and coastal dynamics processes. Three research vessels, two tide gauges and several meteorological stations are available for monitoring and research around Puerto Rico. One tide gauge is located on the DMS Magueyes Island Field Station, on the Southwestern coast of the island.

DMS has the capability to provide academic and technical training in all aspects of oceanography and marine sciences especially in those disciplines in which research is being performed.

## TRINIDAD AND TOBAGO

Dr. S.R. Bachew, Institute of Marine Affairs,
Chaguaramas, Trinidad & Tobago, W.I.

In Trinidad and Tobago there are two institutions involved in research in physical oceanography: (1) The Institute of Marine Affairs and (2) The Hydrographic Unit. The role of the Hydrographic Unit is to conduct hydrographic surveys of the near shore waters of Trinidad and Tobago for which a 15 m. survey vessel, echo sounders and an electrical navigation system were acquired.

The role of the IMA is to conduct research in marine science and development activities with a view to, among other things, advising the Government on the development and optimum utilisation of the marine resource potential of Trinidad and Tobago. Research staff includes one physical oceanographer, three marine geologists and two marine technicians. Equipment available include: current meters, fathometers, salinity recorders, tide gauges, dissolved oxygen recorders, multiparameter recorders, bathythermography, turbidity recorders and a 13 m. research vessel. At present, there are 5 Apple 11 E 128 K microcomputers which are to be phased out and redeployed as word processors. The proposed computer system is a micro Vax II minicomputer system with 2 Mb memory, which should be put on stream in the near future.

The Institute has two tide gauges installed at Chaguaramas (NW end of Trinidad) and the Hydrographic Unit has two stations at the Port of Spain harbour. Two coastal marine weather stations based in Chaguaramas are also monitored by the Institute. Parameters recorded included rainfall, temperature, humidity, wind speed and direction and barometric pressure. There are no other sea level stations on the islands.

Research projects at present are confined to the near shore (up to 20 m.) and include studies on coastal hydrodynamics, bathymetry and hydrography. Research areas which can benefit from integrated regional projects are: (a) Interaction between nearshore and offshore dynamics, (b) the effects of storm surges on the coasts and (c) sea level changes.

## UNITED STATES OF AMERICA

Dr. G.A. Maul, US Dept. of Commerce, NOAA/AOML, Miami, USA

Basin-scale interests in physical oceanography of the Caribbean Sea are spearheaded by a joint NOAA/AOML and U. of Miami program called STACS (Subtropical Atlantic Climate Study). STACS measurements are being made along the eastern margin, to estimate volume flux in the poleward flowing North Atlantic gyre and southward flowing deep (~2500m.) undercurrent. In addition STACS research is directed toward using submarine cables, sea level, current meter moorings, inverted echo sounders, pressure gauges, and satellite altimetry to indirectly measure the volume transport of the Florida Current and the Antilles Current off the northern Bahamas.

A program in the physical oceanography of the Gulf of Mexico is being conducted by the U.S. Department of the Interior. The program has measurements using current meter moorings, satellite tracked drifters, hydrography, and ship of opportunity XBT surveys, focusing on the interaction of the Gulf Loop Current with the USA continental shelf. Numerical modelling is a major aspect of this program.

Several existing basin-scale numerical models are identified: the Anderson-Corry model at Oxford U.; the two NORDA (Naval Oceanographic Research and Development Activity) models of Thompson and Kinder; a model under development by Sturges at Florida State U.; and an Atlantic Ocean model by Bryan at NOAA's Geophysical Fluid Dynamics Laboratory.

The major U.S.A. research vessel is the NOAA Ship RESEARCHER. It spends 60-90 days per year on STACS and is equipped with GPS navigation, Ametek-Straza doppler current profiler, LaCoste-Romberg gravimeter, a narrow beam echo sounder, CTD and XBT capability and a computer facility capable of processing most records while underway.

A summary of the existing NODC hydrographic, bathytermograph, and CTD data was presented showing calculations of the mean depth of the 15°C, 17°C and 20°C isotherms, the data distribution, the standard error of the mean, and the standard deviation of the mean. The data suggests an increased need for information in the Lesser Antilles and along the North coast of South America up to the Jamaica-Honduras Ridge.

## VENEZUELA

M.Sc. R.A. Aparicio Castro, Instituto Oceanográfico de Venezuela, Universidad de Oriente, Cumaná, Venezuela

The implementation of activities related to any marine science field in Venezuela is coordinated by the "Comisión Nacional de Oceanografía".

In Venezuela, physical oceanography is mainly done by two institutions: the Oceanography Department of the "Instituto Oceanográfico de Venezuela" and the Oceanography Division of the "Dirección de Hidrografía y Navegación de la Comandancia General de la Armada".

Facilities to work out coastal physical oceanography research in Venezuela include a research vessel equipped to carry out basic hydrography. Conventional instrumentation (current meters, bathythermographs, salinometers, etc.) appears in limited quantities. Human resources are restricted to only two physical oceanographers (one per the institution mentioned above).

Four tide gauge stations, not adequately located to measure the variability of sea level necessary to develop coastal dynamic research, are in activity. In addition, fourteen coastal weather stations distributed along the entire Venezuelan shoreline and maintained by the Air Force, permit a good spatial coverage of regional wind field monitoring.

Specific interest includes a serious attempt to understand the local transport regime under a general program where the Ekman surface divergence regime and the geostrophic flow seem to play the most important role. So, three basic parameters which are the wind field, the local pattern of sea level variability and the thermal structure of the near surface layer receive monitoring priority. The impact of coastal sea surface temperature variability (which is explained by the local pattern of coastal upwelling due to wind-driven Ekman divergence) on local climatology and particularly on the regional precipitation regime is also an active research area.

## BARBADOS, WEST INDIES

Dr. G. Gambers, Coastal Conservation Project, St. Michael, Barbados

### 1. EXISTING INFRASTRUCTURE

The major governmental organization dealing with physical oceanography in Barbados is the Coastal Conservation Project Unit, which is administered by the Ministry of Housing and Lands. This Unit consists of ten persons of which there are four professionals, and its main function is to deal with coastal erosion and coastal management issues. The Unit is funded by the Government of Barbados. Major oceanographic equipment consists of surveying equipment and two wave rider buoys. In addition it is planned to install a tide gauge later this year.

The Bridgetown and South and West Coast Sewerage Project has also collected some oceanographic data in relation to the siting of ocean outfalls. All equipment for this project was rented.

Outside of Government the major institution is the Bellairs Research Institute of McGill University. This is financed and run by McGill University, Canada, and it is essentially their tropical field station. It has library and laboratory facilities and deals mainly in biological oceanography.

In addition the Caribbean Meteorological Institute is a regional body which collects weather data from the islands and produces monthly summaries, as well as carrying out research.

2. PROGRAMMES WHICH WILL BENEFIT FROM THE STUDY

The Coastal Conservation Project Unit is the principal organization which will benefit from this study. Coastal erosion is a severe problem in Barbados and while some of the causal factors are man-induced, such as near-shore pollution killing the reefs, other causal factors are natural and include hurricanes and sea level rise. At present there are no long term data about sea level rise in this region, so the Coastal Conservation Project Unit plans to install a tide gauge on an open oceanic site in the Harbour in Bridgetown to start a data record.

Other organizations such as the Bellairs Research Institute and the Caribbean Meteorological Institute would benefit in a general sense from this study.

3. DATA PROCESSING AND MANAGEMENT CAPABILITY

The Coastal Conservation Project Unit has sufficient management capability to take part in this programme. The professional staff include a physical oceanographer, a geographer, a coastal engineer and a land surveyor.

Unfortunately the Coastal Conservation Project Unit does not have its own computing facilities yet, however, it does have access to Government computing facilities.

4. NEEDS

Barbados obviously needs tide gauge data to help assess sea level rise as a factor in the coastal erosion problem.

Obviously improved knowledge of the atmospheric and oceanic circulations would benefit the nearshore and offshore fishing industry as well as being of use for potential hazards such as oil spills, etc.

5. OPERATING AND POTENTIAL TIDE GAUGE STATIONS

The National Ocean Survey of the National Oceanic and Atmospheric Administration established a tidal station at Bridgetown, Barbados, for the period November 1968 to July 1970.

The Coastal Conservation Project Unit installed a tide gauge at the mouth of the Careenage, a semi-enclosed estuary, in Bridgetown for one month in 1983.

The Coastal Conservation Project Unit now plans to purchase and install a tide gauge, for long term continuous measurements, this is to be located on the outer breakwater of the Deep Water Harbour at Bridgetown, a full oceanic site.

## 6. DESCRIPTION OF BENCH MARKS

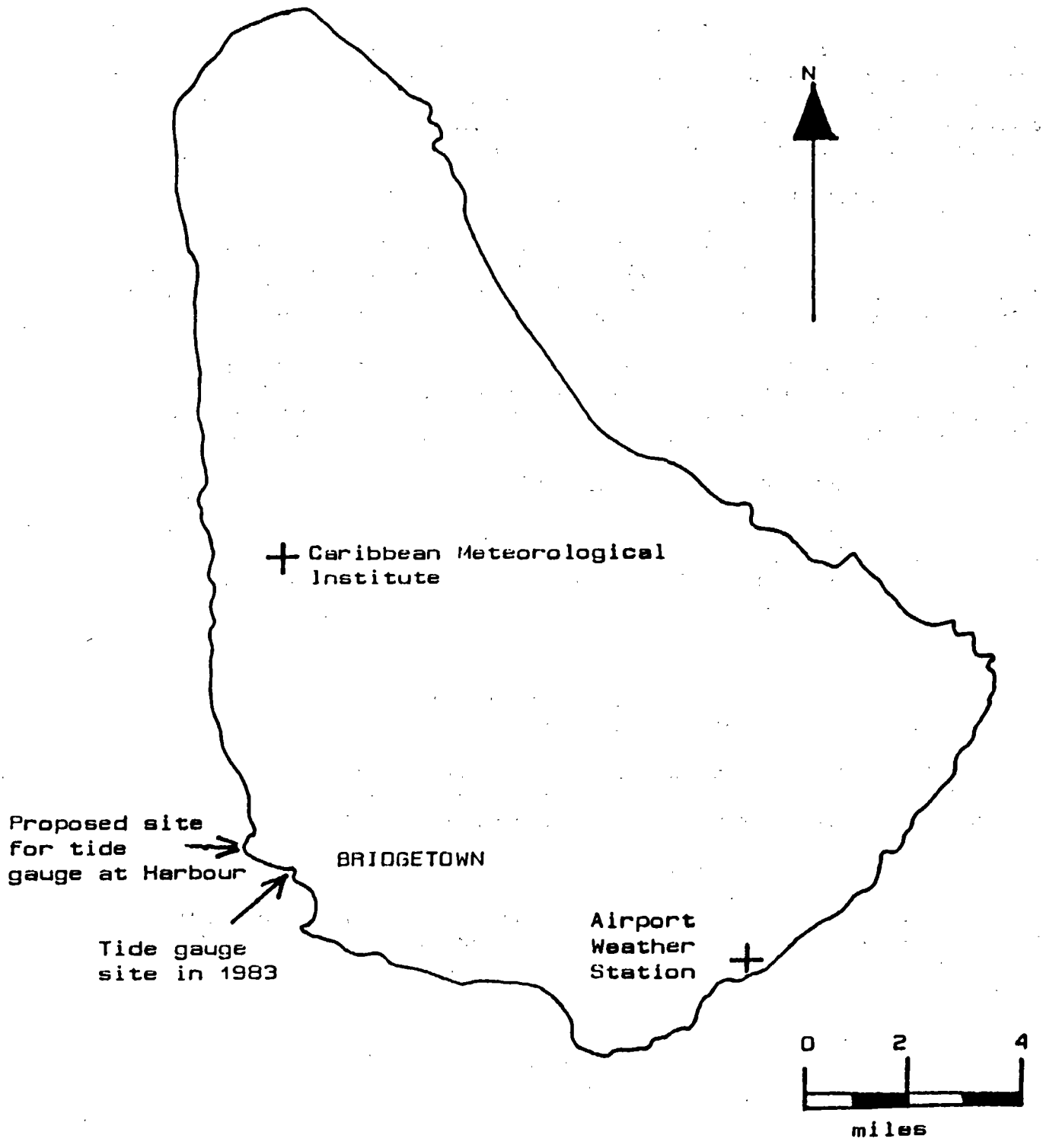
The Admiralty Charts for Barbados are reduced to a bench mark in "the concrete base of the flagstaff at the Port of the Harbour Police Station Pier in Carlisle Bay". The tide gauge installed by the Coastal Conservation Project Unit in 1983, was referenced to this bench mark by differential levelling. Predicted tides were in good agreement with measured tides in phase and amplitude but the measured tide was 0.306 $\pm$ 0.054 m. above the predicted tide. Whether this is an error, or an actual sea level rise has not yet been determined, the matter is under correspondence with the British Admiralty. (It is suspected that the difference is due to an error in converting chart datum to mean sea level, but it is necessary to have this clarified).

## 7. OPERATION COASTAL/MARINE WEATHER STATIONS

The Government Meteorological Station collects weather data at the Airport which is located on the southeast coast of the island. The data include wind speed, wind direction, barometric pressure, temperature, cloud cover, rainfall; all these measurements except rainfall are collected on an hourly basis. The data are recorded, but the data are not computerized. So data extraction is at present a tedious operation.

The Caribbean Meteorological Institute, which is located 2 km. from the west coast of Barbados, used to collect wind data until 1980, but has not done so since that time. The Caribbean Meteorological Institute collects data from the other islands and produces monthly summaries.

LOCATION OF TIDE GAUGES AND WEATHER STATIONS IN BARBADOS



GRENADA, WEST INDIES

Dr. G. Gambers, Coastal Conservation Project,
St. Michael, Barbados

1. EXISTING INFRASTRUCTURE

The only governmental organization dealing with physical oceanography in Grenada is the National Council for Science and Technology. They have recently started a Coastal Monitoring Programme, which is being funded by the Organization of American States and the Government. The programme has been started as a response to the severe coastal erosion problem, and the programme involves two people working on a part-time basis.

2. PROGRAMMES WHICH WILL BENEFIT FROM THE STUDY

The Coastal Monitoring Programme is the principal organization which will benefit from this study. Coastal erosion is a severe problem in Grenada and while some of the causal factors are man-induced, such as nearshore pollution killing the reefs, other causal factors are natural and include hurricanes and sea level rise. In Grenada the sea level rise issue is complicated by land movements, for Grenada is a fairly young and active volcanic island. At present there are no long term data about sea level rise in the region, so a tide gauge (water level recorder type) has been purchased and will be installed on the west coast south of St. Georges in September 1986.

3. DATA PROCESSING AND MANAGEMENT CAPABILITY

At present there are two professionals working on the coastal monitoring programme, a consultant and a graduate employed by the National Council for Science and Technology. So management facilities are limited, as are computing facilities.

4. NEEDS

Grenada obviously needs tide gauge data to help assess sea level rise as a factor in the coastal erosion problem.

Obviously improved knowledge of the atmospheric and oceanic circulations would benefit the nearshore and offshore fishing industry as well as being of use for potential hazards such as oil spills, etc.

5. OPERATING AND POTENTIAL TIDE GAUGE STATIONS

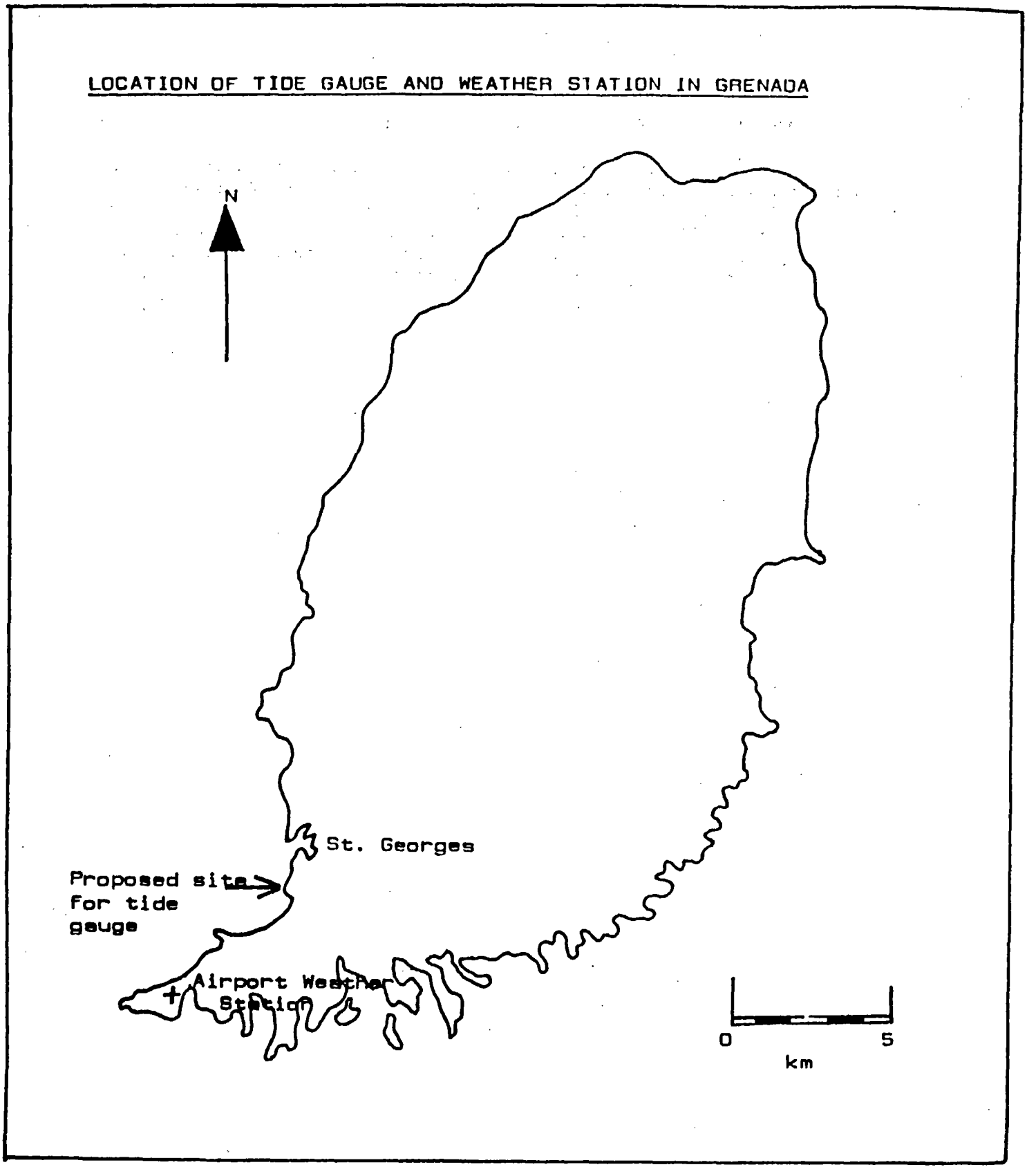
A water level recorder type tide gauge will be installed on the Ross Point Jetty south of St. Georges in September 1986, this is a fully oceanic site.

6. DESCRIPTION OF BENCH MARKS

These have yet to be located for the tide gauge installation.

7. OPERATING COASTAL/MARINE WEATHER STATIONS

The Government meteorological station collects weather data at the Airport which is located on the Southwest coast. (See following map). The data include wind speed, wind direction, barometric pressure, temperature, cloud cover, rainfall; all these measurements except rainfall are collected on an hourly basis. The data are recorded, but the data are not computerized. So data extraction is at present a tedious operation.


LOCATION OF TIDE GAUGE AND WEATHER STATION IN GRENADA
N
St. Georges
Proposed site for tide gauge
Airport Weather Station
0
5
km

# ANNEX V

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AOML | Atlantic Oceanographic and Meteorological Laboratory (NOAA) |
| CARIPOL | Caribbean Pollution Programme |
| CCCO | Committee on Climatic Changes and the Ocean |
| CIOH | Centro de Investigaciones Oceanográficas e Hidrográficas |
| CNES | Centre National d'Etudes Spatiales |
| CSAR | Caribbean Sea and Adjacent Regions |
| CZCS | Coastal Zone Colour Scanner |
| EROS | Earth Resources Observation Service |
| GEOSAT | Geostationary Satellite |
| HIMAT | Instituto de Hidrología, Meteorología y Adecuación de Tierras |
| IGOSS | Integrated Global Ocean Services System |
| IOC | Intergovernmental Oceanographic Commission |
| IOCARIBE | IOC Sub-Commission for the Caribbean and Adjacent Regions |
| IODE | International Oceanographic Data Exchange |
| ITCZ | Intertropical Convergence Zone |
| LANDSAT | USA Land Resources Satellite |
| MCSST | Multichannel Sea Surface Temperature |
| NASA | National Aeronautics and Space Administration |
| NESDIS | National Environmental Satellite Data and Information Service (USA) |
| NOAA | National Oceanic and Atmospheric Administration (USA) |
| NODC | National Oceanographic Data Centre |
| NROSS | Navy Remote Ocean Sensing Satellite (USA) |
| NSCAT | NROSS Scatterometer |
| OOSDP | Ocean Observing System Development Programme |

| | |
|---|---|
| SPOT | French Land Resources Satellite |
| STACS | Subtropical Atlantic Climate Study (USA) |
| TEMA | Training, Education and Mutual Assistance in the Marine Sciences |
| TOGA | Tropical Oceans and the Global Atmosphere |
| TOPEX | Topography Experiment (US Altimetric Experiment) |
| WCRP | World Climate Research Programme |
| WMO | World Meteorological Organization |
| WOCE | World Ocean Circulation Experiment |

| No. | Title | Publishing Body | Languages |
|---|---|---|---|
| 32 Suppl. | Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 33 | Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR) Halifax, 26-30 September 1983 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 34 | IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa) Tenerife 12-17 December 1983 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English French Spanish |
| 35 | CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific Suva, Fiji, 3-7 October 1983 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 36 | IOC/FAO Workshop on the Improved Uses of Research Vessels Lisbon, 28 May - 2 June 1984 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 36 Suppl. | Papers submitted to the IOC-FAO Workshop on Inproved Uses of Research Vessels Lisbon, 28 May-2 June 1984 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 37 | IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 38 | IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region Basrah, Iraq, 8-12 January 1984 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 39 | CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific Suva, Fiji, 24-29 September 1985 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 40 | IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications Sidney, B.C., Canada, 29-31 July 1985 (in press) | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 41 | First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2) Dakar, Senegal, 28 October - 1 November 1985 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 42 | IOC/UNEP Intercalibration Workshop on Dissolved/Dispersed Hydrocarbons in Seawater Bermuda, USA, 3-14 December 1984 (in press) | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 43 | IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean Venice, Italy, 23-25 October 1985 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |
| 44 | IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English Spanish |
| 45 | IOCARIBE Workshop on Physical Oceanography and Climate Cartagena, Colombia, 19-22 August 1986 | IOC, Unesco Place de Fontenoy 75700 Paris, France | English |