Intergovernmental Oceanographic Commission

Workshop Report No. 162

Workshop Report on the Transports and Linkages of the Intra-Americas Sea (IAS)

Cozumel, Mexico
1 - 5 November 1997

UNESCO

Intergovernmental Oceanographic Commission

Workshop Report No. 162

Workshop Report on the Transports and Linkages of the Intra-Americas Sea (IAS)

Cozumel, Mexico
1 - 5 November 1997

UNESCO 2002

IOC Workshop Report No. 162
Paris, May 2002
English Only

(SC-2002/WS/56)

TABLE OF CONTENTS

ANNEXES

1. EXECUTIVE SUMMARY

The Conference on the Transport and Linkages of the Intra-Americas Sea was held 1 to 5 November 1997 in Cozumel, Mexico under the joint sponsorship of the U.S. Minerals Management Service (MMS) and the Sub-commission for the Caribbean and Adjacent Regions of the Intergovernmental Oceanographic Commission (IOC) of UNESCO (IOCARIBE). A total of 52 scientists and engineers mainly from the USA and Mexico, participated. The disciplines of Physical Oceanography, Meteorology, Biological Oceanography, Chemical Oceanography, Marine Geology, Fisheries Oceanography, and Fisheries Science were represented. In addition to a MMS representative, there were representatives from PEMEX, the Mexican oil company.

There were a total of 37 oral and 8 poster presentations made on a broad variety of topics. These presentations led to much discussion of the IAS as a regional system from physical, chemical, and ecological perspectives, with the throughflow of the Gulf Stream System serving as a mechanism to link the physics, chemistry, and ecology of the IAS subdomains. There was a strong consensus that we do not presently have a quantitative understanding of how the IAS functions as a system. However, it was thought possible to gain such an understanding with a coordinated programme of strategically placed long-term observations combined with numerical models in the spirit and fashion of a regional component of the Global Ocean Observing System) GOOS.

Accordingly, a number of findings and recommendations emerged that provide some of the basis for determining the scientific research community's stakeholding interests, both as contributors to the observing systems and as users of the data and information products, in a potential IAS-GOOS.

2. FINDINGS AND RECOMMENDATIONS

2.1 IAS-GOOS STRATEGIES

2.1.1 General information and Infrastructure

F1. An IAS-GOOS would serve as a regional bridge between global GOOS and national coastal GOOSs.

R1. IAS-GOOS should be linked to regional climate variability and change issues, and to regional coastal ecosystem health issues, and their inter-relationships. As a first step, an effort should be made to extend existing global GOOS programmes (drifters, floats, XBT lines, TAO buoys) into the region.

F2. Broad support from regional national governments will be essential to the vitality and utility of IAS-GOOS.

R2. As GOOS is an IOC-WMO-UNEP-ICSU programme, and as IOCARIBE is the IOC regional organization covering the IAS, IOCARIBE has an essential role to play in regional coordination for IAS-GOOS. Contacts on behalf of the IAS-GOOS concept also need to be made with individual regional nations and intergovernmental organizations; e.g., Summit of the Americas, Iberoamerica-nations, French-nations, Dutch-nations, British-nations, and OAS.

F3. IAS-GOOS should build upon regional institutional and technological infrastructure.

R3. Explore utilization of the data telecommunications, prediction services, etc. of the USA (and other) National Weather Services, Caribbean Meteorological Institute (CMI), etc. to support IAS-GOOS.

F4. Information (from IOC) about GOOS has not been broadly distributed to the IAS scientific community.

R4. Make the essential information available through the IAS homepage.

2.1.2 IAS-GOOS Design

F5. The combination of strategic time series (e.g., transport through the Straits of Florida) and synoptic maps (e.g., surface winds, satellite thermal and colour imagery, seasurface height, and surface flows) is invaluable for monitoring the state of coastal ecosystems, etc. and should be a strategy useful for IAS-GOOS.

R5. Maintain (or initiate) time series at strategic locations; for example,

CATS (Northeast Caribbean)	Campeche Bank/Bay
CARIACO Basin	Florida Keys
NECOP (Louisiana hypoxic zone)	Guantonomo Bay (Cuba)
ACTS	Flower Gardens (Texas)
	Barbados
	Panama (Canal Zone)

F6. The development of relationships (between physical and biogeochemical transports and their ecological and fisheries consequences) useful for monitoring requires time series information (plus the results of process studies) that relate biological and physical processes at strategic sites.

R6. Research into efficient and effective stratified sampling strategies is required to design IAS-GOOS. The design requires criteria for the selection of strategic sites that represent all of the various subregions of the IAS.

F7. Very significant progress has been made in observing the flow (and, thus, the volume transport) through the island passages of the Antillean Archipelago, Yucatan Channel, and Straits of Florida. A basis has been established in some cases, and is being established in other cases, for the design of efficient and effective monitoring strategies for the highly variable transport, and possibly the flow field. However, much work remains to be done (especially in the Windward and Anegada Passages), and the task of monitoring the mass and biogeochemical fields and fluxes has yet to be addressed.

R7. Steps should be taken to design (establish) a long-term monitoring strategy (system) for the transport, flow, and property fields, and the fluxes through the passages and straits of the IAS. Such a system should be able to document the mesoscale, seasonal, and interannual variability, as well as the mean and secular trends, for IAS-GOOS.

F8. Remote sensing methodologies (from satellites, aircraft, coastal and continental radars, acoustics, etc.) are proving to be effective in characterizing the space-time variability of the upper ocean in the IAS.

R8. Considering the vastness of the IAS, it is critical to incorporate remote sensing as a fundamental monitoring methodology for IAS-GOOS.

F9. An IAS-GOOS must be oceanic model-based in order to best evaluate, utilize, and disseminate associated observational data sets. A regional, mesoscale atmospheric model may also be necessary.

R9. A significant part of the IAS-GOOS implementation process will involve the development of an adequate, validated oceanic model (or models) of the IAS and the determination of observational needs required to support the model. Similarly, existing atmospheric numerical model products need to be assessed for their adequacy; if they are not adequate, an IAS atmospheric model (or models) will need to be selected and implemented.

2.1.3 Historical and Monitoring Data

F10. Much valuable historical data exists in a variety of institutions throughout the region which would benefit IAS-GOOS and regional research.

R10. Identify unarchived data and prioritise it for potential archival. Seek funding for processing and analysing these data.

F11. There exist several valuable "endangered time series"; i.e., they may be discontinued in the near future:

- precipitation stations at Cristobal (Panama), etc.
- sealevel stations at Guantonomo Bay (Cuba), etc.
- rawinsonde stations at Howard AFB (Panama), etc.

R11. Efforts should be made to preserve these stations, based on a defensible scientific rationale, as part of IAS-GOOS.

2.1.4 Dissemination

F12. A considerable amount of real-time and near-real time data exists that would be useful to have broadly available as an early step towards IAS-GOOS.

R12. Cultivate the development of the IAS homepage with broad-based contributors of real-time data as well as users. Link it to CMI, etc.

F13. Consequential environmental and ecological events (e.g., anomalous river discharges and plume transports, oil spills, and harmful algal blooms) occur in the IAS which are not ordinarily well documented, but which could be studied and mitigated if synoptic information were available.

R13. Prototype ocean information products on surface, etc. properties (e.g., currents, temperature, and salinity) should be developed, disseminated on a trial basis, and evaluated in the experimental phase of IAS-GOOS.

F14. There already exist several synthetical maps and numerous remote sensing images that convey invaluable structural information about the IAS circulation and ecological systems.

R14. These maps and images would be useful additions to the IAS homepage and could form a "gallery" useful to the conceptual development of IAS system science in conjunction with IAS-GOOS.

2.2 IAS CHARACTERIZATION

F15. The seasonality of the IAS varies latitudinally, from seasonal variations in river runoff and consequent nutrient inputs along its southern coast to wintertime cooling, mixed layer deepening, and replenishment of the mixed layer with nutrients, as well as seasonal variations in runoff, along its northern coast.

R15. Organize a high-resolution seasonal (better than ¼°) climatology of the mixed layer depth, upwelling zones, river discharges, etc. for the IAS in preparation for IAS-GOOS.

F16. The present distribution of biogeochemical and ecological data probably does not lend itself to a homogeneous climatology of biological and chemical fields. However, the most basic ecologically relevant fields are (1) mixed layer depth (MLD), (2) PAR (or, equivalently, the depth of the 1% light level), and (3) nitrate concentration, and for which enough data may exist to construct seasonal climatologies with useful spatial resolution for the IAS.

R16. The database for MLD, 1% light level depth, and nitrate concentration should be assessed in the IAS. If it is adequate for the purpose, a seasonal climatology should be constructed for IAS-GOOS.

F17. The IAS has many critical habitats (e.g., coral reefs, mangrove swamps, and sea grass beds). Similarly, it has spawning and nursery grounds for major fisheries.

R17. IAS systems science would be facilitated with maps of the critical habitats, and the major spawning and nursery grounds, placed on the IAS homepage as part of IAS-GOOS.

F18. Considering that the IAS is "flushed" with the oligotrophic water of the Atlantic Ocean, its biological productivity is remarkable. It is unknown whether its primary productivity is due to nitrogen inputs from various upwelling mechanisms for surfacing the nitrogen pool or from fluvail transport of terrigeneous nitrogen (or DOM) by the several major rivers discharging to the IAS, from coastal wetlands, or from benthic biota.

R18. Upwelling processes, zones, and rates need investigation, as do the physical and biogeochemical dynamics of riverine plumes in the IAS. The results of these investigations should serve to design an effective monitoring strategy, and to set priorities.

F19. Economically important species in several subregions of the IAS may be linked by the physical transport of larvae and juveniles. The spiny lobster (with populations in northern Brazil, Nicaragua, Belize, southern Cuba, and South Florida) is thought to be an example, based on correlative studies.

R19. Environmental data should be analysed together with fisheries data regarding these species to explore plausible relationships. However, process and case studies are needed to place any such relationships on a firm scientific foundation.

F20. The IAS is rich in mesoscale variability, which has characteristic patterns and cycles that are unique to various subdomains. The climate of mesoscale variability is best documented in the southeastern, central, and northwestern GOM. It needs better documentation in the southwestern and northeastern GOM and throughout the CS. Moreover, the biogeochemical and ecological consequences of this variability are not well understood. For example, it is not known with certainty whether mesoscale variability over the continental slope leads to significant cross-shelfbreak transfers of nutrients from deepwater to shelf waters.

R20. Efforts should be made to quantify the net cross-shelfbreak exchanges of nutrients, etc. provided by mesoscale variability. Similarly, vertical transports of nutrients, etc. in deepwater (due to mesoscale variability and windstress curl) should be quantified.

2.3 PRIORITY RESEARCH

F21. When the IAS is considered as a system, present knowledge is insufficient to determine if the IAS is a source or sink for moisture, carbon, nitrogen, etc. The throughflow of the IAS provides a "conveyor belt" for various properties that interact with the ambient environment and its boundaries. Thus, to understand the IAS as a physical and ecological system, several basic balances across the IAS ports and the air-sea interface need to be established; e.g.,

- mass
- heat
- salt
- moisture
- carbon
- nitrogen

R21. Aim to integrate atmospheric, oceanic, and biogeochemical information in order to establish the status of the IAS as a net source or sink of moisture, carbon, nitrogen, etc., and any secular trends in that status. Existing (observed or proxy) data should be used to make first estimates of these balances, and to establish error bars and whether the IAS is a sink or source.

F22. There is circumstantial evidence that certain biological populations (e.g., spiny lobsters, corals, shrimp, snappers/groupers, tuna, Dolphin fish (Dorado), flying fish, etc.) may be maintained by the transport and dispersal of larvae from "upstream" sources in the IAS, but these conjectures are not firmly established. Interestingly, these species not only represent some of the regions' main

fisheries, but also a spread of life history strategies that make them variably susceptible to fishing pressures as well as larval exchange.

R22. Research should be focused on documenting the transport pathways and rates from known spawning grounds to known nursery grounds, which includes establishing the physical basis for known or suspected dispersal and retention zones, their variability, events, and the probability of their co-occurrence with critical developmental stages. There is a clear need for process-oriented studies to understand the role of retention versus long-distance transport for all of the above species. There is also a clear need for research on the concept of source versus sink populations, as well, as the scale of connectivity among local populations. These topics are very important to both ecological conservation issues and fishery management.

F23. It is well known that biodiversity in the IAS decreases strongly from south to north. However, it is not known whether the cause is the "island effect" (where biodiversity decreases downstream from an island embedded in a mean flow), the "latitudinal effect" (due to decreasing temperature with latitude), or some other effect.

R23. The cause of the biodiversity gradient in the IAS should be investigated because of its fundamental ecological importance and its influence on ecosystem management.

F24. The IAS is known to have rich coastal ecosystems and valuable fisheries. However, it is not understood whether the supporting primary productivity is driven by nitrate or nitrogen regeneration. It is also possible that primary production by shelf benthos or coastal wetlands is more important than that provided by pelagic algae or mesoscale intrusions from offshore.

R24. Devise an approach for analysing the ecosystem dynamics of the IAS as a system of linked subsystems. As a corollary, *in situ* process studies are needed to correctly interpret the chlorophyll patterns seen in satellite colour imagery.

F25. Atmospheric synoptic scale events; e.g., hurricanes and cold front passages, frequently occur and perturb the physical and ecological regimes of the IAS through, for example, vigorous mixing and heavy precipitation. However, the net, long-term effects of the aggregate of these perturbations are not understood, especially in the context of the altered frequency of occurrence, intensity, storm-tracks, etc. associated with climate variability and global change, including ENSO events.

R25. Conduct multi-year investigations into the short-term and long-term impact of atmospheric storm systems on the marine ecosystems of the IAS.

3. OCEANOGRAPHY OF THE IAS-HOMEPAGE

3.1 EXCHANGE OF OCEANOGRAPHIC INFORMATION

To facilitate the exchange of oceanographic information about the IAS, and especially to promote an increase in the availability and utilization of near-real-time oceanographic data, an Oceanography of the IAS-homepage www.aoml.noaa.gov/phod/wimp/iai/) is maintained at NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML). The IAS-homepage also serves as a demonstration and pilot programme for IAS-GOOS information and data exchange. One of its design principles is to utilize a distributed approach (through links to other Websites) to share the effort, stakeholding, and credit/recognition.

Presently, the IAS-homepage provides links to several sources of data, e.g., satellite altimetric sea surface height maps; infrared, visible, and colour imagery; meteorological buoy winds and ocean conditions; oceanographic buoy currents; over-the-horizon radar (OTHR) current maps; and regional sea level data. It also provides a partial list of ongoing field programmes, marine science institutions, data archives, and scientific organizations. Maps of surface drifters in the IAS [including those sponsored by the National

Ocean Partnership Programme (NOPP)'s Year of the Ocean (YOTO) Drifter programme] are displayed and updated daily.
Comments on the IAS-homepage may be addressed to Doug Wilson at wilson@aoml.noaa.gov.

3.2 PLANNED FUTURE CAPABILITIES INCLUDE:

3.2.1 Documentation of the existing IAS observing system, e. g.,

- locations and sensor/sampling attributes of coastal tide gauges, meteorological buoys and coastal stations, and river discharge gauges
- CARICOMP and other coral reef monitoring sites
- data from repeated transects and time series sites (e.g., HOTS and CARIACO) sites
- satellite observations (e.g., VOS data)

3.2.2 Resource information

- oceanographic, meteorological, hydrological, and fisheries institutions;
- research vessels and cruise schedules;
- regional scientists, their fields of expertise, and ongoing programmes;
- regional bibliography;

3.2.3 Base maps of

- bottom topography and coastal orography, with an outline of the IAS drainage basin
- IAS climatology
- institutions and monitoring sites
- generic coastal ecological and geological domains

3.2.4 Model and analysis output fields and time series

- sea surface height
- sea surface temperature
- sea surface salinity
- surface currents
- surface particle trajectories
- mixed layer depth
- optical depth
- mixed layer nitrate and phosphate
- mixed layer N and P

4. CONFERENCE BACKGROUND

4.1 CO-CONVENERS:

Prof. Christopher N.K. Mooers/RSMAS (University of Miami) [physical oceanographer]
Dr. Victor Vidal/Instituto de Investigaciones Electricas (Cuernavaca) [physical oceanographer]

4.2 PROGRAMME COMMITTEE (CO-CONVENERS SERVED AS CO-CHAIRS):

Prof. M. Elizabeth Clarke/RSMAS (University of Miami) [fisheries oceanographer]
Prof. J. Eduardo Aquayo Camargo/ICMyL, UNAM [geological oceanographer]
Prof. Jorge Corredor/University of Puerto Rico [biogeochemical oceanographer]
Prof. Elva Escobar/ICMyL, UNAM [biological oceanographer]
Prof. Kent Fanning/University of South Florida [geochemical oceanographer]

Prof. Robert N. Ginsburg/RSMAS (University of Miami) [geological oceanographer]
Prof. George A. Maul/Florida Institute of Technology [physical oceanographer]
Prof. Frank Muller-Karger/University of South Florida [biological oceanographer]
Prof. Gil Rowe/Texas A&M University [biological oceanographer]
Prof. Julio Sheinbaum/CICESE (Ensenada) [physical oceanographer]
Dr. Nancy Thompson/Southeast Fisheries Science Center/NOAAA [fisheries oceanographer]
Dr. Francisco Vidal/ Instituto de Investigaciones Electricas (Cuernavaca) [physical oceanographer]

4.3 INTRODUCTION

This conference brought together scholars concerned with observing and modelling the oceanic circulation and ventilation of the Intra-Americas Sea (IAS) (i.e., the Gulf of Mexico, Caribbean Sea, the Bahamas, the Guianas, and their environs; basically, from 55W to the Americas and 6 to 30N), and with the biogeochemical, ecological, and fisheries consequences of the IAS circulation and ventilation. While these areas of knowledge are relatively well developed in the Gulf of Mexico, the same is not the case in other subdomains of the IAS, and it is now known that the coupling between the Caribbean Sea and the Gulf of Mexico is not only strong but even two-way. We expect to stimulate further advances in understanding of the IAS circulation and ventilation, biogeochemistry, marine ecosystems, and fisheries oceanography for both scientific and societal purposes, through cultivation of international, multidisciplinary cooperative and joint studies.

A Chapman Conference on IAS Circulation was held in January 1995 at La Parguera, PR; it served to:

(i) identify many of the active regional research issues [and researchers (in particular, several Puerto Rican scientists proved to possess special knowledge and active research projects in the Caribbean Sea)],

(ii) establish that several Mexican ocean scientists had similar interests and levels of expertise relative to USA ocean scientists,

(iii) highlight new technologies (e.g., Over-The-Horizon-Radar and numerical models) with promise for providing synoptic current information in the IAS,

(iv) outline some of the fisheries and ecosystem concerns (e.g., fish larvae retention near islands, plus coral reef and sponge die-offs) which may be linked to variable circulation (including that of inshore waters with reefs), and

(v) establish a need and willingness for cooperative efforts between scientists throughout the region, which need to be fostered by continuing communication, including finding the means to establish a nowcast/forecast system offering synoptic information (and other datasets) via the World Wide Web.

Though the above Chapman Conference on a similar theme was held as recently as 1995, it was timely to convene a follow-up conference to maintain the momentum in this topic area as there are new research initiatives developing in the IAS region; such as, the Intra-American Institute (IAI) programme on climate change and its impacts, IOCARIBE's proposed regional Global Ocean Observing System (GOOS) and planned Large Marine Ecosystem (LME) programme for the Caribbean Sea, and a USA/MEXICO bilateral initiative in ocean sciences being developed through the national academies of science of both countries. (Several members of the Programme Committee also served on the USA/MEXICO Joint Working Group for the latter initiative.) This follow-up conference offered an informal atmosphere conducive to promoting communication between active researchers throughout the region who have begun to interact inspite of various cultural and economic barriers and a paucity of cooperative research programmes.

4.4 THE SCIENTIFIC PROBLEM

The IAS is a major semi-enclosed sea. Waters flow into the IAS from the South and North Atlantic Oceans and from several rivers [especially the Orinoco, Magdelena, and Mississippi Rivers and occasionally the Amazon River; thus, the North Brazil Current (and its retroflection anticyclones) must be considered,

too.] Hence, the IAS circulation is linked to the global ocean circulation and its variability. The Gulf Stream System begins to form in the IAS: first in the Caribbean Sea as the Caribbean Current, which becomes successively the Cayman Current, Yucatan Current, Loop Current (in the Gulf of Mexico), and Florida Current (which exits the IAS through the Straits of Florida). The Antilles Current, which affects the Windward Islands and Bahamas and merges with the Florida Current, must be considered, too. As is typical of the ocean, there is a great deal of mesoscale eddy activity, as well as seasonal and interannual variability, in the circulation. The upper ocean flow through island passages and around islands is of particular interest for both scientific and societal reasons. There is also a deep circulation in the IAS associated with the Deep Western Boundary Current, flow over sills, ventilation of the deep basins, and water mass formation; these phenomena are connected to important questions concerning the exchange of waters between the North Atlantic, Caribbean, and Gulf of Mexico on seasonal-to-climate time scales.

Significant wind-driven coastal upwelling occurs along the coasts of Venezuela, Colombia, Yucatan, and Cuba. Notable atmospheric phenomena include tropical cyclone and cold front passages and the IAS response to them; in turn, the IAS provides heat and moisture to such weather elements and, thus, modifies the marine boundary layer and the lower troposphere. Air-sea interaction over the IAS has links to the ITCZ (typically located along the southern coast of the IAS) and contributes to the North American Monsoon and its impact on precipitation over the US Midwest. The IAS assimilates runoff from many rivers, most notably the Mississippi, Magdelana, and Orinoco Rivers. Thus, there are elements of meteorology and hydrology involved in IAS studies as well as oceanography.

Furthermore, the deposition of airborne pollutants, nutrients, and pathogens may be of significance to biogeochemical processes and marine ecosystems in the IAS. The coastal upwelling zones and riverine plumes are particularly amenable to investigation via satellite thermal and colour imagery. Many commercially and recreationally important fisheries are located in the IAS. Also, extensive coral reefs are found in various IAS locales. The advective and turbulent transports of the IAS affect the distribution and fate of pollutants, the distribution of fish eggs and larvae, and the recruitment of adult fish and populations of significant economic importance. For example, it is not clear whether the tropical species and ecosystems of the Gulf of Mexico; e.g., the “Flower Gardens” (off the Texas -Louisiana coast) and the coral reefs of the Florida Keys, can sustain their populations or whether they must have continual inputs of larvae from the Caribbean to survive.

The IAS is a major source of offshore oil and gas and is a major pathway for the marine transport of oil, as well as for cruise ships and other marine cargos. In 1995, an IMO study determined that the IAS was second only to the Mediterranean Sea in being at risk to oil spills. Considering the societal importance of pollution abatement and fisheries management for the 33 countries bordering and within the IAS, and that chemical and biological processes in the EEZ of individual countries are linked by the physical transport mechanisms of the IAS, scientific issues of common interest need be considered.

While tropical seas have been traditionally thought of as “oligotrophic”, in fact, fertilization through incompletely understood processes, principally upwelling and river plume dispersal, periodically enhances biological productivity at mesoscale and indeed basin scale levels. River plume fertilization is in turn affected by human activities at the continental scale given the vast drainage areas of the major rivers. Such fertilization profoundly affects ocean/atmosphere exchange of biogenic greenhouse gases (CO_2, N_20, CH_4). Given the enhanced biological productivity, the rate of CO_2 drawdown by marine phytoplankton increases while promoting N_2O production through microbial nitrification and denitrification and methane production through microbial methanogenesis. Understanding the contribution of the IAS region to global ocean/atmosphere exchange budgets requires a detailed understanding of the magnitude and effects of circulation patterns and nutrient additions on bacterial and phytoplankton metabolism.

4.5 CONFERENCE GOAL

The scientific goal of the conference was to define better the physical, biological, and biogeochemical transports that link the marine ecosystems and fisheries of the IAS; in addition to elucidating transport pathways and rates, this goal includes identification of retention zones and mechanisms thought important for marine ecosystems and fisheries recruitment. This goal also serves to address the role of the

IAS in regional climate variability and global climate change by providing a forum for an improved understanding of the effect of mesoscale circulation features on biogenic ocean/atmosphere gas exchange budgets, as well as more familiar issues of air-sea transfers of momentum, heat, and moisture. (The IAS is one of the world's major semi-enclosed seas which are generally not understood to a predictive level as combined physical, biogeochemical, and marine ecological systems. The Mediterranean Sea is another example, and one for which there is a higher level of knowledge than the IAS; even so, it is now the subject of studies two orders of magnitude more intense than those presently focused on the IAS, a situation that should change over the course of the next generation.) It is important to recognize that multinational and multidisciplinary cooperation is essential to making major progress in understanding the IAS physical, biogeochemical, and marine ecological systems, and that, while the more-developed countries predominantly pursue long-term, curiosity-driven science, the less-developed countries tend to address scientific issues of immediate societal concern. Thus, this conference encompassed societal applications as well as fundamental science. Perhaps the most succinct way to express our common interests is to say we attempted to ***"****improve the scientific basis for monitoring and modelling (and, eventually, managing) the IAS environment"*.

4.6 STATEMENT OF OBJECTIVES

This conference intended to achieve the following general objectives in support of the above goal:

(i) increase the exchange of scientific knowledge concerning IAS circulation, marine ecosystems, and physical-biogeochemical coupling (especially identify the predominant processes and scales) in the characterization of marine ecosystems;

(ii) stimulate the development of further cooperative and joint research on IAS circulation and marine ecosystems;

(iii) focus the observational and modelling efforts on developing an IAS nowcast and forecast system for scientific research and societal purposes, plus constructing ecological models that facilitate comparisons between oligotrophic, riverine-influenced, and coastal upwelling systems, contrasting ergoclines, etc.;

(iv) foster the development of ecosystem models that derive from circulation and water quality models, and that can be used to predict future conditions in the IAS in response to human activities and climate change;

(v) build stronger bridges between USA, Canadian, Caribbean, and Latin American scientists concerned with IAS circulation, biogeochemistry, and marine ecosystems; and

(vi) build bridges to the marine fisheries and ocean pollution scientists, meteorologists, and hydrologists who have needs for improved information on the IAS circulation and marine ecosystems.

In particular, it is important to describe the coupling of physical, biological, and biogeochemical processes that characterize both pelagic and benthic environments in their structural (diversity, time-space stability, production, etc.) and functional (complexity of interactions, flow of energy, etc.) aspects. (For example, the space and time scales of variability in pathways for biogenic carbon and nutrient (e.g., silica) fluxes are germane. Yet to be explained are the anomalous distributions of nutrients in the surface waters of the eastern Caribbean and the contrasting nutrient distributions in the deep waters of the Colombian/Venezuelan Basin versus the Cayman/Yucatan Basin, with the deep Gulf of Mexico being intermediate between those two extremes.)

To these ends, this conference was designed to achieve the following specific objectives:

(i) create a new synthesis of physical, chemical, ecosystem, and fisheries information on the transport pathways and rates and the retention zones of the IAS;

(ii) based on 1), identify probable and possible linkages between the ecosystems and fisheries of the various IAS nations' EEZs in order to define better their common interests;

(iii) based on 1) and 2), identify the role of the IAS in regional climate and global change; and

(iv) based on 1), 2) and 3), derive a set of critical scientific questions that will lead to the next generation of cooperative, multidisciplinary research, and lay the foundations for the efficient design of a regional GOOS (IAS-GOOS).

4.7 DATES AND VENUE

The conference was held 1 to 5 November 1997 in Cozumel, Mexico. This timeframe was chosen to avoid direct schedule conflicts with the AGU/Brazilian joint meeting in September 1997, the Fall 1997 AGU Meeting, and the Ocean Sciences Meeting in February 1998. It also corresponded to a favourable weather period at the end of hurricane season and prior to the prime tourist season.

This conference was held in Cozumel, Mexico in order to reach out to the Latin American and Caribbean scientific communities. Cozumel is an attractive and easily accessible site on the Caribbean Sea which offers an informal and secure atmosphere and fine, yet inexpensive, facilities.

5. ABSTRACTS

5.1 COASTAL DYNAMICS AND ENVIRONMENTAL IMPACT IN THE WESTERN GULF OF MEXICO

J. Eduardo Aguayo
C. Instituto de Ciencias del Mar y Limnología
UNAM. Apdo. Postal 70-305
Mexico, D.F.

The Gulf of Mexico is a natural laboratory, offering the opportunity to understand the dynamics of the several marine geological environments, from tidal flats to abyssal plains, subjected to (1) distinctive geography (climate, physiography and hydrology) which control sediment load, flow regime, and water quality; (2) sedimentary settings affected by erosional, depositional, and non-depositional processes; (3) local and regional tectonic settings which affect the dynamics of the sedimentary environments by subsidence, emergence, and stationary basement; and (4) the role of the collision of the Loop Current anticyclonic rings against the continental slope-shelf in sediment transport, dispersion, and deposit. The observable geology results from these factors that control the sedimentary cycles and the suite of resulting sedimentary structures; therefore, to understand regional and local sedimentary environments in detail and to develop predictive models, systematic, fundamental marine research is needed to describe and quantify river discharges of sediments to the coastal zone, the riverine input, coastal erosion, and sediment deposit and redistribution.

Land-ocean interactions affecting the marine sedimentary environments in the western Gulf of Mexico are complex and vary among regions of the coastal zone. These variations are due to differences in river discharges of sediments and contaminants from both Mexico and the United States, collision of the Loop Current anticyclonic rings against the continental slope and shelf, longshore currents and waves, and human activities such as sewage discharge, dam building, coastal urban development, tourism, oil and gas exploration and extraction, and fisheries. These factors have contributed to short-and long term changes in the marine environment, like the coastal zones of the states of Tabasco and Campeche wherein the sea is advancing inland about 3 meters each year. The coastal zones in the States of Veracruz and southern Tamaulipas is affected by erosional and depositional-transport processes, and in northern Tamaulipas the coastal setting is prograding faster. Moreover, the coastal zone on the Gulf of Mexico is particularly vulnerable to damage due to the extensive extraction of hydrocarbon resources, because the semi-enclosed nature of the gulf and its circulation patterns. Thus, the production of oil and gas in this marine province requires special attention to protect the oceanic and coastal ecosystems.

5.2 DIRECT OBSERVATIONS OF CURRENTS IN THE YUCATAN CHANNEL

A. Badan, J. Candela, J. Sheinbaum, & J. Ochoa
CICESE
Ensenada, Mexico

Six months of direct observations with current meters moored over the western slope and over the central sill of the Yucatan Channel document some important features of the exchange between the Caribbean Sea and the Gulf of Mexico and of the Yucatan Current. As expected, water flows generally from the Caribbean into the Gulf of Mexico with currents strongest at above 1 m/s near the surface and at the central mooring. Mean flows decrease markedly with depth and evidence of a weaker counterflow is detected near the bottom and against the western slope. Current fluctuations, typically of O (0.2 m/s), are quite uniform with depth and across the channel, thus smaller than the mean near the surface, but larger than the mean in the lower half of the water column. The surface current is a permanent, fluctuating or meandering jet, whereas the counterflow is characterized by sporadic events of southward flow. The Yucatan Current in the first six months of 1997 appears dominated by three large low-frequency events, with a spring transition in early April. After the transition both the mean and fluctuating currents and temperature fluctuations are larger, but salinity is lower. Although tides are known to be small in the region, tidal currents contribute appreciably to the higher-frequency fluctuations. Currents appear vertically coherent in events from a few days to the tidal frequencies and well correlated across the channel in the lower frequencies.

5.3 THAR SHE BLOWS! SPERM WHALES, SST FRONTS, AND CYCLONIC EDDIES IN THE NE GULF OF MEXICO

D.C. Biggs & J.H. Wormuth
Department of Oceanography
Texas A&M University
College Station, TX

J. Norris & R. Davis
Dept. Marine Biology
Texas A&M University
College Station, TX

R.R. Leben
Colorado Center for Astrodynamics Research
University of Colorado
Boulder, CO

M. Seymour
Earth Scan Lab
Louisiana State University
Baton Rouge, LA

W. Evans
Department of Oceanography
Department of Marine Biology
Texas A&M University
College Station, TX

Quarterly cruises from spring 1992 through fall 1993 to visually and acoustically survey marine mammals in the Gulf of Mexico often encountered sperm whales over the slope of the northern Gulf. Most contacts were within 100 km of the Mississippi River delta. On two cruises last year (1996), remotely-sensed SSH and SST were used to resolve the mesoscale circulation and then surveyed the continental margin along station lines from 100 to 2000 m isobaths. Also surveyed were DeSoto Canyon and a mesoscale, deep-water cyclone-anticyclone pair which TOPEX-ERS-2 data show was present most of 1996. MOCNESS trawls collected greater micronekton biomass in the cyclone than in the anticyclone, and most sperm whale contacts were on the cold side of SST fronts around the cyclone-anticyclone pair. In October 1996, 41 sperm whales were sighted by visual observers and 10 whale groups were heard by acoustic survey. Most of these were off the Mississippi delta and at the perimeter of the cyclone. Sperm whales were uncommon in the canyon and even rarer in the warm-core ring. Most of the sperm whale groups seen in/near the cyclone were females and young calves, and it is speculated that their distribution reflects foraging preference and reproductive success.

This ongoing research is supported by the USGS Biological Resources Division and US Minerals Management Service under USGS BRD contract #1445-C109-96-004. For more info, see: http://www.tamug.tamu.edu/gulfcet/

5.4 MOORED ADCP MEASUREMENTS OF THE YUCATAN CURRENT IN THE COZUMEL CHANNEL AND IN THE WESTERN SIDE OF THE YUCATAN CHANNEL

Julio Candela, A. Badan, J. Sheinbaum, & J. Ochoa
CICESE
Ensenada, B.C., Mexico

Two bottom mounted RDI 150 kHz BBADCPs were installed, for a period of six months (Dec/96-June/97), to monitor the currents in the upper 300 meters of the water column at two locations along the path of the Yucatan Current. One ADCP was located at the centre of the Cozumel Channel and the other off Contoy Island. At the Cozumel Channel site, the ADCP measurements were complemented by two shallow (~10 meters) pressure sensors installed across the channel to provide an independent measure of the surface flow assuming geostrophic balance. Over the six-month measuring period, the mean transport of the Yucatan Current through the Cozumel Channel was 3.6 Sv with an rms of 0.9 Sv. There was no correlation between the measurements in the Cozumel Channel and those off Contoy Island, which is interpreted as an indication of the strong meandering behaviour of the Yucatan Current as it enters the Gulf

5.5 CANEK: EXCHANGE THROUGH THE YUCATAN CHANNEL AND UPWELLING DYNAMICS OVER THE YUCATAN SHELF

Julio Candela
CICESE
Ensenada, B.C., Mexico

The CANEK Project was initiated in December 1996 with two main objectives:

(i) to measure, for the first time, the exchange through the Yucatan Channel for characterization of its magnitude and variability throughout the water column,

(ii) to clarify the upwelling dynamics over the Yucatan Shelf, its relation to the Yucatan Current's strength and variability, and quantify its effect on the primary production occurring on the Shelf.

This Project is a collaborative effort between CICESE, ICMyL-UNAM, UAM, Mexico, NOAA, USA and IOC, Cuba. Two cruises have successfully been concluded: 3 to 21 December 1996 and 23 May to 12 June 1997 onboard UNAM's R/V "Justo Sierra". Extensive shipboard ADCP and CTD/LADCP surveys of the region were carried out. During the May/June 1997 cruise, the CTD/LADCP survey was complemented with intensive bio-chemical sampling along the upwelling front over the Shelf.

During the first six months of the Project, between the Dec96 and May/Jun97 cruises, four moorings and three shallow pressure sensors were installed and successfully recovered, and a set of two moorings and four shallow pressure sensors were left installed to be recovered during our next cruise scheduled for December 1997. A description of the Project goals and its relation to other programmes in the region were presented, as well as a general description of the results from the two cruises and mooring observations obtained so far, this was complemented by specific detailed short talks that followed.

5.6 SHIPBOARD ADCP OBSERVATIONS IN THE YUCATAN CHANNEL DURING THE CANEK PROJECT

Julio Candela, J. Sheinbaum, J. Ochoa, & A. Badan
CICESE
Ensenada, B.C., Mexico

Observations obtained during two cruises in December 1996 and in May/June 1997 within the CANEK Project are discussed. The cruises were made with the R/V JUSTO SIERRA, equipped with a ship-mounted RDI 75 kHz ADCP, usually measuring up to 400 m depth, and covered the area around the Yucatan Channel within 20 to 22.5 N. Both cruises showed a persistent and swift Yucatan Current flowing towards the Gulf of Mexico, on the western side of the Channel, with surface speeds as high as 2 m/s. Transport estimates in the upper 300 meters indicate that this current was transporting about 8 Sv into the Gulf during both cruises, for an equivalent cross-shelf section about 50 km in length near 22 N and oriented nearly in west-east direction. A complete cross-Channel section between Isla Contoy, Yuc. and Cabo San Antonio, Cuba, during the May cruise, gives a total transport of 19 Sv into the Gulf in the upper 300 m.

5.7 NUMERICAL MODELING OF HYDROTHERMAL EFFLUENTS DISPERSION IN COASTAL MARINE SITES

J. Portilla Casillas, F. V. Vidal, & V. M.V. Vidal
Instituto Politécnico Nacional
Cuernavaca, Morelos, México

A three-dimensional differential-numerical model of coastal circulation and heat exchange reproduces the hydrodynamical behaviour of the surface discharge cooling water to the sea incoming from the Laguna Verde Nuclear Power Plant under four different atmospheric and oceanic conditions; Case I, north winds, average speed of 6.9 m s^{-1}; Case II, south winds, average speed of 2.8 m s^{-1}; Case III, north winds, average speed of 11.2 m s^{-1}, and Case IV, south winds, average speed of 4.3 m s^{-1}. The results are analysed and constitute the verification of the model.

The statistical analysis of the wind speed and direction time series measured at the Laguna Verde Site from January 1, 1980 to December 31, 1992, shows that the prevailing anemometric regime is bimodal with probabilities of 45% and 41% for south and north winds, respectively. The south winds induce a sea surface circulation towards the north which drives the hydrothermal effluent towards the intake. On the contrary, the north winds drive the discharged hot water away from the intake, towards the south hugging the coastline.

Comparisons between the numerical simulation results and field data show that under different atmospheric and oceanic conditions, representative of the Laguna Verde Site, the model correctly predicts the hydrothermal effluents surface dispersion and diffusion patterns measured on December 16, 1992 (Case I), June 25, 1992 (Case II), April 24, 1992 (Case III), and March 16, 1992 (Case IV). The model predicts the extent of the impacted areas with cooling water with a precision of ±10%.

With the exception of Cases II and III, the thermal gradients induced by the hydrothermal discharge fluctuated within the natural temperature ranges measured in the Laguna Verde Site. For all the analysed cases, the real size of the impacted areas that might have adverse effects on the marine ecosystem was not larger than 0.2 km^2. Thus, these possible adverse effects are considered to be of local significance only.

The simulated vertical profiles of temperature show that the cooling water discharged remains mostly on the surface of the receiving water mass and reaches a maximum depth of 3 m. This floatability of the discharge plume is a consequence of the low density and small Froude number (F_r « 1), at the discharge, that characterizes the Laguna Verde Nuclear Power Plant effluent.

5.8 A REGIONAL OBSERVATION NETWORK: CARIBBEAN PLANNING FOR ADAPTATION TO GLOBAL CLIMATE CHANGE (CPACC)

J. Lee Chapin
CPACC - Acting Regional Network Coordinator
Organization of American States - Unit of Sustainable Development & Environment
Caribbean Meteorological Institute
St. James, Barbados, W.I.

The CPACC project's overall objective is to support the eleven participating Caribbean nations, all having significant coastal vulnerability, in preparing to cope with the adverse effects of global climate change. The project is funded by a grant from the GEF/World Bank with the Organization of American States as the Executing Agency. The countries included in the CPACC project are those CARICOM member states that requested participation during the 1994 "Global Conference of the Sustainable Development of Small Island Developing States". Those countries and the number of monitoring sites in each country are;

Antigua (1)	Dominica (1)	St. Kitts (1)
Bahamas (3)	Granada (1)	St. Lucia (1)
Barbados (1)	Guyana (2)	Trinidad & Tobago (3)
Belize (1)	Jamaica (2)	

The type of sensors installed at each monitoring site will be;

Sea level (acoustic sensor)	6-minute logging interval
Wind direction, wind speed & gust	
Relative humidity	
Air Temperature	hourly logging interval
Sea Surface Temperature	
Barometric Pressure	
Precipitation (tipping bucket)	

All data will be transmitted at scheduled three-hourly intervals via the GOES satellite. Data are downlinked at the Caribbean Meteorological Institute (CMI) in Barbados. All data will have QA/QC applied "on-the-fly", archived, and then made available on the Internet in near real-time. Short-term (<1 week) data sets will be graphically depicted on the homepage, with tabular data available. Long-term data files will be available by location, data type, and time/date via FTP.

Access to the data will be initially available on the CPACC homepage; http://www.cpacc.oas.org

The future plans call for the data to become available from a CMI homepage, with products from CMI and other regional and local institutions. Linkage with other regional programmes is encouraged.

The installation of the monitoring sites will begin in December 1997, and be completed by December 1998. Data from each monitoring site will be available on the Internet as soon as it is installed.

5.9 SEASONAL CYCLE OF MIXED-LAYER FEATURES IN THE NORTHEASTERN CARIBBEAN SEA: RESULTS FROM THE CATS (CARIBBEAN TIME SERIES) STATION

Jorge E. Corredor & J.M. Morell
University of Puerto Rico
Lajas, Puerto Rico

Mixed-layer properties of the northeastern Caribbean undergo a distinct seasonal cycle. A deep (100 m), well-mixed surface layer with high salinity and density prevails in the region during the early part of the year. This water mass appears to be advected through the northern passes of the Caribbean from the tropical Atlantic Ocean. A recurrent but transient decrease in surface salinity occurs in mid summer followed by continued decreases for the remainder of the year. The former feature appears to be tied to advection of Amazon River water from the tropical Atlantic. The subsequent salinity decrease corresponds to spreading of the Orinoco River plume throughout the eastern Caribbean following the seasonal rains in the Orinoco drainage basin. As temperature variations are moderate, surface density distribution closely follows the observed salinity patterns.

Phytoplankton populations are characterized by the presence of a deep chlorophyll maximum at ca. 100 m close to the base of the mixed layer during the early part of the year. As freshwater influence

increases during the second half of the year, the chlorophyll maximum is displaced vertically reaching depths of between 75 and 100 m in September and October. While silicate concentrations co-vary inversely with salinity throughout the year, concentrations of nitrogenous nutrients remain low throughout the year.

5.10 BIOLOGICAL AND PHYSICAL PROCESSES CONTRIBUTING TO PATTERN AND VARIABILITY IN THE RECRUITMENT OF CORAL REEF FISHES

Robert K. Cowen, Kamazima M.M. Lwiza, Su Sponaugle
Marine Sciences Research Center
State University of New York
Stony Brook, NY 11794-5000

It is widely appreciated that the transport of fish larvae by ocean currents to juvenile habitats, while poorly understood, nonetheless plays a decisive role in fish population dynamics. Recent research has advanced the hypothesis that larval distribution patterns may reflect behaviours that are adapted to circulation features occurring in a wide variety of pelagic environments, thereby facilitating return to the juvenile and adult habitat. Examples are given from our work around the island of Barbados, West Indies, in terms of predictable temporal and spatial patterns in the supply and recruitment of coral reef fishes, and possible bio-physical processes responsible for island scale retention of locally produced larvae. Further, we discuss what physical processes have been identified that contribute to variability in amplitude of recruitment; notably local, wind-generated offshore surface flows, and remotely-generated, mesoscale eddies (North Brazil Current Retroflexion Eddies). We conclude by discussing future directions for work both in terms of appropriate scales of study and interdisciplinary approaches.

5.11 RECRUITMENT AND ONSHORE TRANSPORT OF EARLY LIFE HISTORY STAGES OF FISHES AND CRUSTACEAN DECAPODS IN THE SANTA MARTA REGION, COLOMBIAN CARIBBEAN (RECOLCA)

Maria Criales
Division of Marine Biology and Fisheries
University of Miami/RSMAS
Miami, FL

This planned project is a multidisciplinary investigation to study recruitment processes and onshore transport mechanisms of the early life history of "ELH" stages (e.g., eggs, larvae, postlarvae, and juveniles) of a variety of important commercial species of fishes, shrimps, and swimming crabs between the Gulf of Salamanca and the nursery grounds of the Cienaga Grande de Santa Marta (CGSM) in the Colombian Caribbean. There is currently a dearth of research on the relationship between oceanic processes and recruitment of significant commercial species in this area rich in fisheries resources. The proposed study site is unique. Here, waters of the Caribbean mix with the complex deltaic ecosystem of the Magdalena River, creating a highly diverse and dynamic ecosystem that is influenced by the action of Trade Winds, coastal upwelling, freshwater discharges, and a coastal counter current. The proposed project provides an ideal opportunity for the detection of recruitment mechanisms for a wide range of species, and the effect of hydrographic factors on their onshore movements to the CGSM through the study of spatial-temporal variability of presettlement stages entering CGSM and the description of the most relevant meso- and small-scale oceanic features around the Gulf of Salamanca and the CGSM.

The initial phase of the proposed research is designed for two years. During these two years, ELH stages of plankton samples and hydrographic data will be collected at the entrance of the CGSM, and the data will be analysed together with the biological and oceanic data collected on the continental shelf of the Gulf of Salamanca. ARGOS satellite-tracked surface drifters will be monitored throughout this project, and the results will be augmented with wind and current data and satellite imagery. This research is funded by COLCIENCIAS (Colombian Government Agency) through the Institute of Marine Research (INVEMAR), the Rosenstiel School of Marine and Atmospheric Science (RSMAS) of the University of Miami, and the Southeast Fisheries Science Centre (SEFSC) of the National Oceanic and Atmospheric Administration (NOAA). The research is planned to start in January 1998.

5.12 THE SPINY LOBSTER, PANULIRUS ARGUS, AS A KEY SPECIES INDICATOR OF ECOSYSTEM TRANSPORTS AND LINKAGES OF THE INTRA-AMERICAS SEA

Nelson M. Ehrhardt
University of Miami/RSMAS
Miami, FL

Spiny lobster, *Panulirus argus*, distributes widely throughout the Western Central Atlantic Ocean and the Caribbean Sea from Brazil to the United States and Bermuda. Within its distributional range the species supports intense exploitation due to the high value of spiny lobsters in the international markets. The species is characterized by spawning conspicuously during well-defined seasonal periods. The free-swimming larvae may be transported in ocean currents for up to six months. During this time, and depending on regional physical larval retention mechanisms, the larvae may settle in immediate surrounding areas as well as in far away grounds. In this paper, an analyses of the temporal-spatial variability of spiny lobster resources in two extreme equidistant points (Florida and Brazil) and an intermediate point (Nicaraguan-Honduran Shelf) are compared for similarities in annual population abundance. Results of the analyses show highly correlated regional trends in the spiny lobster stocks considered and that the Pan Caribbean origin of spiny lobster larvae may be an important key factor to the sustainability of fisheries in the eastern boundary regions. In one particular case, it is demonstrated that spiny lobster spawning coincides with seasonal cyclonic gyre formations that act as retention mechanisms for larval recruitment to coastal regions in Central America.

5.13 BENTHIC BIOMASS DISTRIBUTION IN THE IAS: A PELAGIC CONTROLLED SYSTEM?

Elva Escobar, ICMyL
Luis A. Soto, ICMyL
Frank Muller-Karger, University of South Florida
Gilbert T. Rowe, Texas A & M University

Benthic macrofaunal density, biomass and size are controlled among other factors by the rates of detrital food supply. It is the purpose of the present work to analyse some of the factors that define the distribution of the benthic biomass in the IAS. The analysis included both non-published information mainly in the SW and W Gulf and existing records in the Caribbean Sea. Macrofaunal data considered the continental shelf, slope, and deep-sea habitats. Additional information used to explain contrasting benthic biomass included percentage of organic carbon and nitrogen, the C:N ratios, and grain size. Pigments in the water column interpreted from colour images of the entire IAS from two contrasting seasons, winter and summer, were correlated with the benthic biomass. Sediment organic carbon content in the deepest portions of the entire basin is uniformly low (0.18-0.72%) as in %N (0.02-0.16%). Organic carbon and nitrogen are highest near river outflows. Clay makes up the finer fraction of sediments throughout the deep-sea IAS which contrasts with the carbonaceous, coarse-grained bottoms in the shallower portions or the sites with high continental input, off the major rivers, in the basin. The biomass variability in the IAS correlates to the regional surface production. These results are compared with the empirical relationships between wet preserved weight and water depth developed by Rowe in the early 80's. The low biomass recorded throughout the central portion of the IAS is attributed to the low flux and poor nutrient value of detrital material deposited on the sea floor. It is characterized by low percentage and refractory nature of organic matter in sediments. In shallow-water environments along the shelf and off the major river systems, the biomass shows contrasting invertebrate biomass values. High values are attributed to the availability of labile food, the latter to changing environmental conditions (hypoxic-anoxic) and sediment instability. In shallow hypoxic zones the benthos can be characterized by very high biomass of sediment bacteria, whereas in deep water the highly mobile nature of the seabed and the diminished detrital food availability results in a poor assemblage of deep-sea fauna. Records show that seasonal turbidity flows may have contributed to regional paucity of fauna; deep-sea sediments are a result of pelagic sedimentation interspersed with sediment distribution by turbidity flows. As well, islands seem not to have a significant supply of sediment to the deep-sea (e.g., along the Puerto Rico Trench). Oligotrophic community models related to pelagic low input

contrast with eutrophic assemblages on the shelves that can be supported by a few sediment community metabolic values recorded in localized areas of the IAS.

5.14 HIDROLOGÍA DE LOS ESTRECHOS DEL MAR CARIBE NOROCCIDENTAL

Artemio Gallegos
UNAM
Mexico City, Mexico

The Caribbean Sea and the Gulf of Mexico maintain an important mass, heat, and kinetic energy exchange with the Atlantic Ocean through many passages. The most important of these are the Windward Passage; the Anegada-Jungfern, Saint Vincent, and Grenada Passages; the Havana - Key West (Florida) Strait and the Yucatan Channel. The hydrology of these passages presents a strategy to study the diverse physical marine processes which occur on the wide range of space-time scales existing in these oceanic basins, and are determinants of the ocean climate of the region. A basic analysis of 10 hydrographic surveys made at the Yucatan Channel, the Havana - Key West (Florida) Strait, the Old Bahamas Channel and the Windward Passage between 1968 and 1995 is presented. The meaning of the estimates of geostrophic transport of volumes of water and heat through these passages is discussed in relation to the circulation and the ocean climate of the Caribbean Sea and the Gulf of Mexico.

Key words: *northwestern Caribbean Sea, hydrology, geostrophic transports.*

Hidrología de los estrechos del Mar Caribe noroccidental

Resumen.

El Mar Caribe y el Golfo de México mantienen con el Océano Atlantico un importante intercambio de masa, calor y energía cinética a través de muchos pasos, estrechos y canales. Los más importantes son el Paso de los Vientos, los pasos Anegada-Jungfern, San Vicente y Granada, el estrecho La Habana - Cayo Hueso y el Canal de Yucatán. La hidrología de estos pasos es una estrategia para estudiar diversos procesos físicos, típicamente marinos, que en un amplio rango de escalas espacio-temporales suceden en estas cuencas oceánicas y que determinan el clima oceánico de esta región. Se presenta un análisis hidrográfico elemental de 10 campañas oceanográficas que tuvieron lugar en el Canal de Yucatán, el estrecho Cayo Hueso - La Habana, el Canal Viejo de Bahamas y el Paso de los Vientos entre 1968 y 1995. Se discute el significado de las estimaciones de los transportes geostróficos de volumen de agua y calor a través de éstos pasos con relación a la circulación y al clima oceánico del Mar Caribe y el Golfo de México.

Palabras clave: *Mar Caribe noroccidental, hidrología, transporte geostrófico.*

5.15 NEW FEATURES OF IAS CIRCULATION SEEN WITH OVER-THE-HORIZON RADAR

T. M. Georges & J. A. Harlan
NOAA/ERL/ETL
Boulder, CO

We have made vector surface current maps in selected IAS regions, using two HF over-the-horizon (ionospheric) radars operated by the U.S. Navy. They resolve the structure of mesoscale eddies, seamount wakes, boundary current bifurcation, and counterflow through the Yucatan Strait. A surface current map inside a hurricane resolves strong surface currents in the storm's right-front quadrant, and inertial oscillations in its wake, as well as the surface current divergence responsible for upwelling of cooler thermocline water. Radar-derived surface currents have been validated by comparison with ADCP current measurements in the Gulf of Mexico.

5.16 CURRENTS ALONG THE COAST OF TEXAS AS OBSERVED BY THE TEXAS AUTOMATED BUOY SYSTEM

Norman L. Guinasso, Jr., F.J. Kelly, & L.L. Lee
Texas A & M University
College Station, TX

The Texas Automated Buoy System (TABS) currently measures ocean currents at 5 sites on the Texas Louisiana shelf. At each site is a modified spar buoy that has a Marsh-McBirney current sensor mounted at a depth of 2m. A five-minute vector average of the current data and surface water temperature are measured every 30 minutes and stored internally.

The buoys use a solar-powered cellular phone system to transmit the most recent data back to our facility in College Station, Texas. A computer system automatically calls each of the buoys every 6 hours, and downloads and processes the data. After an automated QC process, the data are posted on World Wide Web page where they can be viewed in graphical or tabular form. The Web page also contains a database query engine that allows the public to download selected data in either graphic or tabular form.

The response of the Texas coastal current to the passage of Tropical Storm Josephine in 1996, as recorded by TABS, includes currents accelerating up to 1 meter per second as the storm passes through the Gulf of Mexico.

We are currently procuring eight new buoys that will be installed in 1997 and early 1998. These new buoys have a satellite communication system that will allow the buoys to be located anywhere in the Gulf of Mexico. Two of these buoys will be installed near the border of Texas with Mexico. Four others will be installed on a line extending from Galveston to near the Flower Garden Banks as part of a National Ocean Partnership Programme.

5.17 DIRECT OBSERVATIONS OF VELOCITY STRUCTURE IN THE PASSAGES BETWEEN THE INTRA-AMERICAS SEA AND THE ATLANTIC OCEAN, 1984 TO 1996

Elizabeth Johns & W.D. Wilson
NOAA/AOML
Miami, FL

Shipboard Acoustic Doppler Current Profiler (ADCP) velocity data acquired between 1984 and 1996 in connection with several NOAA research programmes have been used to examine the mean and variability of the velocity structure within the Straits of Florida, the Northwest Providence Channel, a northern approach to the Windward Passage, the Mona and Anegada Passages, and across the eastern Caribbean Sea. Historically, direct velocity data acquisition in these important passages between the Gulf of Mexico, the Caribbean Sea and the Atlantic Ocean has been very sparse. Here, the transport and velocity structures in the passages are examined using a more complete data set than previously available. This newer data set allows computation of statistically significant mean and standard deviations of the transport and velocity fields, and examination of the temporal (seasonal to interannual) variability of these fields. Comparison are made of the mean and varying flow fields with the results of previous studies and with available time series of regional forcing functions such as the COADS wind stress data set. Most importantly, the mean transports should prove useful to numerical modellers of the Intra-Americas Sea for calibration and refinement of model boundary conditions.

5.18 INFLOW TO THE EASTERN CARIBBEAN: RESULTS FROM BASIN-SCALE ATLANTIC MODELS

W. Johns , T. Townsend, E. Chassignet, and Z. Garraffo
University of Miami/RSMAS
Miami, FL

Results from three different Atlantic basin models are reviewed in terms of the structure and variability of the inflow to the eastern Caribbean and IAS system. The models range in complexity from the coarse resolution, two-layer, linear wind-driven model of Anderson and Corry (1985); to the six-layer, 0.25 degree, nonlinear U.S. Navy's layered model with wind and meridional overturning forcing, and to a recent high-resolution simulation (1/12 degree, 16-layer) using the Miami Isopycnal Model (MICOM) model with full wind and thermodynamic forcing. The Anderson and Corry model predicts a wind-driven mean transport of 22.5 Sv through Yucatan Strait, with over half of this contributed by the Windward Passage (12.5 Sv), and with nearly zero net inflow to the southern Caribbean. The Navy model simulation driven only by wind forcing predicts a weaker mean transport through the Yucatan (17.2 Sv) and Windward (7.4 Sv) Passages, but otherwise shows a similar inflow distribution including zero net transport through the southern Caribbean passages. Inclusion of a 14 Sv meridional overturning cell in the Navy model increases the Yucatan transport to 28.3 Sv and produces a significant inflow of 12.3 Sv through the southern passages (Grenada, St. Vincent, and St. Lucia passages). The high-resolution MICOM simulation, while still spinning up to equilibrium after 5 years of integration, shows a net transport of nearly 37 Sv through Yucatan Strait with more than 20 Sv of inflow through the southern Caribbean passages.

Variability in the inflow to the eastern Caribbean simulated by the two nonlinear models (Navy and MICOM) is dominated by intraseasonal fluctuations on time scales of 1-to-3 months. Much of the variability appears to be related to the influence of North Brazil Current Rings that propagate northwestward along the South American coast and interact with the Lesser Antilles Island chain. These features are particularly energetic in MICOM and can cause fluctuations in the southern passages of +-10 Sv or more. The range of model results was discussed in relation to available observations.

5.19 GEOSIS: AN ENVIRONMENT TO PROCESS OCEANOGRAPHIC DATA

Z. García Lagunas, F. V. Fidal, V. M.V. Vidal, & S.C. Vergara
Instituto Politécnico Nacional
Cuernavaca, Morelos, Mexico

The combined increases in portable computing and flows of experimental data have enabled the development of a scientific software environment for data processing. Modern scientific data processing in observational sciences is typically quite complex, and a great deal of expertise is needed in chaining each step of data processing, and executing the adequate programmes for problem solving. This situation applies especially in oceanography due the large amount of data collected.

Problem-solving environments are developed in order to solve automatically routine problems, but often, the problem-solving process cannot be completely automated. The most effective way of processing oceanic data is by means of a system capable of turning a large mount of data into visual presentations so more time can be dedicated to analysis and less time to processing. Also users must have the possibility to supervise the whole problem-solving process, and they must be able to intervene whenever they want, for example, to solve specific subtasks or validate input or output data. The effective use, analysis, and interpretation of such volumes of data is quite complex and is possible only under the condition of automation of the process of acquisition, transmission, archiving, processing and visualization of experimental data with a scientifically based approach. To satisfy user-requirements, the system should include a modelling network capable of solving scientific tasks.

At present, a system to aid oceanographers in data processing (called GEOSIS) is being developed. We have developed the system primarily for processing and planning of oceanic data. This system is composed of three modules: quality control, data modelling, and visual representation. The quality control module deals with access to data and graphics, and it also performs quality control on data. The data-modelling module has the main functions of interfacing end users with mathematical algorithms providing the expertise required to exploit the potential of hydrographic data. The visual representation module automatically defines characteristics of graphics for visualization and display of the results with publication-quality graphics.

For the researcher, GEOSIS provides a large selection of high quality analysis and graphics options for data acquired using CTD microprofilers and associated water samples. The programmer is provided a single application-programme interface, and the user is provided a modelling network which validates the processing. GEOSIS analysis and display tools are available for VMS environments. Tools are designed to calculate a wide range of oceanic variables; such as, dynamic height, geotropic velocity, and potential density. Because GEOSIS tools are individual programmes, it is easy for a researcher to add a new analysis technique. The topography of The Gulf of Mexico has been included in GEOSIS for the automatic display of transects representation.

Generally, the most difficult task in data processing is to connect the phases of data quality control, data modelling, and data visualization, because each phase is composed of a large amount of technical data and the coupling of variables involved requires a lot of effort.

5.20 TROPICAL INTRASEASONAL AND LONGER-PERIOD OSCILLATIONS IN PRECIPITATION OVER THE ISTHMUS OF PANAMA

Kevin D. Leaman
University of Miami
Miami, FL

Maria C. Donoso
Water Center for the Humid Tropics
of Latin America and the Caribbean
Panama, R.P.

Daily records of precipitation from stations distributed over the central Isthmus of Panama (Panama Canal Zone) have been collected for durations ranging from 30 years (24 stations) to almost a century (five stations), while less complete data extend the time series from 1862. These data show a fascinating wealth of intraseasonal and interannual variability in the amplitude of the signal and in its structure over the Isthmus that is superimposed on the general pattern of wet and dry seasons caused by the seasonal migration of the Intertropical Convergence Zone (ITCZ). Variability at periods of the so-called Tropical Intraseasonal Oscillation (TIO) in the range of 40 days to 110 days is surprisingly strong (5 to 10 mm/day) given that precipitation was not previously thought to show TIO signals in the eastern Pacific. This TIO-period oscillation is also, and for reasons which are as yet unexplained, phase-locked to the annual signal (or equivalently, to the seasonal march of the ITCZ). This latter property of phase locking appears to link TIO-period precipitation variations with other aspects of the seasonal cycle that are well recognized in Panama. In particular, the "Barrehobo" rainy period in the midst of the winter (January) dry season and the short dry period ("Veranillo de San Juan") during the rainy season in mid-summer appear to be associated with this same oscillation. Interannual variations in some empirical modal structures computed over the Isthmus appear to be associated with 3 to 5 year periods related to ENSO. We suggest that these variations in precipitation are also detectable over the western Caribbean and should influence precipitation patterns there.

5.21 MONITORING OF THE NEAR-REAL-TIME VARIATIONS OF SEA SURFACE HEIGHT IN THE IAS ARE AVAILABLE FROM THE CCAR ALTIMETER DATA ARCHIVE HOME PAGE BY ACCESSING THE GLOBAL MESOSCALE ANALYSIS VIEWER---HTTP://WWW-CCAR.COLORADO.EDU/-LEBEN/REAL-TIME/

Robert R. Leben
University of Colorado
Boulder, CO

George H. Brown
University of Colorado
Boulder, CO

Douglas C. Biggs
Texas A&m University
College Station, YX

We have been hosting several regional analyses (Bering Sea and Gulf of Mexico) and could easily set up one for the IAS if desired by the community. To make this regional site of most use, we would like to have contributions from the modelling community of "mean sea level" estimates for generating a synthetic geoid for the IAS. We have begun validation efforts of synthetic geoids in our sea surface topography estimates for the Gulf of Mexico and have been able to identify probable sources of systematic errors in the mean. Much of the errors in the eastern Gulf are associated with interannual circulation variability that are manifested as systematic errors when the altimeter data are referenced to a short term (~1 year) altimetric means. Similar systematic errors may be a problem in the IAS.

It is presently difficult to address the importance of monitoring Yucatan inflow for nowcasts and forecasts in the Gulf of Mexico or IAS without considering the option of properly assimilating altimeter data into a nowcast/forecast model. Forward modelling would benefit from any direct measurement of this inflow, as would skill assessment studies of a nowcast/forecast system; however, direct improvement in the skill of nowcasts and forecasts may not be worth the level of effort needed to obtain those measurements. If the measurement programme is intended to provide a synthetic geoid along a TOPEX track, then the benefit maybe much greater to a nowcast/forecast system. Ideally a combination of tide guages and inverted echo sounders would be a part of such a system. Any hydrographic programme must be coordinated with over-flights of the altimeter and sampled along a TOPEX ground track to be of direct benefit to a nowcast/forecast system. Tandem OTHR observations should also be acquired.

5.22 THE INFLUENCE OF COASTAL AND OCEANIC FLOWS ON RECRUITMENT OF FISH AND LOBSTER LARVAE TO THE FLORIDA KEYS

Thomas N. Lee
Division of Meteorology and Physical Oceanography
University of Miami/RSMAS
Miami, FL

Long-term moored observations of current and temperature variability have been made along the offshore fringes of the Florida Keys reef tract from Carysfort Reef to the Dry Tortugas as part of multidisciplinary studies of larval recruitment processes (SEFCAR: South East Florida and Caribbean Recruitment) and studies of surface transport processes (SFOSRC: South Florida Oil Spill Research Centre). These data are used to make robust estimates of magnitudes and patterns of mean flow and temperature fields in coastal waters of the outer shelf, as well as their annual cycles, and are compared to spatial patterns of the wind field. Significant annual cycles in coastal current and temperature fields are found related to atmospheric and Florida Current forcing. These mean flow patterns and annual cycles are discussed in terms of their impact on larval recruitment pathways.

The combined influences of downstream flow of the Florida Current, onshore Ekman transports in the upper layer, coastal countercurrents and cyclonic circulation in the Tortugas gyre tends to aid retention and ultimately recruitment of both locally- and foreign-spawned larvae into the Florida Keys. Seasonal cycles of currents and winds favor enhanced larval recruitment in the fall season of persistent southwestward winds that can cause a coastal countercurrent over the entire length of the Keys from Key Largo to the Dry Tortugas, combined with seasonal maximum onshore surface Ekman transport and minimum downstream flow in the Florida Current.

5.23 A SIMPLE COUPLED PHYSICAL-BIOLOGICAL MODEL OF THE MARINE PELAGIC ECOSYSTEM

Ivan Lima and Donald Olson
Division of Marine Biology and Fisheries
University of Miami/RSMAS
Miami FL 33149-1098

Coupled physical-biological models are developing as a “tool” in Biological Oceanography. Physical models simulate environmental structure and forcing, and biological models simulate the response of biological systems to this forcing as well as to biological interactions. A three-dimensional, primitive equation, ocean circulation model (Princeton Ocean Model - POM) has been coupled with a Nitrogen-Phytoplankton-Zooplankton-Detritus (NPZD) model to investigate the effects of ocean circulation features and mesoscale variability on the distribution and dynamics of plankton.

In this experiment the coupled model was configured for an idealized 200x150 km zonal channel with a flat bottom and cyclic boundary conditions. The model has a horizontal resolution of 5x5 km with 25 sigma (depth) levels and is forced by an eastward wind stress. The biological fields were initialised with depth profiles (equilibrium solutions) for the four biological compartments obtained from a one-dimensional

version of the biological model, forced only by the vertical distribution of light. Model experiments consisted of 500-day runs.

With this configuration the model produces an eastward jet with strong meandering motions and intense upwelling in the northern part of the channel. The biological compartments respond according to the enhanced flux of nutrients into the photic zone and an area of intense biological production is formed in the upwelling zone. Major biological structures; such as, the Deep Maximum Chlorophyll Layer (DMCL), are reproduced by the model. Although this is a highly idealized case, the overall distribution of phytoplankton and zooplankton produced by the model is also in general agreement with what is observed in upwelling areas.

5.24 OCEANIC PRIMARY PRODUCTION AT THE CARIBBEAN TIME-SERIES STATION (CATS) ESTIMATED FROM PHOTOSYNTHETIC PARAMETERS AND SATELLITE DATA

José M. López, E. Alfonso, A. Dieppa
University of Puerto Rico
Mayaguez, Puerto Rico

Integrated, water column phytoplankton primary production was estimated at the CATS (Caribbean Time-Series Station, 17°36'N, 67°00'W) using available algorithms that relate phytoplankton photosynthetic pigment biomass and available photosynthetic radiation (PAR). Both quantities may soon be operationally available from satellites thus permitting the estimation of oceanic primary production at global scales. We measured vertical profiles of chlorophyll-a fluorescence *in situ* and obtained chlorophyll concentrations by regression with known samples and measured profiles of the underwater light field to obtain diffuse attenuation coefficients in order to model the vertical propagation of PAR incident at the ocean surface. Surface PAR irradiance was modelled by using satellite-derived cloud cover estimates to reduce extraterrestrial solar irradiance. Radiocarbon experiments using a Photosynthetron were conducted to generate P vs E (photosynthesis vs irradiance) curves from which to obtain the photosynthetic parameters α, the Maximum Light Utilization Coefficient and $P^B_{S,}$ the Potential Maximum Photosynthetic Rate. This approach generates data useful for validation and calibration of satellite-derived oceanic primary productivity estimates.

Key words: phytoplankton, primary production, photosynthetic parameters, satellite data, P vs E curves, radiocarbon, irradiance

5.25 THE GULF OF MEXICO PHYSICAL OCEANOGRAPHY PROGRAMME OF THE U.S. MINERALS MANAGEMENT SERVICE

Alexis Lugo-Fernandez
Minerals Management Service,
New Orleans, LA

The Minerals Management Service (MMS), an agency of the U.S. Department of the Interior, oversees the activities of the oil and gas industry in federal waters (from 3 miles offshore to the outer edge of the Exclusive Economic Zone [EEZ]). To fulfil its mission successfully, the MMS needs to collect oceanic data for use in environmental assessments, designing drilling and production structures, conducting drilling operations, and supporting research in other disciplines. In the Gulf of Mexico, MMS has funded or is funding about 50 physical oceanography projects worth about $36 million. These projects include the Gulf of Mexico Physical Oceanography Programme, which concentrated on deepwater and eddies, and the LATEX Programme, which examined the circulation on the Louisiana-Texas shelf and impinging Loop Current eddies and cyclones. More recently, we have funded the Northeastern Gulf of Mexico Programme. This programme consists of five projects: shelf circulation using satellite-tracked drifters, meteorology, remote sensing, circulation in DeSoto Canyon, and the soon-to-begin chemical oceanography and hydrography study.

Plans for the future focus on the deepwater area, slope and rise, where the oil and gas industry is moving very quickly. Our latest lease sales have produced a record number of leases and revenues; over $1 billion have been collected for the rights for exploration and production. This is a frontier area that poses new problems, technologically and environmentally, and imposes new information requirements. In early 1997, we conducted a workshop in New Orleans, Louisiana, and brought together experts to identify and offer advice on the information gaps and needs. Based on this workshop we have designed a deepwater physical oceanography programme that will start in 1998-1999. As recommended by the workshop, we envision a total of three studies: data synthesis, numerical modelling, and field work.

From 16 to 18 December 1997, we will hold the annual Information Transfer Meeting (ITM), a forum for our researchers to present to the public the findings of their studies and to coordinate their different programmes, in New Orleans. We will also discuss topics on environmental and policy concerns with interested parties. This year the ITM will feature a session dedicated to issues of interest to Mexico and the U.S. Because deepwater oil and gas operations are moving so close to the outer edge of the EEZ, both nations recognize the possibility of issues arising that may affect their territories. One objective of this session is to present to industry the international treaties either signed by both countries or under negotiation, which may need to be considered when planning their operations for this area. We are hoping to have speakers from the Mexican Ministry of Energy, PEMEX, and academicians. In fact, Drs. Victor and Francisco Vidal of Instituto Politecnico Nacional, Mexico, have graciously agreed to talk at this session.

5.26 CLIMATE CHANGE SCENARIOS IN THE INTRA-AMERICAS SEA (IAS) REGION

Victor Magaña
Centro de Ciencias de la Atmosfera
Universidad Nacional Autónoma de México
Mexico

Defining the signal of climate change is a complicated problem. Isolating such a signal for a particular region or its role in the dynamics of climate change is a real challenge. At present, very little is known about the role of the Intra-Americas Sea (IAS) in the dynamics of global climate. It is known that it constitutes a major source of heat to the midlatitudes through ocean currents such as the Gulf Stream. From the atmospheric point of view, the intense convective activity during the summer over the IAS results in a strong thermal convective forcing over the Atlantic Ocean and Europe. However, the processes that modulate convective activity over the IAS region, on interannual or longer time scales, are not fully understood. Since the impact of tropical convective activity at a particular location may affect climate at a global scale, the tropical convection variability over the IAS is analysed.

The temporal and spatial characteristics of the NH summer tropical convective activity over the Americas are examined. The evolution of the annual cycle in precipitation over southern Mexico and Central America and the Caribbean exhibits a bi-modal distribution. The structure and intensity of the Trade Winds over the region appear to modulate the intensity of precipitation. During July and August, strong easterlies result in enhanced precipitation along the Caribbean coast of Central America and a decrease in convective activity over the Pacific coast. During El Niño years, enhanced Trade Winds appear over the Caribbean. This effect results in less deep tropical convective activity and fewer hurricanes over the Atlantic and the IAS. Therefore, changes in large-scale circulations may be important in modulating convective activity and are used to generate regional climate change scenarios. Based on this premise, an analysis of some CO2 doubling experiments using General Circulation Models is presented.

5.27 A MASS-BALANCE MODEL OF THE GULF OF MEXICO ECOSYSTEM FOR EVALUATION OF ECOLOGICAL RELATIONSHIPS AND FISHERY STOCKS

Eduardo Martinez
National Marine Fisheries Service
Southeast Fisheries Science Center
Galveston, TX

A collaborative effort among scientists from Mexico and the United States is underway to develop a Large Marine Ecosystem (LME) model which describes trophic linkages among living marine resources and fishery components in the Gulf of Mexico (Pauly et al., in press). Development of the LME is spearheaded by Daniel Pauly (ICLARM, Manila; Univ. of British Columbia, Vancouver), Villy Christensen (The North Sea Centre, Denmark), and Francisco Arreguin-Sanchez (CICIMAR-IPN, Mexico). Additional coordinators include Laura Vidal-Hernandez (INP, Mexico; Univ. of British Columbia, Vancouver), and Eduardo Martinez/Joan Browder (NMFS, Southeast Fisheries Science Center, USA). The Gulf of Mexico ecosystem is appropriate for development of this type of model because of the presence of strong internal fluxes (trophic fluxes) relative to fluxes into and out of the Gulf (Pauly et al., in press). Thus, the elements within the Gulf tend to form an integrated ecosystem as opposed to an assemblage of independent parts.

The proposed LME is a mass-balance trophic model based on the development and integration of various submodels of lagoons, estuaries, and coastal shelf systems (Christensen and Pauly, 1993; Pauly and Christensen, 1993). The subsystems are developed in a standardized format using the Ecopath software (Christensen and Pauly, 1992). Standardization of the subsystems is required to quantify the transfers within and among different areas of the Gulf of Mexico. The model is stratified into subsystems to incorporate local data on trophic groups and their interactions, as well as to account for spatial differences in trophic flux.

The LME and its submodel components are based on the ecological principle that for any given time period, production (biomass) equals consumption (mortality). The Ecopath software and the mass-balance approach allow for minimum input and maximum output, in comparison with other trophic modeling techniques. Since the submodels will be integrated into one concentric model of the Gulf of Mexico, several guidelines have developed for quantifying the subsystems: 1) submodels must include fishery catches for their area such that the sum of all catches, for all areas, equals the total reported fishery catches for the Gulf; 2) submodels must include population estimates for marine mammals, seabirds, and sea turtles such that the combined estimates approximate the best available estimates for stock size within the Gulf; 3) submodels for lagoons and estuaries should primarily include the juveniles of species with strong ontogenetic offshore migration (thus recruiting to offshore waters) and shifts in diet composition; and 4) submodels for the shelf and offshore areas should focus on adult forms of living marine resources (Pauly et al., in press).

Currently, 15 submodels are being developed for inclusion in the LME. The submodels encompass different geographic areas throughout the Gulf of Mexico, including estuarine, mangrove, and coral reef habitats, as well as shrimping grounds and coastal shelf ecosystems. Of the 15 submodels, at least 11 of them are from areas in the southern Gulf of Mexico in waters under Mexican jurisdiction. Four submodels for the northern Gulf of Mexico are being developed and quite possibly an additional four subsystems in the northern Gulf will be included in the LME. The project is ongoing and completion of the LME is expected by late 1998.

References

Christensen, V. and D. Pauly, 1992. Ecopath II - A software for balancing steady-state models and calculating network characteristics. Ecol. Model., 61: 169-185.

Christensen, V. and D. Pauly (eds.), 1993. Trophic models of aquatic ecosystems. ICLARM Conference Proceedings, 26. 390 pp.

Pauly, D and V. Christensen, 1993. Stratified models of large marine ecosystems: A general approach, and an application to the South China Sea. In, K. Sherman, L.M. Alexander and B.D.Gold (eds.), Stress, Mitigation and Sustainability of Large Marine Ecosystems. AAAS Press, Washington, D.C., p. 148-174.

Pauly, D., F. Arreguín-Sanchez, J. Browder, V. Christensen, S. Heilemann, E. Martinez, and L. Vidal-Hernandez, 1997. Toward a stratified mass-balance model of trophic fluxes in the Gulf of Mexico large marine ecosystem. In, H. Kumpf and K. Sherman (eds.), Proceedings of the Gulf of Mexico Symposium, April 1997, New Orleans, La. Manuscript in review for publication in 1997.

5.28 SIMULATED SURFACE TRANSPORTS IN THE IAS

Christopher N.K. Mooers and Lianmei Gao
Ocean Prediction Experimental Laboratory (OPEL)
University of Miami/RSMAS
Miami, FL

IAS-POM is a mesoscale eddy-admitting implementation of POM for the IAS. For the case presented, only climatological mean throughflow and windstress forcing are used to drive the model. Of particular interest here is the intrinsic space-time variability in the southwestern Caribbean Sea; viz., the Panama-Colombia (cyclonic) Gyre (PCG) subsystem. IAS-POM is used to simulate some possible surface particle trajectories from a surface particle source in the PCG. This simulation serves to illustrate some of the surface transport processes, pathways, and rates. The results include patterns that indicate connectivity between the PCG and various subdomains of the Gulf of Mexico on ecologically interesting time scales.

5.29 FAR FIELD PROCESSES AND RED TIDES IN THE MID-IAS AND EASTERN GOM

Frank E. Müller-Karger
University of South Florida
St. Petersburg, Florida

Fred M. Vukovich
Earth and Atmospheric Systems Operation
Science Applications International Corp.
Raleigh, NC 27605

Toxic dinoflagellate blooms occur on the Bank of Campeche of the Yucatan Peninsula (Mexico) during summer and fall, in contrast with diatom blooms in the winter and spring. Data from the Coastal Zone Color Scanner shows these blooms are often entrained into the Yucatan/Loop Current (LC) system, and then transported north and east into the GOM. LC water can then be entrained onto the shelves in the eastern GOM, and reach as close as 10 km from the coast. These intrusions have been found to contain microscopic toxic algae which may "seed" the shelf and produce red tide blooms.

Here we propose that investigators of the IAS develop a joint programme to document the frequency of occurrence of red tide organisms on and near Campeche, and to test the hypothesis that phytoplankton from the Campeche Bank are responsible for red tides on the continental shelves of the eastern GOM. The objective would be to investigate the relationship between transport of algal biomass from the Campeche Bank by the LC into the eastern GOM and red tide blooms on the continental shelf in these regions. We propose to establish a monitoring programme in the GOM using satellite remote sensing data to develop case histories depicting the biomass transport from the Campeche Bank, entrainment of LC water onto the shelf in the eastern GOM, and the subsequent occurrence of red tides. This proposal includes retrospective CZCS and AVHRR satellite data. A robust cruise plan is needed to validate the satellite data taking taxonomic samples and key bio-optical measurements.

A contribution will be the capability to monitor remote areas for hazards that may have an impact on local communities, and thus enhance our ability to forecast the occurrence red tides along the coasts of the IAS. As a part of this programme, we propose to develop a programme to provide satellite imagery to other investigators in the region and other products to the public via our web page.

5.30 THE CARIACO (CARBON RETENTION IN A COLORED OCEAN) TIME SERIES PROGRAMME

Frank Muller-Karger
University of South Florida
St. Petersburg, FL

Robert Thunell
University of South Carolina
Columbia, SC

Mary Scranton
State University of New York at Stony Brook
Stony Brook, NY

CARIACO (CArbon Retention In A Colored Ocean) is a multidisciplinary oceanographic time series programme established in the Cariaco Basin (Caribbean Sea) to define a budget which assesses the total CO_2 upwelled with deep, nutrient-rich water with respect to annual export of organic carbon from surface waters along a continental margin. The time series was implemented in November 1995, with funding from the NSF in

collaboration with the Consejo Nacional de Investigaciones Cientificas y Tecnologicas (CONICIT) of Venezuela. In February, 1997, NASA selected CARIACO to be part of the SIMBIOS network for validation of satellite ocean color products. This is a collaborative programme between US and Venezuelan institutions, in which each of the participating groups is separately funded to address unique hypotheses.

There is increasing evidence that the tropical Atlantic, and particularly the Caribbean Sea, may function as a "barometer" of global change. Indeed, the Caribbean experiences the most marked of the El Niño teleconnections in the Atlantic Ocean. The Cariaco Basin is ideal for a study of the connection between such processes and carbon flux because it forms a natural sediment trap in a continental shelf area where advection below 150 m is restricted. Therefore, the sinking flux of organic matter is sequestered into the Basin, making it easier to quantify compared to other continental margins. The Cariaco Basin is a natural recorder of climate change; it is the only permanently anoxic basin in the world's oceans, and as such serves as an oceanic analog of the Black Sea.

The main objective of CARIACO is to examine how large-scale phenomena and changes in climate affect carbon flux at a continental margin site. This requires systematic observation of a few core variables over a long period, to be able to recognize the long-term trends over short-term variations. Three US institutions (University of South Florida/USF, University of South Carolina/USC, and State Univeristy of New York, Stony Brook/ SUNY) have joined with three Venezuelan institutions (Fundacion La Salle/FLASA, Universidad Simon Bolivar/USB, and Universidad de Oriente/UDO) to implement the time series programme required to address this objective. This partnership provides substantial scientific results for very low cost.

The time series is located at 10.50 N, 64.66 W, and consists of a mooring with four sediment traps (200, 400, 800, 1200 m; bi-weekly sample integrations), an upward-looking Acoustic Doppler Current Profiler (ADCP, 200 m), and monthly cruises. USF, FLASA, UDO, and USB have primary responsibility for a basic set of core measurements, interpretation of synoptic satellite observations, and modelling processes which affect the flux of carbon and of other elements. The core measurements, defined as those most relevant to understanding the exchange of CO_2 with the atmosphere and upper ocean, as well as understanding processes which affect the exchange of waters on the shelf, include the basic hydrography, winds and ancillary parameters, the stocks of carbon and nutrients including the carbonate system, particulate composition, and phytoplankton biomass, and primary productivity. USC works closely with FLASA to measure the vertical flux of particulate material, using the moored sediment traps. SUNY works closely with UDO and FLASA to address time variations in the vertical distribution of bacterial biomass and productivity, which are key components of this anoxic ecosystem. Combined, the results from these separate studies provide a robust basis from which to address the overarching hypotheses.

5.31 THE CONNECTIVITY OF MESOSCALE VARIABILITY IN THE CARIBBEAN SEA, THE ATLANTIC OCEAN, AND THE GULF OF MEXICO

Sylvia J. Murphy & Harley E. Hurlburt
Naval Research Laboratory
Stennis Space Center, MS

James J. O'Brien
Florida State University
Tallahassee, FL

A set of global numerical simulations is used to investigate Caribbean Sea mesoscale variability. Two nonlinear simulations have 1/4° resolution using a 5.5-layer reduced gravity model and a 6-layer model with realistic bottom topography. The third simulation is from a 1/2° linear model. In the two nonlinear simulations, eddies form on the western side of the Lesser Antilles because potential vorticity that is advected through the island passages from the Atlantic act as finite amplitude perturbations for both baroclinic and barotropic instability. There are two sources of this potential vorticity 1) decaying rings from the North Brazil Current Retroflection, and 2) rings from the Subtropical Gyre. Additional eddies form in the wake of Grenada. As these eddies transit the basin, they intensify in association with a multi-year anomaly in the strength of the Caribbean circulation that is concentrated in the central and western Caribbean Sea. This multi-year circulation anomaly is linked to anomalous wind stress fields for the same period. The intensified eddies are observed in the numerical simulations to influence the Loop Current eddy-shedding in the Gulf of Mexico. In the nonlinear reduced gravity simulation, 56% of the eddy-shedding events can be linked to eddies from the Caribbean Sea propagating through the Yucatan Channel.

5.32 A METHOD TO ESTIMATE THE GEOSTROPHIC BALANCED FIELDS FROM SIMULTANEOUS HYDROGRAPHIC AND HORIZONTAL VELOCITY OBSERVATIONS IN THE WATER COLUMN

J. Ochoa[1], J. Sheinbaum[1], J. Candela[1], A. Badan[1] and D. Wilson[2]
[1]Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Baja California, Mexico
[2]AOML, NOAA, Miami, FL

Measuring horizontal velocities together with hydrography, by lowering an ADCP on a typical CTD cast, allows new estimates of the fields in geostrophic balance. Here we propose a method which searches for the geostrophicaly balanced fields which are closer, in some quadratic measure, to the observations.

Cross differentiation to eliminate pressure in the geostrophic balance gives a purely horizontal nondivergent flow and the thermal wind equation, balances that are not well preserved in most instantaneous maps. Besides, the geostrophic information of the measurements resides precisely in the combination of partial derivatives which add to the potential vorticity. As in geostrophic adjustment, the potential vorticity deduced from the measurements must remain in the geostrophic components, the residual anomalies are potential vorticity free.

This classical result in the geostrophic adjustment of arbitrary fields is re-established, in this version for linearized dynamics, as a result of minimizing the energy present in the anomalies. The measured distributions are the addition of the geostrophically balanced fields and the anomalies. This variational approach leads to the Poisson equation for the geostrophic pressure forced by the potential vorticity inferred from the measurements, hence, yielding the conservation law. In addition, this method offers a direct choice for the boundary condition, that which optimises the energy retained in the geostrophic estimate.

As an example, the method is applied to a vertical section across the Yucatan Channel, interpolating our measurements by objective mapping.

5.33 COMPARISON OF MODEL SIMULATIONS WITH OBSERVATIONS OF THE LOUISIANA-TEXAS SHELF

Renellys C. Perez and Christopher N.K. Mooers
University of Miami/RSMAS
Ocean Prediction Experimental Laboratory (OPEL)
Miami, FL

The Dynalysis of Princeton version of POM was driven by synoptic atmospheric forcing for 10 years to simulate the circulation of the Gulf of Mexico. The LATEX current meter data were used to evaluate the numerical simulations, especially along the Louisiana-Texas shelfbreak. The model output has variability similar to the observations, especially for near-inertial motions; though the model variance was less than that observed, the agreement generally improved with increased model horizontal resolution. However, there were large discrepancies between the model and observed means. In particular, the model output indicates a mean eastward, subsurface jet over the shelfbreak that does not exits in the observed means. Presumably, this mean jet is associated with the Western Gulf of Mexico Anticyclonic Gyre which may have been displaced northward in the model. Other possible explanations include various physical and numerical errors in the model. Nonetheless, the model output *versus* observational data comparison is encouraging.

5.34 PRELIMINARY ANALYSIS OF SEA SURFACE HEIGHT VARIABILITY FROM TOPEX/POSEIDON OVER THE INTRA-AMERICAS SEA

Robert W. Pratt & G.A. Maul
Division of Marine and Environmental Systems
Florida Institute of Technology
Melbourne, FL

The basis of this study is the analysis of sea surface height variability of the IAS for the period of OCT 1992 through DEC 1995. The TOPEX/Poseidon data set used in this study was obtained from the ftp site for NOAA's Laboratory for Satellite Altimetry. This analysis involves the study of the time series for sea level deviation for 529 points located along the satellite tracks.

The standard deviation of each time series was determined and contoured for the region. The data were gridded using a bi-linear method for interpolation. Points in close proximity to land masses showed aliasing that appears to be tidal. In the vicinity of the Loop Current, results showed similarity to those of prior studies by *Maul and Herman (1985)*.

This study also includes an analysis of several crossbasin satellite tracks. Variances in the sea surface height time series were identified and tracked along the path of the Caribbean Current and the Loop Current in an attempt to quantify the frequency and magnitude of eddy events.

5.35 INSTRUMENTATION REQUIREMENTS IN THE GULF OF MEXICO: MEXICAN OIL INDUSTY PERSPECTIVE

Rafael Ramos
Instituto Mexicano del Petróleo
Eje Central L. Cárdenas 152
México D. F., 07730
México

Miguel Castañeda
PEMEX Exploración y Producción
1 Piso Blvd. A. Ruiz C. 1202
Villahermosa, Tabasco, 86030
México

In general, the oil industry around the world is interested in gathering meteorological and oceanographic (metocean) information for several purposes. Among other reasons, the metocean information is required for evacuation of personnel, structural design and assessment of production facilities, oil spill response, and marine operations. From the structural design and assessment point of view, the characterization of different sea states by defining significant wave heights and associated periods, surges, currents (at different depths), and wind velocities is sufficient for analysis purposes. Once these properties are defined for an adequate sample of storms (e.g., hurricanes and winter storms in The Gulf of Mexico) an analysis of extremes is performed to establish adequate return periods for design and assessment.

In general, given the limited storm measurements, wave models are used to hindcast each storm in the sample. However, storm characteristics seem to be model dependent. Even for the most refined state-of-the-art models, the storm characteristics are biased. Hurricane Roxanne, in 1995, gave PEMEX and IMP the opportunity to review the storm characterization and redefine wave parameters for design and assessment of platforms and pipelines in Campeche Bay. The damage found in the facilities urged the development of risk-based criteria that considered wave model biases. This, however, was based on very limited measurements.

From the above background, it is clear that there is an immediate need for a comprehensive wave, current, surge, and wind measurement campaign in the area in order to further refine the design and assessment criteria. Additionally, special topics like wave-soft-soil interaction and pipeline-soil interaction must be addressed with proper instrumentation for model calibrations. The proposed campaign is likely to include oil spill response and wave forecast topics within its scope.

5.36 ACOUSTIC ESTIMATES OF ZOOPLANKTON AND MICRONEKTON BIOMASS USING AN ADCP IN WARM AND COLD-CORE RINGS OF THE GULF OF MEXICO

Patrick H. Ressler, D.C. Biggs, and J.H. Wormuth
Department of Oceanography
Texas A&M University
College Station, TX

A 153 kHz narrow-band Acoustic Doppler Current Profiler (ADCP) was used to acquire calibrated backscatter intensity (Sv) data during two cruises in the Gulf of Mexico. The first cruise, 10 to 28 OCT 1996, sampled a cold-core ring and Loop Current Eddy C in the eastern Gulf during a survey of marine

cetacean habitat and abundance. Sv data on this cruise were acquired while underway along transect survey lines across the two features, and zooplankton and micronekton stocks were sampled at 19 locations with a 1 m2 MOCNESS (Multiple Opening-Closing Net Environmental Sensing System). The second cruise, 23 to 28 June 1997, revisited Eddy C in the western Gulf and acquired a 60-hour time series of Sv data of opportunity near the eddy centre. Spatial and temporal variations in Sv and differences in standing stocks of zooplankton/micronekton were correlated; there was a positive functional relationship between Sv and the wet displacement volume of MOCNESS collections (r2=0.57, n=99). Sv data collected with ship-mounted as well as with moored ADCPs may provide insights into cetacean habitat preference, for many marine mammals feed either directly or indirectly on deep-scattering layer migrators. It is thought that Sv data used as an index of zooplankton/micronekton standing stocks will allow to making inferences about differences in secondary biological productivity of such vertical migrators in warm- and cold-core rings, which are the dominant mesoscale circulation features in the Gulf of Mexico.

5.37 A GENERIC ONE-DIMENSIONAL (VERTICAL) NUMERICAL SIMULATION OF OXYGEN DISTRIBUTION IN COASTAL ECOSYSTEMS: A COMPARISON OF BIOLOGICAL AND PHYSICAL PROCESSES

Gilbert T. Rowe
Department of Oceanography
Texas A&M University
College Station, TX

A generic, one dimensional, time-dependent numerical simulation has been constructed to explain the distribution of oxygen concentrations in coastal oceans. Production is a function of both light and available inorganic nutrients. Data available within and under the Mississippi Rive plume indicate that production can be important throughout the water column and on the sea floor. Production is a function of diel variations in available light at all depths. Consumption is dominated by respiratory processes in deep water and in the sediments, especially when light transmission in the water column is restricted due to high particle loading from suspended clays or phytoplankton cells. The model attempts to compare the relationship between net biological production or consumption terms with the redistribution by vertical mixing processes. Simulations are used to explain large and small-scale temporal variations in oxygen concentration under the Mississippi River plume during the summer. It is anticipated that the model could be applied to most isolated basins in which horizontal exchanges are relatively unimportant. Horizontal advective processes will need to be included for application to open shelf ecosystems.

5.38 VELOCITY AND TRANSPORT MEASUREMENTS WITH A LOWER-ACOUSTIC DOPPLER CURRENT PROFILER IN THE YUCATAN CHANNEL: SOME PRELIMINARY RESULTS

J. Sheinbaum, J.Candela, J. Ochoa, A. Badan, & I. Gonzalez
CICESE
Ensenada, B.C., Mexico

D. Wilson & R. Smith
NOAA/AOML
Miami, FL

We present preliminary results from the extensive surveys carried out onboard UNAM's R/V "Justo Sierra" using a shipboard ADCP and a CTD/LADCP during DEC 1996 and MAY 1997 in the Yucatan Channel. These cruises were part of the CANEK Project, a collaborative effort between, CICESE, ICMyL-UNAM, UAM, Mexico, NOAA, USA and IOC, Cuba, to measure the exchange between the Caribbean Sea and the Gulf of Mexico. Velocity measurements and transport estimates from both instruments are analysed and compared. The MAY 1997 cruise had a standard GPS instrument to fix ship positions, which were recorded almost continuously (every second) during the entire cruise. These data were filtered before velocity and transport calculations were made. Details of the data processing and sensitivity of absolute velocity estimates from the LADCP instrument to the ship's position are also discussed.

5.39 PROGRESS IN THE STUDY OF THE BENTHIC SYSTEM OF THE GULF: SHELF AND DEEP-WATER ENVIRONMENTS

Luis A. Soto & Elva Escobar Briones
UNAM
México

The long-term study of the Mexican continental shelf environment in the Gulf of Mexico has revealed the existence of a complex benthic system whose production mechanisms appear governed by a two-layered hydrographic condition promoted by the prevailing annual oceanic climatic regime. In the SW region, benthic biomass is enhanced by pelagic-benthic coupling, and a heavy subsidy of coastal organic materials during the winter storm period.

Much of the allochtonous material is diverted to the benthos where the organic carbon flows through an essentially detrital food web. These conditions are mainly restricted to the inner and middle shelf boundaries; the outer shelf reflects a situation in which oceanic intrusion is more evident but the reduced benthic complexity cannot assimilate the heavy organic load provided by local rivers; presumably much of such materials is being exported to the immediate upper continental slope. Recent observations made across the slope just off the Coatzacoalcos River attest to an unsually enriched epibenthic community detected in canyon like structures that act as carbon sinks to the benthos, near the depth of the permanent thermocline (500 m).

The benthic system of the NW continental shelf, in turn, is highly influenced by antyciclonic rings shed by the Loop Current, and the river runoffs and fronts. The former phenomenon promotes a high benthic production along the shelf margin, and the latter accounts for much of the inputs of organic materials to the coastal benthic compartment.

The Yucatan shelf has low terrigeneous input, and its benthic production is largely supported by autochtonous bottom primary productivity, complemented by an impoverished vertical flux of POC.

An attempt to generate a mass-balance trophic model of the SW sector of the Gulf confirmed the imbalance between primary production and consumption, and the high exportation to a detritus sink. Based on this preliminary model, the SW shelf system is relatively mature and stable.

5.40 EFFECTS OF MODEL GRID RESOLUTION AND ATMOSPHERIC FORCING ON SIMULATED FLOW IN THE INTRA-AMERICAS SEA REGION OF NORTH ATLANTIC BASIN-SCALE OCEAN MODELS

Tamara L. Townsend, H.E. Hurlburt, & P.J. Hogan
Naval Research Laboratory Code 7323
Stennis Space Center, MS 39529-5004

When modelling the North Atlantic basin circulation, the simulated transports and transport pathways in the Intra-Americas Sea (IAS) region are heavily dependent on the atmospheric forcing set, the grid resolution, and the representation of the passages, which in turn depends on the grid resolution, the accuracy of the topographic data set, and the interpolation of the topographic data on to the model grid.

Many large-scale models have failed to produce sufficient transport through Yucatan Channel and, as a result, a realistic Gulf of Mexico Loop Current and Loop Current eddy shedding. The reason for this shortcoming is insufficient model grid resolution, which results in inaccurate simulated pathways of the flow through the passages in the Bahamas region. This is shown using linear and non-linear versions of the NRL Layered Ocean Model (NLOM), with grid resolutions ranging from 1/2 to 1/16 degree for the linear simulations and 1/2 to 1/32 degree for the non-linear simulations. There is resistance to flow through Windward Passage into the Caribbean Sea at 1/8 degree, yet this resistance is not present in the 1/16 degree and 1/32 degree simulations. The same resistance which results in the 1/8-degree model is present in the 1/4 degree version, although a realistic pathway through Windward Passage occurs because there is greater

resistance to northward flow east of the Bahamas, a consequence of the presence of several narrow island passages north of Windward Passage.

It has been previously demonstrated that the North Atlantic Sverdrup transport varies depending on the wind stress data set used. A linear reduced gravity version of NLOM has been forced at 1/2, 1/4, 1/8 and 1/16 degree resolution by ten different wind stress data sets to examine the effects of wind stress forcing and the resolution of the complicated IAS geometry on the model-simulated linear flow. Within the IAS, this flow includes portions of the North Atlantic subtropical gyre and the adjacent cyclonic tropical gyre to the south. Eight of the ten wind stress climatologies used to force the model were derived from interannual time series; three were derived entirely from observations, four were generated from operational atmospheric model nowcasts, and three were reanalyses formed from current and fixed-in-time versions of operational atmospheric forecast models.

Comparison of the simulated linear flow in the Caribbean Sea, Bahamas and Gulf of Mexico regions indicates the importance of careful selection of the wind stress data set used for computation of Sverdrup transport. Computed numerically using realistic geometry, the northward Sverdrup flow at 27^{o}N resulting from the different atmospheric forcing datasets ranges from less than 19 Sv to nearly 37 Sv. There are several features of the simulated IAS circulation whose characteristics depend on the wind stress forcing used in the model. In addition to its dependence on the model grid resolution, the simulated Sverdrup flow through Yucatan Channel differs by more than 8 Sv between simulations forced by monthly mean wind stress climatologies of the operational ECMWF 1000 mb 1981-1993 and the FNMOC surface stress products. Cyclonic local wind stress curl north of Windward Passage yields southward Sverdrup transport along the western boundary formed by Cuba. The characteristics of the Gulf of Mexico circulation and the anticyclonic gyre in the northern Caribbean Sea vary depending on the wind stress data set as does the magnitude of the cyclonic gyre (PCG) north of Panama and Colombia.

5.41 FORMATION AND EVOLUTION OF THE WESTERN BOUNDARY CURRENT IN THE GULF OF MEXICO

Víctor M.V. Vidal, F.V. Vidal, L. Zambrano, & J. Portilla
DEPI - Instituto Politecnico Nacional
Instituto Politécnico Nacional
Cuernavaca, Morelos, México

The geostrophic circulation in the Gulf of Mexico during MAR 1985 reveals the collision of a Loop Current (LC) anticyclonic ring 500 km in diameter against the western Gulf margin. The anticyclone's collision originated north and south flanking cyclones 100-200 km in diameter; 40 cm/s baroclinic currents characterized this ring triad system. During JUL to AUG 1985, the ring triad weakened and evolved into a 900 km north flowing, along-slope, western boundary current and cyclonic-anticyclonic ring pairs distributed throughout the central and western Gulf. The western boundary current system had a maximum intensity of 40 cm/s and mass-transport of 8 Sv between 95° to 96°W at 25°N. Its evolutionary period, from gestation to decay, is ~ 300 days. Thus it appears plausible that the ~ 11 month LC ring-shedding periodicity could be associated with the strengthening and/or slackening of the western boundary current's oscillation mode within the Gulf basin. Although the Gulf's western boundary current has been attributed to the annual wind-stress curl, our data and observations reveal that the current is driven by the collision of LC anticyclones against the continental shelf-slope and by the decay of cyclone-anticyclone-cyclone triads which are subsequently created from these ring-slope collisions.

5.42 VERTICAL TRANSPORTS IN CYCLONIC-ANTICYCLONIC RING PAIRS AND ITS IMPLICATION FOR REGULATING CO_2 EXCHANGE BETWEEN SURFACE AND DEEP WATERS IN THE GULF OF MEXICO

Víctor M. V. Vidal, F.V. Vidal, L. Zambrano, & J. Portilla
DEPI - Instituto Politecnico Nacional
Instituto Politécnico Nacional
Cuernavaca, Morelos, México

The resultant effect of the coupled interaction between cyclonic-anticyclonic ring pairs and triads in the Gulf of Mexico is the surging of the water mass in the cyclones and its sinking in the anticyclones. This mechanism controls the magnitude, direction, and location of vertical advection and the transfer of kinetic energy from the upper layer to the deep-water layers. Vertical transport estimates through the 1000 m-depth interface, for the western Gulf cyclonic-anticyclonic system, during JUL to AUG 1985 and OCT to NOV 1986, revealed a net vertical descending transport of 0.4 Sv. This mass flux constitutes the principal mechanism that propels the Gulf's deep horizontal circulation. The volume renewal time for the western Gulf ring triad systems' 0 to 1000 dbar layer is ~5 years. The water renewal time for Gulf's deep water layer (2000 to 3000 dbar), estimated as a function of its horizontal outflowing mass transport of 0.6 to 2.0 Sv, is of the same order of magnitude and reveals that the deeper layer of the Gulf of Mexico is as well ventilated as its upper layer (0 to 1000 dbar). Given this efficient vertical exchange within the Gulf's surface and deep water layers and the net 0.6 Sv downward transport estimated through the 0 to 3000 dbar layer for JUL to AUG 1985, it is concluded that this descending mass flux constitutes an efficient mechanism by which surface water CO_2 is most likely being downwelled into the Gulf's deep layer. If an average CO_2 concentration in the Gulf's surface waters (100 dbar) of 2.3×10^{-3} mol $[CO_2]$ L^{-1} is assumed, then the rate of CO_2 removal from the Gulf's surface waters into its deep layer, when considering a downwelling transport of 0.6 Sv, is of the order of 60×10^3 kg $[CO_2]$ s^{-1}. If this estimate is ballpark-accurate, it would indicate that the western Gulf of Mexico probably constitutes an important regional sink for atmospheric CO_2. It would also further indicate that accurate knowledge of the distribution of relative vorticity in the world's oceans is crucial to estimate the oceans' capacity to remove surface water CO_2 into its intermediate and deep water layers.

5.43 HYDROLOGICAL EVIDENCES OF DEEP AND SHELF WATER EXCHANGE OVER THE EASTERN YUCATAN SLOPE

Ivan Victoria
Instituto de Oceanologia, CITMA
Havana, Cuba.

The hydrography of the eastern shelfbreak of the Yucatan peninsula, measured during oceanographic cruises in July 1994, March 1995, and May 1997 shows different structures. In the first two cases, the outcrop of the thermocline at the surface was clear, and a hydrological front was present. In comparison with winter, an intensification of property gradients across the frontal zone was noticed during summer, which is the season of more intense oceanic circulation in the region and more important upwelling episodes over the Yucatan slope. In May 1997, the evidence for the existence of a hydrological front was unexpectedly weak. A hypothesis of a possible relationship among oceanic circulation, continental slope upwelling, and frontal zone occurrence is discussed, based on the analysis of hydrographic conditions and geostrophic transport estimates through Yucatan Channel. This analysis leads to the idea that the more intense the western Caribbean circulation is, expressed in terms of geostrophic volume transport through the Yucatan Channel, the more significant are the episodes of upwelling and frontal zone occurrence over the slope. However this hypothesis cannot be considered conclusive because it is not well documented with observational data, and because the role of the wind in the upwelling formation processes is not included in the analysis.

5.44 SATELLITE OBSERVATIONS AND NUMERICAL MODELING OF UPWELLING OVER THE CAMPECHE BANK

Susan E. Welsh & Nan D. Walker
Coastal Studies Institute
Louisiana State University
Baton Rouge, LA 70803

Satellite data from the GOES-8 geostationary satellite and from the NOAA polar-orbiting satellites were used to investigate the spatial and temporal variability of upwelled waters at the surface over the Campeche Bank from MAR to OCT 1997. The satellite data were received and processed at the Earth Scan Laboratory, LSU. The GOES-8 night-time composite imagery, produced using 10 to 12 images/night using the mid-infrared channel (3.5-3.9 μm), provided relatively "cloud-free" Channel 4 imagery, revealing the

presence of upwelled waters on the bank from March into October 1997. Two main upwelling regions were identified. One upwelling region was located north of Cabo Catoche, with an upwelling tongue extending towards the northwest. The second upwelling region appeared as a cool coastal band which extended along the length of the north Yucatan coastline and 30 to 40 km from the coast. During summer, the upwelled waters were often observed to curve southward into Bahia de Campeche. At other times, NOAA satellite imagery suggested surface flow towards the northwest. Animation of the GOES imagery clearly demonstrated a westward flow within this band during August 1997. The coldest upwelled waters were about 23.5°C from March through August 1997, and somewhat warmer in September and October 1997. The upwelled waters became more distinct as the Campeche Bank waters warmed in late spring and summer to 30°C. The site of minimum temperature varied from image-to-image, suggesting a very dynamic system.

The most likely source for the cool surface water on Campeche Bank is the water upwelled along the bottom on the eastern flank of the Yucatan Current. Hydrographic measurements have revealed the presence of vigorous upwelling near Cabo Catoche primarily in spring and sometimes in summer (Cochrane, 1968,1969; Ruiz, 1979; Merino, 1997). In spring and summer, a dome of cool water has been observed near the bottom with a strong thermocline separating it from the warmer surface water. This cool subsurface water breaks the surface at Cabo Catoche and along the Yucatan coastline when upwelling-favorable northwestward winds prevail. Climatological data shows that this wind regime occurs most frequently in spring and summer.

A primitive-equation numerical model, developed primarily to describe seasonal circulation in the Gulf of Mexico, successfully reproduces the spring peak in upwelling near Cabo Catoche. The model features relatively low friction and small grid spacing to realistically simulate the behaviour of the Loop Current, associated rings, and other mesoscale circulation features. The model upwelling plume is observed to generally extend northwestward off the northern coast of Yucatan, but it also can extend northward along the western link of the Loop Current. East-west cross-sections of model temperature across Yucatan Channel, and animations of horizontal temperature and velocity fields in Yucatan Channel at 187.5 m, indicate that the model upwelling is fed by cool waters along the eastern slope of the Yucatan Peninsula. These model results indicate that the upwelling is at least partly due to Ekman transport from bottom friction induced by the bottom current. The timing of the late spring maximum in model upwelling is directly correlated with both the maximum upper layer current speeds of the Yucatan Current and the maximum in the northward component of the local wind stress. The maximum southward local wind stress coincides with the minimum in the Yucatan Current speed and the abatement of the upwelling in winter. The north-south component of wind stress appears to indirectly diminish the upwelling produced by bottom Ekman transport in winter, and to contribute to the upwelling in late spring and summer.

5.45 CONSTRUCTING AN IAS REGIONAL GLOBAL OCEAN OBSERVING SYSTEM

W. Douglas Wilson
NOAA/AOML
Miami, FL

The Global Ocean Observing System (GOOS) was established as an international programme in 1993 by the IOC, WMO, UNEP, and ICSU. The main elements are the collection and timely distribution of oceanic data and products, including assessments, assimilation of data into numerical prediction models, the development and transfer of technology, and capacity building within participating member states to develop analysis and application capability. To date, national GOOS operational activities worldwide are primarily split between global programmes (supported almost entirely by a small number of the more-developed countries) and regional networks of linked coastal and nearshore programmes, such as EURO-GOOS in the EU and NEAR-GOOS in northeastern Asia. The IOC suggests that "...In regions having existing IOC Sub-Commissions (e.g., IOCARIBE), countries organizing regional GOOS activities will do so in consultation with the Sub-Commission." Subsequently, both IOC and IOCARIBE have expressed support for the development of an IAS regional GOOS.

Because of the nature of the IOCARIBE Member States, which contain far fewer autonomous national oceanographic programmes than eastern Asia or western Europe, the IAS-GOOS paradigm will

have a somewhat different structure than NEAR-GOOS or EURO-GOOS. A dialogue is promoted about planning for the implementation of an IAS regional GOOS. For discussion purposes, some important issues to be addressed in planning an IAS-GOOS include:

- Identification of customer concerns; e.g., fisheries, climate studies, pollution management, etc., in keeping with the primary GOOS goal of providing practical benefits to society;
- Design of a scientifically sound, expandable pilot observing system for continual monitoring;
- Model development to provide framework for data synthesis and programme expansion;
- Utilization of existing and planned regional programmes and regional parts of global programmes as components for cost-efficiency;
- Regional dispersal of technology and capacity building for synoptic data acquisition, management, and utilization.

5.46 ATLANTIC - CARIBBEAN WATER EXCHANGE: A QUANTITATIVE SUMMARY OF OBSERVATIONS

Doug Wilson & Elizabeth Johns
NOAA/AOML
Miami, FL

William Johns
University of Miami/RSMAS
Miami, FL

The need for capable IAS circulation models is growing as regional researchers seek input for studies of air-ocean-land interaction, climate variability, fisheries management, and pollution control. Proper boundary conditions will be essential to the operation and validation of these models. The water masses that enter, transit, and exit the IAS are determined by interaction between the Atlantic thermohaline and wind-driven circulations as well as regional modifications within the IAS itself. Existing data on transports into, within, and out of the IAS are quantitatively summarized to aid understanding of the IAS general circulation, provide initial conditions, and serve as benchmarks for model evaluation.

Passages are categorized as inflows (passages of the Antilles and Bahamas), internal (Pedro Banks, Yucatan Channel, western Straits of Florida), or outflows (northern Straits of Florida). Inflow passages are further subdivided by geographic location (southern / northern); transport and water mass characteristics vary markedly between northern and southern due to their location relative to the western Atlantic gyre and wind field structure. Range of variability as well as mean flow values are estimated when possible, as this is important to the evaluation of model dynamics.

A significant result of this summary is a ‘best estimate’ of mean transport distribution and variability by region, passage, and depth level. These values are compared to transports derived from mean hydrographic and wind fields.

5.47 MONITORING THE PULSE OF THE DWBC IN THE ANEGADA PASSAGE

W. Douglas Wilson
NOAA/AOML
Miami, FL

Douglas Wallace
Brookhaven National Laboratory
US Department of Energy
Upton, NY

Ronald Olivacce & Roy A. Watlington
University of the Virgin Islands
St. Thomas, VI

William E. Johns
University of Miami/RSMAS
Miami, FL

A serial station in the Anegada Passage, site of significant surface transport and of the deepest exchange between the Atlantic Ocean and the Caribbean Sea, is contributing to earlier observations at this location to provide a useful background against which variability of the Deep Western Boundary Current (DWBC) can be contrasted. Profiles of dissolved inorganic carbon, dissolved oxygen, chlorofluorocarbons,

and standard hydrographic variables have successfully portrayed the several water masses transiting this location at depths down to 1900 m. Significantly, the southward advance of the prodigious flow of Labrador Sea Water observed at Abaco is expected to manifest itself at this station within the coming year. ACTS is a project of the University of the Virgin Islands conducted in partnership with BNL and the AOML. The study, in itself, represents a successful collaborative model whereby long-term oceanic observations are conducted at minimal expense.

5.48 THE COMPREHENSIVE OCEAN-ATMOSPHERE DATA SET (COADS): HIGH RESOLUTION PRODUCTS AND FUTURE PLANS

Scott D. Woodruff & Henry F. Diaz
NOAA/Climate Diagnostics Center
Boulder, CO

Steven J. Worley
National Center for Atmospheric Research
Boulder, CO

The Comprehensive Ocean-Atmosphere Data Set (COADS) is the most extensive and widely used surface marine data set available for the World Ocean back to 1854, prepared as part of of a continuing cooperative project since 1981 between the U.S. National Oceanic and Atmospheric Administration (NOAA) and National Center for Atmospheric Research (NCAR). Meteorological observations from ships, augmented in recent years by automated *in situ* (e.g., buoy) measurements, have been unified into a single format, the data quality controlled, and monthly summaries constructed using 2-degree latitude x 2-degree longitude boxes for each year of the period-of-record, now 1854 to 1995.

Available COADS observational and summary products are reviewed, highlighting new sets of summaries created for 1960 to 1993 at higher spatial resolution (1-degree x 1-degree), including an expanded set of 22 variables, in support of NOAA's Pan-American Climate Studies (PACS) Programme. In addition to a global grid, the PACS products include summaries for the equatorial region from 10.5N to 10.5S, with the grid reoriented with respect to the global set so that a 1-degree box straddles the equator (0.5N-0.5S). Thus, for example, the equatorial upwelling zone can be more sharply delineated. Future improvements in data and metadata planned for COADS, and COADS-compatible near-real-time products useful for environmental monitoring, are also briefly discussed.

5.49 UNUSUAL LARVAL ABUNDANCES OF A SLIPPER LOBSTER SCYLLARIDES NODIFER AND A SAND CRAB ALBUNEA SP. IN THE FLORIDA KEYS DURING THE INTRUSION OF LOW SALINITY MISSISSIPPI FLOOD WATER IN SEPTEMBER, 1993

C. Yeung & M. M. Criales
University of Miami/RSMAS
Miami, FL

Some marine populations in the Florida Keys may be dependent on larval supply from upstream sources. Such is widely believed of the spiny lobster *Panulirus argus*, one of the most economically important species in the region. Its phyllosoma larvae have an estimated planktonic duration of about one year, which could translate into a long oceanic odyssey. Unravelling larval sources and transport processes are critical to resource management.

Possible mechanisms of larval transport to the Keys were revealed during an anomalous oceanographic event. Massive intrusions of low-salinity waters were detected in the southern Straits of Florida during the Great Mississippi Flood in the summer of 1993. Surface salinity normally exceeds 36 ppt in the Straits, but during a cruise on 10 to 13 September 1993, salinities of 31 to 35 ppt were observed in a surface band measuring approximately 40 km wide and 30 m deep, and over a 260 km range from Key West to Miami. In this low-salinity water were unusual abundances of intermediate-stage larvae of a slipper lobster Scyllarides nodifer, and a sand crab *Albunea* sp. These species are associated with the northeastern Gulf of Mexico, but are little known in the Keys. Early stages of these species are not usually abundant in the Keys. The influx of intermediate stages is consistent with a transport of spring-spawn larvae from the Gulf.

An anomalous, persistent eastward wind drove Mississippi floodwaters into the Loop Current, which was at a high northward position in the northeastern Gulf. These conditions brought low-salinity waters to the southern Straits of Florida via the Loop Current-Florida Current conduit, and may also expatriate larvae of northeastern Gulf origin. Under typical salinity conditions in the Straits, *P. argus* larvae comprise the majority of phyllosomas in the plankton. Although they have distinct differences in adult ecology, the phyllosoma of S. nodifer is a close analogue to that of *P. argus*. However, they appear to be subjected to different larval recruitment processes. Whereas the transport of S. nodifer larval recruits to the Keys may be linked with specific environmental conditions in the northeastern Gulf, the transport of *P. argus* larvae may be less restricted. A wide range of stages of *P. argus* larvae are typically abundant year-round in the Keys, suggesting multiple sources from upstream of the Gulf.

5.50 THE ATMOSPHERIC ANNUAL CYCLE OF THE INTRA-AMERICAS SEA

Chidong Zhang
University of Miami/RSMAS
Miami FL

A comprehensive study of the atmospheric seasonal cycle in the Caribbean Sea and the surrounding regions is proposed. The objectives of this study will be (1) to document the climatology of the seasonal cycle of surface winds, surface fluxes, precipitation amounts, convective activity, atmospheric dynamic and thermodynamic structures for the Caribbean Sea using *in situ* and remote sensing observations and global model reanalysis (NCEP/NCAR); (2) to estimate the moisture budget over the Caribbean Sea for two selected years using both upper-air soundings and surface marine observations and to compare the results with those based on the global reanalysis, and (3) to simulate high-resolution atmospheric forcing to the ocean using a regional atmosphere model (NCAR/PSU MM5) initialised with coarse-resolution observations/reanalysis. This study, by achieving these objectives, will demonstrate (i) the feasibility of validating the global reanalysis in the tropical oceanic region over a finite area from which a relatively large amount of observations are available and (ii) the capability of the regional atmosphere model to provide high-resolution surface forcing needed for detailed study of air-sea interaction and ocean circulation in the area.

This proposed study is the atmospheric component of a coordinated programme PRECURSOR ("Precipitation in the Caribbean and Upwelling Response in the Southern Region" or "PREcipitacion en el Caribe y Ubicacion del Regimen de Surgencia en le Occidente de la Region"), which is a multidisciplinary and multinational project aimed at a better understanding of the air-sea interaction in the Caribbean Sea and its implications. PRECURSOR also consists of ocean modelling and field observational components. Atmospheric surface winds, fluxes, and precipitation of coarse resolutions from observations and those of high resolutions from regional model simulations will be used respectively to force a regional ocean model. Sensitivity of the regional atmospheric model to fine structures of sea surface temperature in the region provided by the ocean model will also be tested. Field observations of surface winds and precipitation will be used in the moisture budget estimate. Real-time atmosphere-ocean modelling support to the oceanographic fieldwork will be developed.

The success of this study will contribute to the long-term goals of the atmospheric component of PRECURSOR: (1) to document the four-dimensional structure of the atmosphere in the IAS (the Caribbean and the Gulf) using *in situ* and remote sensing observations as a testbed for validation and comparison of global model reanalyses and simulations; and (2) to develop a fully coupled atmosphere-ocean regional modelling strategy for an understanding of the air-sea-land interaction in the IAS and the surrounding regions and its impacts on weather, climate, marine pollution transport, marine biology, and fisheries of the region.

6. ACKNOWLEDGEMENTS

Partial financial support was provided by the U.S. Minerals Management Service (MMS) and the Sub-commission for the Caribbean and Adjacent Regions (IOCARIBE) of the Intergovernmental

Oceanographic Commission (IOC) of UNESCO. Mexican colleagues recruited participation from Cuban colleagues. This report is dedicated to the late Prof. John D. Cochrane, Texas A&M University, for his pioneering descriptive physical oceanographic studies of the IAS.

ANNEX I

PROGRAMME OF THE WORKSHOP

SATURDAY 1 November

19:00-19:10 Opening Remarks, Victor Vidal & Chris Mooers
IAS Oceanography
Session Chair, Victor Vidal

19:10-19:40 Jorge E. Corredor & J.M. Morell, Seasonal Cycle of Mixed-Layer Features in the Northeastern Caribbean Sea: Results from the CATS (Caribbean Time Series)Station

19:40-20:10 Julio Candela, CANEK: Exchange Through the Yucatan Channel and Upwelling Dynamics over the Yucatan Shelf

20:10 Adjourn

SUNDAY 2 November

IAS Circulation: Observations and Models
Session Chair, Julio Sheinbaum

09:00-09:30 Bill Johns, T. Townsend, E. Chassignet, & Z. Garraffo, Inflow to the Eastern Caribbean: Results from Basin-Scale Atlantic Models

09:30-10:00 Artemio Gallegos, Hidrología de los Estrechos del Mar Caribe Noroccidental

10:00-10:30 Doug Wilson, W. Johns, & E. Johns, Atlantic - Caribbean Water Exchange: A Quantitative Summary of Observations

10:30-11:00 Sylvia Murphy, H.E. Hurlburt, & J.J. O'Brien, The Connectivity of Mesoscale Variability in the Caribbean Sea, the Atlantic Ocean, and the Gulf of Mexico

11:00-11:20 Julio Candela, J. Sheinbaum, J. Ochoa, & A. Badan, Moored ADCP Measurements of the Yucatan Current in the Cozumel Channel and in the Western side of the Yucatan Channel

11:20-11:40 Antonio Badan, J. Candela, J. Sheinbaum, & J. Ochoa, Direct Observations of Currents in the Yucatan Channel

11:40-12:00 Julio Candela, J. Sheinbaum, J. Ochoa, & A. Badan, Shipboard ADCP Observations in the Yucatan Channel During the CANEK Project

12:00-12:20 Tamara L. Townsend, H.E. Hurlburt, & P.J. Hogan, Effects of Model Grid Resolution and Atmospheric Forcing on Simulated Flow in the Intra-Americas Sea Region of North Atlantic Basin-Scale Ocean Models

12:20-12:40 Víctor M.V. Vidal, F.V. Vidal, L. Zambrano, & J. Portilla, Formation and Evolution of the Western Boundary Current in the Gulf of Mexico

12:40-13:00 Víctor M.V. Vidal, F.V. Vidal, L.Zambrano, & J. Portilla, Vertical Transports in Cyclonic-Anticyclonic Ring Pairs and its Implication for Regulating CO_2 Exchange Between Surface and Deep Waters in the Gulf of Mexico

13:00-13:20 Roy A. Watlington, W.D. Wilson, D. Wallace, R. Olivacce, & W.E. Johns, Monitoring the Pulse of the DWBC in the Anegada Passage

13:20-13:40 Tom M. Georges & J.A. Harlan, New Features of IAS Circulation Seen with Over-The-Horizon Radar

13:40 Adjourn

17:00-19:00 Working Groups Session
Chairs: Bill Johns, Julio Candela, Doug Biggs, & Victor Vidal

19:00 Adjourn

MONDAY 3 November

IAS Role in Climate and Global Change and Marine Ecosystems
Session Chair, Bill Johns

09:00-09:30 Victor Magaña, Climate Change Scenarios in the Intra-Americas Sea (IAS) Region

09:30-10:00 Scott D. Woodruff, H.F. Diaz, & S.J. Worley, The Comprehensive Ocean-Atmosphere Data Set (COADS): High Resolution Products and Future Plans

10:00-10:30 Kevin D. Leaman & M.C. Donoso, Tropical Intraseasonal and Longer-Period Oscillations in Precipitation Over the Isthmus of Panama

10:30-11:00 Frank E. Muller-Karger, M. Scranton, R. Thunell, R. Varela, Y. Astor, & R. Bohrer, The CARIACO (Carbon Retention In A Colored Ocean) Time Series

11:00-11:20 Julio Sheinbaum, D. Wilson, J. Candela, J. Ochoa, A. Badan, I. Gonzalez, & R. Smith, Velocity and Transport Measurements with a Lowered-Acoustic Doppler Current Profiler in the Yucatan Channel: Some Preliminary Results

11:20-11:40 Jose Luis Ochoa, J. Sheinbaum, J. Candela, & A. Badán, A Method to Estimate the Geostrophic Balanced Fields from Simultaneous Hydrographic and Horizontal Velocity Observations in the Water Column

11:40-12:00 Renellys C. Perez & C.N.K. Mooers, Comparison of Model Simulations with Observations of the Louisiana-Texas Shelf

12:00-12:20 Nelson M. Ehrhardt, The Spiny Lobster, Panulirus Argus, As a Key Species Indicator of Ecosystem Transports and Linkages of the Intra-Americas Sea

12:20-12:40 Christopher N.K. Mooers & L. Gao, Simulated Surface Transports in the IAS

12:40-13:00 Gilbert T. Rowe, A Generic One-Dimensional (Vertical) Numerical Simulation of Oxygen Distribution in Coastal Ecosystems: A Comparison of Biological and Physical Processes

13:00-13:20 Chidong Zhang, The Annual Cycle of the Intra-Americas Sea

13:20 Adjourn

17:00-19:00 Working Group Session
Chairs: Victor Magaña, Gil Rowe, Jorge Corredor, & Tom Lee

19:00 Adjourn

TUESDAY 4 November

IAS Marine Ecosystems, Fisheries Oceanography, and Management Issues
Session Chair, Gil Rowe

09:00-09:30 Luis A. Soto & E. Escobar Briones, Progress in the Study of the Benthic System of the Gulf: Shelf and Deep-Water Environments

09:30-10:00 Elva Escobar Briones, L.A. Soto, F. Muller-Karger, & G.T. Rowe, Benthic Biomass Distribution in the IAS: A Pelagic Controlled System?

10:00-10:30 Robert K. Cowen, K.M.M. Lwiza, & S. Sponaugle, Biological and PhysicalProcesses Contributing to Pattern and Variability in the Recruitment of Coral Reef Fishes

10:30-11:00 Thomas N. Lee, The Influence of Coastal and Oceanic Flows on Recruitment of Fish and Lobster Larvae to the Florida Keys

11:00-11:30 Eduardo Martinez, A Mass-Balance Model of the Gulf of Mexico Ecosystem for Evaluation of Ecological Relationships and Fishery Stocks

11:30-12:00 Eduardo Aguaya, Coastal Dynamics and Environmental Impact in the Western Gulf of Mexico

12:00-12:20 Alexis Lugo-Fernandez, The Gulf of Mexico Physical Oceanography Programme of the U.S. Minerals Management Service

12:20-12:40 Jose M. Lopez, E. Alfonso, & A. Dieppa, Oceanic Primary Production at the Caribbean Time-Series Station (CATS) Estimated from Photosynthetic Parameters and Satellite Data

12:40-13:00 Frank E. Muller-Karger & F.M. Vukovich, Far Field Processes and Red Tides in the Mid-IAS and Eastern GOM

13:00-13:20 Patrick H. Ressler, D.C. Biggs, & J.H. Wormuth, Acoustic Estimates of Zooplankton and Micronekton Biomass using a ADCP in Warm and Cold-Core Rings of the Gulf of Mexico

13:20-13:40 Maria M. Criales & C. Yeung, Unusual Larval Abundances of a Slipper Lobster Scyllarides Nodifer and a Sand Crab Albunea Sp. in the Florida Keys during the Intrusion of Low Salinity Mississippi Flood Water in September, 1993

13:40 Adjourn

17/00-19:00 Working Group Session
Chairs, Elva Escobar, Roger Zimmerman, Frank Muller-Karger, & Doug Biggs

19:00 Adjourn

WEDNESDAY 5 November

IAS-GOOS, A Regional Global Ocean Observing System
Session Chair, Chris Mooers

09:00-09:30 W. Doug Wilson, Constructing an IAS Regional Global Ocean Observing System

09:30-10:15 Working Group Findings and Recommendations

10:15-11:00 Final Synthesis and Future Plans

11:00 Adjourn Conference

NOTE: The following posters were set up through out the Conference

J. Portilla Casillas, F.V. Vidal, & V.M.V. Vidal, Numerical Modeling of Hydrothermal Effluents Dispersion in Coastal Marine Sites

Norman L. Guinasso, Jr., F. J. Kelly, & L. L. Lee, Currents along the Coast of Texas as Observed by the Texas Automated Buoy System

Elizabeth Johns & W.D. Wilson, Direct Observations of Velocity Structure in the Passages Between the Intra-Americas Sea and the Atlantic Ocean, 1984 to 1996

Z. García Lagunas, V. M.V.Vidal, F.V. Fidal, & S. Chapa Vergara, GEOSIS: An Environment to Process Oceanographic Data

Douglas.C. Biggs, R.R. Leben, J.H. Wormuth, J. Norris, R. Davis, W. Evans, & M. Seymour, Thar She Blows! Sperm Whales, SST Fronts, and Cyclonic Eddies in the NE Gulf of Mexico

Robert W. Pratt & George A. Maul, Preliminary Analysis of Sea Surface Height Variability from TOPEX/Poseidon over the Intra-Americas Sea

Susan E. Welsh & N.D. Walker, Satellite Observations and Modeling of Upwelling Over the Campeche Bank

Ivan Victoria, Hydrological Evidences of Deep and Shelf Water Exchange Over the Eastern Yucatan Slope

ANNEX II

LIST OF PARTICIPANTS

Prof. J. Eduardo Aguayo
Instituto de Ciencias del Mar y Limnología
UNAM. Apdo. Postal 70-305
Mexico, D.F.
Tel: 52-622 5819
Fax: 52-616 2715
E-mail: jaguayo@mar.icmyl.unam.mx

Ms. Lilliam Arriaza Oliveros
Physical Oceanography Department
KM. 107, Carr. Tijuana-Ensenada
Ensenada, Baja California 22860
Mexico
Tel: 52-61-75-05-46
Fax: 52-61-75-05-47
E-mail: none

Dr. Antonio Badan Dangon
CICESE
Physical Oceanography Department
KM. 107, Carret. Tijuana - Ensenada
Ensenada, B.C., Mexico 22860
Tel: 61-75-05-46
Fax: 61-75-05-47
E-mail: abadan@cicese.mx

Mr. Federico Barranco Cicilia
Instituto Mexicano del Petróleo
Eje Central Noite Lazaro Cardene
#152, Mexico, D.F.
Tel: 52-368-5911 X20327
Fax: 52-368-4538
E-mail: fbarran@akal.si.imp.mx

Dr. Douglas C. Biggs
Department of Oceanography
Texas A & M University
College Station, TX 77843
Tel: 409-845-3423
Fax: 409-845-6331
E-mail: dbiggs@ocean.tamu.edu

Mr. Miguel A. Castaneda Roldan
Pemex Exploraccion y Produccion
1 Piso Blvd. A. Ruiz C. No. 1202, Tabasco 2000
Villahermosa, Tabasco, C.P. 86030
Mexico
Tel: 93-10-1762
Fax: 93-10-1762
E-mail: mgcastrl@pep.pemex.com

Dr. Julio Candela Perez
CICESE
Physical Oceanography Department
KM. 107, Carret. Tijuana - Ensenada
Ensenada, B.C., Mexico 22860
Tel: 61-75-05-46
Fax: 61-75-05-47
E-mail: jcandela@cicese.mx

Mr. J. Lee Chapin
Organization of American States
615 19th Avenue, NE
St. Petersburg, FL 33704

Tel: 813-822-1453
Fax: 813-822-6448
E-mail: chapin_l@msn.com

Dr. Robert K. Cowen
Marine Sciences Research Center
State University of New York
Stony Brook, NY 11794-5000
Tel: 516-632-8711
Fax: 516-632-8820
E-mail: bcowen@ccmail.sunysb.edu

Dr. Maria M. Criales
University of Miami/RSMAS/MBF
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Tel: 305-361-4073
Fax: 305-361-4600
E-mail: mcriales@rsmas.miami.edu

Dr. Jorge E. Corredor
University of Puerto Rico
Department of Marine Sciences
PO Box 908
Lajas, Puerto Rico 00667
Tel: 787-899-3838
Fax: 787-899-2630
E-mail: quimocea@caribe.net

Dr. Thomas M. Georges
NOAA/ERL/ETL
325 Broadway, R/E/ET1
Boulder, CO
Tel: (303) 497-6437 or 6470 (secr. Sharon)
Fax: (303) 497-3577
E-mail: tgeorges@etl.noaa.gov

Dr. Nelson M. Ehrhardt
RSMAS - University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Tel: 305-361-4741
Fax: 305-361-4902
E-mail: nehrhardt@rsmas.miami.edu

Dr. Norman L. Guinasso, Jr.
Texas A & M University
833 Graham Road
College Station, TX 77845
Tel: 409-862-2323
Fax: 409-862-1247
E-mail: norman@gerg.tamu.edu

Dr. Elva G. Escobar Briones
Benthic Ecology Laboratory
Instituto de Ciencias del Mar y Limnologia
Universidad Nacional Autonoma de Mexico
A.P. 70-305
04510 Mexico, D.F. Mexico
Tel: 52-5-622-58-35
Fax: 52-5-616-07-48
E-mail: escobri@mar.icmyl.unam.mx

Dr. Peter Hamilton
SAIC
615 Oberlin Road
Raleigh, NC 27605
Tel: 919-836-7565
Fax: 919-832-7262
E-mail: phamilton@raleigh.saic.com

Dr. Artemio Gallegos
ICMyL, UNAM
C.D. Universitaria, Coyoacan
Mexico City, Mexico 04510
Tel: 622-5792
Fax: 616-0748
E-mail: gallegos@mar.icmyl.unam.mx

Dr. William E. Johns
University of Miami/RSMAS/MPO
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Tel: 305-361-4054
Fax:
E-mail: wjohns@rsmas.miami.edu

Ms. Zulma Haydee Garcia Lagunas
Instituto Politecnico Nacional-Cinvestav
Av. Reforma 113, Col Palmira
Cuernavaca, Morelos 62490
Mexico
Tel: 73-18-38-11
Fax: 73-18-98-54
E-mail: zgarcia@iie.org.mx

Dr. Elizabeth Johns
NOAA/AOML
4301 Rickenbacker Causeway
Miami, FL 33149
Tel: 305-361-4360
Fax: 305-361-4412
E-mail: johns@aoml.noaa.gov

Prof. Kevin D. Leaman
University of Miami/RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149
Tel: 305-361-4057
Fax: 305-361-4696
E-mail: leaman@bartok.rsmas.miami.edu

Mr. Carlos Alberto Luna Lopez
PEMEX Exploracion Produccion
Rancheria el Limon S/N
Paraiso, Tabasco 86600
Mexico
Tel: 52-938-2-30-39
Fax: 52-938-2-30-39
E-mail: crgarcvl@mso.pep.pemex.com

Prof. Thomas N. Lee
University of Miami/RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Tel: 305-361-4046
Fax: 305-361-4696
E-mail: tlee@rsmas.miami.edu

Mr. Ivan Lima
University of Miami/RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Tel: 305-361-4796
Fax: 305-361-4600
E-mail: ivan@nauplius.rsmas.miami.edu

Dr. Jose M. Lopez
University of Puerto Rico
PO Box 9013
Mayaguez, Puerto Rico 00681
Tel: 787-834-7620 X2231
Fax: 787-834-8025
E-mail: jo_lopez@rumac.upr.clu.edu

Mr. Alexis Lugo-Fernandez
MMS
1201 Elmwood Park Blvd.
New Orleans, LA 70123
Tel: 504-736-2593
Fax: 504-736-2901
E-mail: alexis.lugo.fernandez@mms.gov

Prof. Frank Muller-Karger
University of South Florida
Department of Marine Science
140 7th Avenue South
St. Petersburg, FL 33701
Tel: 813-553-3335
Fax: 813-553-1103
E-mail: carib@carbon.marine.usf.edu

Ms. Sylvia Murphy
Naval Research Laboratory
Code 7322
Stennis Space Center, MS 39529
Tel: 601-688-7043
Fax: 601-688-4759
E-mail: murphy@nrlssc.navy.mil

Dr. Victor O. Magana
UNAM
Centro de Ciencias de la Atmosfera
Mexico City, Mexico 04510
Tel: 622-4088
Fax: 616-0789
E-mail: victor@regino.atmosfer.unam.mx

Mr. Eduardo Xavier Martinez
NMFS/SEFSC
4700 Avenue U
Galveston, TX 77551
Tel: 409-766-3524
Fax: 409-766-3520
E-mail: eduardo.martinez@noaa.gov

Prof. Christopher N.K. Mooers
University of Miami/RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Tel: 305-361-4825
Fax: 305-361-4797
E-mail: cmooers@rsmas.miami.edu

Dr. Julio M. Morell Rodriguez
Department of Marine Sciences
University of Puerto Rico
PO Box 908
Lajas, Puerto Rico 00667
Tel: 787-899-3838
Fax: 787-899-2630
E-mail: oceano@coqui.net

Dr. Josue Portilla Casillas
Instituto Politecnico Nacional
Reforma 113
Texmixco, Morelos 62490
Mexico
Tel: 73-18-38-11 X 7536
Fax: 73-18-98-54
E-mail: portilla@axp7.iie.org.mx

Mr. Robert William Pratt
Florida Institute of Technology
150 West University Blvd.
Melbourne, FL 32901
Tel: 407-768-8000 X7453
Fax: 407-768-8000 X7212
E-mail: rpratt@winnie.fit.edu

Dr. Jose Luis Ochoa de la Torre
CICESE
Physical Oceanography Department
KM. 107, Carret. Tijuana - Ensenada
Ensenada, B.C., Mexico 22860
Tel: 305-361-4607
Fax: 305-361-4797
E-mail: jose@alpha3001.rsmas.miami.edu

Mr. Ronald Olivaccé
University of the Virgin Islands
Eastern Caribbean Center
#2 John Brewers Bay
St. Thomas, Virgin Islands 00802
Tel: 340-693-1341
Fax: 340-693-1385
E-mail: oli2144@sttmail.uvi.edu

Ms. Renellys C. Perez
University of Miami/RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Tel: 305-361-4825
Fax: 305-361-4797
E-mail: renellys@alpha3001.rsmas.miami.edu

Dr. Julio Sheinbaum Pardo
CICESE
Physical Oceanography Department
KM. 107, Carret. Tijuana - Ensenada
Ensenada, B.C., Mexico 22860
Tel: 61-75-05-46
Fax: 61-75-05-47
E-mail: julios@cicese.mx

Dr. Luis A. Soto
Instituto de Ciencas del Mar y Limnolgia
UNAM
Mexico, D.F. 70-132
Mexico
Tel: 622-5797
Fax: 616 07 48
E-mail: lasg@mar.icmyl.unam.mx

Ms. Tamara L. Townsend
Naval Research Laboratory
Ocean Dynamics & Prediction Branch
Stennis Space Center, MS 39529
Tel: 601-688-5589
Fax: 601-688-4759
E-mail: townsend@nrlssc.navy.mil

Mr. Rafael J. Ramos Heredia
Instituto Mexicano del Petroleo
Subdireccion de Ingenieria
Eje Central Lazaro Cardenas 152
Del. Gustavo A. Madero
07730, Mexico, D.F.
Tel: 52-368-9333 or 52-587-2977 X20504 X20559
Fax: 52-368-4537
E-mail: rramos@akal.si.imp.mx

Mr. Patrick H. Ressler
Department of Oceanography
Texas A & M University
College Station, TX 77843
Tel: 409-845-2599
Fax: 409-845-6331
E-mail: pressler@ocean.tamu.edu

Dr. Gilbert T. Rowe
Texas A & M University
Mail Stop 3146
College Station, TX 77843
Tel: 409-845-4092
Fax: 409-845-6331
E-mail: growe@ocean.tamu.edu

Dr. Nan D. Walker
Coastal Studies Institute, LSU
Louisiana State University
Baton Rouge, LA 70803
Tel: 504-388-5331
Fax: 504-388-2520
E-mail: nwalker@antares.esl.lsu.edu

Mr. Roy A. Watlington
University of the Virgin Islands
Eastern Caribbean Center
#2 John Brewers Bay
St. Thomas, Virgin Islands 00802
Tel: 340-693-1341
Fax: 340-693-1385
E-mail: rwatlin@uvi.edu

Dr. Susan E. Welsh
Coastal Studies Institute
Louisiana State University
Baton Rouge, LA 70803
Tel: 504-388-0439
Fax: 504-388-2520
E-mail: swelsh@gom.csi.lsu.edu

Dr. Ivan Victoria
Instituto de Oceanologia (IDO)
Agencia de Medio Ambiente
Ministerio de Ciencia, Tecnologia y Medio Ambiente (CITMA)
Ave.1ra. No.18406 entre 184 y 186. Reparto Flores, Playa
Habana 21. Ciudad de la Habana. C.P.12100
Tel: (537) 216008 or 210300 or 211380 or 21224
E-mail: ocean@oceano.inf.cu

Prof. Victor M.V. Vidal
Instituto Politecnico Nacional
Av. Reforma No. 133, Col. Palmira
Temixco, Morelos 62490
Mexico
Tel: 52-73-183811 X7541
Fax: 52-73-18-98-54
E-mail: vvidal@iie.org.mx

Prof. Chidong Zhang
University of Miami/RSMAS
MPO
4600 Rickenbacker Cswy.
Miami, FL 33149
Tel: 305-361-4042
Fax: 305-361-4686
E-mail: czhang@rsmas.miami.edu

Mr. William Douglas Wilson
NOAA/AOML
4301 Rickenbacker Causeway
Miami, FL 33149
Tel: 305-361-4352
Fax: 305-361-4412
E-mail: wilson@aoml.noaa.gov

Mr. Scott Woodruff
NOAA/ERL Climate Diagnostics Center
325 Broadway
Boulder, CO 80303
Tel: 303-497-6747
Fax: 303-497-7013
E-mail: sdw@cdc.noaa.gov

Dr. Roger J. Zimmerman
NMFS/SEFSC
4700 Avenue U
Galveston, TX 77551
Tel: 409-766-3500
Fax: 409-766-3508
E-mail: roger.zimmerman@noaa.gov

ANNEX III

LIST OF ACRONYMS

ACTS	Anegada Climate Tracers Study
AOML	Atlanta Oceanographic and Meteorological Laboratory
AVHRR	Advanced Very High Resolution Radiometer
BNL	Brookhaven National Laboratory
CANEK project	Mexican-Cuban study of the Yucatan Current System; it is not an acronym, but it is the name of a Mayan hero in the classical Yucatan novel of that name by Ermilio Abreu Gomez
CARIACO	Carbon Retention in a Colored Ocean
CARICOMP	Caribbean Consortium for Ocean Monitoring of Productivity
CATS	Caribbean Time Series
CICESE	Centro de Investigacion Cientifica y de Educacion Superior de Esenada
CMI	Caribbean Meteorological Institute
COADS	Comprehensive Ocean-Atmosphere Data Set
CPACC	Caribbean Planning for Adaptation to Global Climate Change
CS	Caribbean Sea
CZCS	Coastal Zone Color Scanner
DMCL	Deep Maximum Chlorophyll Layer
DOM	Dissolved Ocean Matter
DWBC	Deep Western Boundary Current
EEZ	Exclusive Economic Zone
ENSC	El Niño – Southern Oscillation
GOM	Gulf of Mexico
GOOS	Global Ocean Observing System
IAI	Intra-American Institute
IAS	Intra-Americas Sea
IMP	Instituto Mexicano del Petróleo
IPN	Insituto Politecnico
ITCZ	Inter-Tropical Convergence Zone
LC	Loop Current
LME	Large Marine Ecosystem
MICOM	Miami Isopycnal Community Model
MLD	Mixed Layer Depth
MMS	Minerals Management Service
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NH	Northern Hemisphere
NLOM	NRL Layered Ocean Model
NPZD model	Nutrient-Phytoplanton-Zooplankton-Detritus model
NRL	Naval Research Laboratory
OAS	Organization of American States
OTHR	Over-the-Horizon Radar
PAR	Photosynthetic Radiance
PCG	Panama Colombia (cyclonic) Gyre
PEMEX	Petroleos Mexicanos, the Mexican oil company
POM	Princeton Ocean Model
PRECURSOR	Precipitation in the Caribbean and Upwelling Response in the Southern Region
QA	Quality Assessment
QC	Quality Control

RSMAS	Rosenstiel School of Marine and Atmospheric Science
TAO	Tropical Atmosphere/Ocean Programme
TABS	Texas Automated Buoy System
TIO	Tropical Intraseasonal Oscillation
UNAM	Universidad Nacional Autonoma de México
YOTO	Year-of-the-Ocean

IOC Workshop Reports

The Scientific Workshops of the Intergovernmental Oceanographic Commission are sometimes jointly sponsored with other intergovernmental or non-governmental bodies. In most cases, IOC assures responsibility for printing, and copies may be requested from:

Intergovernmental Oceanographic Commission – UNESCO
1, rue Miollis, 75732 Paris Cedex 15, France

No.	Title	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),	E (out of stock)
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (UNESCO Technical Paper in Marine Sciences, No. 20).	E (out of stock) S (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean; Monte Carlo, 9-14 September 1974.	E,F E (out of stock)
4	Report of the Workshop on the Phenomenon known as 'El Niño'; Guayaquil, Ecuador, 4-12 December 1974.	E (out of stock) S (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	E (out of stock) S
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.	E
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.	E, F,S, R
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters; Penang, 7-13 April 1976	E (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience; Mauritius 9-13 August 1976.	E, F, S, R
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring; Monaco, 14-18 June 1976	E, F E (out of stock) R
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.	E, S (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	E (out of stock), S
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects; Fort-de-France, Martinique, 28 November-2 December 1977.	E, F, S
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area; Port of Spain, Trinidad, 16-18 January 1978.	E, S
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas; Abidjan, Côte d'Ivoire, 2-9 May 1978	E, F
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific; Santiago de Chile, 6-10 November 1978.	E (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	E, F, R
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS); Moscow, 9-11 April 1979.	E
17 suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceano-graphic Products and the IGOSS Data Processing and Services System; Moscow, 2-6 April 1979.	E
18	IOC/UNESCO Workshop on Syllabus for Training Marine Technicians; Miami, U.S.A., 22-26 May 1978 (UNESCO reports in marine sciences, No. 4 published by the Division of Marine Sciences, UNESCO).	E (out of stock), F, S (out of tock), R
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, published by the Division of Marine Sciences, UNESCO).	E (out of stock), S, R, Ar
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources; Bandung, Indonesia, 17-21 October 1978	E
21	Second IDOE Symposium on Turbulence in the Ocean; Liège, Belgium, 7-18 May 1979.	E, F, S, R
22	Third IOC/WMO Workshop on Marine Pollution Monitoring; New Delhi, 11-15 February 1980.	E, F, S, R
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific; Tokyo, 27-31 March 1980.	E, R
24	WESTPAC Workshop on Coastal Transport of Pollutants; Tokyo, Japan, 27-31 March 1980.	E (out of stock)
25	Workshop on the Inter-calibration 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.	E (Superseded by IOC Technical Series No.22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region; México City, 24 September- 5 October 1979.	E, S
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Nouméa, New Caledonia, 9-15 October 1980.	E
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes. Lima, 20 April-5 May 1980.	E
29	WESTPAC Workshop on Marine Biological Methodology; Tokyo, 9-14 February 1981.	E
30	International Workshop on Marine Pollution in the South-West Atlantic; Montevideo, 10-14 November 1980.	E (out of stock) S
31	Third International Workshop on Marine Geoscience; Heidelberg, 19-24 July 1982.	E, F, S
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, France, 27 September-1 October 1982.	E, F, S
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, France, 27 September-1 October 1982.	E
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR); Halifax, 26-30 September 1963.	E
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa); Tenerife, 12-17 December 1963.	E, F, S
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.	E
36	IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, Portugal, 28 May-2 June 1984.	E
36 Suppl.	Papers submitted to the IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, 28 May-2 June 1984	E
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.	E
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region; Basrah, Iraq, 8-12 January 1984.	E
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.	E
40	IOC Workshop on the Technical Aspects of Tsunami Analysis, Prediction and Communications; Sidney, B.C., Canada, 29-31 July 1985.	E
40 Suppl.	First International Tsunami Workshop on Tsunami Analysis, Prediction and Communications, Submitted Papers; Sidney, B.C., Canada, 29 July-1 August 1985.	E
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.	E
43	IOC Workshop on the Results of MEDALPEX and Future Oceano-graphic Programmes in the Western Mediterranean; Venice, Italy, 23-25 October 1985.	E
44	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E (out of stock) S
44 Suppl.	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities, Submitted Papers; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E
45	IOCARIBE Workshop on Physical Oceanography and Climate; Cartagena, Colombia, 19-22 August 1986.	E
46	Reunión de Trabajo para Desarrollo del Programa "Ciencia Oceánica en Relación a los Recursos No Vivos en la Región del Atlántico Sud-occidental"; Porto Alegre, Brasil, 7-11 de abril de 1986.	S
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence; Townsville, 1-6 December 1966	E
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on 'Ocean Science in Relation to Non-Living Resources (OSNLR)'; Havana, Cuba, 4-7 December 1986.	E, S
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on 'El Niño'; Guayaquil, Ecuador, 27-31 October 1986.	E
50	CCALR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR); Paris, France, 2-6 June 1987.	E
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations; Lae, Papua-New Guinea, 1-8 October 1987.	E
52	SCOR-IOC-UNESCO Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere; Paris, France, 6-10 May 1985.	E
53	IOC Workshop on the Biological Effects of Pollutants; Oslo, 11-29 August 1986.	E
54	Workshop on Sea-Level Measurements in Hostile Conditions; Bidston, UK, 28-31 March 1988.	E
55	IBCCA Workshop on Data Sources and Compilation, Boulder, Colorado, 18-19 July 1988.	E
56	IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Cleveland, Australia, 24-30 July 1988.	E
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms; Takamatsu, Japan, 16-17 November 1987.	E
58	International Workshop on the Technical Aspects of the Tsunami Warning System; Novosibirsk, USSR, 4-5 August 1989.	E
58 Suppl.	Second International Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness,	E

No.	Title	Languages
	Observation and Instrumentation. Submitted Papers; Novosibirsk, USSR, 4-5 August 1989.	
59	IOC-UNEP Regional Workshop to Review Priorities for Marine Pollution Monitoring Research, Control and Abatement in the Wider Caribbean; San José, Costa Rica, 24-30 August 1989.	E, F, S
60	IOC Workshop to Define IOCARIBE-TRODERP proposals; Caracas, Venezuela, 12-16 September 1989.	E
61	Second IOC Workshop on the Biological Effects of Pollutants; Bermuda, 10 September- 2 October 1988.	E
62	Second 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; Accra, Ghana, 13-17 June 1988.	E
63	IOC/WESTPAC Workshop on Co-operative Study of the Continental Shelf Circulation in the Western Pacific; Bangkok, Thailand, 31 October-3 November 1989.	E
64	Second IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Phuket, Thailand, 25-31 September 1989.	E
65	Second IOC Workshop on Sardine/Anchovy Recruitment Project (SARP) in the Southwest Atlantic; Montevideo, Uruguay, 21-23 August 1989.	E
66	IOC ad hoc Expert Consultation on Sardine/ Anchovy Recruitment Programme; La Jolla, California, U.S.A., 1989	E
67	Interdisciplinary Seminar on Research Problems in the IOCARIBE Region; Caracas, Venezuela, 28 November- 1 December 1989.	E (out of stock)
68	International Workshop on Marine Acoustics; Beijing, China, 26-30 March 1990.	E
69	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Leningrad, USSR, 28-31 May 1990.	E
69 Suppl.	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Submitted Papers; Leningrad, USSR, 28-31 May 1990.	E
70	IOC-SAREC-UNEP-FAO-IAEA-WHO Workshop on Regional Aspects of Marine Pollution; Mauritius, 29 October - 9 November 1990.	E
71	IOC-FAO Workshop on the Identification of Penaeid Prawn Larvae and Postlarvae; Cleveland, Australia, 23-28 September 1990.	E
72	IOC/WESTPAC Scientific Steering Group Meeting on Co-Operative Study of the Continental Shelf Circulation in the Western Pacific; Kuala Lumpur; Malaysia, 9-11 October 1990.	E
73	Expert Consultation for the IOC Programme on Coastal Ocean Advanced Science and Technology Study; Liège, Belgium, 11-13 May 1991.	E
74	IOC-UNEP Review Meeting on Oceanographic Processes of Transport and Distribution of Pollutants in the Sea; Zagreb, Yugoslavia, 15-18 May 1989.	E
75	IOC-SCOR Workshop on Global Ocean Ecosystem Dynamics; Solomons, Maryland, U.S.A., 29 April-2 May 1991.	E
76	IOC/WESTPAC Scientific Symposium on Marine Science and Management of Marine Areas of the Western Pacific; Penang, Malaysia, 2-6 December 1991.	E
77	IOC-SAREC-KMFRI Regional Workshop on Causes and Consequences of Sea-Level Changes on the Western Indian Ocean Coasts and Islands; Mombasa, Kenya, 24-28 June 1991.	E
78	IOC-CEC-ICES-WMO-ICSU Ocean Climate Data Workshop Goddard Space Flight Center; Greenbelt, Maryland, U.S.A., 18-21 February 1992.	E
79	IOC/WESTPAC Workshop on River Inputs of Nutrients to the Marine Environment in the WESTPAC Region; Penang, Malaysia, 26-29 November 1991.	E
80	IOC-SCOR Workshop on Programme Development for Harmful Algae Blooms; Newport, U.S.A. 2-3 November 1991.	E
81	Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality Control; Paris, France, 12-13 October 1992.	E
82	BORDOMER 92: International Convention on Rational Use of Coastal Zones. A Preparatory	E
	Meeting for the Organization of an International Conference on Coastal Change; Bordeaux, France, 30 September-2 October 1992.	
83	IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 12-13 October 1992.	E
84	Workshop on Atlantic Ocean Climate Variability; Moscow, Russian Federation, 13-17 July 1992	E
85	IOC Workshop on Coastal Oceanography in Relation to Integrated Coastal Zone Management; Kona, Hawaii, 1-5 June 1992.	E
86	International Workshop on the Black Sea; Varna, Bulgaria, 30 September – 4 October 1991	E
87	Taller de trabajo sobre efectos biológicos del fenómeno «El Niño» en ecosistemas costeros del Pacífico Sudeste; Santa Cruz, Galápagos, Ecuador, 5-14 de octubre de 1989.	S only (summary in E, F, S)
88	IOC-CEC-ICSU-ICES Regional Workshop for Member States of Eastern and Northern Europe (GODAR Project); Obninsk, Russia, 17-20 May 1993.	E
89	IOC-ICSEM Workshop on Ocean Sciences in Non-Living Resources; Perpignan, France, 15-20 October 1990.	E
90	IOC Seminar on Integrated Coastal Management; New Orleans, U.S.A., 17-18 July 1993.	E
91	Hydroblack'91 CTD Intercalibration Workshop; Woods Hole, U.S.A., 1-10 December 1991.	E
92	Réunion de travail IOCEA-OSNLR sur le Projet « Budgets sédimentaires le long de la côte occidentale d'Afrique » Abidjan, côte d'Ivoire, 26-28 juin 1991.	E
93	IOC-UNEP Workshop on Impacts of Sea-Level Rise due to Global Warming. Dhaka, Bangladesh, 16-19 November 1992.	E
94	BMTC-IOC-POLARMAR International Workshop on Training Requirements in the Field of Eutrophication in Semi-enclosed Seas and Harmful Algal Blooms, Bremerhaven, Germany, 29 September-3 October 1992.	E
95	SAREC-IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 23-25 November 1993.	E
96	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Zanzibar, United Republic of Tanzania, 17-21 January 1994.	E
96 Suppl.	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 1. Coastal Erosion; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
96 Suppl	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 2. Sea Level; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
97	IOC Workshop on Small Island Oceanography in Relation to Sustainable Economic Development and Coastal Area Management of Small Island Development States; Fort-de-France, Martinique, 8-10 November, 1993.	E
98	CoMSBlack '92A Physical and Chemical Intercalibration Workshop; Erdemli, Turkey, 15-29 January 1993.	E
99	IOC-SAREC Field Study Exercise on Nutrients in Tropical Marine Waters; Mombasa, Kenya, 5-15 April 1994.	E
100	IOC-SOA-NOAA Regional Workshop for Member States of the Western Pacific - GODAR-II (Global Oceanographic Data Archeology and Rescue Project); Tianjin, China, 8-11 March 1994.	E
101	IOC Regional Science Planning Workshop on Harmful Algal Blooms; Montevideo, Uruguay, 15-17 June 1994.	E
102	First IOC Workshop on Coastal Ocean Advanced Science and Technology Study (COASTS);	E
	Liège, Belgium, 5-9 May 1994.	
103	IOC Workshop on GIS Applications in the Coastal Zone Management of Small Island Developing States; Barbados, 20-22 April 1994.	E
104	Workshop on Integrated Coastal Management; Dartmouth, Canada, 19-20 September 1994.	E
105	BORDOMER 95: Conference on Coastal Change; Bordeaux, France, 6-10 February 1995.	E
105 Suppl.	Conference on Coastal Change: Proceedings; Bordeaux, France, 6-10 February 1995	E
106	IOC/WESTPAC Workshop on the Paleographic Map; Bali, Indonesia, 20-21 October 1994.	E
107	IOC-ICSU-NIO-NOAA Regional Workshop for Member States of the Indian Ocean - GODAR-III; Dona Paula, Goa, India, 6-9 December 1994.	E
108	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Paris, France, 9-12 May 1995.	E
108 Suppl.	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Submitted Papers; Paris, France, 9-12 May 1995.	E
109	First IOC-UNEP CEPPOL Symposium; San José, Costa Rica, 14-15 April 1993.	E
110	IOC-ICSU-CEC regional Workshop for Member States of the Mediterranean - GODAR-IV (Global Oceanographic Data Archeology and Rescue Project) Foundation for International Studies, University of Malta, Valletta, Malta, 25-28 April 1995.	E
111	Chapman Conference on the Circulation of the Intra-Americas Sea; La Parguera, Puerto Rico, 22-26 January 1995.	E
112	IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials (GESREM) Workshop; Miami, U.S.A., 7-8 December 1993.	E
113	IOC Regional Workshop on Marine Debris and Waste Management in the Gulf of Guinea; Lagos, Nigeria, 14-16 December 1994.	E
114	International Workshop on Integrated Coastal Zone Management (ICZM) Karachi, Pakistan; 10-14 October 1994.	E
115	IOC/GLOSS-IAPSO Workshop on Sea Level Variability and Southern Ocean Dynamics; Bordeaux, France, 31 January 1995	E
116	IOC/WESTPAC International Scientific Symposium on Sustainability of Marine Environment: Review of the WESTPAC Programme, with Particular Reference to ICAM, Bali, Indonesia, 22-26 November 1994.	E
117	Joint IOC-CIDA-Sida (SAREC) Workshop on the Benefits of Improved Relationships between International Development Agencies, the IOC and other Multilateral Inter-governmental Organizations in the Delivery of Ocean, Marine Affairs and Fisheries Programmes; Sidney B.C., Canada, 26-28 September 1995.	E
118	IOC-UNEP-NOAA-Sea Grant Fourth Caribbean Marine Debris Workshop; La Romana, Santo Domingo, 21-24 August 1995.	E
119	IOC Workshop on Ocean Colour Data Requirements and Utilization; Sydney B.C., Canada, 21-22 September 1995.	E
120	International Training Workshop on Integrated Coastal Management; Tampa, Florida, U.S.A., 15-17 July 1995.	E
121	IOC-EU-BSH-NOAA-(WDC-A) International Workshop on Oceanographic Biological and Chemical Data Management, Hamburg, Germany, 20-23 May 1996.	E
122	IOC-EU-BSH-NOAA-(WDC-A) International Workshop on Oceanographic Biological and Chemical Data Management, Hamburg, Germany, 20-23 May 1996.	E
123	Second IOC Regional Science Planning Workshop on Harmful Algal Blooms in South America; Mar del Plata, Argentina, 30 October - 1 November 1995.	E, S
124	GLOBEC-IOC-SAHFOS-MBA Workshop on the Analysis of Time Series with Particular Reference to the Continuous Plankton Recorder Survey;	E

No.	Title	Languages
	Plymouth, U.K.,4-7 May 1993.	
125	Atelier sous-régional de la COI sur les ressources marines vivantes du Golfe de Guinée ; Cotonou, Bénin, 1-4 juillet 1996.	E
126	IOC-UNEP-PERSGA-ACOPS-IUCN Workshop on Oceanographic Input to Integrated Coastal Zone Management in the Red Sea and Gulf of Aden. Jeddah, Saudi Arabia, 8 October 1995.	E
127	IOC Regional Workshop for Member States of the Caribbean and South America GODAR-V (Global Oceanographic Data Archeology and Rescue Project); Cartagena de Indias, Colombia, 8-11 October 1996.	E
128	Atelier IOC-Banque Mondiale-Sida/SAREC-ONE sur la Gestion Intégrée des Zones Côtières ; Nosy Bé, Madagascar, 14-18 octobre 1996.	E
129	Gas and Fluids in Marine Sediments, Amsterdam, the Netherlands; 27-29 January 1997.	E
130	Atelier régional de la COI sur l'océanographie côtière et la gestion de la zone côtière ;Moroni, RFI des Comores, 16-19 décembre 1996.	E
131	GOOS Coastal Module Planning Workshop; Miami, USA, 24-28 February 1997	E
132	Third IOC-FANSA Workshop; Punta-Arenas, Chile, 28-30 July 1997	S/E
133	Joint IOC-CIESM Training Workshop on Sea-level Observations and Analysis for the Countries of the Mediterranean and Black Seas; Birkenhead, U.K., 16-27 June 1997.	E
134	IOC/WESTPAC-CCOP Workshop on Paleogeographic Mapping (Holocene Optimum); Shanghai, China, 27-29 May 1997.	E
135	Regional Workshop on Integrated Coastal Zone Management; Chabahar, Iran; February 1996.	E
136	IOC Regional Workshop for Member States of Western Africa (GODAR-VI); Accra, Ghana, 22-25 April 1997.	E
137	GOOS Planning Workshop for Living Marine Resources, Dartmouth, USA; 1-5 March 1996.	E
138	Gestión de Sistemas Oceanográficos del Pacífico Oriental; Concepción, Chile, 9-16 de abril de 1996.	S
139	Sistemas Oceanográficos del Atlántico Sudoccidental, Taller, TEMA;Furg, Rio Grande, Brasil, 3-11 de noviembre de 1997	S
140	IOC Workshop on GOOS Capacity Building for the Mediterranean Region; Valletta, Malta, 26-29 November 1997.	E
141	IOC/WESTPAC Workshop on Co-operative Study in the Gulf of Thailand: A Science Plan; Bangkok, Thailand, 25-28 February 1997.	E
142	Pelagic Biogeography ICoPB II. Proceedings of the 2nd International Conference. Final Report of SCOR/IOC Working Group 93; Noordwijkerhout, The Netherlands, 9-14 July 1995.	E
143	Geosphere-biosphere coupling: Carbonate Mud Mounds and Cold Water Reefs; Gent, Belgium, 7–11 February 1998.	E
144	IOC-SOPAC Workshop Report on Pacific Regional Global Ocean Observing Systems; Suva, Fiji, 13-17 February 1998.	E
145	IOC-Black Sea Regional Committee Workshop: 'Black Sea Fluxes' Istanbul, Turkey, 10-12 June 1997.	E
146	Living Marine Resources Panel Meeting, Paris, France, 23-25 March 1998.	E
147	IOC-SOA International Training Workshop on the Intregration of Marine Sciences into the Process of Integrated Coastal Management, Dalian, China, 19-24 May 1997.	E
148	IOC/WESTPAC International Scientific Symposium – Role of Ocean Sciences for Sustainable Development Okinawa, Japan, 2-7 February 1998.	E
149	Workshops on Marine Debris & Waste Management in the Gulf of Guinea, 1995-97.	E
150	First IOCARIBE-ANCA Workshop Havana, Cuba, 29 June-1 July 1998.	E
151	Taller Pluridisciplinario TEMA sobre Redes del Gran Caribe en Gestión Integrada de Áreas Costeras Cartagena de Indias, Colombia, 7-12 de septiembre de 1998.	S
152	Workshop on Data for Sustainable Integrated Coastal Management (SICOM) Maputo, Mozambique, 18-22 July 1998	E
153	IOC/WESTPAC-Sida (SAREC) Workshop on Atmospheric Inputs of Pollutants to the Marine	E
	Environment Qingdao, China, 24-26 June 1998	
154	IOC-Sida-Flanders-SFRI Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA project) Capetown, South Africa, 30 November-11 December 1998.	E
155	Science of the Mediterranean Sea and its applications UNESCO, Paris 29-31 July 1997	E
156	IOC-LUC-KMFRI Workshop on RECOSCIX-WIO in the Year 2000 and Beyond, Mombasa, Kenya, 12-16 April 1999	E
157	'98 IOC-KMI International Workshop on Integrated Coastal Management (ICM), Seoul, Republic of Korea 16-18 April 1998	E
158	The IOCARIBE Users and the Global Ocean Observing System (GOOS) Capacity Building Workshop, San José, Costa Rica, 22-24 April 1999	E
159	Oceanic Fronts and Related Phenomena (Konstantin Federov Memorial Symposium) – Proceedings, Pushkin, Russian Federation, 18-22 May 1998	E
160	Under preparation	
161	Under preparation	
162	Workshop report on the Transports and Linkages of the Intra-americas Sea (IAS), Cozumel, Mexico, 1-5 November 1997	E
163	Under preparation	
164	IOC-Sida-Flanders-MCM Third Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA Project), Cape Town, South Africa, 29 November – 11 December 1999	E
165	An African Conference on Sustainable Integrated Management; Proceedings of the Workshops. An Integrated Approach, (PACSICOM), Maputo, Mozambique, 18 –25 July 1998	E, F
166	IOC-SOA International Workshop on Coastal Megacities: Challenges of Growing Urbanization of the World's Coastal Areas; Hangzhou, P.R. China, 27 –30 September 1999	E
167	IOC-Flanders First ODINAFRICA-II Planning Workshop, Dakar, Senegal, 2-4 May 2000	E
168	Geological Processes on European Continental Margins; International Conference and Eight Post-cruise Meeting of the Training-Through-Research Programme, Granada, Spain, 31 January – 3 February 2000	E
169	International Conference on the International Oceanographic Data & Information Exchange in the Western Pacific (IODE-WESTPAC) 1999, ICIWP '99 Langkawi, Malaysia, 1-4 November 1999	***under preparation***
170	IOCARIBE-GODAR-I Cartagenas, Colombia, February 2000	***under preparation***
171	Ocean Circulation Science derived from the Atlantic, Indian and Arctic Sea Level Networks, Toulouse, France, 10-11 May 1999	E
172	(*Under preparation*)	
173	(*Under preparation*	
174	IOC-SOPAC Regional Workshop on Coastal Global Ocean Observing System (GOOS) for the Pacific Region, Apia, Samoa, 16-17 August 2000	E
175	Geological Processes on Deep-water European Margins, Moscow-Mozhenka, 28 Jan.-2 Feb. 2001	E
176	MedGLOSS Workshop and Coordination Meeting for the Pilot Monitoring Network System of Systematic Sea Level Measurements in the Mediterranean and Black Seas, Haifa, Israel, 15-17 May 2000	E
177	*(Under preparation)*	
178	*(Under preparation)*	
179	*(Under preparation)*	
180	Abstracts of Presentations at Workshops during the 7th session of the IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Honolulu, USA, 23-27 April 2001	E
181	*(Under preparation)*	
182	*(Under preparation)*	
183	Geosphere/Biosphere/Hydrosphere Coupling Process, Fluid Escape Structures and Tectonics at Continental Margins and Ocean Ridges, International Conference & Tenth Post-cruise Meeting of the Training-through-Research Programme, Aveiro, Portugal, 30 January-2 February 2002	E