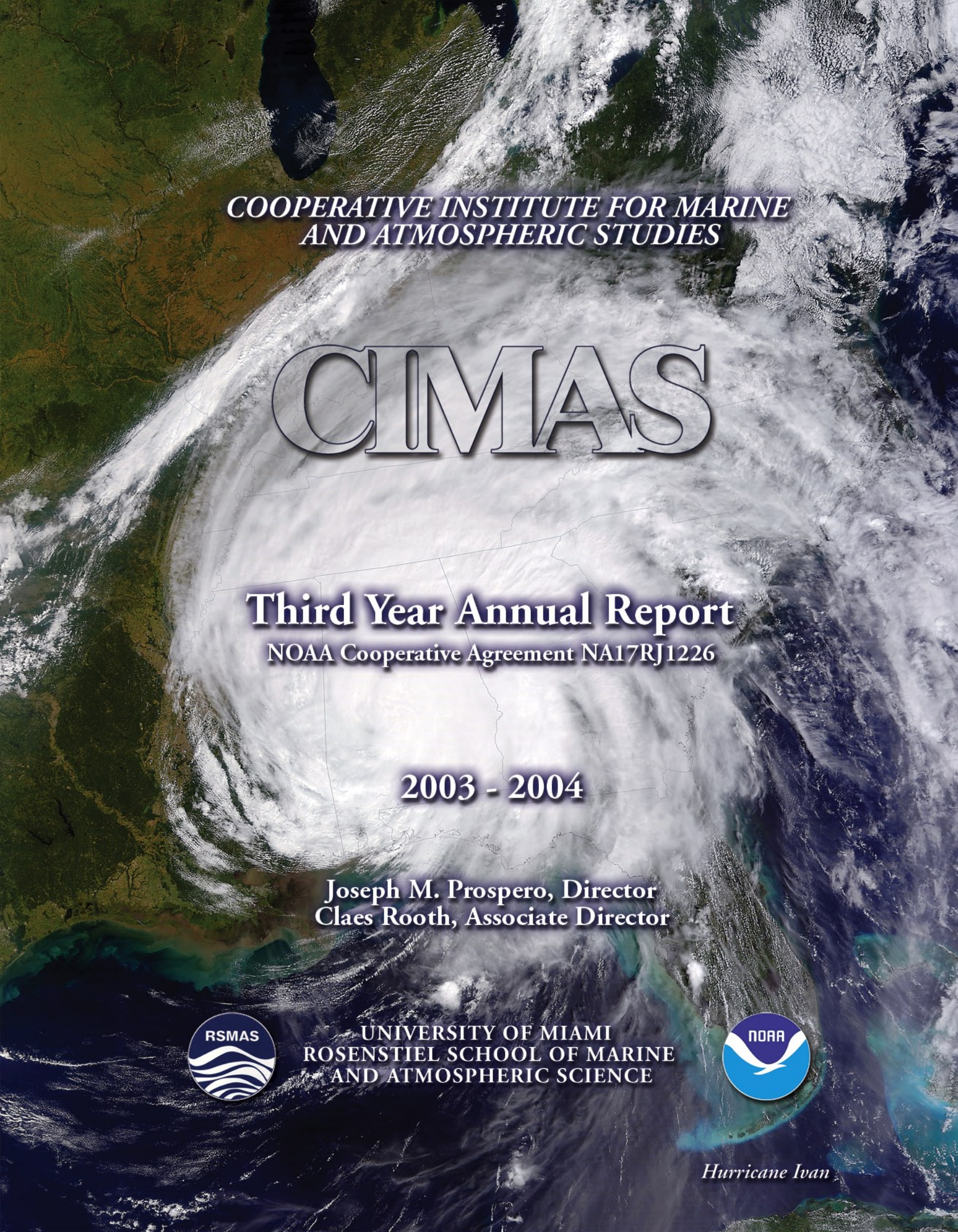

COOPERATIVE INSTITUTE FOR MARINE AND ATMOSPHERIC STUDIES

CIMAS

Third Year Annual Report

NOAA Cooperative Agreement NA17RJ1226

2003 - 2004

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UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL OF MARINE
AND ATMOSPHERIC SCIENCE

Hurricane Ivan

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CIMAS MISSION

CIMAS, the University, and NOAA
The Cooperative Institute of Marine and Atmospheric Studies (CIMAS) is a research institute at the University of Miami in the Rosenstiel School of Marine and Atmospheric Science (RSMAS). CIMAS is sponsored jointly by the University of Miami and the National Oceanic and Atmospheric Administration (NOAA) through NOAA's Office of Oceanic and Atmospheric Research (OAR), a line office in NOAA also known as "NOAA Research".

CIMAS was established in 1977 through a Memorandum of Understanding between NOAA and the University of Miami. It is one of twelve such Institutes nationwide. As an Institute of the University, CIMAS operates under the same policies and procedures as those that apply to the other units of the University.

The CIMAS Vision:

- *To become a center of excellence in Earth Systems Science and the human interactions with the Earth System;*
- *To serve as a means of using this knowledge to improve and protect our environment and to use it more effectively and benevolently;*
- *To convey this knowledge to the public through education and outreach.*

Above, a view of Virginia Key looking toward the southeast, showing the Rosenstiel School, right, the NOAA Atlantic Oceanographic and Meteorological Laboratory, center foreground, and the Southeast Fisheries Science Center of the National Marine Fisheries Service (left). Virginia Key is about 3 mile east of downtown Miami, Florida.

The CIMAS Mission:

- *To conduct research in the terrestrial, ocean, and atmospheric environment within the general context of the NOAA's mission;*
- *To focus on the physical, chemical, and biological interactions between and among these environments;*
- *To understand the role of humans in affecting these environments and the impact of the changes in the environment on humans;*
- *To facilitate and participate in education programs that are grounded in advanced Earth System Science.*

How CIMAS Carries Out Its Mission

CIMAS serves as a mechanism to promote synergisms between University scientists and those in NOAA. Most of our research is related to programs in OAR and in the National Marine Fisheries Service (NMFS). Over recent years we have had increasing interactions with NOAA's National Environmental Satellite Data and Information Service (NESDIS). Most activities in CIMAS are associated with research programs at the local NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML) and the Southeast Fisheries Science Center (SEFSC) both of which are located on Virginia Key in close proximity to the CIMAS/RSMAS campus.

CIMAS addresses issues of national interest within the context of NOAA's missions of environmental prediction and stewardship. CIMAS accomplishes this:

- *By fostering joint projects between University of Miami scientists and those employed at the NOAA laboratories;*
- *By providing a mechanism for engaging undergraduate students, graduate students and post-doctoral fellows in the research at these laboratories;*
- *By arranging for short-term visiting specialists to enhance the general effort in relevant research areas through short term consultations and seminars or by arranging for their involvement in ongoing projects for longer time periods;*
- *By providing training for personnel in various areas of research in marine and atmospheric science.*

CIMAS enhances NOAA-University cooperation and thus promotes both the quality and attractiveness of the local NOAA laboratories as a scientific working environment. It also serves to increase the breadth of University activities in research areas that are complementary to NOAA's mission.

CIMAS research and its scientific objectives are guided by the general objectives of NOAA's Strategic Plan for FY 2003-2008. NOAA identifies four mission goals:

1. *Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.*
2. *Understand climate variability and change to enhance society's ability to plan and respond.*
3. *Serve society's needs for weather and water information.*
4. *Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.*

Each research project in CIMAS is associated with a specific NOAA mission goal.

CIMAS activities during FY 2003-2004 involved 104 persons in various capacities. Table 1 shows the distribution of personnel by category and the NOAA laboratories with which they are associated. Of this number a total of 77 persons are employed in association with the local NOAA laboratories, 47 with AOML and 30 with SEFSC.

Table 1: CIMAS Personnel 2003-2004

Category	CIMAS	AOML	SEFSC	Total
Research Associate/Scientist		25	9	34
Postdoctoral Fellow		4	4	8
Research Support Staff		9	11	20
Graduate Students		2	4	6
Undergraduate Students		3	2	5
Part Time (Less 50% NOAA Support)		4		4
Subtotals		47	30	77
Visiting Scientist		4		4
Administrative	5			5
Fellows	18			18
Totals	23	51	30	104

Research Associates/Scientists are those employees under Task 2 who work closely with the local NOAA laboratories. There has been a steady growth in Task 2 personnel in the middle and late 1990s. This appears to have leveled off. The total personnel count in Years 1 through 3 of the Agreement is essentially unchanged.

CIMAS Research Associates/Scientists are hired into a well-delineated series of categories that allow for professional advancement in the research ranks. There is a sequence of five positions targeted for advanced technical or scientific staff who are required for the support of research activities at the University. These positions constitute the normal research classification progression at the University of Miami. Advanced education, continuing professional achievement, and/or increased experience are the basis for advancement to a higher-level position. The progression order is: Research Associate, Senior Research Associate, Assistant Scientist, Associate Scientist, and Scientist. The "Scientist" ranks (Assistant Scientist, Associate Scientist, Scientist) are structured to parallel those of the research faculty at the University (i.e., Assistant Research Professor, Associate Research Professor, Research Professor).

There are a total of 8 Postdoctoral Fellows. Postdocs have become an important part of the CIMAS employee pool during the current Agreement.

Research Support Staff are temporary employees, hired for the duration of specific projects. These include persons from a variety of backgrounds including local high schools as a part of outreach programs.

Four CIMAS scientists are employed part-time (less than 50% support from NOAA) as a part of ongoing research programs.

It should be noted that although CIMAS has the status of a division in the School it has no faculty. School faculty participate in CIMAS activities in many ways, but they hold their primary appointment in one of the aforementioned academic divisions. Similarly, graduate students who work on CIMAS programs have their primary affiliation with an academic division which has the ultimate responsibility for overseeing the students' academic performance and the degree-granting degrees.

Many faculty participate in CIMAS as Fellows who play a role in the governance of the Institute. The Fellows act much like a Board of Directors. At present there are 18 CIMAS Fellows. Fellows are scientists of established national or international standing who either hold regular teaching or research faculty appointments or who are staff members of NOAA. Fellows who are NOAA staff members also serve as adjunct faculty in the various academic divisions of the School in accordance with standard University procedure. In addition to the regular members of the Fellows, there are three ex officio members, the Dean of RSMAS (O. Brown) and the heads of the two local NOAA laboratories (P. Ortner, AOML; N. Thompson, SEFSC).

A list of the CIMAS Fellows membership is shown in the Fellows section of this report along with their affiliation. At present 10 Fellows are University faculty and 8 are NOAA employees. We normally strive for an approximately equal balance of University and NOAA members. During the past year, two new members were added to the Fellows. Mark Donelan, a member of RSMAS Division of Applied Marine Physics, specializes in studies of air-sea interactions. Lynn (Nick) Shea, RSMAS Division of Meteorology and Physical Oceanography, focuses on research in air-sea fluxes in the vicinity of tropical storms and hurricanes.

CIMAS staff consists of the Director and Associate Director, who hold their primary appointments in School academic divisions, and three administrative personnel.

During the past year three CIMAS employees assumed positions as Federal Employees at the local NOAA laboratories.

The distribution of degrees amongst CIMAS personnel engaged in NOAA-related research in 2003-2004 is shown in Table 2.

Table 2: Degree Status of CIMAS Employees

Category	Number	B.S	M.S.	Ph.D.
Research Associate/Scientist	34	17	13	4
Postdoctoral Fellows	8			8
Research Support Staff	20	2	2	
Part-Time (under 50% NOAA support)	4	1	2	1
Graduate Students	6	4	2	
Undergraduate Students	5			
Totals	77	23	19	13

The employees in the Research Associate and Research Scientist ranks have a rather diverse demographic profile. The population is 38% female. Foreign-born individuals make up 42% of the personnel. White non-Hispanics make up 64% of the ranks. The ethnic profile is: 8 Hispanic, 6 Asian, 1 Black non-Hispanic. Countries of origin include: Argentina, Brazil, China (3), Cuba (4), Greece, Haiti, India, Korea (2), Mexico, Netherlands, Thailand. The population of CIMAS is relatively young with a median age of 35.

CIMAS FUNDING

CIMAS continues to show steady growth in its funding. In Year 3, funds from all sources totaled $7,301,000. A summary of CIMAS funding under the current Cooperative Agreement is shown in Table 1. The table summarizes funding from all sources including the contribution from the University in support of CIMAS administration.

Table 1: CIMAS Funding Under the Cooperative Agreement: 1 July 2001 - 30 June 2006:
(Thousands of Dollars)

	Task I	Task II	Task III	Task IV	UM Admin	Total
'01-02: Yr 1	1,620	1,434	2,604	320	200	6,179
'02-03: Yr 2	1,381	2,059	1,444	625	190	5,699
'03-04: Yr 3	700	2,435	3,548	413	205	7,301

Funding increase sharply in Year 3, by about 1.4M over the means of Year 1 and Year 2.

In Year 3, CIMAS received a total of $7.1 million from various agencies. The agency sources are shown in Figure 1. The National Marine Fisheries Service (NMFS) and Oceanic and Atmospheric Research (OAR) are the dominant sources, each providing about a 28% of the total funding; the Office of Global Programs is next with 16% and National Ocean Service at 14%. NOAA sources account for 95% of total funding.

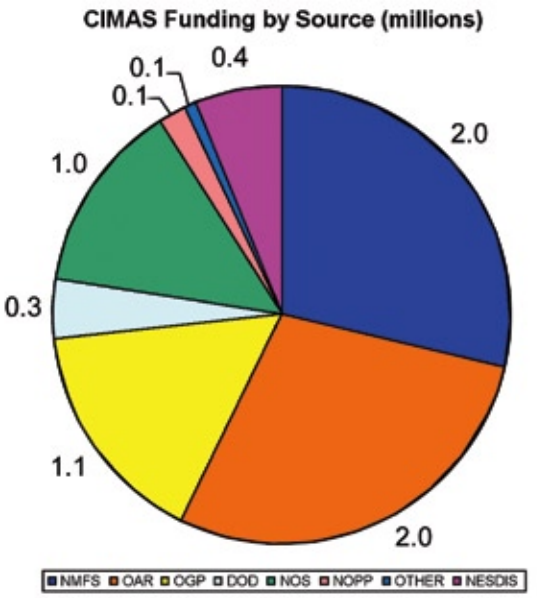


Figure 1

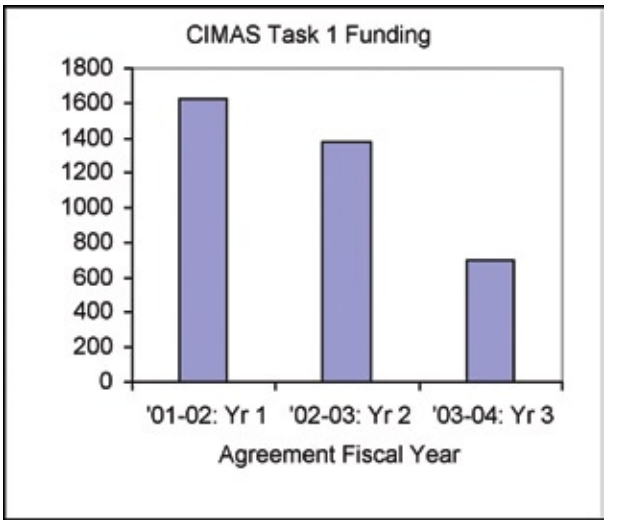


Figure 2

CIMAS activities are administratively grouped under four distinct Tasks that are related to different aspects of the CIMAS mission.

• Task 1 provides the administrative structure for the Institute and includes support for limited-term postdoctoral research associates, graduate students and limited-term collaborating research scientists from outside Miami. The University contributes to the administrative support of CIMAS in its role as a Division in the School. Task 1 also covers the costs of short-term visits by scientists under the CIMAS Visiting Scientist program.

• Task 2 provides support for highly specialized research scientists who are employed by CIMAS to complement existing expertise in NOAA and the University in the collaborative research themes of the Institute.

• Task 3 and Task 4 encompass the directed research programs of CIMAS. These provide support for research in CIMAS themes by University faculty, scientists, and students. Task 3 encompasses activities of CIMAS scientists that are carried out in cooperation with the personnel at the local NOAA laboratories in Miami. Under Task 4 are projects that support or complement activities at NOAA laboratories other than those located in Miami. The indirect cost rates for these two tasks differs in recognition to the direct funding support that CIMAS receives under Task 1 from the local NOAA laboratories.

The history of Task 1 funding over the first three years of the Cooperative Agreement is shown in Figure 2. The figure shows a substantial decrease in Task 1 funding in Year 3 of the Agreement. This is due in part to the timing of fund transfers at the time Year 2 was coming to an end. Nonetheless, the average funding in Years 2 and 3 is about 600K less that in Year 1.

The history of funding for the Research Associate program (Task 2) is shown in Figure 3. There has been steady growth in Task 2 reflecting the growth of research personnel in CIMAS. The past year saw a substantial increase in Task 2 funding with most of the growth through the SEFSC.

Total funding for Task 1 and Task 2 by year over the current Agreement period is shown in Figure 4. The totals show little change over the period largely because the decline in Task 1 offset the strong growth in Task 2.

The history of research funding (Task 3 and Task 4 combined) is shown in Figure 5. There has been a substantial growth in funding over the three years of the Cooperative Agreement. However the picture is skewed by the large increase in Year 3 relative to Year 2 which is due in part to the delay in finalizing the Federal budget in Congress in Year 2. However there has been a real increase which largely reflects increased research associated with the South Florida - Everglades Restoration program.

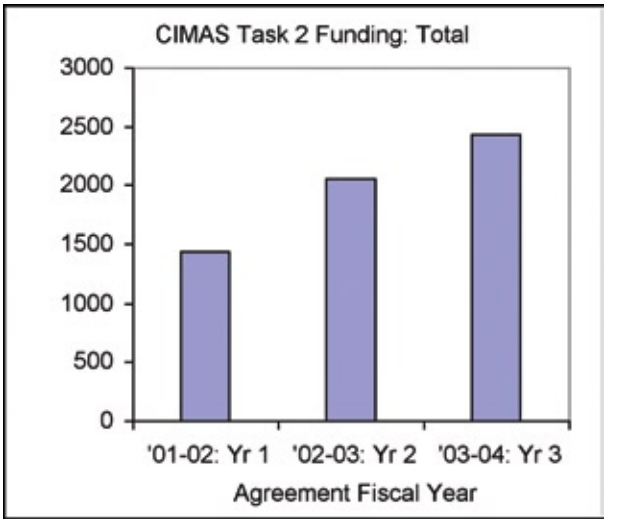


Figure 3

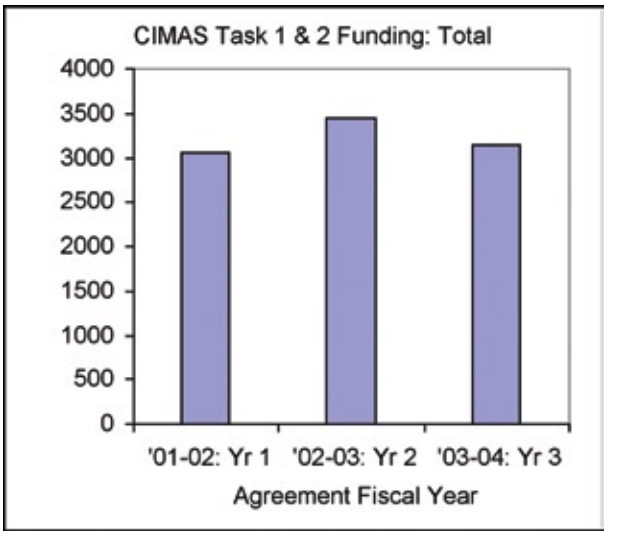


Figure 4.

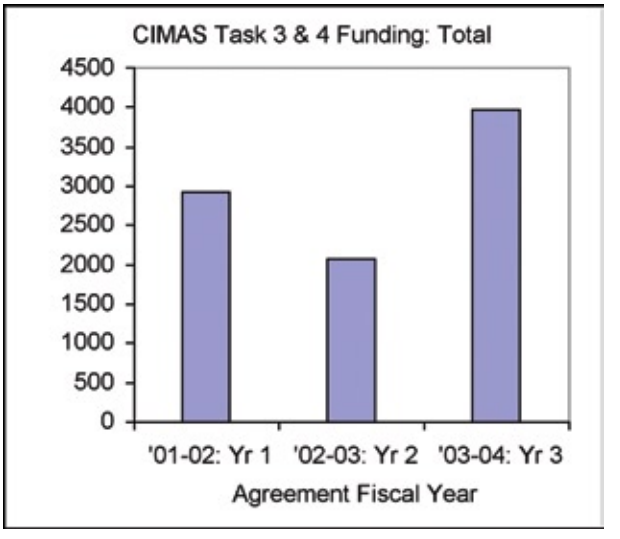


Figure 5

CIMAS RESEARCH THEMES

Scientific activities in CIMAS are organized under broad Research Themes. The selection of Theme topics is guided by the major environmental issues that confront our nation today. CIMAS' scientific objectives complement those in NOAA's Strategic Plan. Specific goals are set in the context of the research activities and expertise resident in the University and the local Miami laboratories of NOAA. Under the current Cooperative Agreement, scientific activities in CIMAS are carried out under six themes.

Theme 1: Climate Variability
Theme 2: Fisheries Dynamics
Theme 3: Regional Coastal Ecosystem Processes
Theme 4: Human Interactions with the Environment
Theme 5: Air-Sea Interactions and Exchanges
Theme 6: Integrated Ocean Observations

Theme 1: Climate Variability

• Investigate the dynamics of the ocean and the atmosphere and the ways in which they interact on interannual and longer-scales and they link to climate variations.

The major challenges of climate research today are to accurately characterize climate variability on time scales ranging from weeks to centuries, to detect trends in climate, and to identify the factors causing those changes, especially those deriving from human activities. Theme 1 research focuses on climate variations that occur on an interannual-to-longer time-scale. The objective is to understand the dynamics of oceanic and atmospheric processes that affect climate variations. The ultimate goal is to increase our capability to predict climate through the use of models.

The CIMAS program places emphasis on systematic analysis of environmental data sets. These tend to be very large and require special processing techniques. These consist of specific diagnostic studies as well as fundamental research into the principles of analysis. The CIMAS effort, combined with a continuing commitment to climate-oriented long-term observations of oceanic transport processes, contribute to the development of climate-prediction capabilities and to the assessment of climate change.

RSMAS pursues a vigorous program in atmospheric and ocean chemistry as related to climate processes and their variability. Research is underway with regards to the role of chemistry in radiative energy transfer processes by direct effects as well as indirect aerosol effects that involve the modification of oceanic cloudiness. Recently RSMAS has expanded its research capability in tropical meteorology; this will enhance the CIMAS mission in aspects of tropical atmospheric processes that relate to climate variability and to activities in the AOML Hurricane Research Division.

Because climate and climate variability are fundamentally global-scale phenomena, CIMAS research activities often involves strong interactions with the national and international research communities. To this end, CIMAS plays a role in fostering international cooperation. The major focus is with individuals and institutions in Latin America in the area of tropical air-sea interaction and in Europe with regard to research into the climatic role of the subtropical and tropical Atlantic circulation.

Theme 1 activities contribute to NOAA Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.

Research in this theme is consistent with three NOAA Mission Strategies:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*

(Above) Up close to a school of large permit (*Trachinotus falcatus*) in the Florida Keys. (Jerry Ault)

Theme 2: Fisheries Dynamics

• Enhance our understanding of fisheries and ecosystem dynamics so as to improve the management of fisheries and marine protected species.

Many ocean fisheries are undergoing rapid change, some due to natural variability and others due to human activities – over-fishing, the destruction and polluting of coastal habitats, climate changes resulting from greenhouse gases. While these issues are complex, in many cases it is clear that heavy fishing pressures, both recreational and commercial, are the primary cause. The main objectives of Theme 2 are to enhance our understanding of fisheries dynamics so as to foster better fisheries management, and to provide educational opportunities in this area of research.

CIMAS has a long history of research that focuses on applications of prediction models to specific fisheries. Recently emphasis has shifted to the development and use of risk assessment methods that take into account the role of uncertainty in our understanding of ecosystem and fishery dynamics and the impact of uncertainty in the management process.

The current emphasis on rational management of fishery resources is coincident with an increasing demand for these resources, often in the face of declining fish catches. Emphasis is also placed on proper management of marine protected species. Analysis has shown that there are fundamental constraints on our knowledge of fisheries systems in the context of marine ecosystems. In particular, theoretical models are mostly based on hypothesized relationships among the various components of marine ecosystems, including exploitation by humans. Most models are still in the development stage and they have limited ability as forecasting tools.

Many activities related to this theme are carried out in a sub-unit in CIMAS, the Cooperative Unit for Fisheries Education and Research (CUFER). CUFER was established in 1992 in response to a need for the development of methods for improved quantitative assessment of fish populations and as a source of advice for resource sustainability. CUFER offers the opportunity to work on research issues with long-time horizons, an advantage afforded by academic research. An important ancillary component of CUFER is to develop the human resources and expertise needed for the future research and management of Florida and Caribbean fishery resources. However, the results from this program are broadly applicable to tropical and subtropical fisheries all over the world.

Another fisheries-related unit housed in CIMAS is the Center for Independent Experts (CIE) established in 1998. The primary function of CIE is to organize and facilitate independent peer reviews of stock assessments carried out by the National Marine Fisheries Service (NMFS). Under

this program, CIE arranges for the solicitation and selection of qualified scientists who carry out reviews of ongoing and completed assessments and who serve as independent experts on advisory panels and working groups.

Theme 2 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.
Research in this theme is consistent with three Mission Strategies as related to fisheries research:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*
- *Manage coastal and ocean resources to optimize benefits to the environment, the economy, and public safety.*

A massive sandstorm sweeping over the Persian Gulf state of Qatar as it races southward toward southeastern Saudi Arabia.

Theme 3: Regional Coastal Ecosystem Processes

• Carry out research on the ecological health of coastal ocean ecosystems in the Southeast U.S. so as to lead to better management strategies.

South Florida is beset with a broad range of environmental problems that are the result of many decades of intense development in this fragile subtropical environment, unique in the continental United States. Because of the unique character of the region and the widely-diverse and closely-linked terrestrial and aquatic ecosystems, new strategies are required to address these issues. To this end Theme 3 focuses on the development of a scientific framework that links the multitude of special problems and scientific studies across the region.

A major part of the research in Theme 3 is carried out in the context of the South Florida Ecosystem Restoration initiative, a program that seeks to reverse the damage caused by the rapid growth in this region. Legislation passed by Congress several years ago allocates over eight billion dollars for this effort which will take place over several decades. CIMAS and NOAA's Miami laboratories are playing a central role in this program. Research activities under Theme 3 include:

- *Observations and analyses of atmospheric and ocean chemical and physical variability and their impact upon the health of the regional coastal ocean.*
- *Observations and modeling to elucidate how indigenous biological populations and communities respond to the unique physical and chemical environment of South Florida. How does variability in the environment influence the viability and distribution of biological populations? How is the system changing? What changes (and what consequences) might we expect in the future as the restoration program is implemented?*
- *Special integrated studies of critically-stressed or keystone components of the South Florida coastal ecosystem. These include studies that characterize natural and anthropogenic stressors, that identify causal mechanisms, and that establish ecological endpoints as well as the measurable indicators of progress towards achieving regional coastal ecosystem health.*
- *Development of theories and methodologies necessary to understand the biological, ecological*

and oceanic variables controlling and regulating South Florida coastal fisheries populations, their food sources and their habitat. We need such knowledge in order to predict variability in space and time with an accuracy useful for management purposes. Fishery problems are an important subset of the coastal ocean ecosystem processes because of their large economic significance both commercially and recreationally in South Florida.

The activities under Theme 3 bring together local management expertise and experience so as to provide analytical tools - models and techniques - for making timely and informed assessments of the combined effects of natural processes and restoration-related actions upon the regional coastal ecosystem. Such tools are essential for the informed management of regional coastal ecosystem resources.

Theme 3 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management. They also contribute to Mission Goal 3: Serve society's needs for ... water information.

Research in this theme is consistent with three Mission Strategies as related to coastal ocean processes and their impact on fisheries and other aspects of the coastal environment.

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*
- *Manage coastal and ocean resources to optimize benefits to the environment, the economy, and public safety.*
- *Study how humans interact with the environment so as to lead to better policy making.*

Theme 4: Human Interactions with the Environment

- ***Study how humans interact with the environment so as to lead to better policy making***.

Theme 4 highlights the role of human systems in environmental decision making. Humans interact with the environment in many ways. Studies of these interactions range from assessing societal risks from natural hazards to considering how population growth and land use changes may affect the health of ecosystems. Humans shape natural systems and are shaped by them. Examples are climate change, the utilization of marine resources, and the urbanization of coastal regions. The inter-dependence of humans and ecosystems makes human interactions a topic of interest to environmental managers as well as to stakeholders and the scientific community.

Researchers use integrated assessments to study and resolve the complex dynamics of overlapping human and natural systems. This approach goes beyond synthesizing and advancing what is known about a problem - it also ensures that the results are relevant to society. Estuaries, to take one example, are considered as integrated systems. While often thought of as natural systems in terms of their rates of soil and water movement and rich habitats, estuaries are also appropriately regarded as socio-economic systems in terms of the size and distribution of costs and the benefits they help create. It is the interplay of natural and human systems that creates problems for resource managers and opportunities for stakeholders.

There are three distinct foci in Theme 4:

- *Human dimensions of climate change and variability.*

Researchers seek to improve our understanding of how social and economic systems are currently influenced by climatic fluctuations, and how human behavior can be affected by using our gained knowledge about variability in the climate system, for example, by using El Niño forecasts in agriculture.

- *Sustainable use of the world's fisheries.*

Researchers emphasize the role of human behavior in the fisheries and marine ecosystems to be managed. The study of marine reserve networks, for example, has explored their optimal design in terms of biological and physical connections and the socio-economic consequences of implementation within fishing communities.

- *Urbanization of the Coastal Zone.*

Half the nation's population lives on coastal lands which comprise only 17% of the total land area.

Recent assessments of coastal zone impacts identify the dominant ecological risks as habitat alteration, hydrological alteration, and the over-exploitation of natural resources. Moreover, the steadily increasing population within the coastal environment increases the potential for exposure to environmental risks such as storms and hurricanes.

To have a shared vision of sustainable use, a multidisciplinary, multi-institutional dialog is needed. Research under Theme 4 facilitates this dialog and leads to the development of new analytical tools with which to identify problems, to characterize sources of environmental degradation, and to monitor progress towards restoration.

Theme 4 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management. Also, Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.

Research in this theme is consistent with all five Mission Strategies as related to the human dimensions of environmental change:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*
- *Engage, advise, and inform individuals, partners, communities, and industries to facilitate information flow, assure coordination and cooperation, and provide assistance in the use, evaluation, and application of information.*
- *Manage coastal and ocean resources to optimize benefits to the environment, the economy, and public safety.*

Theme 5: Air-Sea Interactions and Exchanges

• Understand the energy exchanges and interactions between the atmosphere and the oceans and the consequent effects on atmospheric and ocean mixing and circulation.

The oceans are an important source of the energy that drives large-scale atmospheric circulations; conversely, the wind systems drive oceanic mixing and circulation. The interplay between the ocean and the atmosphere can result in large variations in global weather patterns as demonstrated by the impact of El Niño events. These interactions involve a wide range of properties such as the air and sea-surface temperatures, humidity, wind speed, rainfall, salinity, mixed-layer depth and heat content. These properties vary on scales from a millimeters to 1000 km; they underlie the variability of oceanic and atmospheric circulations from the scale of a single ocean wave to tropical cyclones. The ocean plays a major role in the biogeochemical cycles of many important species that can have an important role in climate forcing: e.g., CO_2, halocarbons, aerosols. Air-sea exchange processes control the amount of these materials that remain in the atmosphere and thus the degree to which these species, both natural and pollutant, can affect radiative processes and climate.

Research on air-sea interactions largely focuses on processes in the marine atmospheric boundary layer and the surface waters of the ocean including the oceanic mixed layer and the top of the seasonal thermocline. It also extends into maritime cloud climatology and to maritime weather system prediction - from coastal fog and stratus clouds to tropical waves, squall lines and hurricanes.

An equally important area of research focuses on the exchange and interaction between the atmospheric environment of the coastal urban complex and the coastal marine atmosphere; the deposition of pollutants to coastal waters are known to have a substantial impact on coastal ecosystems. The ultimate objective of these various programs is to develop and verify physical-chemical models of the atmosphere and the ocean and the processes that couple them. Another critical area of research is to understand the role of the upper ocean on hurricane intensity changes.

RSMAS has developed a strong program in air-sea interaction studies. University scientists work closely with AOML in research on *in situ* exchange processes and in the development of new instrumentation such as airborne oceanography. Remote sensing techniques are playing an increasing role in studies of the marine boundary layer and the upper ocean including the interface. Both RSMAS and AOML have strong programs in this area as well and these two groups work closely together in these areas.

Theme 5 activities contribute to NOAA Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.
Research in this theme is consistent with two Mission Strategies:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Assess and predict the changes of natural systems, and provide information about the future.*

Theme 6: Integrated Ocean Observations

• Study the integration of modeling and physical measurements in the ocean and the atmosphere so as to achieve optimal designs of observing systems.

Observing systems are costly to design, to deploy, and to maintain. To design an efficient system it is necessary to first identify the critical variables to be measured, the spatial configuration of sensors, and the frequency of measurements necessary to identify and characterize temporal and spatial trends. Consequently the development of integrated observing systems requires the interplay of numerical models and observing system networks so as to accurately and efficiently estimate the optimal fields of essential oceanic variables. Another objective of this research is to develop the criteria for the acquisition of oceanic data needed to determine and document the role of the ocean in long-term climate change and to monitor these changes.

The optimal system must accomplish several objectives. It must efficiently characterize climate variability and change in the presence of geophysical noise; it must provide a product that can support marine ecosystem management with physical transport estimates; and it must provide initialization, validation, and verification data for climate forecast models. The design of ocean observing systems depends on the scale of the domain, the processes of interest, and the application of the data that is to be obtained. For example, on global scales systems must be designed to observe climate variability and dynamics. Regional scales must be observed for marine resource management, waterborne pollution mitigation, and efficient navigation. Coastal scales must be observed to support marine ecosystem management, pollution response, safe navigation, and coastal flooding.

Careful design studies are needed to determine the optimal mix of *in situ* (Eulerian and Lagrangian) sensors, satellites, and other remote sensing observations. Observational evidence indicates that the coupled air-sea system is undergoing dramatic changes on long time scales - for example, the melting of the Arctic and Greenland ice caps, the increasing surface temperatures. These changes will have a great impact on transport and mixing in the Atlantic. CIMAS investigators have a long history of tracking Atlantic thermohaline circulation, a major factor in climate variability over longer periods. We currently lack a good understanding of the time-scales of the factors that control Atlantic circulation. This will require continued observations in the Atlantic coupled with numerical modeling.

Theme 6 activities contribute to NOAA Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond. Also, Mission Goal 4: Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.
Research in this theme is consistent with three Mission Strategies:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*

Research carried out by CIMAS scientists over the past year has produced many new and interesting results. In this section we highlight some of these activities which are organized by Theme. For more details on this work, please refer to the section "Research Reports".

Theme 1: Climate Variability

Climate Information System for Agriculture and Water Resources Management in Southeastern USA

G. Podestá, D. Letson, K. Broad (UM/RSMAS); F. Miralles-Wilhelm (UM/School of Engineering)

The goal of the Southeastern Climate Consortium (SECC) is to develop a climate information and decision support system for the Southeastern USA that will contribute to an improved quality of life, increased profitability for agriculture, decreased economic risks, and more ecologically sustainable management of agriculture, forestry, and water resources. We use nested, coupled, regional climate models to explore the process of using an ENSO forecast system to provide tailored output for various socioeconomic sectors in small regions, primarily the Southeast United States and Southeast South America. These models show considerable skill in predictions of seasonal climate anomalies. We are working to resolve the complete spectrum of anomalous climatic behavior required for agricultural and climate study purposes.

Western Boundary Current Time Series

Christopher S. Meinen, Rigoberto F. Garcia, Carlos Fonseca (UM/RSMAS); Molly Baringer (NOAA/AOML)

Climate models show that variations in the transport of the Deep Western Boundary Current in the Atlantic Ocean (DWBC) have significant impacts on the climate at both the national and global level. We have developed a low-cost method for monitoring the DWBC in the Atlantic Ocean east of Florida using bottom pressure gauges, inverted echo sounders, and hydrographic data. This is supplemented by continuous measurements in the Florida Current cable program which we manage. We study the variations in the mass flow in real time by measuring the changes in the voltage induced in a submarine telephone cable that spans the Straits of Florida.

Tropical and South Atlantic Drifters

Claude Frederick Lumpkin (UM/RSMAS)

The equatorial Atlantic Ocean has a nearly closed near-surface circulation pattern consisting of a basin-wide clockwise gyre. In order to quantify heat transports to the North Atlantic and its impact on climate, we need to know how this gyre connects to the subtropical gyres of the northern and southern hemispheres. As a part of the Tropical/South Atlantic Drifter program, we analyzed data from satellite-tracked drifting buoys and show that the southern gyre bifurcates against the coast of South America, with a fraction of the flow heading northward and entering the equatorial gyre. Seasonal variations in the tropical currents are directly coupled to the northern and southern subtropical gyres at two key locations: the North Brazil Current retroflection and the South Equatorial Current bifurcation. These data greatly enhance our understanding of current structures in the Atlantic.

Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Eric P. Chassignet, George R. Halliwell, Mohamed Iskandarani, Arthur J. Mariano, Mike Chin (UM/RSMAS)

In order to improve weather and climate forecasts we need to improve the performance of ocean models. As part of the National Ocean Partnership Program (NOPP), a broad partnership of institutions (NRL/SSC, NOAA, LANL, etc.) is collaborating in developing and demonstrating the performance and application of eddy-resolving, real-time global and basin-scale ocean prediction systems using the University of Miami's HYbrid Coordinate Ocean Model (HYCOM). These systems will be transitioned for operational use by the U.S. Navy and by NOAA. In our recent work we compared the performance of HYCOM in the Gulf of Mexico and Intra-Americas Seas against various satellite products (sea-surface height, ocean color) and we obtained excellent results.

The Impact of the Saharan Air Layer on Atlantic Tropical Cyclone Activity

Jason Dunion, Joseph Prospero (UM/RSMAS); William Barry, Michael Black, Neal Dorst, Steve Feuer, John Kaplan, Christopher Landsea, Paul Leighton, Frank Marks, Mark Powell, Robert Rogers (NOAA/AOML)

Tropical cyclones (TCs) usually develop from easterly waves that emerge from the west coast of North Africa. Our prior research shows that TCs often interact with the Saharan Air Layer (SAL), a hot, dry, dust-laden layer of air often found over the tropical Atlantic during the summer and fall. Research over the past year shows that the SAL greatly alters our picture of the vertical temperature-moisture structure of the atmosphere in the tropics which is usually represented by "the Jordan mean sounding". We find that profiles fall into two radically different groupings because of the SAL. The results of this study are likely to have a great impact on our understanding of the baseline climatology of moisture in the western North Atlantic and Caribbean Sea and the consequent impact on precipitation and the evolution of tropical storms and hurricanes.

Meridional Heat Transport in the South Atlantic

Qi Yao (UM/RSMAS); Silvia L. Garzoli, Molly O. Baringer, Gustavo Goni (NOAA/AOML)

The South Atlantic Ocean is a major conduit for the warm upper-layer water that flows northwards across the equator. In order to better understand the dynamics and impacts of coupled atmosphere/ocean/and systems in the Atlantic and its impact on climate it is necessary to reduce the heat flux uncertainty in the South Atlantic. Starting in 2002, and as part of the NOAA Global Ocean Observing System, a new XBT high-density line was started in the South Atlantic between Cape Town, South Africa, and Buenos Aires, Argentina. The line was designed to close the upper layer mass budget in the Atlantic and to estimate the variability of the upper limb of the MOC transport. These data have provided a much improved picture of heat flows in the region.

New Estimates of the Heat Budget in the Tropical Atlantic, First Results

Rick Lumpkin, Qi Yao (UM/RSMAS); Claudia Schmid, Silvia L. Garzoli (NOAA/AOML)

The characterization of the heat budget of the Atlantic Ocean is critical to understanding climate trends. Using a combination of data from XBTs, ARGO and pre-ARGO floats, and surface drifters we have described the annual cycle of the heat budget of the tropical Atlantic based on data obtained in 1997-2003. These estimates are an improvement over previous results because ARGO provides data that not only improve the temperature data density but also provides salinity. This allows the direct computation of the salinity-dependent parameters which results in better heat budget estimates.

Moisture Budget in the Intra-Americas Sea, Its Transport into North America and Their Roles in Warm-Season Precipitation

Alberto M. Mestas-Nuñez, Bruce A. Albrecht, Chidong Zhang (UM/RSMAS); David B. Enfield (NOAA/AOML)

The warm pool of the Intra-Americas Sea (IAS, i.e. Gulf of Mexico and Caribbean Sea) plays a major role as a source of moisture transport into North America and it is linked to warm-season precipitation over North America. In order to understand climate trends in this region, we must be able to estimate the moisture balance - that is, the relative amounts of evaporation and precipitation. We used atmospheric observations and model analyses in and around the IAS to evaluate uncertainties in calculating moisture fluxes. We found that while the IAS as a whole is a sink for moisture from August-October, the Gulf is a source all year around and the Caribbean is a sink from August through November.

Development of the WRF Model for Tropical Cyclone Research and Forecasting

David S. Nolan (UM/RSMAS); Morris Bender, Timothy Marchok (NOAA/GFDL); Robert Tuleya (NECP)

As a part of an effort to improve forecasts for tropical cyclones we continue to work on the development of forecast models, especially the Weather Research and Forecast Model (WRF). In this work we assess the performance of WRF run retrospectively against past hurricanes and compare the results against those of other models. WRF shows great promise. On some occasions the WRF track forecasts for Hurricane Isabel (2003) were excellent and the WRF intensity forecasts were better than the GFDL model.

Mid-Infrared Sea-Surface Temperatures During the Day – Retrievals Into the Sun-Glitter Pattern

Peter J. Minnett, Robert H. Evans, Ajoy Kumar (UM/RSMAS)

Sea-surface temperatures (SSTs) are important for weather and climate forecasts. These are routinely derived from satellite-borne infrared radiometers. Measurements of SST during the day are problematical because of significant contributions from reflected sun-light (sun-glitter). We have developed an algorithm to correct for this problem by making use of the measurements from the MODerate-resolution Imaging Spectrometers (MODIS) on the NASA EOS Terra and Aqua satellites. We also use numerical radiative transfer models to explore the feasibility of extracting useful SST values in the regions of the sun-lit swath contaminated by the sun-glitter pattern. Thus far our results suggest that SSTs might be reliably retrieved from regions of sun-glitter.

Theme 2: Fisheries Dynamics

Monitoring Coral Reef Fish Populations in the Florida Keys

Jerald S. Ault, Steven G. Smith (UM/RSMAS); James A. Bohnsack (NOAA/SEFSC)

No-take reserves (NTRs) in the Florida Keys National Marine Sanctuary (FKNMS) are a joint fishery and ecosystem management effort between the NOAA National Marine Sanctuary Program, National Park Service (NPS), and the State of Florida. We designed and conducted the first-ever comprehensive surveys of coral reefs and reef fish stocks along the Florida coral reef tract. Simultaneous assessment surveys were conducted of fishes, corals, conch, spiny lobster, other reef species and coral reef habitats using newly developed state-of-the-art sampling strategies. Results from this unique study have been used to define current baseline conditions and to establish a baseline with which to monitor future changes that result from management actions in Biscayne National Park, the Florida Keys National Marine Sanctuary, and Dry Tortugas National Park.

Abundance and Diel Migrations Of Demersal Mesozooplankton and Small Reef Fishes And Their Trophodynamic Contribution to the Coral Reef Ecosystem

Sharon Smith, Jiangang Luo, Peter Lane, Dora Pilz (UM/RSMAS); Peter B. Ortner, James C. Hendee, Shailer Cummings, Jack Stamates (NOAA/AOML); John Lamkin, Dave Jones (NOAA/SEFSC)

In order to address the issue of the health of the coral reef communities, we must be able to describe and quantify the functional bio-physical relationships and processes that control and impact planktonic processes associated with coral reef ecosystems. To this end a variety of autonomous sensors were deployed in the Salt River Natural Historical Park and Ecological Preserve on the north shore of St. Croix, USVI, near a NOAA Coral Reef Early Warning System (CREWS) station. Preliminary analyses of acoustic data showed distinct daily cycles of biomass change over the reef. The local current regime and the migratory behavior of some zooplankton species appear to interact to modify the plankton community over the reef on a daily basis.

Upstream Larval Supply to Florida Bay-Dry Tortugas

Monica R. Lara, Cynthia Yeung, David L. Jones, and Maria M. Criales (UM/RSMAS); John T. Lamkin, and William J. Richards (NOAA/SEFSC)

Results from previous work suggested that the formation and movement of coastal eddies play a critical role in the supply of early-life-history stages to the South Florida ecosystem. Many species in South Florida use estuarine Florida Bay as a juvenile nursery, whereas the principal spawning ground for these species lies in the Dry Tortugas some 150 km upstream (southwest) of the Bay. Cyclonic eddies are believed to play a critical role in regional recruitment. In our program we studied the passage of eddies using a high-frequency (HF) Ocean Surface Current Radar (OSCR) array erected in the Florida Keys. The OSCR system has proven to be extremely useful in guiding the biological sampling of larval fishes associated with small scale, ephemeral oceanographic features.

Western Atlantic Pelagic Longline Sea Turtle Mitigation Research / Effect of Hook Size on Ingestion of Hooks by Loggerhead Sea Turtles

Lesley Stokes (UM/RSMAS); Sheryan Epperly, John Watson, Arvind Shah, Dan Foster, Dominy Hataway, Charles Bergmann (NOAA/NMFS/SEFSC)

Large numbers of sea turtles are captured in pelagic longline fisheries. We conducted research in the Western Atlantic Northeast Distant Waters to develop and evaluate fishing gear modifications and tactics that would reduce the incidental capture of endangered and threatened sea turtle species by longline fishing gears. Our study showed that relatively minor changes in gear (e.g., hook shape and size) and bait could greatly reduce the turtle capture and mortality in this fishery.

Simulation of Management Strategies (FEMS)

David Die (UM/RSMAS); Murdoch McAllister (Imperial College); Molly Lutcavage, Andy Rosenberg (Univ. of New Hampshire)

The evaluation of management strategies for migratory species is important for improving the management of fisheries and achieving sustainable use of marine resources. This project has developed an analysis framework for the statistical evaluation of fishery management strategies. The framework has already been used to evaluate both theoretical and real fisheries which target highly migratory species such as Atlantic Yellowfin tuna and Atlantic marlins.

Modeling Pink Shrimp Recruitment from Florida Bay

Maria M. Criales, John Wang (UM/RSMAS); Joan A. Browder, Steven Wong, Thomas Jackson (NOAA/SESFC); Michael Robblee, Clinton Hittle (USGS/CWRS)

Pink shrimp are an important part of the commercial fishery in Florida. We are developing a pink shrimp simulation model to evaluate the impact of upstream water management changes on Florida Bay as a consequence of the South Florida-Everglades restoration and to better understand the ecology of this fishery species in relation to the processes influencing transport, settlement, survival, and recruitment. As a part of this effort we investigated the transport mechanisms of planktonic stages from spawning grounds (Dry Tortugas) to nursery grounds (Florida Bay). Results suggest that only planktonic stages that are able to recognize and act upon changes in the direction of the current could reach the nursery grounds within 30 days.

Monitoring Coral Reef Fish Utilization of MPA's and Inshore Habitats in Florida Bay

Monica R. Lara, David L. Jones (UM/RSMAS); John T. Lamkin (NOAA/SEFSC)

Our research has focused on developing techniques that could be used to identify the principal nursery areas of commercially, recreationally, and ecologically important reef fish species in South Florida. Many species are believed to migrate to reefs from juvenile nursery areas such as sea grass and mangrove habitats in Florida Bay and the lower Florida Keys. To monitor coral reef fish recruitment processes we have successfully developed a technique that is based on the measurement of trace elements, including rare earths, in the otoliths (ear bones) of fishes. This is the first study to use rare earth elements as a tracer in otoliths.

Development of an In-Water Stereo Video System for Use in Fish Surveys

Kenneth Voss, G. Chris Boynton (UM/Physics); Jerald S. Ault (UM/RSMAS); James A. Bohnsack (NOAA/NMFS)

Fish surveys are an essential part of monitoring and assessing the health of fish populations but they are difficult to carry out because they require many well-trained and experienced divers to identify the fish as well as estimate size and numbers. To improve the accuracy of fish surveys and reduce their cost we have developed and successfully tested an autonomous stereo video camera system and an all-digital format data system that allows us to use digital image techniques for data reduction.

Theme 3: Regional Coastal Ecosystem Processes

Spectral Optimization in Case 2 Waters

Kenneth J. Voss, Howard R. Gordon (UM/Department of Physics)

The remote-sensing of ocean color is widely used in studies of the global oceans to retrieve information such as chlorophyll concentration, dissolved organic matter content, and turbidity caused by suspended particles. However the open-ocean algorithms are not applicable to coastal waters where the overlying atmosphere often contains high concentrations of pollutants and where the water is often shallow thereby causing an interference from bottom reflectance. In this study we developed an algorithm which when applied to SeaWiFS images gives us much improved performance in coastal waters.

Settlement, Growth, and Migration of Snappers in Florida Bay and Adjacent Marine Ecosystems

Monica Lara, Dave Jones, Peter Swart (UM/RSMAS); Trika L. Gerard (NOAA/SEFSC)

In order to make sound management decisions, we need to understand the ecological and biological dynamics of reef fish species and the economic impacts of human uses as a basis. Many exploited reef fish species directly use Florida Bay as critical settlement and nursery habitats before reaching maturity when they migrate back to the reefs as adults. In our program we have developed a technique to measure stable isotopes of ^{13}C and ^{18}O in the otoliths (ear bones) of gray snapper (*Lutjanus griseus*). We use these ratios to look for spatial and temporal variation within Florida Bay, to detect significant variations between Florida Bay and other surrounding marine ecosystems, and to determine if there were any significant variation between habitats. We find that these isotopes do serve as a basis for distinguishing habitats.

Reef Fish Community Dynamics and Linkages with Florida Bay

Jerald S. Ault, Steven G. Smith (UM/RSMAS); James A. Bohnsack (NOAA/SEFSC)

The goal of this research is to quantify community and reef fish population changes in management zones under different levels of protective management. It provides data needed to model the effects of the Everglades Restoration on coral reef fishes and to assess the effectiveness of restoration in terms of ecological recovery. The study focused on important reef fish species in the Florida Keys snapper-grouper complex. We find that the average size of reef fish within the exploited phase for the last 25 years has remained relatively constant for 35 species, but that size is very close to minimum size of capture for most of the exploited stocks. Overall, 77% of the 35 stocks that could be analyzed were overfished by federal standards. The current level of exploitation (that is, fishing mortality) for grouper stocks was 3 to 10 times the exploitation level that would achieve maximum sustainable yield, a minimum sustainability benchmark under federal standards. Some stocks appear to have been chronically overfished since at least the late 1970's and high sustained exploitation pressures have precipitated serial overfishing of key resources. These data suggest that fishing has been a dominate factor influencing reef fish community structure.

Real-Time Currents and Water Quality Monitoring in the FKNMS

Thomas N. Lee, Nelson Melo, Grant Rawson, Ben Kates (UM/RSMAS); Elizabeth Johns, Peter B. Ortner, James C. Hendee, Ryan Smith (NOAA/AOML)

The current system in the Florida Keys, especially currents through the passages between Florida Bay and the reef tract, are known to have a strong impact on the reef environment. Our objective is to make real-time observations of important oceanographic parameters at various sites throughout the Florida Keys National Marine Sanctuary. We use a combination of a deployed sensor network (e.g., bottom-mounted acoustic Doppler current profilers), satellite-tracked CODE surface drifters, and targeted cruises. The network of real-time sites is expanding to include additional instruments at selected sites in the FKNMS. Our measurements continue to show that currents through inter-island passages in the Florida Keys are strongly influenced by local wind forcing and by gravity-driven transports produced by cross-key sea level differences on time scales of several days to weeks.

Relative Importance of Threats Facing Florida Keys *Acroporids*

Dana E. Williams (UM/RSMAS); Margaret W. Miller (NOAA/SEFSC).

Caribbean *Acroporid* species have experienced extreme declines since the 1970s. In some areas this has resulted in local-to-regional extirpation and led to their identification as candidates for endangered species listing. Population-level recovery will depend on re-colonization by juveniles or fragments which are particularly vulnerable to threats such as predation and disease. We have recently observed a rapidly progressing die-off of *Acropora cervicornis* (staghorn coral) over a wide geographic range (>200 km) in the Florida Keys. Field experiments demonstrate that the syndrome causing the die-off is transmissible not only via direct contact between affected and healthy staghorn coral tissue but also via a predator vector (the corallivorous snail, *Coralliophila abbreviata*). Transmissibility implies that the condition is indeed a biotic disease and the demonstration of effective vector transmission suggests that predation may exacerbate disease outbreaks in remnant Caribbean acroporid populations so as to further impede their recovery.

Detection, Mapping and Characterization of Groundwater Discharges to Biscayne Bay

Harold R. Wanless, Christina Smith (UM/RSMAS); John Proni (NOAA/AMOL)

Historical accounts suggest that in the early years of the past century, prior to drainage of Everglades and the lowering of fresh groundwater levels, numerous springs flowed into Biscayne Bay. It is important to identify the present-day flows in these springs so that we can assess their importance to the hydrology of Biscayne Bay in the present day and to observe the increased flows that are anticipated when the Everglades Restoration is completed. We have thus far identified over 30 springs of various sizes. The status of the canal gates appears to have a major influence on the strength of flow of the larger springs and presence or absence of flow in the smaller ones. This is important because another objective of this project is to anticipate role of springs in freshwater discharge if wetland sheet flow (rather than canal discharge) is re-established.

Theme 4: Human Interactions with the Environment

Remote Biosensing for Improved Protection of Coastal Resources and Public Health

Michael J. LaGier, Jack W. Fell (UM/RSMAS); Kelly Goodwin, Peter Ortner (NOAA/AOML); Joseph Wang (New Mexico State University); Alderon Biosciences Inc. (North Carolina); Chris Scholin (Monterey Bay Aquarium Research Institute, CA)

Coastal waters can be highly impacted by a wide variety of pathogens that can affect aquatic ecosystems and humans. In order to minimize impacts we need small, rugged, sensitive, and cheap sensors that would enable us to detect and to monitor for specific organisms. In our program we use DNA sequences as markers to indicate the abundance of specific species in an environmental sample. We are developing marine biosensors to measure DNA via cutting-edge electrochemical detection methods. Thus far we have promising results with sensors for fecal-indicator bacteria (coliforms) and harmful algae (*Karenia brevis*). In addition, DNA probes are being developed for simultaneous detection of harmful algae, invasive species, fecal-indicator bacteria and human pathogens from a single water sample.

Theme 5: Air-Sea Interactions and Exchanges

Evaluation of Upper Ocean Mixing Parameterizations

Lynn K. Shay, George R. Halliwell (UM/RSMAS); S. Daniel Jacob (University of Maryland Baltimore County)

Tropical cyclone intensity is sensitive to the upper ocean heat content relative to 26°C isotherm in the directly-forced region of the storm. One of the major uncertainties in a coupled hurricane ocean forecasting model is the choice of mixing scheme because oceanic-mixed-layer cooling and deepening during a storm passage is usually dominated by entrainment mixing. In support of NOAA's Joint Hurricane Testbed we are using the UM Hybrid Coordinate Ocean Model (HYCOM) with several vertical mixing parameterization schemes to study the effects on hurricane development in conjunction with the atmosphere models currently under development at NOAA's National Center Environmental Prediction (NCEP). These parameterizations are being tested with data from hurricane Gilbert with promising results.

Air-Sea Interactions in Tropical Cyclones

Eric W. Uhlhorn (UM/RSMAS); Peter Black (NOAA/AOML).

The prediction of hurricane intensity remains a major issue confronting meteorologists. This is due to the considerable uncertainty in many of the physical processes that control hurricanes. One such aspect concerns the exchanges of heat and momentum at the air-sea interface. Hurricanes derive their energy from the ocean. Thus understanding these processes is crucial to accurately predicting a cyclone's intensity. We continue our program of validating satellite-sensed wind speed estimates through comparisons with winds measured by Global Positioning System (GPS) dropwindsondes, the current standard for estimating the maximum wind in hurricanes. These measurements have contributed to the development of better satellite algorithms and improved flux parameterization schemes in mesoscale numerical models which should lead to better hurricane intensity predictions.

Investigating Tropical Storm Characteristics with Near Real Time Space–Borne Synthetic Aperture Radar Images

Susanne H. Lehner, Mark A. Donelan, Hans C. Graber (UM/RSMAS)

Synthetic aperture radar (SAR) imagery offers a unique capability to observe features associated with tropical storms and hurricanes. In this project we developed methods for SAR measurements made at the UM RSMAS Center for Southeastern Tropical Advanced Remote Sensing (CSTARS) facility where RADARSAT images are acquired and processed on an operational basis. These images can be calibrated and converted into wind fields in near-real-time. These techniques have proven to be extremely valuable for the study of the four hurricanes that struck Florida in 2004.

Initial Steps Towards a Global Surface Water pCO_2 Observing System

Frank J. Millero (UM/RSMAS); Rik Wanninkhof, Steven Cook (NOAA/AOML); Nick Bates (BBSR, Bermuda); Richard Feely (NOAA/PMEL); Taro Takahashi (LDEO/Columbia University)

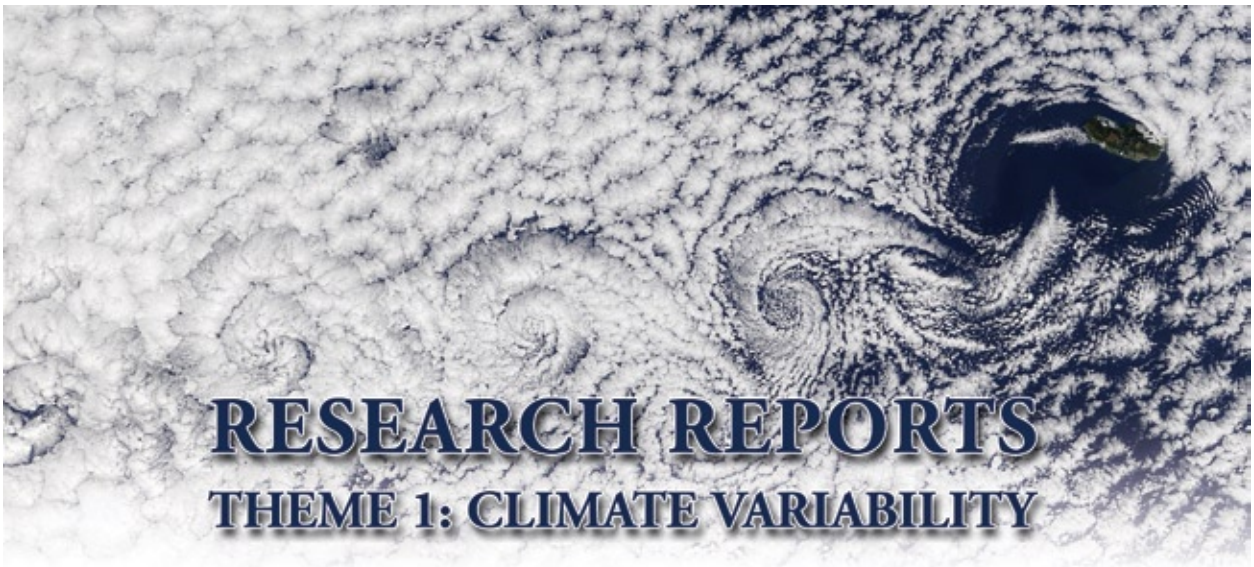
Because of the role of CO_2 in global warming, it is critically important to understand the global carbon cycle and to determine the regional sources and sinks of carbon. In order to characterize the role of the oceans in the global CO_2 cycle it is necessary to measure the concentration of CO_2 in surface waters of all oceans. Our program, "The Underway pCO_2 Observing Program", will accomplish this goal by placing autonomous CO_2 instruments aboard volunteer observing ships (VOS). To this end we have designed, constructed, and tested four prototype instruments. These were highly successful and copies of this instrument are now being constructed for deployment around the world.

Theme 6: Integrated Ocean Observations

Upper Ocean Transports in the Atlantic Ocean

Qi Yao (UM/RSMAS); Gustavo. J. Goni, Molly O. Baringer (NOAA/AOML)

In this program we investigate the interbasin mass exchange between the Indian and Atlantic Ocean, the meridional heat transport at 30°S and 30°N, and the zonal current system in the tropical Atlantic. These are all important components of the Meridional Overturning Circulation in the Atlantic Ocean, To this end we established high density XBT transect lines in the North and South Atlantic Oceans. The high density XBT lines are yielding real-time high resolution temperature profiles at 30-50 km intervals along five important lines in the Atlantic Ocean.



A Study on the MJO-ENSO Problem

Project Personnel: Chidong Zhang (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand effects of the Madden-Julian Oscillation (MJO) on the El Niño – Southern Oscillation (ENSO) cycle. **Strategy**: To test various MJO and ENSO interaction hypotheses through data analysis and numerical modeling

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
The effects of the MJO on ENSO were studied using a hierarchy of coupled models (one model of intermediate complexity and two hybrid coupled models). MJO forcing including its low-frequency variability can explain a large fraction of the interannual variability in asymptotically stable versions of the models. The modeled interaction between the MJO and ENSO takes place via linear dynamics. The largest coupled wind anomalies are initiated after a sequence of several Kelvin waves of the same sign have been forced by the MJO. Coupled processes are identified as important in amplifying these perturbations. The cumulative effect of the stochastically forced Kelvin waves act to maintain the small SST anomalies in the eastern Pacific just long enough for the coupled mechanism to develop a mature ENSO. The amount of energy in the MJO is only a modest fraction of that contained in the total stress. However, a large fraction of the modeled interannual variability is excited by this estimate.

Based on the idea of the generalized stability theory, we have shown that the MJO estimates have large projections on the leading stochastic optimum of the intermediate model (i.e., the spatial pattern of stochastic forcing preferred by the model). This explains why a larger fraction of the modeled variance is linearly excited by the MJO forcing. This result suggests that the large zonal extent of the MJO is an important factor that differentiates the MJO from other sources of stochastic forcing. Our results suggest that a large fraction of ENSO variability is linearly excited by the MJO forcing and the zonal extent of the MJO is an important factor to ENSO.

Research Performance Measure:
Our objective – to distinguish MJO from other types of stochastic forcing of ENSO - was accomplished.

Targeting Strategies to Improve Hurricane Track Forecasts

Project Personnel: Sharanya J. Majumdar (UM/RSMAS); Brian Etherton (UNC at Charlotte); Sim D. Aberson, Paul Leighton (NOAA/AOML); Zoltan Toth (EMC NCEP); Lacey D. Holland (SAIC EMC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve upon current operationally-targeted observing strategies for designing synoptic surveillance missions around tropical cyclones. **Strategy**: To test the use of the Ensemble Transform Kalman Filter (ETKF) to improve upon the currently-used subjective targeted observing technique (ensemble spread) under the Joint Hurricane Testbed (JHT).

Link to NOAA Strategic Plan Goals:
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
The research in this program is a cooperative program involving several groups. The university based activities are funded through CIMAS with a subcontract to UNC Charlotte. The the activities of these two groups are described separately below.

UM-Based Activity
When a tropical cyclone (TC) is deemed as a potential threat to land, the G-IV aircraft is deployed to release GPS dropwindsondes in the TC environment to improve operational track forecasts. The current operational method used to choose the timing and location of dropwindsonde deployments is based on a subjective decision by examining the 'spread' of the NCEP Global Forecast System (GFS) ensemble forecasts of 850-200 hPa deep-layer-mean winds. In order to improve forecasts there is a need: (i) to expedite the flight planning process, (ii) to objectively use numerical model output, (iii) to account for specific TC forecasts, and (iv) to reduce the likelihood of choosing irrelevant target regions. In our program we evaluated the suitability of the Ensemble Transform Kalman Filter (ETKF) targeting strategy as a potential successor to the ensemble spread technique. The ETKF is currently being used in National Weather Service operations for winter storm reconnaissance.

The ETKF predicts a quantity entitled 'signal variance', which gives the expected reduction of forecast error variance in a given verification 'norm' (e.g. wind speed, track, intensity) due to any particular set of targeted observations. An ETKF summary map shows the predicted signal variance for a specific TC forecast of interest, as a function of the observing location. The locations in which signal variance is highest represent areas in which the ETKF suggests that targeted observations would be most useful for reducing TC forecast errors with respect to the given verification norm. An example is a forecast for Isabel, shown in a summary map for in Figure 1. The aim is to reduce wind errors in a 2-day forecast by taking observations on 14 September 2003. The map indicates that the subtropical ridge just north of Isabel is the preferred region for targeted observations to be collected.

In the future, extra flights will be deployed at the request of the National Hurricane Center to evaluate the relative performance of the ETKF and the ensemble spread techniques. In addition to the verification norm of wind speed shown in Figure 1, the ETKF software is being extended to test verification norms of track and/or intensity. Results are being disseminated on http://orca.rsmas.miami.edu/~majumdar/tc/ as targeted observing cases develop during the 2004 hurricane season.

UNC Charlotte-Based Activity
The first task performed by UNC Charlotte personnel was to provide assessments TC cases in 2003 for which the G-IV aircraft was deployed. These assessments contained a description of the general flow of the atmosphere at the time the mission took place, followed by an interpretation of the ensemble spread and ETKF map of the prediction of the reduction in forecast error variance, as they related to the atmospheric flow. An example of such an assessment is given in figure 1.

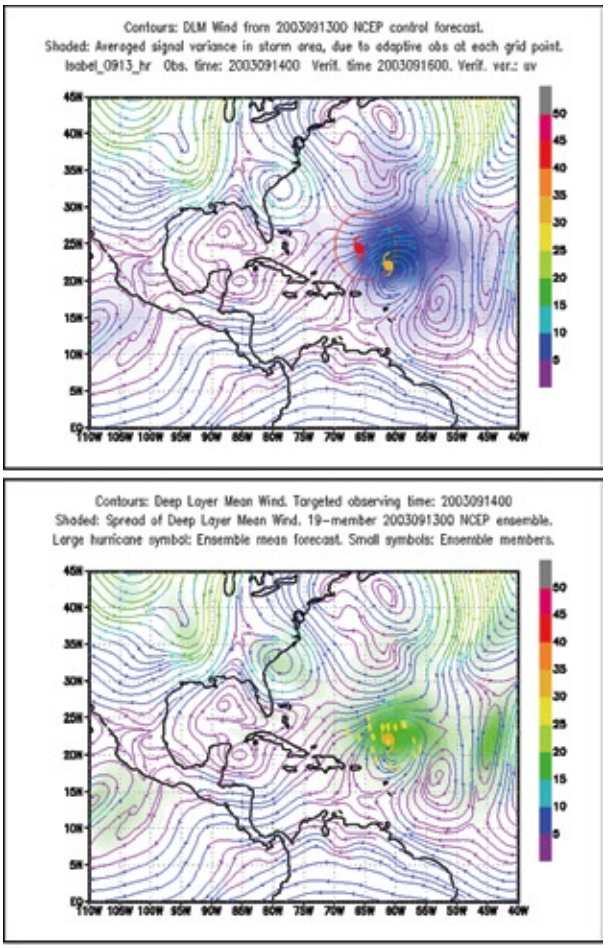


Fig. 1- Blue shading: ETKF Summary map for Hurricane Erika: Contours: 850-200hPa deep layer mean wind at the targeted observing time. Orange and red hurricane symbols represent the ensemble mean track forecast, valid at the targeted observing and verification times respectively. Green shading: Ensemble Spread map for Hurricane Isabel. Yellow hurricane symbols represent the NCEP GFS ensemble forecast tracks at the targeted observing time.

The ETKF software was developed by S. J. Majumdar of RSMAS/University of Miami in the first year of this NOAA/CIMAS JHT project. The ETKF predicts the expected reduction of forecast error variance in a given verification 'norm' (e.g. wind speed, track, intensity) due to any particular set of targeted observations. The estimates of forecast error variance reduction are then fed into additional software (developed by S. D. Aberson and P. Leighton of NOAA/AOML/HRD, also under this project) which designs flight tracks for the G-IV aircraft based on a set of parameters. B. J. Etherton of UNC Charlotte, along with S. J. Majumdar, is running this software to produce real-time flight tracks during the 2004 Hurricane Season. These flight tracks, based on both the ETKF and ensemble spread, are being communicated to NHC. An example of an ETKF based flight track (produced by UNC Charlotte personnel) and an actual flight track for a Hurricane Ivan mission are shown in figure 2.

Research Performance Measure:
The key objectives defined have been accomplished: ETKF code is running on 1-degree resolution ensembles and synoptic assessments have been made. Some of the work planned for Year 2 has been finished ahead of time - the coupling to flight-planning code.

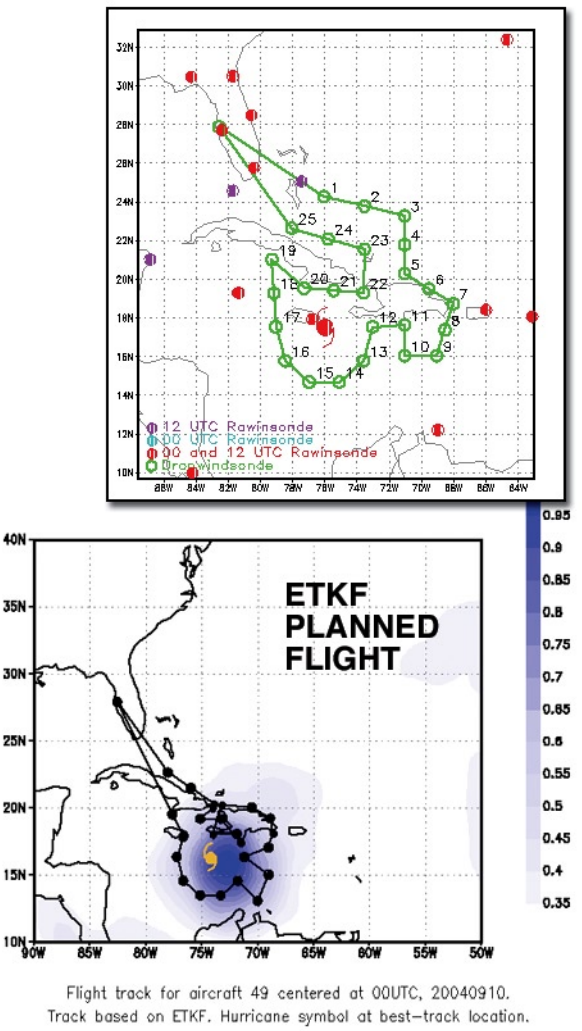


Fig. 2– An ETKF flight track produced by UNC Charlotte personnel (top), and the actual G-IV synoptic surveillance flight track used.

Climate Information System for Agriculture and Water Resources Management in Southeastern USA

Project Personnel: G. Podestá, D. Letson, K. Broad (UM/RSMAS); F. Miralles-Wilhelm (UM/School of Engineering)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To use advances in climate sciences, including improved capabilities to forecast seasonal climate, to provide scientifically sound climate information and decision support tools for agriculture, forestry, and water resources management in the Southeastern USA. **Strategy**: To conduct research and outreach to a broad community of potential users and forms partnerships with extension and education organizations to ensure that climate products are relevant and reliable.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.
Goal 3: Serve Society's Needs for Weather and Water Information.

Research Summary:
The goal of the Southeastern Climate Consortium (SECC) is to develop a climate information and decision support system for the Southeastern USA that will contribute to an improved quality of life, increased profitability, decreased economic risks, and more ecologically sustainable management of agriculture, forestry, and water resources.

Toward this goal we have established the following objectives:
• To develop an improved understanding of seasonal climate variability and climate predictability at local to regional scales across the Southeastern USA.
• To characterize the contributions of climate variability to risks in management of agricultural, forestry, and water resources.
• To develop information and decision aids based on the use of seasonal climate forecasts, historical climate data, and other climate analyses that help decision-makers identify management options to reduce risk and increase profits while sustaining the ecosystems of the Southeast USA.
• To design and implement appropriate vehicles for disseminating climate and decision support information, including an internet-based learning and decision support system.
• To develop partnerships needed to build socially equitable extension and outreach programs for farmers, forest managers, water resource managers, homeowners, and policy makers to enhance users' familiarity with these new seasonal climate forecasts and decision aids and to provide mechanisms for users to give feedback to researchers.

We use nested, coupled, regional climate models to explore the process of using an ENSO forecast system to provide tailored output for various socioeconomic sectors in small regions, primarily the Southeast United States and Southeast South America. However, these models only have skill in predictions of seasonal climate anomalies; further work is needed to resolve the complete spectrum of anomalous climatic behavior required for agricultural and climate study purposes. Thus, additional methods of "downscaling" the model results are utilized to produce worthwhile results.

Additional research at the SECC includes the integration of weather generators with climate models; the assessment of agricultural impact through the analysis of historical crop yields and simulated yield potentials; understanding forestry risk and its minimization; water quality assessment and policy analysis; and the development of crop management optimization toolkits and programs to explore optimal management options under different ENSO conditions and optimization criteria.

This program involves subcontracted research activities. These are described in the section: Research Reports: Subcontracted Programs, page 102.

Research Performance Measure:
The goals in the development of models and forecast-information systems have been met on schedule.

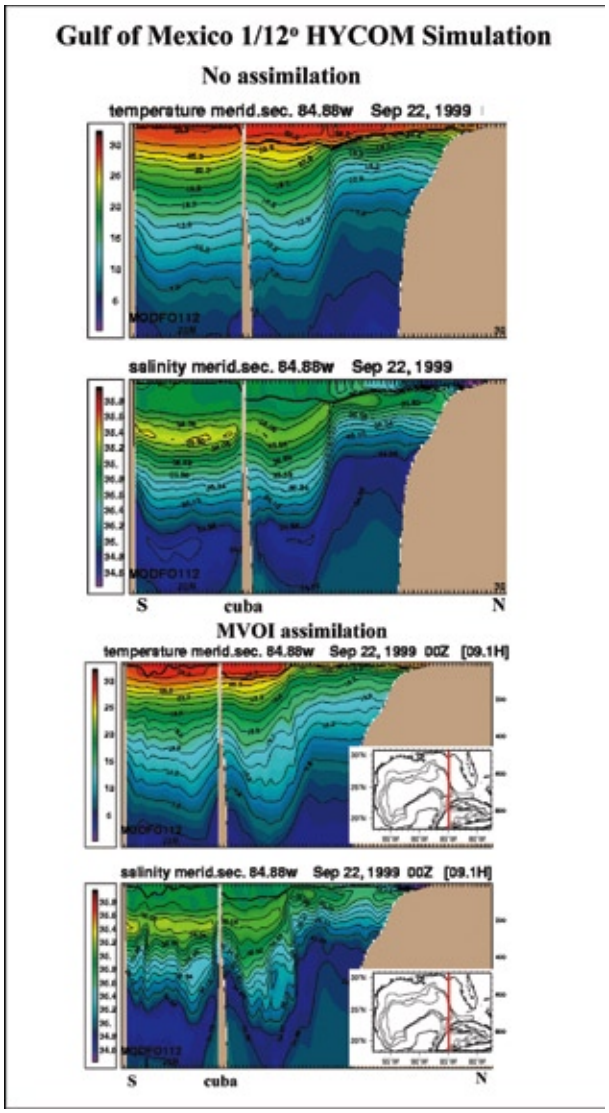
Data assimilation with a Hybrid Coordinate Ocean Model (HYCOM)

Project Personnel: HeeSook Kang (UM/RSMAS); William C. Thacker (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve simulations of climate with the UM/RSMAS Hybrid Coordinate Ocean Model (HYCOM). **Strategy**: To use a multi-variate optimal interpolation (MVOI) to assimilate in-situ and satellite observations.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:
The most difficult aspect of assimilating data into HYCOM is the model's hybrid vertical coordinate which varies both spatially and temporally: it is density-like in and below the thermocline, pressure-like in the mixed layer, and depth-proportionate in shallow water. Ocean models must reduce the vertical structure of the water column into discrete layers. In carrying out this conversion we must make sure that the selected layer structure accurately depicts the true density structure. First we interpolate the density on the hybrid-layers to the z-levels and second we convert the layerized density on the z-levels back to the hybrid-layers.



In order to validate the "layerization" technique several conversion experiments were conducted. Our collaborators at the Naval Research Laboratory (NRL) have mature multi-variate optimal interpolation (MVOI) codes for assimilating data into models with conventional pressure-like vertical coordinates. The most efficient approach is to make their system work with HYCOM. The simplest approach, building a coordinate transforming interface between the two systems, is being tested with 1/12 degree horizontal resolution for the Gulf of Mexico. We found that the tests of the model outputs for temperature, salinity and velocity yielded satisfactory results. However, with MVOI products (temperature, salinity, velocity) several improvements are required to make it work. This effort is now underway. We are about to begin work on a better but more difficult approach, that is, to modify NRL's MVOI codes to work directly with HYCOM's vertical coordinate using methods developed in previous years of this CIMAS project.

Research Performance Measure:
Our objective was to use the MVOI system to assimilate in-situ and satellite observation into HYCOM. To combine the two systems the interface was built and is being used with HYCOM simulations at NRL. All objectives were attained.

Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Project Personnel: Eric P. Chassignet, George R. Halliwell, Mohamed Iskandarani, Arthur J. Mariano, Mike Chin (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve weather and climate forecasts. **Strategy**: To improve model performance through the assimilation of data from a broad range of sources.

CIMAS Research Themes:
Theme 1: Climate Variability
Theme 6: Integrated Ocean Observations

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
A broad partnership of institutions (NRL/SSC, NOAA, LANL, etc.) is collaborating in developing and demonstrating the performance and application of eddy-resolving, real-time global and basin-scale ocean prediction systems using the HYbrid Coordinate Ocean Model (HYCOM). These systems will be transitioned for operational use by the U.S. Navy and by NOAA. The partnership addresses the Global Ocean Data Assimilation Experiment (GODAE) goals of three-dimensional (3D) depiction of the ocean state at fine resolution in real-time and provision of boundary conditions for coastal and regional models. This effort is a part of the National Ocean Partnership Program (NOPP) and builds on the results of a previous NOPP effort to develop and evaluate a data-assimilative hybrid isopycnal-sigma-pressure (generalized) coordinate ocean model, i.e. HYCOM. Here we mostly report on the evaluation of the 1/12° HYCOM Atlantic domain. Our ultimate goal is a transition to a 1/12° global ocean prediction system in 2006. The system assimilates the daily MODAS SSH anomaly analysis and SST of real-time satellite data. The atmospheric forcing of the near-real-time system comes from the Fleet Numerical Meteorology and Oceanography Center (FNMOC) Navy Operational Global Atmospheric Prediction System (NOGAPS). The results can be seen at http://hycom.rsmas.miami.edu.

A comparison of four data assimilative ocean models used by the Navy to SeaWiFS ocean color has been performed in the Gulf of Mexico (Chassignet et al., 2004). The ocean models are the 1/12° Atlantic HYCOM (~8 km resolution in the Gulf of Mexico), the 1/24° Intra-Americas Sea (IAS) NCOM (6 km resolution), the 1/16° global NLOM (8 km resolution), and the 1/32° global NLOM (4 km resolution). They were compared to ocean color from SeaWiFS in the Gulf of Mexico (2 June 2003-29 Sept. 2003). All assimilate the operational 1/8° MODAS sea surface temperature analyses of AVHRR data and satellite altimeter sea surface height (SSH). GFO (through 5 Sept.) and JASON-1 altimeter data were used. The NLOM systems assimilate altimeter track data using the model forecast as a first guess. The altimeter data wasprojected downward using EOF regression (Hurlburt et al., 1990) based on model statistics. The HYCOM and IAS NCOM systems assimilate the operational 1/4° MODAS SSH analyses which were model independent. HYCOM projects SSH downward using the technique of Cooper and Haines (1996) and the NCOM systems assimilate synthetic temperature and salinity profiles based on SSH, SST, and statistics of the historical hydrographic data base. All use atmospheric forcing from the Fleet Numerical Meteorology and Oceanography Center (FNMOC) Navy Operational Global Atmospheric Prediction System (NOGAPS).

The results are presented in Figure 1 in four panel images with model SSH contours overlain on SeaWiFS imagery. Both bright and dark areas of ocean color are very informative. Both the Loop Current and shed eddies show up clearly as especially dark areas of low chlorophyll. When the model matches well, the dark area was pretty well hidden. But mismatches also show up clearly and the 4-way comparison was very effective in bringing this out. The bright areas of high chlorophyll tend to be advected into plumes by strong currents but sometimes also occur in the center of cyclonic (counterclockwise) eddies. The SSH contours are colored prismatically from low (violet) to high (red). Cyclonic eddies are relative lows and anticyclonic are relative highs.

Research Performance Measure:
The assimilation objectives and model intercomparison were accomplished.

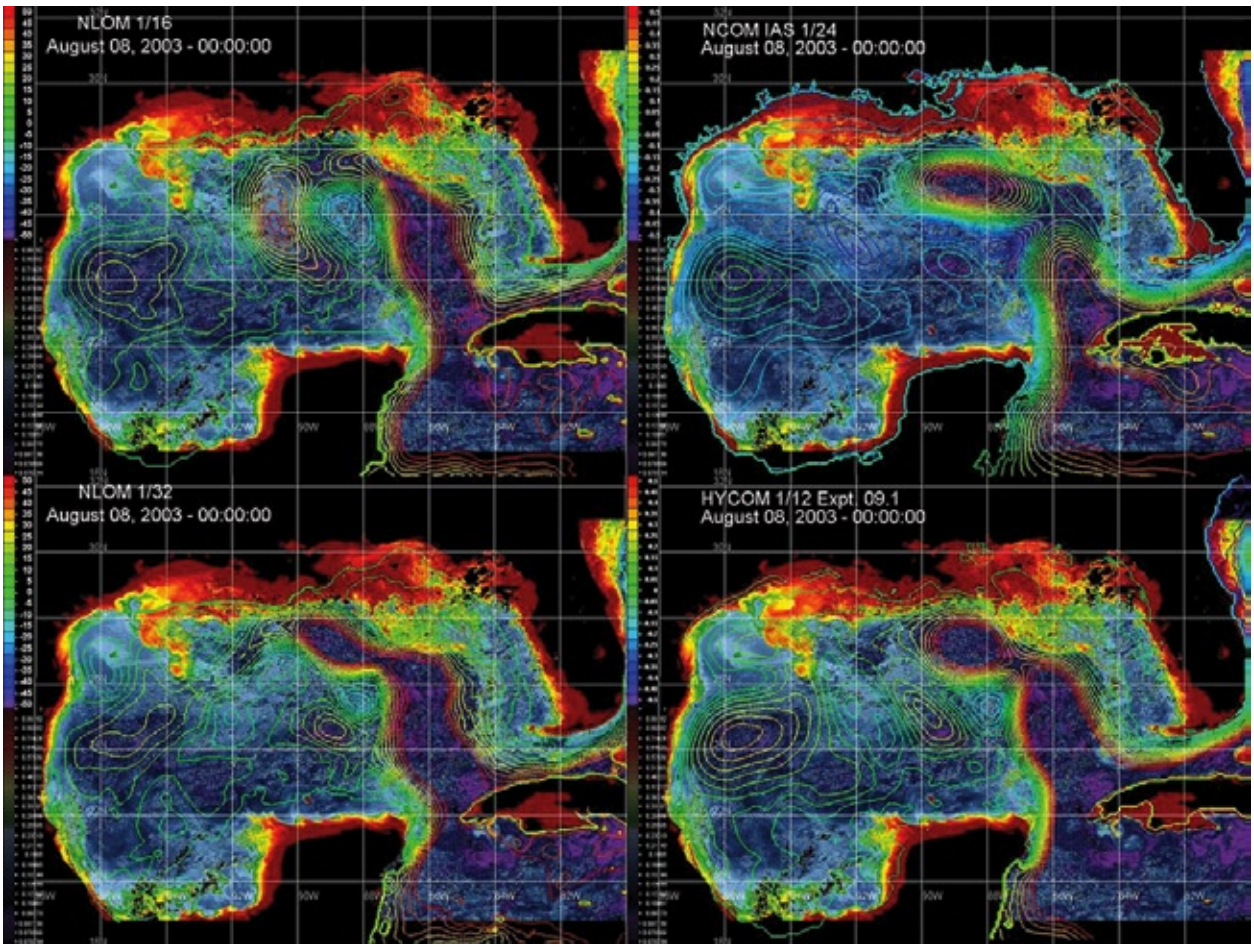


Fig. 1- Model SSH contours overlain on SeaWiFS imagery. The SeaWiFS imagery is a composite of the most recent cloud free pixel over the preceding 6 days.

Processes that Affect the Annual and Inter-Annual Variations of the Western Hemisphere Warm Pool (WHWP)

Project Personnel: Sang-ki Lee (UM/RSMAS); David Enfield, Chunzai Wang (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the oceanic and atmospheric processes that are of primary importance in producing the annual cycle and inter-annual anomalies of the western hemisphere warm pool. **Strategy**: To use both data and HYCOM (Hybrid Coordinate Ocean Model) modeling products to study heat flux processes.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
The heat balance of the Western Hemisphere Warm Pool (WHWP)
We examined the heat balance of the WHWP subregions through two successive types of analysis, first by considering a changing volume ("bubble") bounded by constant temperature wherein advective fluxes disappear and diffusive fluxes can be estimated as a residual; second by considering a slab layer of constant dimensions with the bubble diffusion estimates as an additional input and the advective heat flux divergence as a residual output. Using this sequential procedure we could disqualify as being physically inconsistent four of seven surface heat flux climatologies. The surface flux data sets of da Silva and Southampton (constrained) and Oberhuber have a much narrower range of slab surface warming associated with bubble residual estimates of total diffusion and total advective heat flux divergence. The latter are independently confirmed by direct estimates using wind stress data and drifters for the Gulf of Mexico and eastern North Pacific subregions.

OGCM study on the annual cycle of WHWP
We carried out a series of ocean general circulation (OGCM) model experiments using the Hybrid Coordinate Ocean Model (HYCOM) to assess the model's sensitivity to surface heat flux data and to the parameterizations of light attenuation and vertical turbulent mixing for simulating the seasonal development and decay of the Western Hemisphere Warm Pool (WHWP). Our results yield several important conclusions. (1) When monthly averaged heat flux data are used, the surface turbulent heat fluxes need to be adjusted to compensate for biases arising from nonlinearities at the unresolved shorter time scales. (2) Among the eight surface heat flux data sets assessed in this study, we find that the simulated SST and the WHWP depth are closest to the observations when the Southampton constrained (SHC) and Oberhuber (OBH) heat flux data are used (see Figure 1). (3) The model's performance was optimal in reproducing the WHWP depth and the thermocline structure in the WHWP region if the light attenuation depth was derived realistically from space-based ocean color measurements, a regional average attenuation depth of 17m. (4) The simulated WHWP SST does not appear to be very sensitive to the choice of critical Richardson number. (5) The fine-tuned experiments simulate the annual cycle of the WHWP with fairly good accuracy.

Response of the Western Hemisphere warm pool to El Niño
We find that during an El Niño a warm pool develops in the North Atlantic that in some cases may be twice its normal size in early summer when the North American Monsoon was developing. The unusually large warm pool can produce an augmented tropical heating anomaly that results in a stronger divergent circulation and associated Walker-Hadley outflows. These effects have strong impacts on climate forecasts. However the problem in making extended forecasts of ENSO climate impacts is that the tropical Atlantic response does not occur with every El Niño. Of nine recognized El Niño events after 1950, only five were followed by large warm pools, meaning that the mere knowledge of a culminating El Niño at the end of the onset year cannot be used to issue an empirical forecast of summer impacts in the following year.

In this work we reviewed the tropospheric mechanisms behind the Atlantic extension of El Niño and use several global data sets to examine two hypotheses as to why large warm pools do not invariably follow the mature phase of the Pacific event. By contrasting the canonical evolutions of El Niño (+1) years with and without large warm pools, we see that years with large warm pools usually follow more intense and long-lasting El Niño events and that the corresponding tropospheric bridge and surface forcing in the Atlantic are robust. In contrast we find that these characteristics are absent in years where we do not observe large warm pools. An examination of North Atlantic Oscillation (NAO) configurations associated with the two classes of warm pools suggests that when a positive boreal winter NAO oscillation coincides with the contemporaneous peak of El Niño in the Pacific, conditions are not favorable for the development of a large warm pool. This suggests that both hypotheses retain some validity; furthermore the exceptions to either hypothesis tend to be explainable by the other.

Research Performance Measure:
The first object was to assess the annual WHWP heat budget using commonly used surface heat flux climatologies. The second objective was to fine-tune the HYCOM for the future diagnostic study of the WHWP dynamics. Those objectives were accomplished.

Western Boundary Current Time Series

Project Personnel: Christopher S. Meinen (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the movement of water and heat around the Atlantic Ocean and to determine ways in which these transports affect climate. **Strategy**: To use a wide range of observations - satellite, hydrographic, moored instruments and submarine-cable measurements - to study the Florida Current, Deep Western Boundary Current and other current systems.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond;

Research Summary:
Climate models have shown that variations of the transport of the Meridional Overturning Cell (MOC) in the Atlantic Ocean have significant impacts on the climate at both the national and global level. Near 26.5°N in the Atlantic the southward deep flow of the MOC is contained primarily within the Deep Western Boundary Current (DWBC) east of Abaco Island in the Bahamas, while the northward shallow flow is carried primarily by the Florida Current (FC) between the eastern Florida coast and the Bahamas. Long term observations of the FC and DWBC will be required in order to quantify the natural scales of variability of the current, however because the DWBC has no surface expression it is necessary to make direct measurements of the current using instruments directly moored in the current's path. Such moorings are expensive; so all effort must be expended to seek the most inexpensive but accurate method for monitoring the current variations.

I have developed a low-cost method for monitoring the DWBC in the Atlantic Ocean east of Florida using bottom pressure gauges, inverted echo sounders, and hydrographic data.

These studies are directly applicable to NOAA's goals of improving understanding of the global climate system.

Research Performance Measure:
The objectives of this study have been realized.

New Estimates of the Heat Budget in the Tropical Atlantic, First Results

Project Personnel: Rick Lumpkin, Qi Yao (UM/RSMAS); Claudia Schmid, Silvia L. Garzoli (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the dynamics and impacts of coupled atmosphere-ocean systems through research on climate variability and change. **Strategy**: To use a variety of ocean data sources (e.g., XBTs, ARGO and pre-ARGO floats, and surface drifters) to study the temporal and spatial variability of critical parameters.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
The characterization of the heat budget of the Atlantic Ocean is critical to understanding climate trends. We use a combination of data from XBTs, ARGO and pre-ARGO floats, and surface drifters to study the heat budget of the tropical Atlantic. The annual cycle of the heat storage was derived by estimating the monthly means from data obtained in 1997-2003. The relative importance of the different heat budget terms for changes of the heat storage in the mixed layer were analyzed in three regions of the tropical Atlantic. Surfaces fluxes from NCEP were used to derive the net heat flux through the sea surface. The absorption of shortwave radiation in the mixed layer was computed on the basis of a model that uses chlorophyll A data from merged MODIS/SeaWiFS fields. The role of the advection and upwelling were estimated from the velocity field derived from surface drifter trajectories. Regional differences of the annual cycle of the heat storage and heat fluxes were compiled. They are an improvement over previous results because the ARGO project provides data that not only improve the temperature data density but also provides salinity. This allows the direct computation of the salinity-dependent parameters.

Research Performance Measure:
Our major objective, developing an improved picture of the heat budget of the tropical Atlantic, is being attained using a combination of data from XBTs, ARGO and pre-ARGO floats, and surface drifters. The program is on schedule.

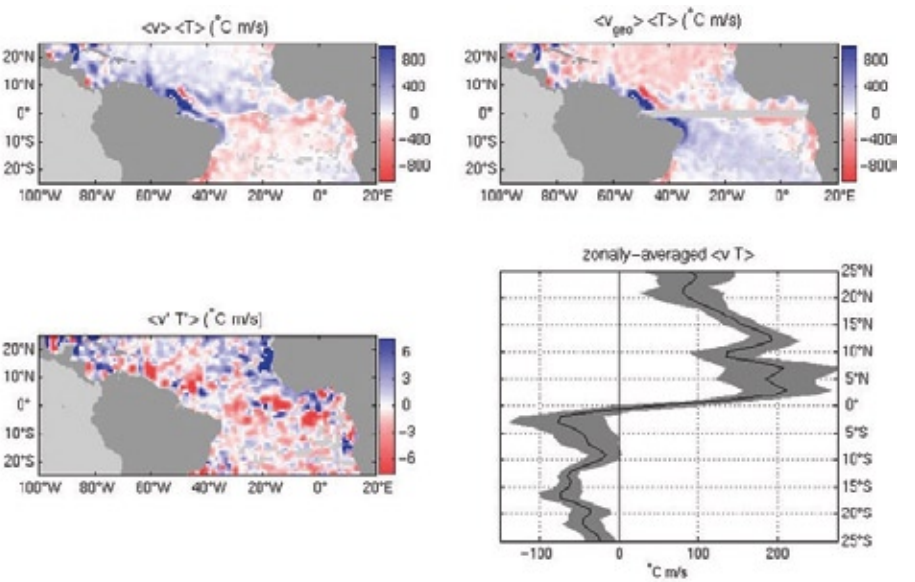


Fig. 1- Meridional temperature fluxes in the Tropical Atlantic mixed layer, calculated from drifting buoy velocities and SSTs. **Top:** transport from the time-mean total (left) and Ekman-removed (right) currents. **Bottom left:** eddy fluxes of temperature. **Bottom right:** zonally-averaged total temperature advection.

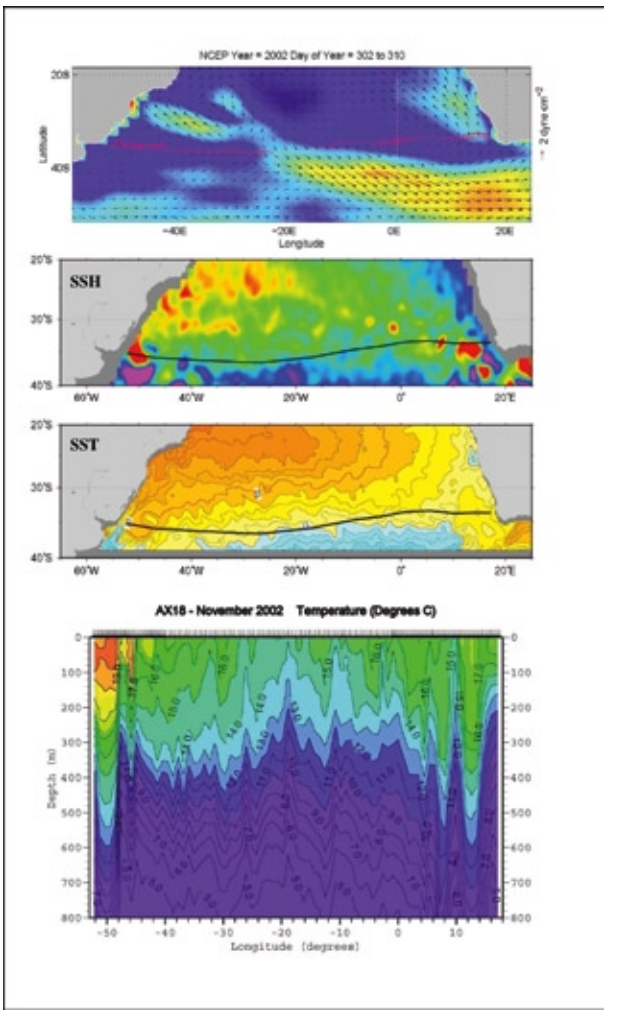
Meridional Heat Transport in the South Atlantic

Project Personnel: Qi Yao (UM/RSMAS); Silvia L. Garzoli, Molly O. Baringer, Gustavo Goni (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the dynamics and impacts of coupled atmosphere/ocean/and systems in the Atlantic. **Strategy**: To study the heat transports in the South Atlantic, a major conduit for the warm water that flows north across the equator, by making repeat XBT transects between Cape Town and Buenos Aires.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
The South Atlantic Ocean is a major conduit for the warm upper layer water that flows northwards across the equator, compensating for the colder southward flowing North Atlantic Deep Water. This large-scale circulation is responsible for the northward heat flux through the South Atlantic and a unique feature among the oceans. Previous estimates of the heat transport in the South Atlantic in the 30° to 35°S band varies from negative values to more that 1 PW. This variability may be a consequence of the different pathways and of the different methods to calculate the heat transport. However natural variability, whether annual or interannual, cannot be ruled out using historical data. The upper branch of the MOC in the South Atlantic can be supplied by warm and saltier water that enters the South Atlantic via the Agulhas leakage (the warm route, Gordon, 1986) or by cold and fresh intermediate water that enters the South Atlantic via the Drake Passage (the cold route, Rintoul, 1991). According to Gordon (1992) the AAIW derived from the Drake Passage returns saltier and warmer via the Agulhas leakage after a loop in the Indian Ocean. It is not clear which of these two routes is the most important and or if there is some seasonal or interannual variability that may lead to the discrepancies in values. What it is clear is that in order to better understand the global ocean thermohaline circulation and its impact on climate it is necessary to reduce the heat flux uncertainty in the South Atlantic.



Starting in 2002, and as part of the NOAA Global Ocean Observing System, a new XBT high-density line was started in the South Atlantic between Cape Town, South Africa and Buenos Aires, Argentina. The line was originally funded to be repeated twice a year but starting in 2004, occupations will be increased to a quarterly schedule. The line was designed to close the upper layer mass budget in the Atlantic and to estimate the variability of the upper limb of the MOC transport.

Research Performance Measure:
The primary objective was to establish a new XBT high-density line in the South Atlantic. These transects were begun in 2002 and thus far 5 transects have been completed, the latest in March/April 2004.

Spatial and Temporal Variability of the North Brazil Current Retroflection and North Equatorial Countercurrent

Project Personnel: Carlos A. Fonseca (UM/RSMAS); Gustavo Goni (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To investigate the seasonal to longer-term variability of the upper ocean in the Tropical Atlantic for climate studies. **Strategy**: To use a combination of hydrographic and remote sensing observations to understand the dynamics and impacts of coupled atmosphere/ocean/land systems.

CIMAS Research Theme:
Theme 1: Climate Variability
Theme 6: Integrated Ocean Observations

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
We seek to understand the dynamics and impacts of coupled atmosphere/ocean/land systems through research on climate variability and change. This work focuses on the North Brazil Current (NBC) which has been shown to play a large role in energy transport and, hence, climate in the Atlantic. Data collected as part of the North Brazil Current Rings Experiment shows that there is a direct relation between the latitude of penetration, the number of rings shed and the intensity of the North Brazil Current. These studies will contribute to our understanding of climate variability over the Atlantic.

Eight years of TOPEX/Poseidon altimeter-derived sea height anomaly and climatological data were used to investigate the temporal and spatial variability of the NBC retroflection and the North Equatorial Countercurrent (NECC). The TOPEX data was compared and integrated with with hydrographic data from various cruises. The NBC retroflection exhibits a mean position of 6.6°N±2.0°, with a strong annual signal and year-to-year variability. A very marked shift in the annual mean location of the NBC retroflection was observed in 1997, probably linked to a continuous increase in the strength of the annual maxima of wind stress curl and, consequently, an increase in the transport values of the currents in the Tropical Atlantic system. The mean latitude of the NECC was estimated to be 6.0°N±1.3°, and its baroclinic transport, with mean monthly values of up to 12 Sv, linked to the wind field.

Research Performance Measure:
The objectives of the comparison were fully accomplished.

Development of the WRF Model for Tropical Cyclone Research and Forecasting

Project Personnel: David S. Nolan (UM/RSMAS); Morris Bender, Timothy Marchok (NOAA/GFDL); Robert Tuleya (NECP)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve forecasts for tropical cyclones. **Strategy**: To continue to develop forecast models, especially the Weather Research and Forecast Model (WRF), and to compare the results with actual events.

Link to NOAA Strategic Plan Goals:
Goal 3: Serve Society's Needs for Weather and Water Information
Goal 4: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

Research Summary:
This project seeks to continue the development and testing of the Weather Research and Forecast Model (WRF) for future use in tropical cyclone forecasting and research. We are performing studies of real-data and idealized data simulations and making close comparisons to identical simulations with the GFDL hurricane model. The objective is to identify the strengths and weaknesses of the WRF model with regard to hurricane modeling. In the process, we are developing tools to run the WRF model from various data sets, such as GFDL hurricane model data, and for the analysis and comparison of WRF output with the GFDL model.

The main goals for year one of this project were to install the latest version of WRF (1.3) on the GFDL High Performance Computing System and evaluate its performance for a number of cases, particularly in comparison to the GFDL Hurricane Model and the GFDL Non-hydrostatic Model,

ZETAC. WRF1.3 was found to reproduce previous results with some small differences, probably due to changes and improvements in the physics parameterizations. We compared forecasts of Hurricane Isabel (2003) with forecasts from the GFDL model. Isabel is a useful case because it was a very strong hurricane whose track was extremely well forecast by the GFS (NCEP) and the GFDL model. Thus WRF forecasts of Isabel depend more on the model resolution and physics parameterizations than on the representation of the large-scale environment.

A large number of Isabel forecasts were performed. From the 11th of September, the WRF track forecasts were excellent, and the WRF intensity fore-casts were better than the GFDL model. However, beginning on the 14th of September, the forecasts were not as good; the WRF model kept the storm much too strong, perhaps due in part to the lack of ocean coupling.

The effects of different physics parameterizations have also been evaluated. For example, we found that the MRF planetary boundary layer scheme (currently in the GFS model) gives excellent forecasts (in both track and intensity), whereas the Mellor-Yamada-Janjic scheme (currently in the ETA forecast model) quickly makes the storm much too weak in all cases.

Research Performance Measure:
The work carried out in the past year was quite similar to that originally planned and the major goals were accomplished.

Repeat Hydrography Surveys in Support of CLIVAR and Carbon Cycle Science Programs

Project Personnel: Kevin Sullivan (UM/RSMAS); Rik Wanninkhof (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve our knowledge of the global carbon cycle and its response to climate change.
Strategy: To monitor changes in the inventory of dissolved inorganic carbon in the oceans by making periodic ship cruise surveys of the oceans.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:
It is necessary to monitor the changing patterns of carbon dioxide (CO_2) and related carbon compounds in the ocean in order to obtain the data needed to improve forecasting skill for oceans and global climate. The recent WOCE/JGOFS global carbon survey program provided the first comprehensive inventory of anthropogenic CO_2 in the ocean. The total anthropogenic inventory of dissolved inorganic carbon (DIC) into the ocean can be determined using concurrent hydrographic, alkalinity, oxygen, nutrient and tracer measurements. A series of cruises reoccupying the WOCE/JGOFS transects have been initiated under the CO2/CLIVAR repeat hydrography project funded by NOAA and NSF to determine the changes in DIC and related biogeochemical parameters.

Three repeat lines were occupied in the North Atlantic during 2003 as shown in Fig. 1. The initial results show a clear increase in DIC in the upper ocean over the last decade. There were also significant changes in other biogeochemical parameters such as oxygen and nitrate. This suggests that besides the invasion of anthropogenic CO_2, there is a biogeochemical response to climate change in the North Atlantic.

Research Performance Measure:
All objectives were attained. A high quality data set of DIC measurements was acquired to function as important benchmarks and to enhence forecasting skills.

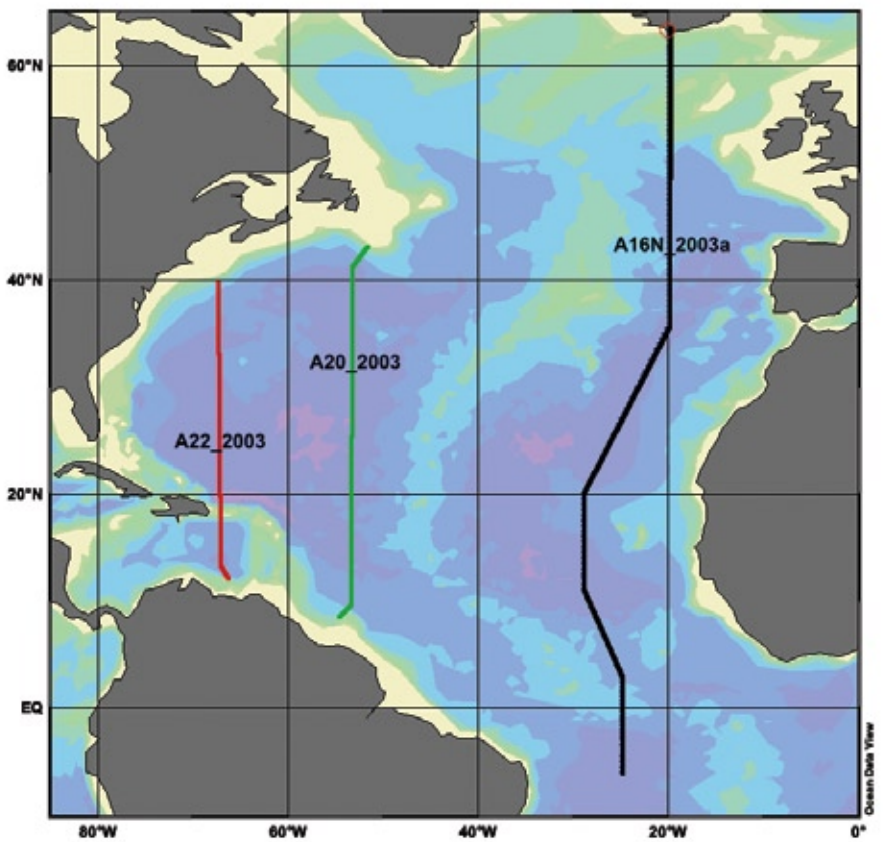


Fig. 1- The cruise track during the North Atlantic survey expeditions of the CO_2/CLIVAR repeat hydrography project in 2003. The A16N_2003a line was occupied by NOAA ship RONALD H. BROWN while the R/V KNORR occupied the A20 and A22 lines

Tropical and South Atlantic Drifters

Project Personnel: Claude Frederick Lumpkin (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To describe and understand upper ocean dynamics, ocean circulation, and its variability; and to evaluate, assess, analyze and recommend improvements for the global array of surface drifting buoys. **Strategy**: Carry out studies of circulation, oceanic transports, and near-surface heat budgets based on the analysis of in-situ and remote observations; derive water transformation rates from a synthesis of these observations and make estimates of air-sea heat and freshwater fluxes.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond; Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:

The equatorial Atlantic Ocean has a nearly closed near-surface circulation pattern consisting of a basin-wide clockwise gyre. How does this gyre connect to the subtropical gyres of the northern and southern hemispheres? This question is of profound climate significance because the upper limb of the Ocean Conveyor Belt is known to pass northward across the Atlantic, crossing the vorticity barrier of the equator. These questions are being addressed as a part of the Tropical/ South Atlantic Drifter program.

Results from the analysis of satellite-tracked drifting buoys (Fig. 1) show that the southern gyre bifurcates against the coast of South America, with a fraction of the flow heading northward and entering the equatorial gyre. Water here enters the northern gyre by two pathways: coastal flow extending from the North Brazil Current retroflection, and directly wind-driven (uppermost layer) flow in the ocean interior. Beneath the wind-driven layer, water actually passes southward in the interior northern tropics.

The seasonal variations of these gyre systems are also closely linked. As demonstrated in Lumpkin and Garzoli (2004), seasonal variations in the tropical currents are directly coupled to the northern and southern subtropical gyres at two key locations: the North Brazil Current retroflection and the South Equatorial Current bifurcation.

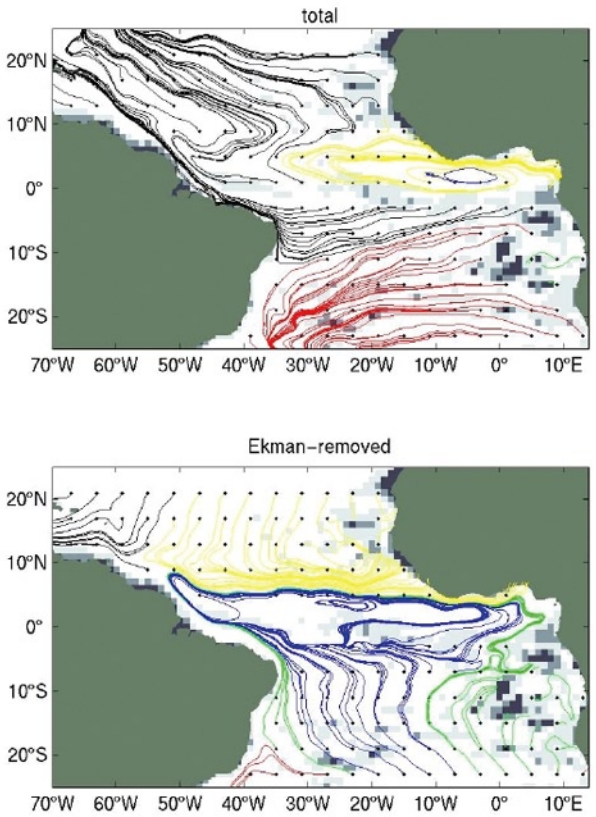


Fig. 1- pathways in the near-surface circulation of the tropical Atlantic Ocean, calculated from drifting buoys. Top: total currents, including the directly wind-driven flow. Bottom: circulation beneath the wind-driven layer.

Research Performance Measure:
The objectives of the study were fully accomplished.

Moisture Budget in the Intra-Americas Sea, Its Transport into North America and Their Roles in Warm-Season Precipitation

Project Personnel: Alberto M. Mestas-Nuñez, Bruce A. Albrecht, Chidong Zhang (UM/RSMAS); David B. Enfield (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To explore the connection among the warm pool of the Intra-Americas Sea (IAS), its moisture budget, moisture transport from the IAS into North America, and warm-season precipitation over North America. **Strategy:** Use observations from a sounding network around the IAS, the Eta regional model analysis, the NCEP/NCAR global model reanalysis, and other datasets.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond; Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
In order to understand climate trends in a region, we must be able to estimate the moisture balance - that is, the relative amounts of evaporation and precipitation. To this end we use atmospheric observations and model analyses in and around the Intra-Americas Sea (i.e. Gulf of Mexico and Caribbean Sea) to evaluate uncertainties in calculating moisture fluxes in that region. The main dataset used is an archive of regional analysis fields from the Eta regional analyses for April 2002 - March 2004. The Eta analyses are 4-times daily and have a resolution of about 32 km. The water vapor fluxes from the Eta analyses compare well with sounding estimates. We check our Eta flux divergence calculations by applying the Gauss theorem and comparing estimates from line and area integrals. We estimate the uncertainties in the moisture flux divergence calculations due to the coarser space and time sampling resolution of the global NCEP/NCAR re-analyses. The estimates of the moisture flux divergence do not change much when the Eta analyses are decimated to the coarser global reanalysis grid. The flux divergences show large differences from month to month and are generally divergent (that is, evaporation exceeds precipitation) during our two-year period. Interannual variability is also investigated using the NCEP/NCAR global reanalysis fields for 1960-2003.

In summary:
• We found good agreement between vertically integrated vapor fluxes estimated from soundings around the IAS and simulated soundings from the Eta regional analyses. This shows that the Eta analyses can be used to estimate the moisture fluxes in the IAS.

• We showed that estimates of the IAS moisture flux divergence using the Eta analyses are not very sensitive to the method used, to spatial sampling, or to daily sampling frequency. This justifies using the longer temporal record of the global NCEP/NCAR reanalysis fields to study interannual variability of the moisture budget.
• We found that while the IAS as a whole is a sink for moisture from August-October, the Gulf is a source all year around and the Caribbean is a sink from August through November.

Research Performance Measure:
Our objective was to estimate the uncertainties in estimating water vapor divergences in the IAS. This objective was accomplished.

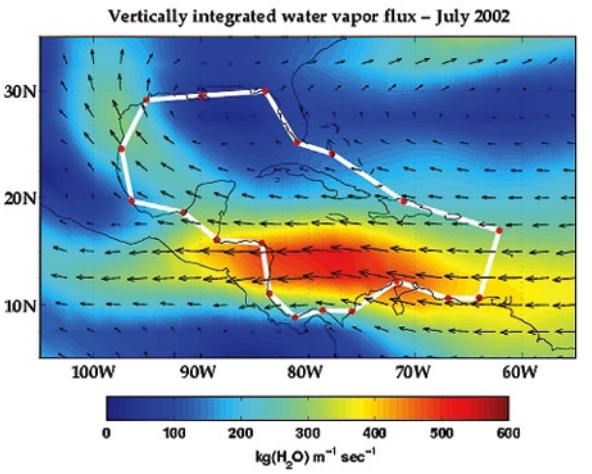


Fig. 1- Mean vertically integrated vapor fluxes calculated from daily NCEP/NCAR global reanalysis fields for July 2002. Vectors indicate the direction of the water vapor transport, whose amplitude is shown by the color. The white solid lines connecting the red dots define the Intra-Americas Sea (IAS) region used to estimate the vapor flux divergence.

Mid-Infrared Sea-Surface Temperatures During the Day – Retrievals Into the Sun-Glitter Pattern

Project Personnel: Peter J. Minnett, Robert H. Evans, Ajoy Kumar (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve derived sea-surface temperatures (SST) from measurements made from satellite-borne radiometers in the mid-infrared atmospheric window, in particular to deal with sun-glitter errors. **Strategy**: Combine several satellite products and use numerical radiative transfer models to explore the feasibility of extracting useful SST values in the regions of the sun-lit swath contaminated by the sun-glitter pattern.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
Sea-surface temperatures derived from measurements made from satellite-borne radiometers in the mid-infrared atmospheric window at about 3.7 μm wavelength. Daytime measurements of SST during the day are problematical because of significant contributions from reflected sunlight (sun-glitter). The conventional approach is to discard the data taken on the illuminated part of each satellite orbit. In this program we attempt to correct for this problem by making use of the measurements from the MODerate-resolution Imaging Spectrometers (MODIS) on the NASA EOS Terra and Aqua satellites. We also use numerical radiative transfer models to explore the feasibility of extracting useful SST values in the regions of the sun-lit swath contaminated by the sun-glitter pattern.

This study uses two separate approaches involving radiative transfer simulations and real on-orbit data from the MODISs on Aqua and Terra. The model selected is the line-by-line spectral code developed for the algorithm derivation for the ATSR sensor adapted to accommodate the latest version of the water-vapor continuum spectrum. In addition we use improved spectra for atmospheric components from the AFGL data base and improved aerosol representation. The model output was used to develop the form of the algorithms to retrieve skin SST in the glitter patterns. These were tested using the "Matchup Data Bases" between the Aqua and Terra MODISs and in situ measurements, and with on-orbit data by comparing the SSTs retrieved in the sun-glitter regions with and without measurements in the 3.7μm spectral region. The algorithms were applied to the problem of day-time measurements of SST from the new generation of GOES Imagers (GOES-12 onwards) which lack the conventional split-window channels in the thermal-infrared atmospheric window that were available on the previous models of the Imager. The atmospheric correction for measurements from the new sensor would require combining the 11 and 3.7μm channels, the later of which is of course contaminated by sun-glitter. Thus far the results are promising and work is progressing. Simulated spectra of the emission of infrared radiation at the top of atmosphere have been derived using a line-by-line radiative transfer model and a large set of marine atmospheric states derived from the data assimilation model of the ECMWF. We have identified MODIS data exhibiting the required characteristics of well defined sun-glitter patterns in otherwise cloud-free ocean areas and we have developed software to manipulate these data sets.

Research Performance Measure:
The project is at about its half way point and is on track.

Western Boundary Current Climate Time Series: Windward Passages Experiment

Project Personnel: Carlos A. Fonseca (UM/RSMAS); Molly Baringer (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the movement of water and heat around the global ocean and to determine ways in which these transports affect climate. **Strategy**: Use a wide range of observations, including satellite, hydrographic, and moored instruments as well as high resolution numerical models.

CIMAS Research Theme:
Theme 1: Climate Variability
Theme 6: Integrated Ocean Observations

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
Climate models have shown that variations of the transport of the Western Boundary Current in the Atlantic Ocean have significant impacts on the climate at both the national and global level. We carry out many studies on this current. As a part of the overall program, we use these cruises to improve instrumentation and data handling procedures. The participation in The Windward Passages Experiment gave us the opportunity to test the quality-control algorithms that were developed to improve the quality of the CTD data collected. Data from past cruises of this project were used to develop and to evaluate the new methods and algorithms to calibrate CTD data using water samples. The choice of these two cruises was excellent because it gave us the opportunity to develop algorithms for different oxygen sensors (the SBE 43 series and the SBE 13 series). In this way we now have a package that covers all the sensors available at AOML. The new algorithms allows us to retain a larger amount of data and to make the regression between sample data and CTD data. The final result shows average residuals smaller than that specified in the WOCE manuals.

Research Performance Measure:
The major objective was to develop a new package to facilitate the calibration of CTD profilers and the quality control of CTD data and to use the package on CTD data obtained on two cruises. This has been accomplished.

Western Boundary Current Time Series: Florida Current

Project Personnel: Rigoberto F. Garcia (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the movement of water and heat around the global ocean and to determine ways in which these transports affect climate. **Strategy**: Use a wide range of observations, including satellite, hydrographic, and moored instruments as well as high resolution numerical models.

CIMAS Research Theme:
Theme 1: Climate Variability
Theme 6: Integrated Ocean Observations

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
The Florida Current represents the upper limb of the Atlantic Ocean Meridional Overturning Circulation (MOC). Variations of the MOC transport have been shown by a variety of numerical models to have significant impacts on climate both on a regional and a global scale. We study the variations in the MOC by measuring the changes in the voltage induced in submarine telephone cables that span the Straits of Florida. The induced voltages are interpreted in terms of water mass flow by comparing them to actual physical measurements of mass flow obtained from dropsonde profiles made across the Straits.

My participation in the Western Boundary Time Series Project has been devoted to assisting with the development of processing and analysis routines for the interpretation of the induced voltages. Our group has nearly completed programs which will allow us to interpret the voltage measured on this cable as a time series of transport for the Florida Current. We have analyzed cable data from the year 2000 to the present, and we have also developed programs to analyze section data from 1991 to the present.

Research Performance Measure:
The major objectives were fully attained.

Western Boundary Current Time Series: Florida Current Cable Measurements

Project Personnel: Christopher S. Meinen (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the movement of water and heat around the Atlantic Ocean and to determine ways in which these transports affect climate. **Strategy**: To use a wide range of observations - satellite, hydrographic, and moored instruments and communication-cable measurements - to study the Florida Current and related regional currents.

CIMAS Research Themes: Theme 1: Climate Variability; Theme 6: Integrated Ocean Observations

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:
Climate models have shown that variations of the transport of the Deep Western Boundary Current (DWBC) in the Atlantic Ocean have significant impacts on the climate at both the national and global level. Long term observations of the DWBC will be required in order to quantify the natural scales of variability of the current, however because the DWBC has no surface expression it is necessary to make direct measurements of the current us-ing instruments directly moored in the current's path. Such moorings are expensive, so all effort must be expended to seek the most inexpensive but accurate method for monitoring the current variations.

I have developed a low-cost method for monitoring the DWBC in the Atlantic Ocean east of Florida using the underwater communications cable that lies across the Straits of Florida. As a part of this program I have taken over the management of the Florida Current cable which provides transport estimates for the Florida Current in near real time and I have written new processing software to analyze the data. In a continuation of work begun last year I have successfully completed a test of a new method for monitoring the DWBC.

I have also worked on analyzing the exchange of upper ocean waters between the South and North Atlantic Oceans in the North Brazil Current Retroflection region and I also completed a study of the exchange of warm water between the equatorial Pacific and the higher latitudes. These studies are directly applicable to NOAA's goals of improving understanding of the global climate system.

Research Performance Measure:
The objectives of this study have been realized.

The Impact of the Saharan Air Layer on Atlantic Tropical Cyclone Activity

Project Personnel: Jason Dunion, Joseph Prospero (UM/RSMAS); William Barry, Michael Black, Neal Dorst, Steve Feuer, John Kaplan, Christopher Landsea, Paul Leighton, Frank Marks, Mark Powell, Robert Rogers (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve hurricane forecasts by studying the affects of the Saharan Air Layer (SAL) on the intensity of Atlantic tropical cyclones. **Strategy:** To carry out research flights to understand how the SAL's strong low-to-mid-level winds, dry air, and embedded mineral dust affect tropical cyclone intensity change as well as to understand how the SAL affects the climatology of moisture in the tropics.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
Tropical cyclones and hurricanes evolve from easterly waves that emerge from the west coast of North Africa during the summer and early fall. The evolution of easterly waves into storms and hurricanes appears to be modulated by interactions with the Saharan Air Layer (SAL) that overlays much of the tropical Atlantic during the summer and fall. The SAL is an elevated layer of hot, dry, dust-laden air that had its origins over the Sahara. The SAL is often associated with a mid-level easterly jet. A temperature inversion occurs at the base of the SAL where very warm Saharan air overlies relatively cooler air above the ocean surface.

The GOES SAL imagery has also been used to assess the validity of the Jordan mean tropical sounding for the 2001 and 2002 Atlantic hurricane seasons. The imagery was used to classify SAL versus non-SAL rawinsondes launched from stations in the Caribbean Sea and western North Atlantic (~1400 soundings over the two year period). We find that the Jordan mean sounding is not representative of "mean" conditions. Rather we see that the moisture-temperature soundings fall into a bimodal distribution (Fig. 1). This reassessment is suggesting that our understanding of the climatology of moisture in these regions

In a procedure developed in our program, we use multi-spectral GOES infrared satellite imagery to detect the SAL through the radiative effects of the entrained dust and dry air. We find that when the SAL engulfs tropical waves, disturbances, or pre-existing tropical cyclones, the dry air, temperature inversion, and mid-level easterly jet (and the associated increase in vertical wind shear) act to inhibit the growth of the weather systems. The SAL's influence on tropical cyclones may be an important contributing factor in the difficulty in forecasting tropical cyclone intensity in the Atlantic. The effects of the SAL may also explain in part why the Atlantic Ocean has relatively less hurricane activity than that in the Pacific.

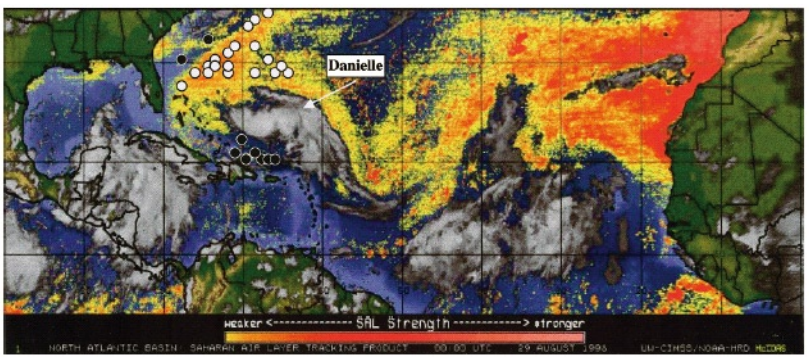
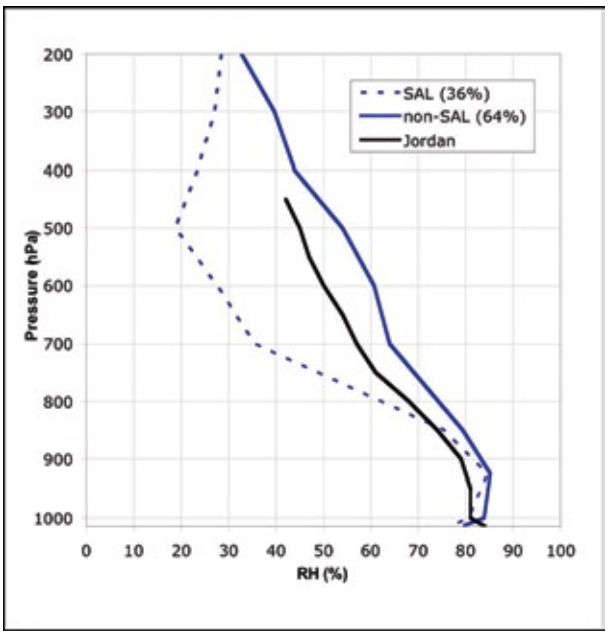


Fig. 1- GOES SAL-tracking satellite imagery with overlaid GPS dropsonde points for Hurricane Danielle on 0000 UTC 29 Aug 1998. The yellow–red shading indicates likely SAL regions with increasing amounts of dust content and dry lower-tropospheric air, as detected by the GOES imagery. Light circles indicate GPS sondes dropped in the SAL environment. Dark circles indicate GPS sondes dropped in non-SAL tropical environments.



needs to be updated. The results of this study are likely to have a profound impact on our understanding of the baseline climatology of moisture in the western North Atlantic and Caribbean Sea.

Research Performance Measure:
All major objectives were attained. We have successfully demonstrated the capability to track the SAL with GOES satellite imagery and also to use this imagery to target the SAL with GPS dropwindsondes launched from NOAA hurricane hunter aircraft. Our understanding of the climatology of moisture has been also been enhanced by the 2001-2002 rawinsounding study of the Jordan mean tropical sounding.

Fig. 2- Reassessment of the Jordan mean tropical sounding during 2001 and 2002 Atlantic hurricane seasons. The mean 2001-2002 SAL sounding (dashed blue) is significantly drier than the mean Jordan sounding (black), while the mean 2001-2002 moist tropical sounding was moister than Jordan. A bi-modal moisture distribution of moisture is indicated by the 2001-2002 data.

Design and Development of the Caribbean-wide Reef Fish Visual Census Universal Database

Project Personnel: Mei-Ling Shyu (UM/ENG); Jerald S. Ault (UM/RSMAS); James A. Bohnsack (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To integrate data over the Caribbean so as to better understand trends in reef fish populations in the region. **Strategy**: Develop a standardized, state-of-the-art, Caribbean wide, web-based data entry, error checking validation, storage, and report-generating system in conjunction with Southeast Coral Reef Database System (SeCoRDS) for centralizing Reef fish Visual Census (RVC) monitoring data collected with the stationary diver method.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Large quantities of reef-fish-related data are collected throughout this broad region. Unfortunately in the past there was little standardization of techniques and data formats so that it was difficult to get a comprehensive picture of trends, if any, in these waters. In our program we designed and developed a new Oracle database schema to store all sample data collected by the divers. The new Oracle database schema minimizes the task of entering data from many diverse sources. It also simplifies the transfer of existing old data (e.g., data in the previously used ACCESS database) into the new database. The data entry program consumes very low processing power and memory capacity, and can automatically validate the data while providing an attractive user interface for divers when they are collecting samples in the fields. The system employs a user-friendly and stable data entry program with an editing capability and also a boatlog program to maintain the accuracy of the sample data.

Research Performance Measure:
The major objectives were accomplished: designing and developing: (1) a user-friendly data entry program for the divers to enter the sample data collected in the fields; (2) a boatlog program to validate the collected sample data; (3) an Oracle database schema to store all sample data collected by the divers; and (4) a set of programs to migrate all the existing old data to the new Oracle database.

Implementation of the NOAA Southeast Coral Reef Database System (SeCoRDS)

Project Personnel: Jerald S. Ault (UM/RSMAS); Mei-Ling Shyu (UM/ENG); Steven Wong (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To develop innovative methodologies to address the issues of information management, spatial data search, access and analysis, and outreach for the NOAA SEFSC coral reef program. **Strategy**: Use state-of-the-art Oracle technology to develop the data management system.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:
We have developed an innovative information management system for the coral reef program. This web-based tool is currently in operation. The system is being used to manage data obtained in the Florida Keys National Marine Sanctuary (FKNMS). The system facilitates the communications among the coral reef managers (from the SEFSC, headquarters of NOAA Fisheries, and other NOAA line offices) and researchers via Web-based tools. Data access and analysis are improved through consolidation of the currently fragmented coral reef data sets in the SEFSC into a spatially enabled Oracle database management system (DBMS). The tools serves as a document/data repository and a spatially enabled database for SEFSC coral reef data sets and related habitat data, which are accessible from the GIS clients (ArcView, ArcExplorer, etc.) and Web browsers. A component of the system is a coral reef metadata and a metadata generator customized for coral reef researchers For this purpose we use a fully integrated suite of Oracle products including Oracle database, Oracle iFS (Internet File System), Oracle application server, and Oracle Business Component for Java (bc4java).

The system facilitates the communications among the coral reef managers (from the SEFSC, headquarters of NOAA Fisheries, and other NOAA line offices) and researchers via Web-based tools. Data access and analysis are improved through consolidation of the currently fragmented coral reef data sets in the SEFSC into a spatially enabled Oracle database management system (DBMS).

Research Performance Measure:
The full range of data management system tools is in place and in operation.

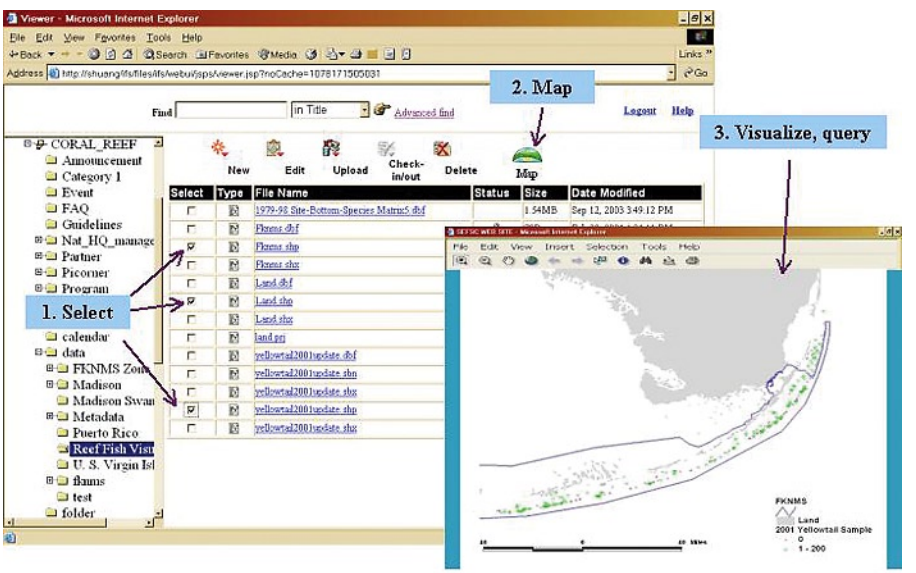


Fig. 1- Web-based mapping is integrated into content management of coral reef data and documents. The above figure shows the design of the user interface for data visualization. A user selects three data sets to be visualized, clicks on the map button, and a map is displayed. Data in the map can be zoomed in/out, queried, etc.

Monitoring Coral Reef Fish Populations in the Florida Keys

Project Personnel: Jerald S. Ault, Steven G. Smith (UM/RSMAS); James A. Bohnsack (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To augment the South Florida Ecosystem Restoration Program research by providing a comprehensive 5-yr quantitative evaluation of trends in FKNMS no-take zones: Sanctuary Preservation Areas (SPAS), Ecological Reserves (ERs), and Research Areas. **Strategy**: Carry out state-of-the-art multispecies assessments in the region, map coral reef habitats, and determine spatial and temporal reef fish-coral reef habitat relationships for the evaluation of the progress being made in the Florida Keys National Marine Sanctuary towards meeting its marine ecosystem management goals.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
No-take reserves (NTRs) in the Florida Keys National Marine Sanctuary (FKNMS) are a joint fishery and ecosystem management effort between the NOAA National Marine Sanctuary Program, National Park Service (NPS), and the State of Florida. The FKNMS has implemented three types of no-take areas: (1) 16 small Sanctuary Preservation Areas (SPAs) totaling approxi-

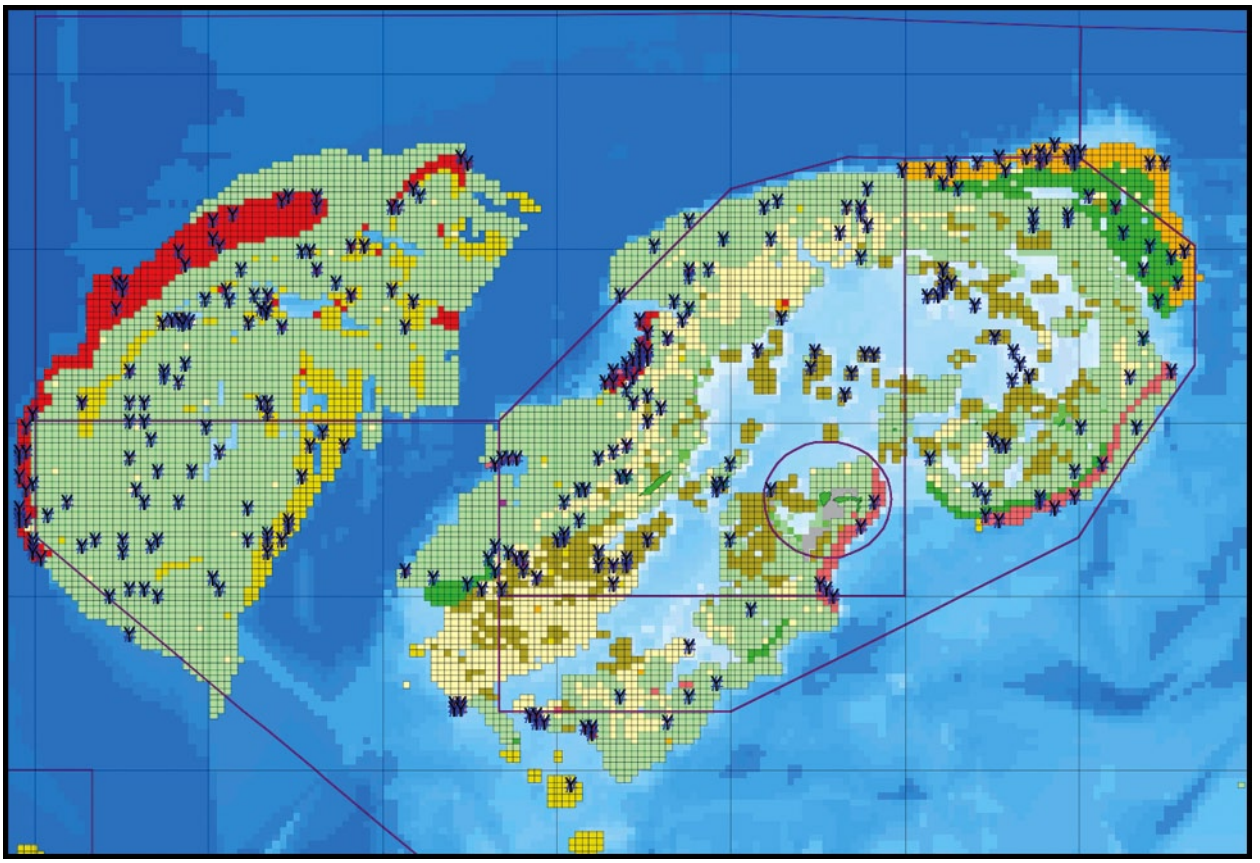


Fig. 1- The 2004 Dry Tortugas Expedition to assess marine reserves. Map shows habitats and bathymetry for Dry Tortugas National Park (left side of image) and Tortugas Bank (right side) outlined by the boundary of the Florida Keys National Marine Sanctuary. Individual blue dots indicate locations of fish census sampling stations where at least 4 science dives were conducted.

Fig. 2- A school of large permit (*Trachinotus falcatus*) swim overhead of visual census divers in the Dry Tortugas.

mately 46 km^2 that protect the high-relief coral reef; (2) one large (30 km^2) ecological reserve (ER) that includes several different habitats; and, (3) 4 special-use SPAs designed for research purposes. Two large Ecological Reserves, 206 and 312 km^2, are were added in 2001 west of the Tortugas, Florida. The NPS Service has scheduled a 100 km^2 Research Natural Area (RNA) for implementation in the western half of Dry Tortugas National Park.

The main objective was to design and conduct comprehensive surveys of coral reefs and reef fish stocks along the Florida coral reef tract. Simultaneous assessment surveys were conducted of fishes, corals, conch, spiny lobster, other reef species and coral reef habitats using newly developed state-of-the-art sampling strategies. Results have been used to define current baseline conditions and to monitor future changes that result from management actions in Biscayne National Park,

Fig. 3- A school of creole wrasse (*Paranthias furcifer*) accentuate the beauty of a reef terrace coral habitat.

the Florida Keys National Marine Sanctuary, and Dry Tortugas National Park. Regionally-synoptic monitoring and assessment expeditions, led by Drs. Ault and Bohnsack, have included participation by scientists from many state and federal agencies, several universities, and a volunteer non-profit organization.

The NOAA/NMFS Southeast Fisheries Science Center Coral Reef Initiative is supporting University of Miami RSMAS scientists in implementing interdisciplinary research on multispecies fisheries dynamics in the Florida Keys and wider Caribbean coral reef ecosystems. Quantitative baseline assessments were conducted on data collected from Biscayne National Park and Dry Tortugas National Park for design and analysis of their coral reef monitoring plans.

Fig. 4- A gray angelfish (*Pomacanthus arcuatus*), red grouper (*Epinephelus morio*), and bluehead wrasse (*Thalassoma bifasciatum*) seem to be looking to scientists for answers concerning overfishing and coral reef declines in the Florida Keys.

This research represents an excellent example of coordination, cooperation, and participation by different government agencies, universities, and private organizations to achieve a common goal. The research was documented in a number of media pieces including National Geographic, Los Angeles Times, BBC (British Broadcasting Company), NBC, Discovery Channel, Animal Planet, Chicago Tribune, Miami Herald, Associated Press, Christian Science Monitor, etc.

Research Performance Measure:
The objectives of this program are being met by the extensive monitoring program that is currently underway.

Upstream Larval Supply to Florida Bay-Dry Tortugas

Project Personnel: Monica R. Lara, Cynthia Yeung, David L. Jones, and Maria M. Criales (UM/RSMAS); John T. Lamkin, and William J. Richards (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To investigate the importance of the formation and movement of coastal eddies to the supply of early life history stages (ELHS) to the South Florida ecosystem. **Strategy**: We follow the evolution of the Tortugas eddy using satellite products, models, and Ocean Surface Current Radar (OSCR) to track in real time the alongshore currents associated with the passage of the eddy; concurrently we deploy nets at channels connecting coastal waters with Florida Bay to monitor the onshore transport of pre-settlement stages.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Results from our previous work suggested that eddy processes were a key component in the recruitment model of South Florida. Evidence supporting this has come from a *posteriori* inferences. One of our main goals was to specifically test the hypothesis that the presence of a coastal eddy enhances the influx of pre-settlement recruits into Florida Bay.

Keystone marine species in South Florida such as snappers (*Lutjanus* spp.), the spiny lobster (*Panulirus argus*), and the pink shrimp (*Farfantespenaeus duorarum*) use the estuarine Florida Bay for a juvenile nursery, whereas a principal spawning ground for these species lies in the Dry Tortugas some 150 km upstream (southwest) of the Bay. A semi-permanent cyclonic eddy frequently resides at the Dry Tortugas. Eventually, the Tortugas eddy propagates downstream in the form of a transient eddy towards the coastal waters offshore of Florida Bay. The Tortugas eddy provides a mechanism for the retention and nourishment of early life history stages (ELHs) at the spawning source and its subsequent progress downstream can transport ELHs towards the nursery.

In our studies we wished to compare the densities of incoming recruits in the Middle and Lower Keys when eddies were present and when they were absent. To investigate the significance of the eddy process to the supply of ELHs to the South Florida ecosystem, we followed the evolution of the Tortugas eddy using satellite SST and SSH imagery in conjunction with the Navy Layered Ocean Model (NLOM). When remote sensing information suggested that the passage of an eddy was imminent, an Ocean Surface Current Radar (OSCR) array was set up to record in real time the alongshore current reversal and enhanced onshore flow; we would expect to see these flows as the leading edge of the eddy passes to the North. OSCR provided in real-time at 1-km resolution the surface current vector fields from nearshore in the vicinity of the channels to 40 km offshore. At the same time, channel nets were deployed inshore of the OSCR domain at channels connecting coastal waters with Florida Bay so as to monitor the onshore transport of pre-settlement stages. Sampling at Long Key channel and Seven-Mile Bridge was timed to coincide with the presence of an eddy offshore, and in the contrasting case, the absence of one. Work involved coordination with the Physical Science Team in SFERPM program to gather in-situ and remotely-sensed oceanographic data to enable detection of eddy conditions

The application of high-frequency (HF) radar remote sensing such as the OSCR to fishery studies is a revolutionary development. The OSCR system has already proven to be extremely useful in guiding the biological sampling of larval fishes associated with small scale, ephemeral oceanographic features.

Experiments to investigate the influence of coastal eddies on the transport of pre-settlement stage snappers, lobster, and shrimp into Florida Bay are currently underway. This work is aimed at providing direct evidence that eddies offshore of

the Florida Keys enhance the transport of larval recruits from spawning areas in the Dry Tortugas to nursery grounds in Florida Bay.

Research Performance Measure:
The objectives have been attained: Two complete eddy experiments have been conducted and final analysis of physical and biological data is nearing completion according to schedule.

Modeling Pink Shrimp Recruitment from Florida Bay

Project Personnel: Maria M. Criales, John Wang (UM/RSMAS); Joan A. Browder, Steven Wong, Thomas Jackson (NOAA/SESFC); Michael Robblee, Clinton Hittle (USGS/CWRS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To develop a pink shrimp simulation model and performance measures to evaluate the impact of upstream water management changes on Florida Bay resulting from efforts to restore the Greater Everglades ecosystem. **Strategy**: To monitor pink shrimp populations and to model the population changes in the context of water quality measures so as to better understand the ecology of this fishery species in relation to the processes influencing transport, settlement, survival, and recruitment.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Within the NOAA-South Florida Ecosystem Restoration Prediction and Modeling (SFERPM) program we are developing a pink shrimp (*Farfantepenaeus duorarum*) simulation model and performance measure to evaluate the impact of upstream water management changes on Florida Bay. As part of the model we are investigating the transport mechanisms of planktonic stages from spawning grounds (Dry Tortugas) to nursery grounds (Florida Bay) using field data and simulations of transport. Post-larvae were collected for four consecutive years (2000-2003) at channels that connect the NW border of Florida Bay with the Florida shelf of the Gulf of Mexico and at channels in the Florida Keys that connect the Bay with the Atlantic Ocean.

Collections of post-larvae showed a large and marked summer peak at the northwestern border of Florida Bay every year, suggesting a larval transport across the SW Florida shelf. A simple lagrangian trajectory model was developed to explore transport mechanisms across the shelf using a current field derived from ADCP data time series and different scenarios of larval behavior. The model simulated particles traveling at night over a 30–day period to fit the estimated development time of pink shrimp before settlement.

Results of simulations suggest that only planktonic stages that are able to recognize and act upon changes in the direction of the current could reach the nursery grounds in 30 days. Simulations of transport developed from amplitudes of the tidal constituents and the day-night cycle demonstrated a distinct annual tidal cycle caused by the covariance between the tidal motion and the diel vertical migration. This annual cycle supports the marked summer peak of near-settlement-stage pink shrimp post-larvae observed every year at the northwest border of the Bay. Therefore, young pink shrimp and other coastal species must use the summer tidal cycle to increase their chance of successfully reaching their coastal nursery habitats.

Research Performance Measure:
Our first objective was to develop a pink shrimp simulation model and performance measure to evaluate the impact of upstream water management changes on Florida Bay. The second was to clarify processes influencing transport and recruitment. These objectives were accomplished.

Abundance and Diel Migrations Of Demersal Mesozooplankton and Small Reef Fishes And Their Trophodynamic Contribution to the Coral Reef Ecosystem

Project Personnel: Sharon Smith, Jiangang Luo, Peter Lane, Dora Pilz (UM/RSMAS); Peter B. Ortner, James C. Hendee, Shailer Cummings, Jack Stamates (NOAA/AOML); John Lamkin, Dave Jones (NOAA/SEFSC)

Long Term Research Objectives and Strategy To Achieve Them:
Objectives: To describe and quantify the functional bio-physical relationships and processes that control and impact planktonic processes associated with coral reef ecosystems. **Strategy**: To monitor and observe the coral-reef-associated plankton community to provide basic information on habitat and community dynamics, with particular emphasis on biological responses to physical processes.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
A variety of autonomous sensors were deployed in the Salt River Natural Historical Park and Ecological Preserve on the north shore of St. Croix, USVI. This location was selected because of the proximity to a NOAA Coral Reef Early Warning System (CREWS) station. The study site includes a relatively vibrant coral community (Figure 1) in approximately 20-70 feet of water with nearby sandy bottom allowing non-invasive deployment of bottom moored instrumentation. The research was conducted during two field studies, each lasting about 25 days, during October 2002 and May 2003. The primary instrumentation utilized for this study consisted of an optical plankton counter (OPC), a multi-frequency Tracor Acoustical Profiling System (TAPS) and a 300 kHz RDI acoustic Doppler current profiler (ADCP) (Figure 2). A 1200 kHz ADCP was added during the May sampling period. In addition to the autonomous sensors, several net collections were made with during daytime and evening hours near the moored instruments.

Preliminary analyses of acoustic data showed distinct daily cycles of biomass change over the reef (Figures 3 and 4). Further analysis will attempt to resolve biomass fluctuations related to tidal cycles and those fluctuations related to night-time migrations of zooplankton out of the reef and into the water column. As part of this analysis, we are attempting to resolve size ranges of the plankton observed by acoustic and optical instrumentation.

Fig. 1- Coral nearby moored instruments in Salt River Natural Historical Park and Ecological Preserve in St. Croix, USVI. (photo by P. Lane)

Laboratory analyses of net samples collected during day and night in late October and early May yielded preliminary information on the seasonal and diel plankton community dynamics near the reef. The abundance of total zooplankton was greater in October than in May. In October, total zooplankton abundance was lower in the afternoon and greater in the morning and evening, whereas in May zooplankton abundance was greater in the afternoon than in the morning or evening. It is interesting to note that unidentified nauplii and copepodites combined were most abundant in the evening (dark) in both the October and May samples.

Although these data are preliminary, they suggest that the local current regime and the migratory

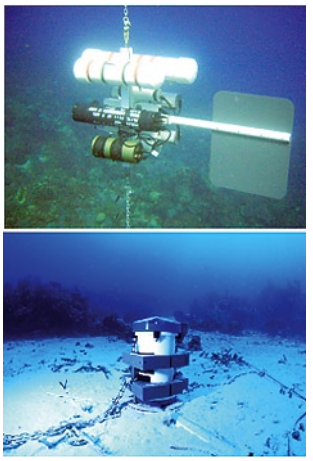


Fig. 2- Autonomous instruments for measuring water column plankton and currents. The photo on left shows the multi-frequency Tracor Acoustical Profiling System (TAPS) and the optical plankton counter (OPC) on a mooring with battery packs, buoyancy canisters and current vain. Photo on right shows 300 kHz acoustic Doppler current profiler (ADCP) mounted on sandy bottom adjacent to coral reef. Photos by P. Lane and J. Luo.

behavior of some zooplankton species interact to modify the plankton community over the reef on a daily basis. For example, in the October net samples, three species of copepod (*Undinula vulgaris, Clausocalanus* sp. and *Oncaea* sp.) were found to be much more abundant in the morning sample than in the afternoon or evening samples. This observation combined with current data suggest that these species were associated with a westerly flowing current, and coincidentally with the incoming tide. The copepod *Temora* turbinata was more abundant in the night sample than in the day samples, suggesting this species may migrate upward from depth at night. Ostracods were also more abundant in the night sample, again suggesting that this group may migrate upward from near-bottom daytime depths.

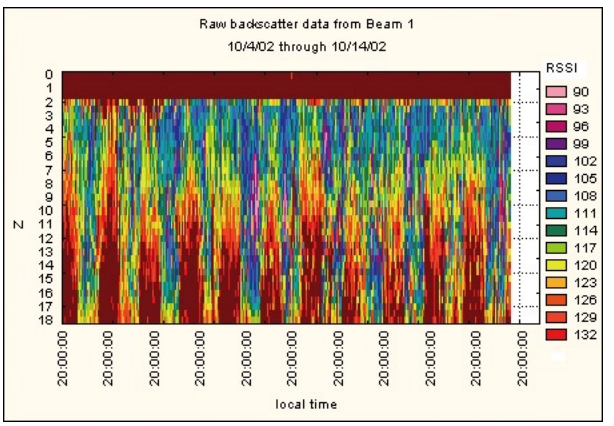


Fig. 4- Acoustic backscatter from the bottom moored 300 kHz ADCP for the 10 day period in October corresponding to TAPS data shown in figure 3. Diel periodicity suggests substantial cycles in planktonic biomass in the water column each day. Note that on the Y axis bin 18 is surface and bin 0 is the bottom (i.e., figure is inverted).

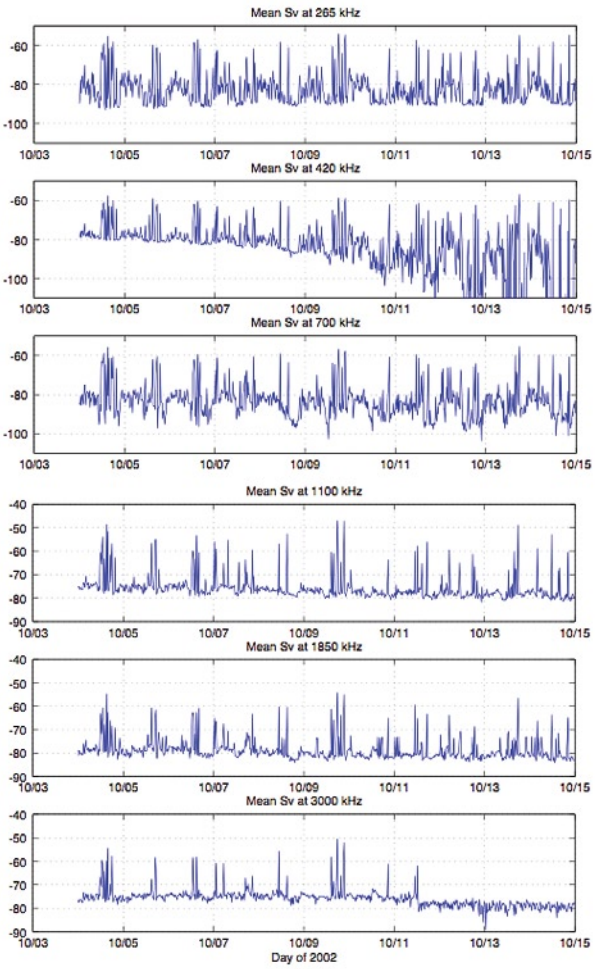


Fig. 3- Mean acoustic scattering at the six TAPS frequencies over a 10-day period in October 2002. Higher frequencies tend to be more sensitive to smaller planktonic organisms. Note that acoustic scattering amplitude data at all frequencies suggest a diel periodicity. Data were recorded in GMT (local time = GMT – 4 hours).

Our research has thus far shown a very interesting, albeit complicated, picture of circulation and bio-physical coupling in the study region. These results suggest the need for further investigations into the species-specific behavior of zooplankton near the reef as well as the development of acoustic and optical techniques to resolve the size classes in the plankton.

Research Performance Measure:
All major objectives were attained. The field deployment and recovery of the instrumentation and data were remarkably successful.

Western Atlantic Pelagic Longline Sea Turtle Mitigation Research: Effect of Hook Size on Ingestion of Hooks by Loggerhead Sea Turtles

Project Personnel: Lesley Stokes (UM/RSMAS); Sheryan Epperly, John Watson, Arvind Shah, Dan Foster, Dominy Hataway, Charles Bergmann (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To reduce the incidental capture and mortality of sea turtles in pelagic longline fishing.
Strategy: Develop a mechanistic understanding of the interaction between loggerhead sea turtles and baited hooks, and test new sea turtle bycatch reduction technologies and methods in the laboratory and the field.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:
Research was conducted in the Western Atlantic Northeast Distant Waters (NED) statistical reporting area to develop and evaluate fishing gear modifications and tactics intended to reduce the incidental capture of endangered and threatened sea turtle species by pelagic longline fishing gears. The effects of hook size and type, bait type, light stick color, and surface water temperature were investigated as they related to catch per unit effort (CPUE) for target species and incidental sea turtle capture.

Three types of hook and bait combinations on swordfish-directed sets were investigated along with hooking location. The research also permitted us to collect further information about general sea turtle biology, such as regional size distributions and biopsy samples for genetic analysis. Flipper and PIT tags were applied to all boated turtles, and five conventional and 14 popup archival satellite tags were deployed on control turtles for post-hooking mortality studies.

Results from the study indicated that switching from J-hooks to larger circle hooks, and from squid to mackerel bait, can substantially reduce loggerhead and leatherback sea turtle capture. Loggerheads were also less likely to swallow the larger circle hooks than the J-hooks, indicating that the circle hooks may reduce post-hooking mortality in those animals captured. In addition, both loggerhead and leatherback turtle catch rates varied with the surface water temperature; fishing in cooler water temperatures can further reduce turtle interaction rates.

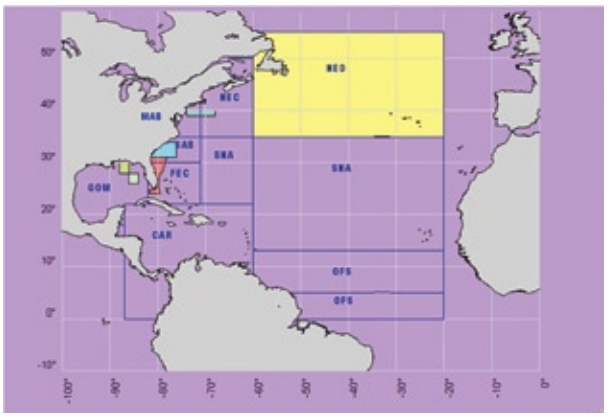


Fig. 1- The area of operation was the Northeast Distant Waters (NED) statistical reporting zone in the Western Atlantic Ocean.

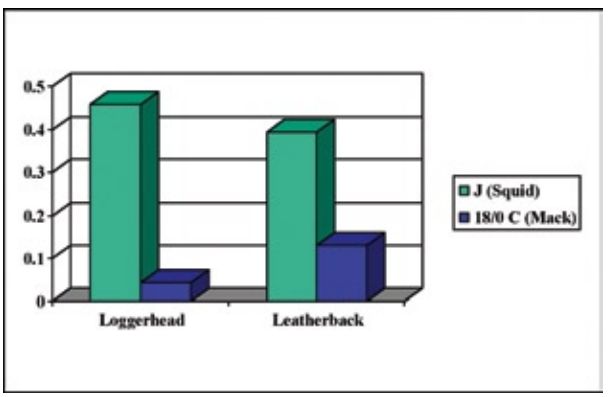


Fig. 2- Loggerhead and leatherback captures 2002-2003 J-hook baited with squid vs. 18/0 circle hook baited with mackerel.

Research Performance Measure:
The objectives of this research has been attained: Turtle bycatch has been reduced through the implementation of new mitigation measures which require the use of circle hooks instead of the standard smaller J-hooks. Also sea turtle release equipment and techniques have been modified in the pelagic longline fisheries.

Based on the findings of these studies, NOAA Fisheries Southeast Fisheries Science Center is currently investigating potential mitigation techniques focusing on the effects of hook design and bait on hook ingestion, one of the primary causes of mortality associated with pelagic longline gear interactions.

Simulation of Management Strategies (FEMS)

Project Personnel: David Die (UM/RSMAS); Murdoch McAllister (Imperial College); Molly Lutcavage, Andy Rosenberg, Andy Cooper (Univ. of New Hampshire)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To develop and test assessment methods to be incorporated into a simulation framework which will help to determine which factors are critical to successful fishery management strategies.
Strategy: Develop a simulation framework that incorporates state-of-the-art operating and assessment models that can be applied to the study of management strategies for highly migratory species.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
The evaluation of management strategies for migratory species is important for improving the management of fisheries and achieving sustainable use of marine resources. This project has developed an analysis framework for the statistical evaluation of fishery management strategies. The framework has already been used to evaluate both theoretical and real fisheries which target highly migratory species such as the Atlantic Yellowfin tuna and Atlantic marlins.

The next phase of the project will focus on the extension of the framework to include models being developed by other research groups working on Atlantic tuna resources. Specifically, the framework will be extended to include spatial Bayesian models (developed by the group of researchers at Imperial College) that use tagging data. These will complement the classical (non-spatial) models incorporated so far in the simulation. Information on movement patterns for bluefin tuna will be provided by University of New Hampshire which leads a program to integrate new knowledge on tuna movement into operational movement models for this species.

The project is linked to an international project funded by the European Union and involving fishery institutions in France (IFREMER), United Kingdom (CEFAS), Spain (Instituto Espanol de Oceanografia), Portugal (Universidade dos Açores), USA (University of Miami) and two international fishery commissions, the International Council for the Exploration of the Sea (ICES). Operational models for three case studies have been implemented as planned leaving two further case studies to be implemented this year. A first prototype of the simulation framework, developed in R software, has been presented at an international meeting of R software developers.

Research Performance Measure:
The major objective, the evaluation of management strategies for migratory species, has been attained.

Investigation of the Movement of Adult Billfish in Potential Spawning Areas

Project Personnel: Robert K. Cowen, Patrick Rice, Jiangang Luo (UM/RSMAS); Eric D. Prince, Joseph E. Serafy, Derke Snodgrass, Eric Orbesen (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To minimize the bycatch of billfish in recreational and commercial fisheries especially when and where they are spawning. **Strategy**: Collect and analyze empirical data on the movement behavior of live billfish during the peak of their spawning seasons as well as on the movement of long-line fishing gear in the water column relative to the fish distributions.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
We used a combination of recreational and commercial fishing vessels to catch adult billfish, attach popup satellite tags to them, and to release them back into pelagic waters. Based on the tracking of the popup tags, we observe and record their horizontal and vertical movements for periods up to 120 days. A total of 54 billfish were popup-tagged in both the Atlantic and the Pacific Oceans: 16 blue marlin, 34 sailfish and 4 swordfish. Approximately 80% of the data collected by these tags was successfully transmitted back to us via the Argos satellite system and is currently undergoing data quality control and analysis.

During May 2004, a pelagic longline research cruise was conducted in the vicinity of the Windward Passage between Haiti and Cuba. Ten pelagic longline sets were deployed from a commercial longline fishing vessel to assess gear behavior under various oceanographic conditions and also to compare the catch rates of several experimental fishing techniques. The species targeted was primarily swordfish (*Xiphias gladius*), although some tunas (*Thunnus* spp.) were also encountered. Typically, about 23 nautical miles of longline fishing gear was deployed each presenting approximately 532 baited hooks. Hook time-at-depth and water temperature were monitored using temperature-depth recorders (TDRs). In addition, several experimental fishing treatments (e.g., different hook types, lights, magnets) were employed to assess impacts on catch composition, catch rates and/or fish condition.

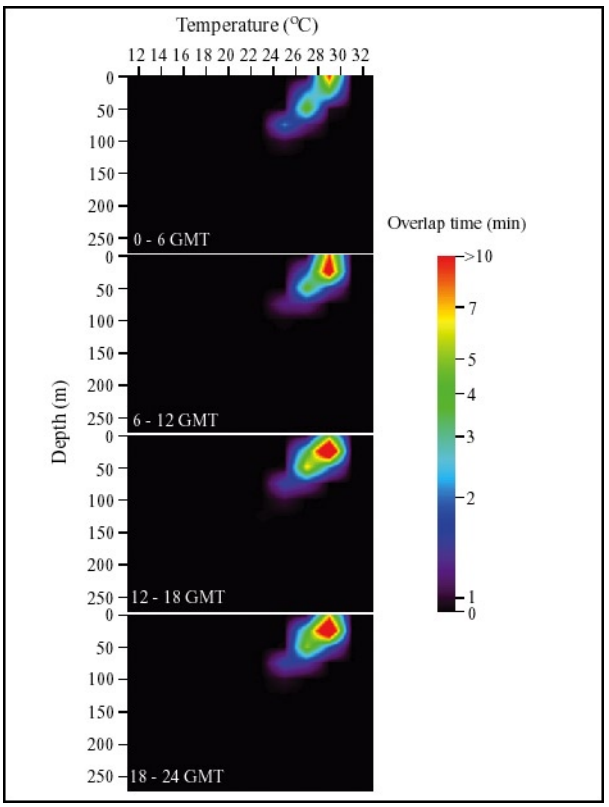


Fig. 1- Depiction of the potential overlap between fishing gear and blue marlin for each time 6-hr time window. Color scale indicates time ranging from 0 to 10 minutes.

We have successful acquired large quantities of high resolution data on pelagic longline gear "behavior" and the effects of gear modifications on animal interactions with pelagic longline fishing gear. Longline cruise data are being analyzed to characterize gear movement and hook distribution in the water column and, ultimately, to determine degree of overlap with pelagic animal habitat (see Figure 1). Preliminary results indicate that longline gear behavior is complex and dynamic.

Research Performance Measure:
The initial tagging objective has been successfully attained.

Pelagic Observer Program

Project Personnel: Debra Abercrombie (UM/RSMAS); Dennis Lee, Cheryl Brown, Larry Beerkircher (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To collect long-term statistical and biological fisheries data from aboard pelagic longline fishing vessels in the Atlantic Ocean. **Strategy**: Carry out observations in the Pelagic Observer Program (POP) which is located at the Southeast Fisheries Science Center and which is responsible for placing observers on fishing vessels in this region.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
In order to obtain a representative sampling of the Atlantic U.S. pelagic longline fleet effort, an eight percent subsampling of the fleet is selected each calendar quarter of the year. Since May of 1992, the Miami Laboratory Pelagic Longline Program has placed observers on 794 trips in the waters of the northwest Atlantic Ocean. Observers have spent over 10,500 days at sea during which they monitored the catch and effort of 5,895 sets. The primary species of fish recorded are swordfish, yellowfin tuna, and a variety of shark species. Within the international arena, these data have been used to compare US catch and effort results with those of other countries prominent in similar Atlantic-wide fisheries. These catch data have also been used in assessment of pelagic stocks, in formulating recommendations in stock management, and supporting various biological research activities conducted on Atlantic species.

Research Performance Measure:
The POP has met all performance measures.

Monitoring Coral Reef Fish Utilization of MPA's and Inshore Habitats in Florida Bay

Project Personnel: Monica R. Lara, David L. Jones (UM/RSMAS); John T. Lamkin (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To monitor coral reef fish recruitment processes in the Florida Keys reef system and adjacent juvenile habitat through the use of trace element analysis of the otoliths (ear bones) of fishes.
Strategy: Develop a chemical signature for adult snapper collected on the Florida Keys reef tract that allows us to estimate the contribution of various nursery habitats as sources of recruits.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Commercially important snapper species are believed to migrate to reefs from juvenile nursery areas such as sea grass and mangrove habitats in Florida Bay and the lower Florida Keys. Little is known about the nature of these nursery areas (physical characteristics, seasonality, quality, persistence), the migration corridors that exist between nursery and reef, and the timing of these migrations. Our research has focused on developing techniques that could be used to identify the principal nursery areas of the commercially, recreationally, and ecologically important reef fish species in South Florida. We have been able to identify their nursery areas based on the concentrations of trace elements, including

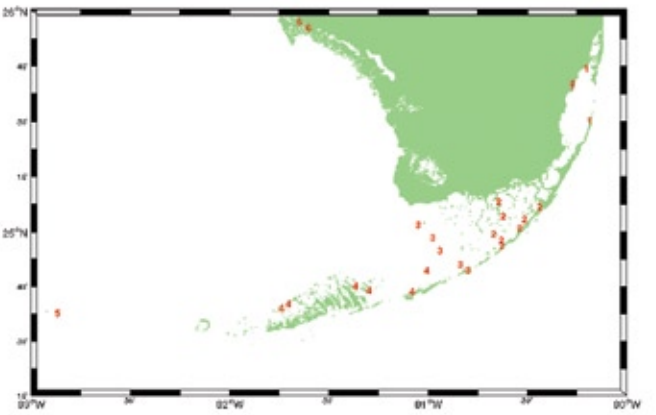


Fig. 1- Map shows the habitat regions which we have identified.

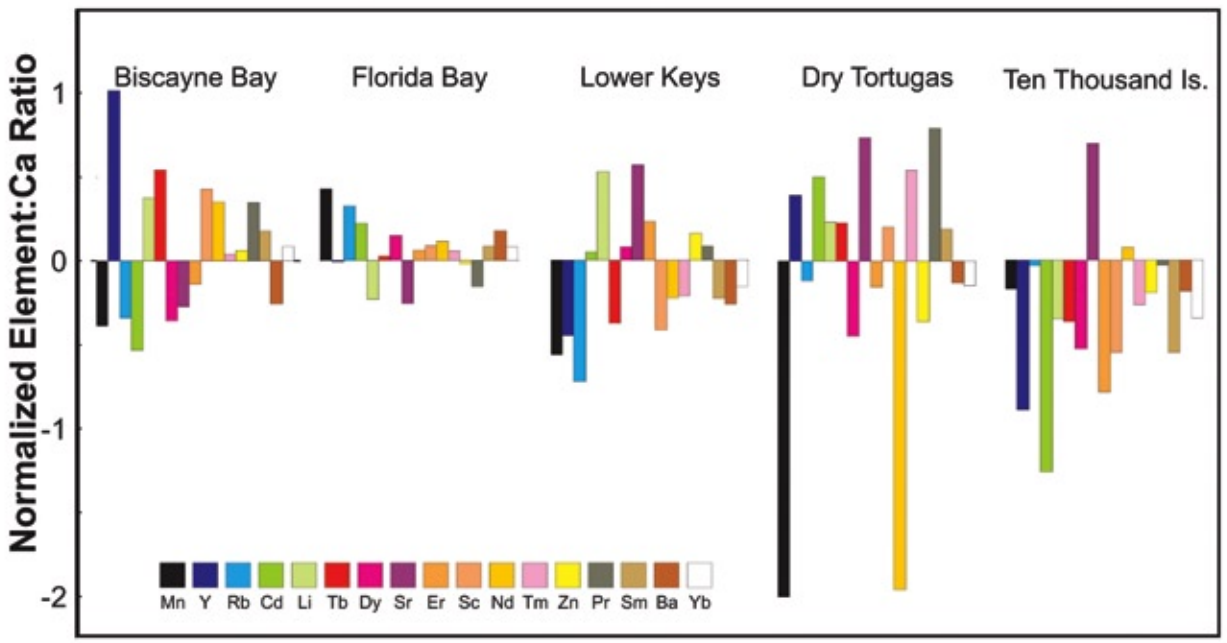


Fig. 2- Bar graph shows the elements which contributed significantly to the spatial identification of source nurseries.

rare earths, in the otoliths (ear bones) of fishes. This is the first study to use rare earth elements as a tracer in otoliths.

Seventeen of the 32 elements examined contributed substantially to the spatial resolution of nursery regions. Cross validation indicated that 80% of all fish were correctly classified to region of origin. When fish were classified as either originating from Florida Bay or not, 13 elements contributed substantially to population separation. In this case, cross validation indicated that 86% of all fish were correctly identified.

We are now studying the use of the same chemical signatures in adults captured on the reefs of South Florida. In this way, we will better understand the contribution of each of these regions as nursery habitats for the adult population of Florida's reefs.

The long-term monitoring and effective management of these areas requires research on the links between habitats and particularly their function as sources and destinations of recruits. This is of particular importance given the recent efforts to restore Florida Bay and the establishment of Marine Protected Areas (MPA s) and the Tortugas Ecological Reserve. The South Florida Coral reef initiative calls for the establishment of no-take reserves within these MPAs. We believe that only with the effective identification and protection of the sources of recruits can we ensure the effective function of MPAs as reef fish sanctuaries. One of the greatest infractions occurring in the parks and sanctuaries in this region is the taking of undersized snapper from the bays and reef. Our work speaks directly to this issue because information on key nursery areas can help guide decisions such as the selection of the best locations for establishing no-take zones and other protected areas.

Research Performance Measure:
Our major objective has been attained: the successful development of a technique that allows us to identify the nursery regions of juvenile fishes in South Florida based on the microchemical signatures in their otoliths.

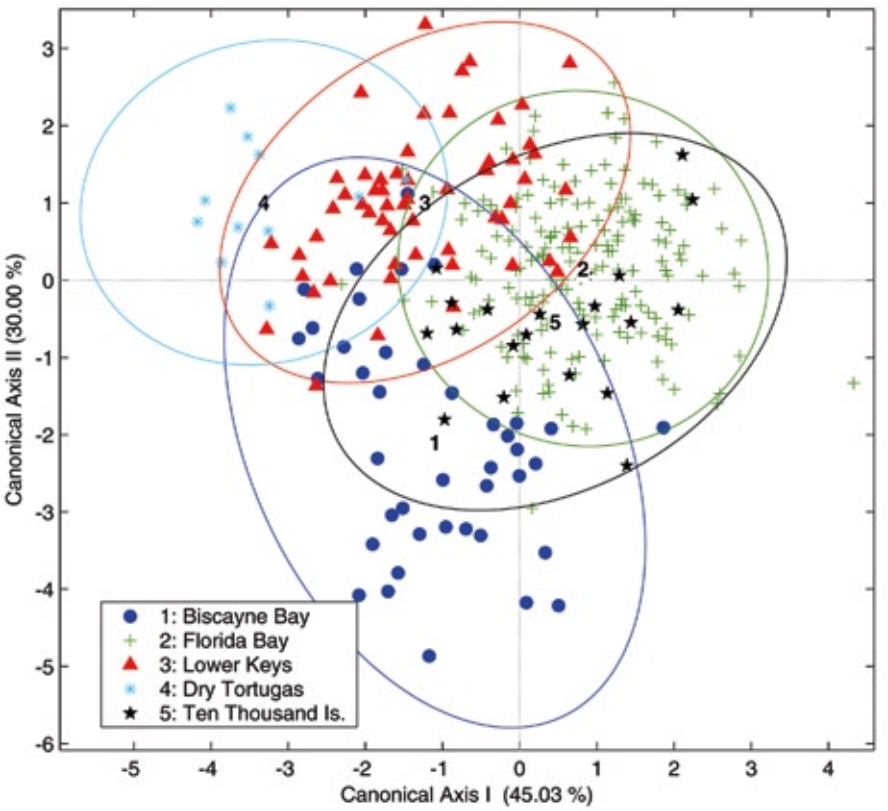


Fig. 3- This figure is a statistical plot that shows all samples and their separation into regions.

Software Development, Data Analysis and Hardware Testing in Support of Spatial Studies of Billfishes and Sea Turtles

Project Personnel: Jiangang Luo (UM/RSMAS); Joseph E. Serafy (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve management strategies for billfishes and sea turtles. **Strategy**: Develop analysis programs for integrating and interpreting data from pop-off satellite archival transmitting (PSAT) tags on these species.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
A quantitative framework and associated Bayesian methodology were developed to characterize vertical habitat utilization by large pelagic animals and to estimate the probability of their capture by certain types of fishing gear. This methodology was applied to data recovered from electronically-tagged blue marlin (*Makaira nigricans*) as well as from a longline fishing gear experiment employing temperature-depth recording devices. The approach appears especially useful for examining pelagic longline fishing impacts on both target and non-target species and could point to ways of reducing bycatch via modification of fishing strategy or gear configuration.

The vertical habitat envelope framework and its associated Bayesian methods allow for the integration of the thermal and depth preferences of PSAT-tagged animals in such a way that vertical habitat use comparisons are simplified to reduced sets of tabular matrices. These matrices are conducive to the study of animal behavior and to calculation (and visualization) of degrees of overlap -- be it among individuals, species or fishing gear. The Bayesian method, when applied to summarized data, produced depth-temperature matrices that were virtually identical to those produced from the much larger, un-summarized dataset. This was encouraging because data summarization is currently a necessity for relatively long-term deployments (i.e., > 30 days) and researchers very rarely physically recover their PSAT tags.

Vertical habitat envelopes can be constructed based on data from fishing gear experiments that employ temperature-depth recording devices. Therefore, a potentially useful application of this approach is to allow assessment of the possible effects of changing fishing strategies (e.g., fishing deeper or at a different time-of-day), both on the animals targeted by a given longline fishery and those unintentionally killed as bycatch. While PSAT-tag technology is being increasingly applied to more individuals of more species, it is equally important to gather and analyze data on the dynamics of gear behavior.

Research Performance Measure:
Our objectives were to develop software and to analyze the PSAT data from billfishes and sea turtles. We developed the software. The data analysis continues as planned and has already produced significant results.

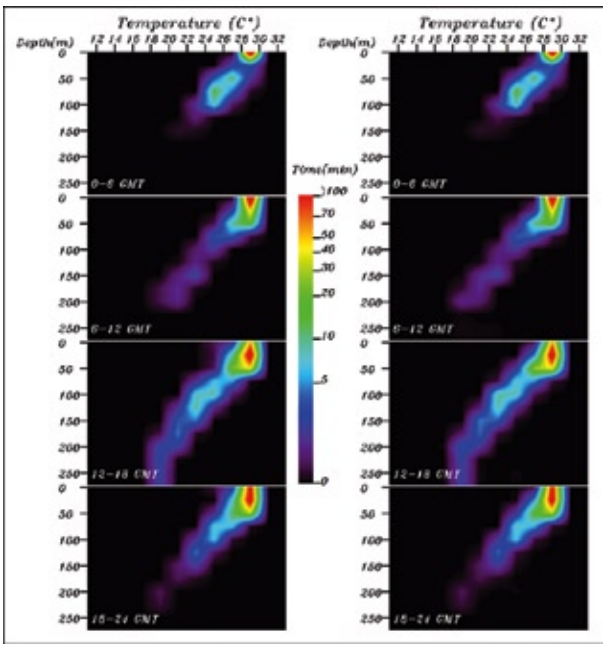


Fig. 1- The Bayesian estimated vertical habitat envelope from satellite transmitted summary data (left) and the actual vertical habitat envelope from the recovered tag (right) of blue marlin.

Development of an In Water Stereo Video System for Use in Fish Surveys

Project Personnel: Kenneth Voss, G. Chris Boynton (UM/Physics); Jerald S. Ault (UM/RSMAS); James A. Bohnsack (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve the accuracy of fish surveys. **Strategy**: To develop and test an underwater, diver-operated stereo video device to obtain more accurate data (size, number and species).

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Fish surveys are an essential part of monitoring and assessing the health of fish populations. Fish surveys currently need many well trained and experienced divers to identify the fish as well as estimate size and numbers. It is difficult for humans to estimate sizes accurately underwater since the air-water interface distorts our sense of distance and size. Furthermore accessing remote or deep locations with divers is expensive, dangerous, and difficult or impossible. People who assess fish populations need an inexpensive and versatile device which could improve the accuracy of fish surveys and reduce their cost; they also need instruments that can be deployed in areas of the ocean that were previously too remote or dangerous. Our goal was to develop this kind of system in the form of a stereo video camera.

Stereo imaging (using pairs of images from separate cameras) is useful since it provides quantitative spatial information for each point in an image. This information can then be used to find the actual size of these objects in the image. For stereo video imaging, synchronization of the cameras is essential to get correct distance information out of the image pairs. In our research we found a vendor which provided a synchronized digital imaging sensors, used for machine vision and robotics. This all-digital format allows us to use digital image techniques for data reduction. We integrated these sensors with an embedded computer and small LCD display to provide control, data storage, display and communications functions. These parts were then integrated into a solid waterproof case that could be easily carried and operated by a single diver.

The camera, a digital compass and pitch/roll sensor, computer with hard drive and 7" display, and a small numeric keyboard all fit in one container measuring 12" x 8" by 6". The power for the system comes from an external battery; the system requires 24V, 1.5 –2A.

Research Performance Measure:
We met all our initial objectives and produced a successful system.

Fig. 1- The above picture shows the back of the camera system. The display shows information on internal temperature, exposure setting, gain, number of frames taken, and current operational status of the system. Images from each camera are shown in the display along with a real-time histogram of the images to help in setting system exposure. Just out of the screen on the right is the system battery. There is a connector on the right side of the case which allows another computer to be connected via Ethernet, to allow data transfer without opening the case.

Faunal Density and Community Composition of the Nearshore Zone Biscayne Bay Biological Community Performance Measures

Project Personnel: Jeremy Hall, Destiny Smith (UM/RSMAS); Joan Browder (NOAA/SEFSC); Mike Robblee, Dave Reed (USGS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To characterize the changes in the ecology of Biscayne Bay that might occur as a result of the South Florida Restoration activities. **Strategy**: To acquire the data necessary for developing performance measures for use in guiding and evaluating restoration activities in southern Biscayne Bay.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
The study has five broad objectives: (1) to characterize the spatial and temporal patterns of density and diversity of fish and macroinvertebrates (emphasis on caridean and penaeid shrimps including the pink shrimp, *Farfantepenaeus duorarum*) in seagrass habitats of the mainland nearshore zone of southern Biscayne Bay (south of Chicken Key) as well as in the adjacent deeper water commercial fishing zone; (2) to evaluate the relationship between the variability in shrimp catch rates of commercial vessels operating in the commercial fishing zone with shrimp densities in fished versus unfished seagrass habitats; (3) to examine trends in commercial pink shrimp fisheries in relation to freshwater inflow and salinity; (4) to evaluate relationships between fishes utilizing mangrove fringe habitats and the abundance and diversity of fish and macroinvertebrates in adjacent seagrass habitats (in collaboration with a separate study); and (5) to examine fish abundance and aggregation in coastal creek/wetland flats habitat.

We find that vegetation cover is an important covariate which adds substantially to the explanation of density variation. Vegetation cover should be included in analyses where possible (i.e., in throw-trap sampling).

A cursory examination of trawl data in relation to throw-trap data for one species only, pink shrimp, suggests that the trawl is roughly one tenth as efficient as the throw trap. Nevertheless, the trawl provides many more specimens for use

in determining size distributions and the ratio of the sexes. In the trawl we have collected 94 fish species, 8 crab species, 3 echinoderm species, 2 pink shrimp species, and 1 species from mollusca and cephalopoda. With the pull-trawls we have only collected 31 fish species, 4 crab species, 2 pink shrimp species, 1 mollusca species, and 1 echinoderm species. With pull-traws, however, the efficiency rate is much higher than that of the commercial trawl.

Off hand, faunal densities seem low in general in the study area. Cursory comparisons with published or available unpublished data from previous studies in Biscayne Bay and nearby areas are planned. Statistical comparisons of sampling results from two gear types are also planned.

Research Performance Measure:
We have accomplished our major objectives in this phase: we have been able to compare density and efficiency rates between trawl, throw-trap and pull-trap data; we have been able to evaluate the variability in shrimp catch rates between fished and unfished seagrass habitats.

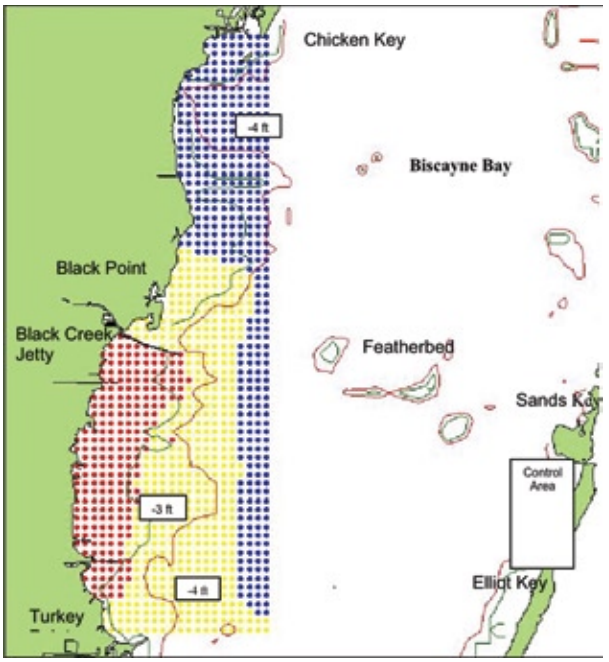


Fig. 1- South Biscayne Bay study area. Salinity strata 1, 2 and 3 are depicted in red, yellow and Blue, respectively. The Black Creek Jetty divides north and south strata.

Research and Development of Oracle Content Management System and Web Tools for the NOAA Southeast Coral Reef Research Program

Project Personnel: Mei-Ling Shyu (UM/ENG); Steven Wong (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To address the issues of information management; spatial data search, access and analysis; and to facilitate outreach for the SEFSC coral reef program. **Strategy**: Develop innovative methodologies to deal with data archiving and retrieval.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
We developed a content management system and web tools that provide utilities to assist in program management, to improve data access and analysis, to increase productivity, and to enhance public education and awareness of coral reef issues as well as SEFSC's role in conserving and protecting coral reef ecosystems. The PReP is a utility that facilitates proposal submission and review process of the NOAA Coral Reef Conservation Program. Among other features it enables working group chairs and members to participate more easily in the proposal review process.

Research Performance Measure:
All data-management program development objectives were attained.

Florida Bay Inner Basins Circulation and Exchange Study: Northeast and Western Basins

Project Personnel: Thomas N. Lee, Vassiliki H. Kourafalou, Nelson Melo (UM/RSMAS); Elizabeth Johns, Ryan Smith (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the circulation and exchange processes that regulate the residence times and flushing rates within interior basins of Florida Bay so that we can predict the effects of modifying fresh water supply to the Everglades as part of Everglades restoration plans. **Strategy**: Make extensive long-term hydrographic surveys in the region.

Link to NOAA Strategic Plan Goal:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
The primary objectives of this project are to quantify the circulation and exchange rates influencing salinity variability in the eastern and western regions of Florida Bay; to determine their interactions with connecting regions; and to identify the controlling physical processes. These studies also serve to characterize the hydrographic interactions with connecting regions, that is, with the local coastal waters on the Straits of Florida and the Gulf of Mexico. This information is needed to aid evolution and evaluation of hydrodynamic models for prediction of the impact of future changes in water deliveries as affected by the South Florida Restoration.. This effort is a continuation of our study of inner basin processes initiated as part of SFERPM 2000 with investigation of Whipray basin in the central bay.

Observational methods consisted of a combination of Eulerian and Lagragian measurements, rapid shipboard surveying and ADCP transects to directly measure the volume and salt transports and changes of basin average salinity needed for salt balance estimates and exchange rates. Thus the measurement program is designed for determination of seasonal changes in basin salt balance and exchange patterns. This effort is highly coordinated with ongoing and planned projects that will place the local basin dynamics in the context of the larger Bay-wide processes, as well as the entire south Florida coastal system to better understand the linkages over different scales, which are important to management and restoration of the south Florida coupled ecosystems.

We continue to carry out surveys in the region so as to quantify the circulation and exchange rates that influence the salinity variability in the central and eastern regions of the Florida Bay. These studies also serve to characterize the hydrographic interactions with connecting regions, that is, with the local coastal waters on the Straits of Florida and the Gulf of Mexico. Such information is essential for the development and evaluation of hydrodynamic models for the prediction of the impact of future water deliveries as affected by the South Florida Restoration. Measurement strategies are concentrated in the eastern bay and consisted of Eulerian and Lagrangian measurements, rapid shipboard surveying, and acoustic

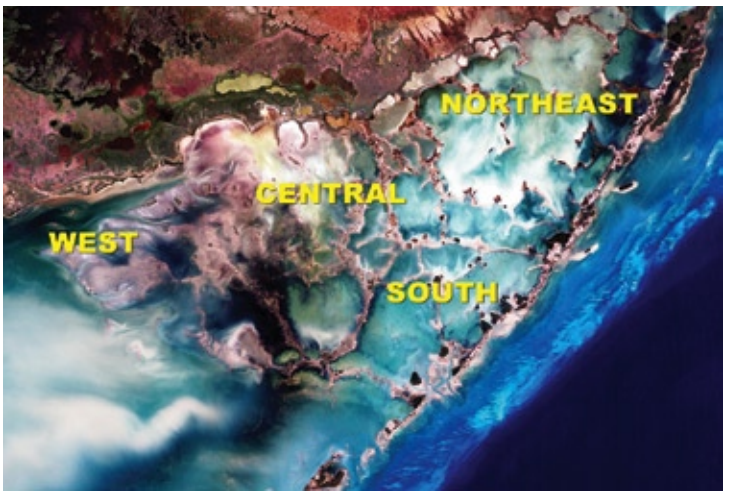


Fig. 1- An aerial photo of Florida Bay, showing the 4 characteristic regions of the Bay.

doppler current profiler (ADCP) transects to directly measure the volume and salt transports and changes of basin-average salinity needed for salt balance estimates and exchange rates in the dry and wet seasons.

Research Performance Measure:
Our objectives - to directly measure transport and salinity variability - are being met satisfactorily. Estimating exchange rates and residence times are proceeding and some data gaps are being filled using regression techniques.

Fig. 2- The *R/V Virginia Key* measuring volume transports through a channel connecting Fla Bay inner basins. The *Virginia Key* was configured specifically for shallow water research.

Real-Time Currents and Water Quality Monitoring in the FKNMS

Project Personnel: Thomas N. Lee, Nelson Melo, Grant Rawson, Ben Kates (UM/RSMAS); Elizabeth Johns, Peter B. Ortner, James C. Hendee, Ryan Smith (NOAA/AOML)

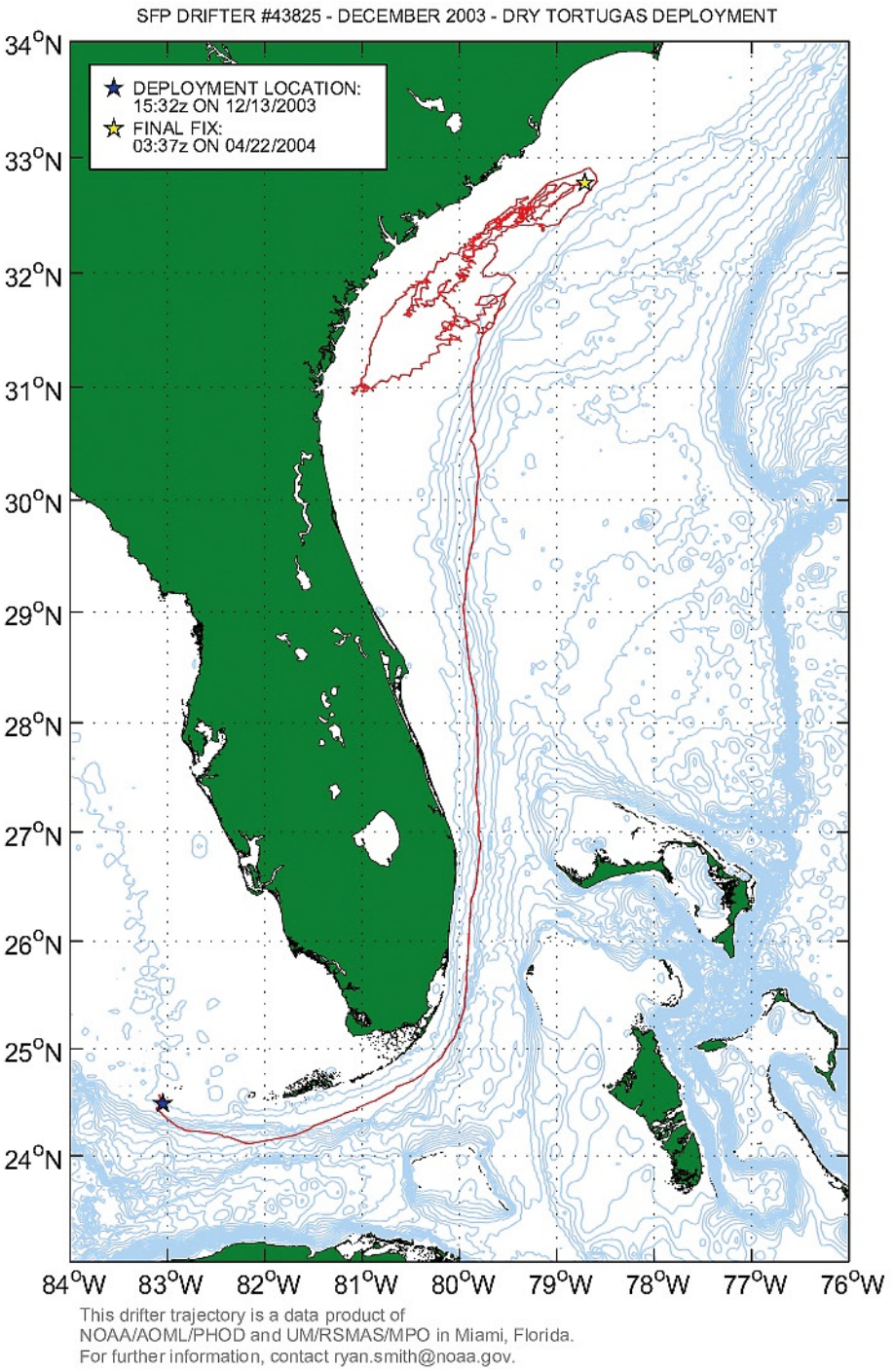
Long-Term Research Objectives and Strategy:
Objectives: To characterize the major water flows between Florida Bay and the FKNMS so as to anticipate impacts of changing fresh-water inputs to the Bay as a result of the South Florida Restoration.
Strategy: To carry out targeted real-time observations of important oceanographic parameters at key locations throughout the Florida Keys National Marine Sanctuary (FKNMS) and to communicate these data and synthesis products to resource managers and to the general public via the internet.

Link to NOAA Strategic Plan:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
This program concentrates on the characterization of the major water flows between Florida Bay and to connecting coastal waters. These data are needed so that we can anticipate the impact of changing fresh-water inputs to the Bay as a result of the South Florida Restoration which will greatly change the water flow patterns in south Florida and adjacent waters. The initial phase of this project focused on the construction, deployment, and testing of the instrumentation needed for real-time data collection. The satellite-tracked CODE surface drifter program has expanded to include bimonthly deployments of drifters at the Shark River mouth, at Riley's Hump in the Dry Tortugas, and at Charlotte Harbor near the mouth of the Caloosahatchie River. Data are posted automatically on the project web page (www.aoml.noaa.gov/sfcoo/SFP_drifters/). Some of these drifters eventually are carried to waters off the east coast of the US and into the mid-latitude Atlantic as shown in the figure, next page.

Results from transport studies conducted at Long Key Channel and Seven-Mile Bridge thus far sup-

port previous findings by T. Lee and N. Smith (2002) which suggest that currents through the passages are influenced by local wind forcing and by gravity-driven transports produced by cross-key sea level differences on time scales of several days to weeks.



Real-time current velocity measurements (via bottom-mounted acoustic doppler current profilers) were added to the conductivity/temperature instrument suite at Looe Key, and data are now being posted hourly to the project web page (www.LooeKeyData.net). This buoy will soon be instrumented with a fluorometer and transmissometer to provide real-time water quality information. Moser Channel in the Seven-Mile Bridge passage has been instrumented with conductivity/temperature, fluorometer, and transmissometer sensors, and will be added to the real-time cellular communications network soon. In addition, plans are underway to instrument the NOAA/NURC underwater laboratory "Aquarius" with real-time current and water quality instrumentation and with a directional wave spectra instrument.

All of these real-time sites should be fully operational by mid-2005 Data will be posted on individual web pages under the project home web page (www.aoml.noaa.gov/sfp).

Research Performance Measure:
The initial phase of the program is nearing completion on schedule. All measurement objectives are on schedule.

Settlement, Growth, and Migration of Snappers in Florida Bay and Adjacent Marine Ecosystems

Project Personnel: Monica Lara, Dave Jones, Peter Swart (UM/RSMAS); Trika L. Gerard (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To investigate the nature of population replenishment of pre-settlement larvae and of newly settled and juvenile stages of gray snapper in Florida Bay and adjacent marine ecosystems. **Strategy**: To use otolith microchemistry, in particular the analysis of stable isotopes of carbon and oxygen, and otolith ageing as tools to study larvae life histories in Florida Bay.

Link to NOAA Strategic Plan Goal:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
In order to protect the fishery resources of South Florida, we need to understand the life-cycles of target species. In our program we use stable isotope ratios of carbon and oxygen in the otoliths (ear bones) of teleost fish. Isotope ratios provide information about habitat temperature and salinity, migratory patterns and habitat use, diet and metabolic rates, and about the degree of stock mixing. In this study, we investigated the size-age structure of gray snapper (*Lutjanus griseus*) juveniles in Florida Bay. We examined their growth rates and migration patterns, and explored how these relate to habitat characteristics and environmental variables such as salinity, temperature, and ontogenetic shifts in habitat.

During phase one of the study, measurements were made of $^{18}O/^{16}O$ and $^{13}C/^{12}C$ ratios in the sagittal otolith carbonate obtained from juvenile gray snapper collected in 2001-2004 from various locations within Florida Bay and surrounding marine ecosystems. This study is complimentary to our research on trace elements in otoliths, reported elsewhere in this report. The study region includes Ten Thousand Islands, Biscayne Bay, Lower Keys and the Dry Tortugas. Statistical analyses using multivariate analyses of covariance reveals significant spatial variability between all of the adjacent marine ecosystems tested. This confirmed spatial variation in the otolith isotopic composition of gray snapper over these regions and suggests differences in the ambient and metabolic environmental conditions experienced throughout the fish life history. Cross validation statistical analyses revealed an 80% successful classification of a single observation in one of five regions.

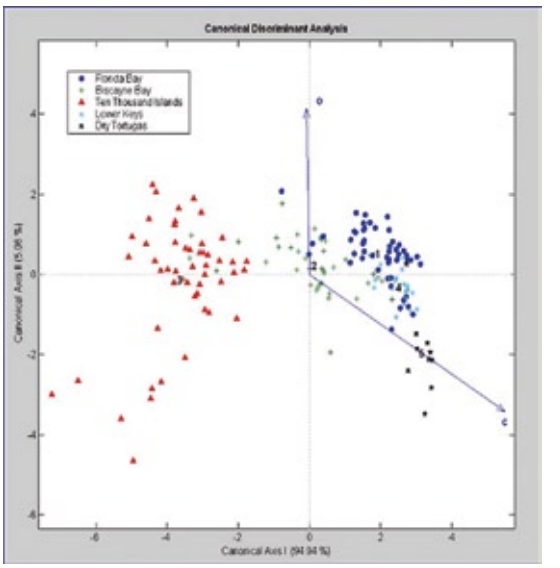


Fig.1- Canonical Discriminant Analysis for ^{13}C and ^{18}O determining differences in otoliths from the five regions.

There was also spatial variation on the order of approximately 10km among sites within all regions tested. Finally, we found significant temporal differences in both carbon and oxygen isotopes from years 2001 through 2003. Thus, we have established that stable isotopes of carbon and oxygen allow for conclusive separation of regions and specific sites within regions.

Research Performance Measure:
Our major objectives were to measure stable isotopes of ^{13}C and ^{18}O in the otoliths of Lutjanus griseus: 1) to look for spatial and temporal variation within Florida Bay, 2) to detect significant variations between Florida Bay and other surrounding marine ecosystems, and 3) to determine if there were any significant variation between habitats. These objectives were attained.

Atmospheric and Ocean Modeling Support for Boundary Inputs to the Florida Bay Hydrodynamic Model

Project Personnel: Vassiliki Kourafalou (UM/RSMAS); Gustavo Goni (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand and quantify the interaction between the coastal flows around Florida Bay and the surrounding oceanic flows so as to anticipate the effects of the South Florida restoration on coastal waters. **Strategy**: To develop a fine-scale regional numerical model around South Florida that encompasses the Florida Straits and the southeastern Gulf of Mexico; the regional model is embedded in a larger scale numerical model which provides boundary inputs to the Florida Bay hydrodynamic model.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
The study focuses on the understanding of the physical and ecological processes that are related to the ongoing restoration plans for the Everglades. The study will help predict the associated changes in water flows and water quality around south Florida's environmentally sensitive areas, namely the Everglades National Park, Florida Bay and the Florida Keys National Marine Sanctuary. These coastal areas are strongly linked to the surrounding seas (the Florida Straits, the southwest Florida shelf and the central Gulf of Mexico) and large scale flows (Loop Current/Florida Current system). In particular, there is strong observational evidence that low salinity waters from remote sources, such as the Mississippi River and the west Florida shelf rivers, can alter the characteristics of local water masses, while the eddies that travel along the Loop Current/Florida Current front can interact with coastal areas, causing sea level changes and altering nutrient supplies.

Numerical models are being developed for Florida Bay to study the proposed changes in water flows and their implications on water quality and the marine life. The proper performance of these models requires that they be linked to the surrounding hydrological environment. This will be done with the regional model of the South Florida seas that is being developed in the present study.

The model domain covers a large area around South Florida, from approximately 22.5°N to 27°N and from 79°W to 84°W. The model is based on the primitive equation model HYCOM (Hybrid Coordinate Ocean Model, http://hycom.rsmas.miami.edu), a state-of-the-art community numerical model which is particularly suited for areas with strong bathymetric changes. In the framework of this project, the regional model has been nested within a larger scale implementation of HYCOM for the North Atlantic and the Gulf of Mexico thereby providing lateral boundary conditions. The large scale model also provides atmospheric inputs (wind stress, heat and salt fluxes) that are necessary for the air-sea interaction processes (i.e., vertical boundary conditions). The numerical simulation strategy follows a multi-nested approach: the medium-resolution (3-4 km grid) regional model takes boundary conditions from the low resolution (6-7 km grid) large scale model and provides boundary conditions to the high resolution (less than 4 km) Florida Bay model. Thus, the local, limited area simulations will include the effects of the interaction with larger scale flows.

Tracer numerical experiments with the regional model have been performed to study the effect of the circulation on passive tracers that are released at different locations that can impact Florida Bay and the Florida Keys. An example is shown in Figure 1 for a continuous release in the Dry Tortugas. The simulation is of the climatological type with long-term, perpetual year forcing. The tracer gets quickly advected northeastward through the strong Florida Current, which is in a position near the Keys in the left panel (early November), but veers away from the Keys in the right panel (late November). When near the Keys, the tracer gets caught in the opposing coastal flow. This flow is in the southwestward

direction, due to the prevailing wind stress. Thus, the tracer has an important effect in the Florida Keys and Florida Bay during a period when the Florida Current does not have a direct influence. This process illustrates the impact of the shelf-to-open-sea interactions which have significant implications on the effects of remote sources on the Florida Bay/Florida Keys ecosystem.

Research Performance Measure:
The major objective has been attained: to develop a model with detailed coastal bathymetry and the nesting within the larger scale model. The model is being tested according to schedule.

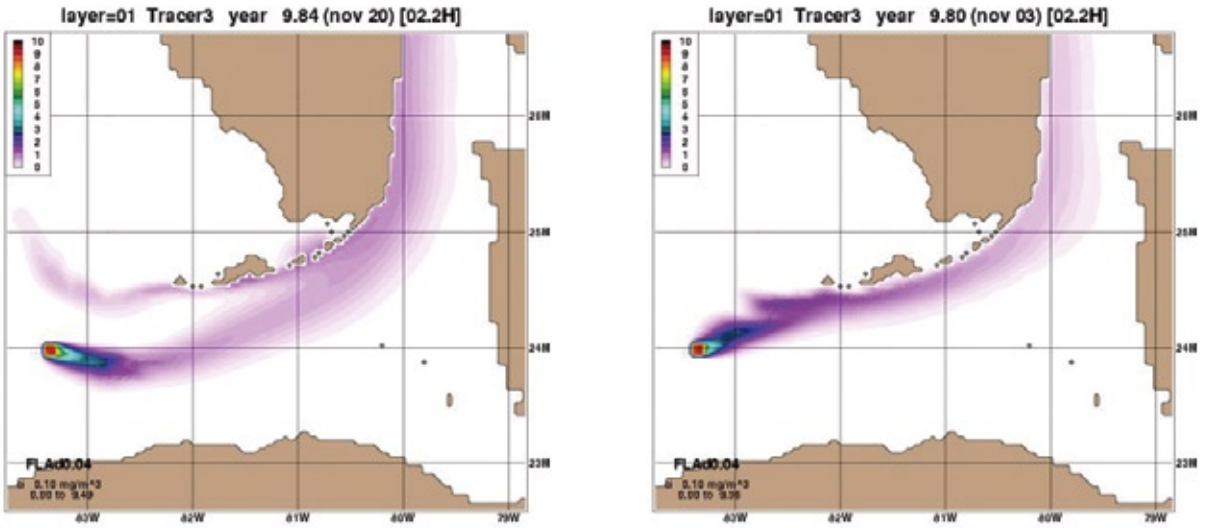


Fig. 1- The pathways of a passive tracer released in the Dry Tortugas, as simulated by the South Florida regional numerical model.

Long-Term Measurement of Physical, Chemical, and Biological Water Column Properties in the South Florida Coastal Ecosystem

Project Personnel: Thomas N. Lee, Chris Kelble, Nelson Melo, Grant Rawson, Ben Kates (UM/RSMAS); Peter Ortner, Elizabeth Johns, Ryan Smith, Jia-Zhong Zhang (NOAA/AOML); Chuanmin Hu (USF)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To determine the circulation and water property patterns within Florida Bay and surrounding coastal waters on "event" to inter-annual time scales. To quantify the effect of tripton, chlorophyll *a*, and chromophoric dissolved organic material (CDOM) on light attenuation in Florida Bay and to estimate the potential of primary production being light-limited in Florida Bay. **Strategy**: Carry out regular monthly and supplemental event-focused monitoring cruises in conjunction with a moored instrument array and targeted drifter releases.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Water properties in Florida Bay and Biscayne Bay can change dramatically depending on a wide range of factors including weather (e.g., storms or the absence of them), runoff from land, and variations in currents in adjacent coastal waters. To better understand the factors effecting these changes we make high resolution surveys of Florida Bay and Biscayne Bay. These are made

Fig. 1-Thesee mini-drifters are designed for deployment in the very shallow waters of Florida Bay. They are tracked by both ARGOS satellite and GPS. This image shows the deployment of shallow water surface drifters designed for our study of inner basin circulation.

on a monthly basis. On these surveys we make continuous measurements of salinity, temperature, chlorophyll, percent light transmittance, and chromophoric dissolved organic material CDOM utilizing a flow-through water system. Periodically the ship stops at a specific sampling stations to make more extensive measurements of chemical, biological and physical parameters. Contour maps are created from these data and posted in near-real time on the worldwide web at www.aoml.noaa.gov/sfp/ thereby permitting timely access by the South Florida Ecosystem Restoration (SFER) scientific and management communities. The figure shows the light-limitation potential for seagrass in Florida Bay.

In addition, we conduct bimonthly surveys on which we measure similar parameters in the nearshore waters of South Florida from Fort Myers to the Dry Tortugas and along the Florida Keys National Marine Sanctuary (FKNMS) reef tract northward to Miami. Acoustic doppler current profiler (ADCP) surveys are made during the large-vessel cruises in an effort to document eddy development and the interaction of the Gulf Stream with FKNMS coastal waters. We also make bimonthly releases of surface drifters in the Dry Tortugas and at the mouth of the Shark River to document current trajectories in these areas. A new deployment site has recently been initiated near the Caloosahatchie River mouth. These data are also made available on the project website in near-real-time. Furthermore, a moored array is maintained to continuously measure current trajectories, temperature, and salinity along the southern SW Florida Shelf and along the perimeter of Florida Bay. Project data can be accessed at www.aoml.noaa.gov/sfp/data.shtml.

Research Performance Measure:
The major objectives have been met: to quantify the effect of tripton, chlorophyll *a*, and CDOM on light attenuation; to determine areas in the Bay in which primary production may be light-limited; to characterize larger scale temporal-spatial hydrographic interactions.

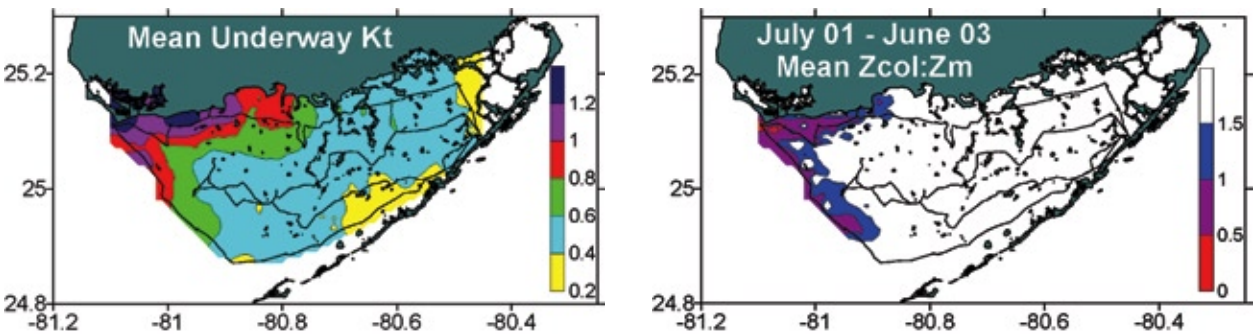


Fig. 2- This figure shows mean light attenuation in Florida Bay from July 2001 until June 2003 as estimated from the underway data on the left and the potential for seagrass growth being light limited in Florida Bay on the right. Purple and red indicate areas where seagrass growth may be light-limited.

Population Dynamics and Early Life History Processes in Corals

Project Personnel: M.J.A. Vermeij (UM/RSMAS); M.W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand coral population dynamics in relation to environmental variability through both space and time so as to lead to better management strategies for the recovery of Caribbean corals reefs especially those in the Florida Keys. **Strategy**: Study the early life history processes in corals and the impact on survival.

Link To NOAA Strategic Plan Goals:
Goal 1: Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Research Summary:
In order to better understand the dominant structuring processes in coral communities we investigate the influence of variable environmental conditions on larval behavior and survival. We developed a basic framework in which the role of the environment vs. population regulatory mechanisms can be compared for their role in the structuring of coral reef populations. We constructed a simulation model that can be used to predict recovery scenario's of degraded coral communities under various environmental conditions.

A link has been found between stresses that a coral planula experiences during its pre-settlement life-phase and its post-settlement performance and survival. This has implications for understanding post-settlement mortality patterns that are traditionally related to local environmental conditions. Our research shows that we also have to consider the planktonic experience of a planula.

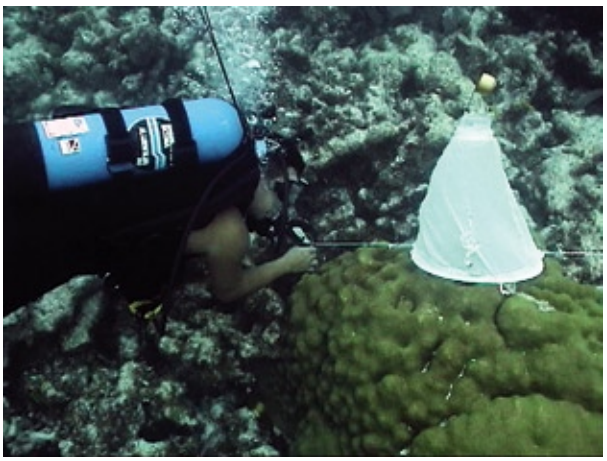


Fig.1- Photo of deployment of coral spawn collector over colony of *Montastraea faveolata.*

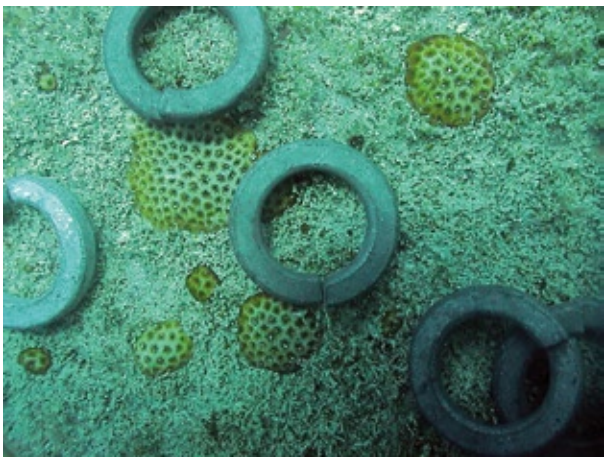


Fig. 2- Permanent monitoring quadrats for population study of brooding corals. The rings are used as visual aids in the photo to point out the location of very small (i.e. single polyp) recruits.

A model based on species specific life-history elements (i.e. growth, competitive capability and larval supply) has been tested for different locations across the Caribbean. The model successfully predicts patterns in coral community structure in response to disturbance and environmental conditions.

We have tested the concept of reticulate evolution for three major Caribbean species complexes and we used the results to generate a conceptual model that successfully explains why genetic divergence between closely related coral species varies across space.

We also carried out additional smaller research topics including the modeling of morphogenesis in branching corals, a study of the effectiveness of small marine parks, and a study addressing the taxonomy of the coral family Agaricia.

Research Performance Measure:
All research objectives have been met.

Photo-Identification of Bottlenose Dolphins in Biscayne Bay, Florida

Project Personnel: Jesse A. Wicker (UM/RSMAS); Lance Garrison, Joseph P. Contillo (NOAA/SEFSC);

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To monitor the populations of bottlenose dolphins in Biscayne Bay so as to detect any long-term trends which might require management actions. **Strategy**: Carry out a monitoring program for dolphin using photographic (dorsal-fin) identification techniques; we develop a population database that facilitates the sharing of dolphin population information and images with research groups in adjacent study areas in south Florida via the Internet.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
The National Marine Fisheries Service (NMFS) is responsible for monitoring the populations of bottlenose dolphins (*Tursiops truncatus*) in southeastern United States waters. The main goals of this monitoring program are the detection of large-scale changes in bottlenose dolphin abundance and establishment of archival databases for long-term trend detection. Biscayne Bay has been greatly affected by development of the Miami area in the past 75 years. Information from 12 years of photo-ID surveys has confirmed the presence of a relatively large, long-term resident, core population of bottlenose dolphins in the Bay. Their role as apex predators characterizes these animals as excellent indicators of the overall health of Biscayne Bay.

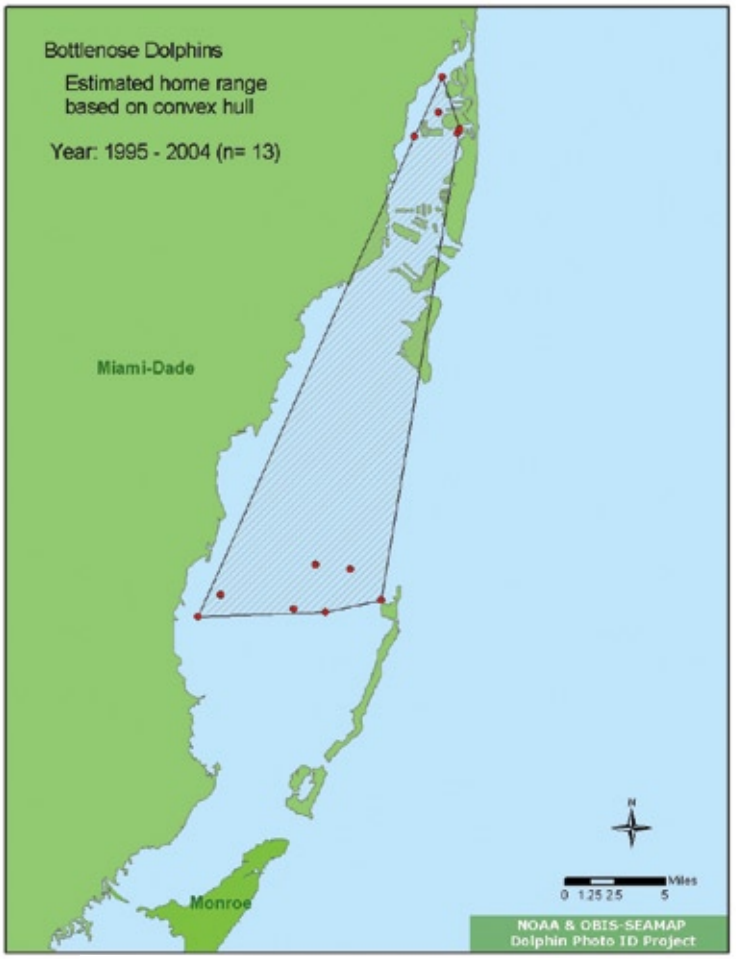


Fig. 1- Bottlenose Dophin range.

We continue to make photographic surveys of bottlenose dolphins sighted in Biscayne Bay and adjacent offshore waters. This program, begun in 1990, has completed a total of 301 photo-ID surveys (1487 hours of sampling effort) in Biscayne Bay. These surveys have defined the basic parameters of the Biscayne Bay bottlenose dolphin population, including abundance, distribution, natality and mortality. To improve data management of photo-ID information in the SEFSC, and to facilitate efficient data sharing among other photo-ID research groups in south Florida, we developed an Oracle database application. This database enables Internet web-based online data entry, update, categorization, search, and download capabilities. The data resident on the system include scanned digital photos, associated collection information and meta-data. It

Fig. 2- Dolphin are identified on the basis of dorsal fin notching patterns.

greatly facilitates the viewing and sharing of this information between researchers and the general public via web browsers.

In May 2002, a genetics based stock-structure program was initiated, and involves a remote biopsy-sampling program to collect skin and blubber samples from dolphins that reside in Biscayne Bay. The principal aims of this program are to; (1) integrate genetic data from skin samples with photo-ID sighting data to give a clearer picture of the overall stock structure of the Biscayne Bay community and, (2) conduct contaminant analysis of the blubber samples to determine the range and degree of toxins contained within these tissues.

Research Performance Measure:
The major objectives of this program - photographic monitoring of dolphins, data dissemination, and tissue sampling - have been attained.

Reef Fish Community Dynamics and Linkages with Florida Bay

Project Personnel: Jerald S. Ault, Steven G. Smith (UM/RSMAS); James A. Bohnsack (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To quantify community and reef fish population changes from management actions associated with Everglades Restoration in Biscayne Bay and Florida Bay and different levels of protective spatial management in the Florida Keys. **Strategy**: To use integrated regional biological and physical spatial data sets from the south Florida ecosystem to facilitate design and development of statistical and analytical models to assess coral reef fish populations and to predict their future abundance

Link to NOAA Strategic Plan Goal:
Goal 1: Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Through our research we seek to understand and describe the ecological and biological dynamics of reef fish species and the economic impacts of human uses as a basis for sound management decisions. It provides critical data needed to assess and model the effects of the Everglades Restoration and spatial management strategies on coral reef fishes. Many exploited reef fish species directly use Florida Bay as critical settlement and nursery habitats before reaching maturity when they migrate back to the reefs as adults. Thus, any changes in Florida Bay and Biscayne Bay will result in changes in recruitment, growth, and mortality that will ultimately be reflected in reef fish species abundance, size, and distribution in the coral reefs.

This research established baselines data for the Florida Keys using a state-of-the-art sampling strategy. The research has also monitored reef fish community abundance and biomass trends by habitat types at sites from Miami through the

Lower Keys with different levels of exposure to Florida Bay and Biscayne Bay influences due to coastal water management strategies and their relationship to areas under different levels of spatial management protection along the inshore and offshore reef tract. Study sites included areas managed by the Florida Fish and Wildlife Conservation Commission (FFWCC), Biscayne National Park (BNP), Everglades National Park (ENP) in Florida Bay (FB), the South Atlantic Fishery Management Council (SAFMC), and the Florida Keys National Marine Sanctuary (FKNMS).

A key aspect of this research program was designed to directly test specific hypothesis involving no-take marine reserves and their importance to reef management following the establishment of 19 no-take zones in the FKNMS in 1997. Specifically, this project collected data from years 3 and 4 following reserve establishment to elucidate the relative importance of fishing as a cause of ecosystem changes, and to precisely measure the successes of the southern Florida Ecosystem restoration efforts. Establishment of one large (79 km^2) Ecological Reserve near Key West and 18 smaller (0.16-4 km^2) no-take Sanctuary Preservation Areas (SPAs) in the middle and upper FKNMS provided a unique opportunity to address the influence of fishing. Fishing and other human extractions are recognized as major disturbances to coral reefs. The establishment of no-take zones provides a control that will allow scientists to distinguish between natural changes versus anthropogenic disturbances. Determining the response of reef fish populations to no-take protection also provides a potential estimate of rates of change that could potentially occur following Everglades restoration.

The data focused on important reef fish species in the Florida Keys snapper-grouper complex. We find that the average size of reef fish within the exploited phase for the last 25 years has remained relatively constant for 35 species, but that size is very close to minimum size of capture for most of the exploited stocks. The current average size in fished populations is considerably smaller than those in historical unfished populations. For example, the average size of black grouper today is 40% of what it was in 1940, and the spawning stock today is less than 5% of its historical unfished maximum. Overall, 77% of the 35 stocks that could be analyzed were overfished by federal standards, including 13 of 16 grouper species, 11 of 13 snapper, 2 of 5 grunt and barracuda. Stock biomass was critically low for most of the key targeted species within the recreational fishery. The current level of exploitation (that is, fishing mortality) for grouper stocks, for example, was 3 to 10 times the exploitation level that would achieve maximum sustainable yield, a minimum sustainability benchmark under federal standards. Some stocks appear to have been chronically overfished since at least the late 1970's and high sustained exploitation pressures have precipitated serial overfishing of key resources.

These data suggest that fishing has been a dominate factor influencing reef fish community structure. Baseline data collected from recently established no-take reserves will eventually permit managers to model design and implementation strategies, to evaluate the efficacy of these measures, and to distinguish between possible impacts on reef fishery resources from changes in water quality from Florida Bay and Biscayne Bay and from those due to fishing.

Research Performance Measure

The objectives were attained and the reef fish community dynamics and linkages monitoring and modeling activity continues as planned.

Detection, Mapping and Characterization of Groundwater Discharges to Biscayne Bay

Project Personnel: Harold R. Wanless, Christina Smith (UM/RSMAS); John Proni (NOAA/AMOL)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To quantify fresh water inputs to Biscayne Bay from springs. **Strategy**: To locate, chemically characterize, and measure flow rates from groundwater discharge outlets into Biscayne Bay.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
In the early years of the past century, prior to drainage of Everglades and the lowering of fresh groundwater levels, springs flowing into Biscayne Bay were reported to have been numerous. This project was initiated because of questions concerning importance of artesian freshwater springs in supplying water to Biscayne Bay in the present day. It is anticipated that when the Everglades Restoration is completed, spring flow will increase. We wish to be able to quantify increasing flows with time.

In our study we carried out field research to locate springs that feed into the Bay. Surveys were carried out using a canoe for the shallow inshore waters and a shallow draft motor boat in deeper waters. Locating springs requires nearly calm water surface conditions. Springs are located by the visible mounding on the Bay water surface (Figure 1), by the presence of schleren (blurry water resulting from the mixing of fresh and saline water, Figure 2), by water temperature differences, and by variations in the benthic community (gaps in seagrass cover and bacterial streamers extending upwards from the bottom. Figure 3). We have spent over 25 days in the field, focusing on the near-shore bottom to the north and south of the Deering Estate area of west-central Biscayne Bay. We have identified over 30 springs. These vary in size from narrow slits in the sediment to areas greater than 2.5m in diameter in which the loose sediment has been washed out exposing the limestone bedrock and associated complex of conduits.

Our field research has spanned dry and wet seasons and times in which the canal flood control gates have been closed and open. The status of the canal gates appears to have a major influence on the strength of flow of the larger springs and presence or absence of flow in the smaller ones. This is important because another objective

Fig. 1- The roiled water surface shows the location of one of the larger artesian freshwater springs that discharge into nearshore Biscayne Bay (at about SW 172nd Street). This spring is a series of closely spaced conduits in the limestone and forms a discharge area about 2.5m across. The spring actively flowed throughout the dry season.

Fig. 2- Underwater flow of spring. Blurriness is result of freshwater mixing with seawater and useful in locating springs. Fish are abundant in larger springs.

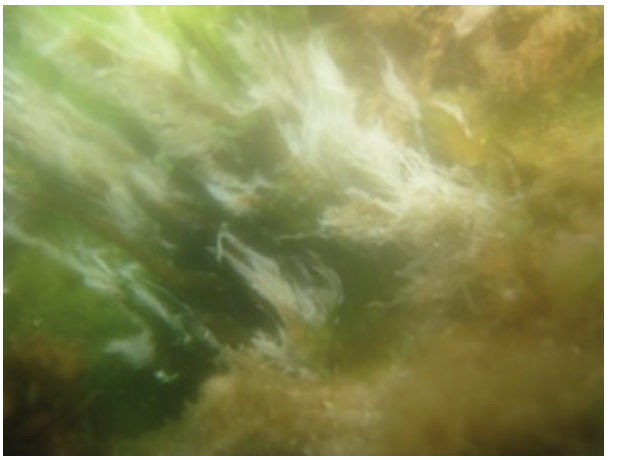


Fig. 3- Long strings of cyanobacteria and bacteria are common streaming from margins of spring conduits. Diameter of this conduit is about 7 cm.

of this project is to anticipate role of springs in freshwater discharge if wetland sheet flow (rather than canal discharge) is re-established.
Water samples from spring discharges have been collected from many of the springs for the analysis of nutrients and ammonium. Additional water samples will be taken from the same springs at a later date to be analyzed for various isotopic compositions with the help of the University of Miami's stable isotope laboratory.

Research Performance Measure:
The identification of the field location of springs is on schedule as is the characterization of the effluent waters.

Determination of Genetically Distinct Subgroups and Contaminant Body Burdens of Resident Bottlenose Dolphin (*tursiops truncatus*) Within Biscayne Bay, FL

Project Personnel: Jenny Litz, Jesse Wicker, Lynne Fieber, Colin Hughes, Pat Walsh, Gregory Bossart (UM/RSMAS); Steven Swartz, Lance Garrison, John Kucklick, Patricia Rosel, Anthony Martinez, Joseph Contillo (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: 1) to define the genetic structure of resident bottlenose dolphin within Biscayne Bay using molecular genetic techniques; 2) to evaluate the current levels of organochlorine contaminant loads in a model organism, the bottlenose dolphin, in Biscayne Bay. **Strategy**: To pinpoint specific compounds of concern by testing the blubber of resident dolphin for bioaccumulated compounds and comparing the identified compounds to those found in dolphin of other Florida embayments.

Link to NOAA Strategic Plan Goal:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Scientists from the NOAA Southeast Fisheries Science Center (SEFSC) and from RSMAS has been conducting a low-level monitoring project of bottlenose dolphin in Biscayne Bay, Florida, for more than ten years. Using dorsal-fin photo-identification techniques, they have been able to identify individual dolphins that inhabit the Bay year round and appear to be long-term residents. This project first determined if the resident bottlenose dolphin population within Biscayne Bay

consists of one breeding stock or several distinct breeding stocks. Integrating these genetic data with the ten years of sighting data, we obtain a clearer picture of the overall social and stock structure of this dolphin community.

Dolphins have previously been shown to bioaccumulate environmental toxins, such as organochlorine compounds, in their blubber layer. Because of these characteristics, bottlenose dolphin can be used as biological indicators of the health of their habitat and also to compare contaminant levels from different geographical areas. This project is collecting baseline data on the types of compounds stored in the blubber of resident dolphin. We compare these results to those found in dolphin in other areas in Florida. Likewise, if we find that there are different breeding stocks within the bay, their contaminants will be compared to determine if any one community of dolphin in Biscayne Bay is at higher risk of anthropogenic impacts than the others.

With approved techniques and the appropriate licenses, we use a remote biopsy sampling procedure to obtain skin and blubber samples. This procedure consists of firing specially designed darts with biopsy sampling heads from a modified rifle. The samples obtained consist of a layer of skin and core of blubber that are roughly 1 cm in diameter and weigh between 0.5 and 1 gram. Photographs are taken of the dorsal fin of each animal sampled to match to the photo-identification catalogue. This allows sighting histories of individuals to be linked with the tissue samples. The dolphins' reactions to biopsy sampling are carefully observed and recorded as required by the Marine Mammal Protection Act. Although we do not expect any long-term effects on the animals caused by the sampling, observations of the biopsy wound and behavior are recorded when previously sampled animals are sighted in subsequent surveys.

Thus far all 78 skin samples have been genotyped to determine gender. They have been genotyped at 14 nuclear loci and the control region of the mitochondrial DNA has been sequenced. Statistical analyses are currently being conducted on these data to evaluate population structure, which meets the first objective. Research to address the second objective is on schedule to begin this fall as planned. Genetic analyses have been conducted at the University of Miami and the NOAA Marine Mammal Molecular Genetics Laboratory in Lafayette, LA. The data is currently being analyzed and the results compiled. The contaminant analysis will be conducted at the NOAA NIST laboratory in Charleston, SC, beginning in October of 2004.

Research Performance Measure:
The program is currently underway and all objectives are being met on schedule.

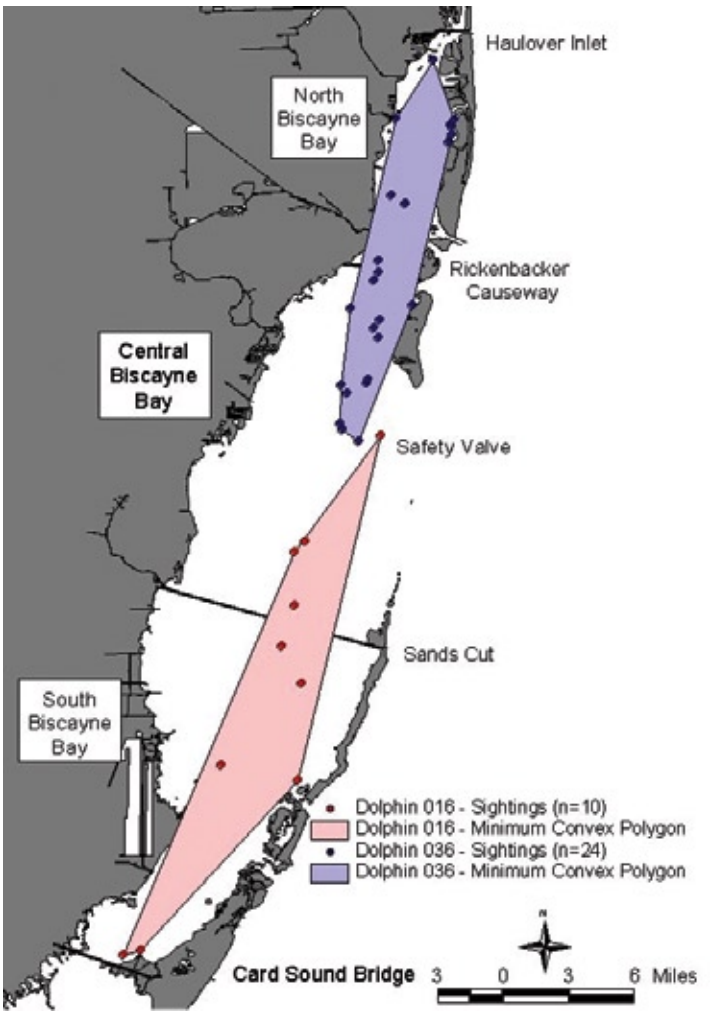


Fig. 1- Minimum Convex Polygons of sightings of 2 individual dolphins from 1990-1999 sighting data. Dolphin 036 was seen in only north and central Biscayne Bay, whereas Dolphin 016 was seen only in south and central Biscayne Bay.

Spectral Optimization in Case 2 Waters.

Project Personnel: Kenneth J. Voss, Howard R. Gordon (UM/Physics)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To use satellite remote sensing to retrieve atmospheric and ocean properties in the near-coastal environment. **Strategy**: To develop a coupled atmosphere-ocean algorithm with specific application to areas such as Chesapeake Bay but which can be extended to other coastal regions including those in Florida.

Link to NOAA Strategic Plan Goals
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
The remote-sensing of ocean color is widely used in studies of the global oceans to retrieve information such as chlorophyll concentration, dissolved organic matter content, backscattering from particles. However the open-ocean algorithms are not applicable to coastal waters where the overlying atmosphere often contains high concentrations of pollutants and where the water is often shallow thereby causing an interference from bottom reflectance. The Spectral Optimization Algorithm (SOA) is an alternative to the standard atmospheric correction algorithm used for open-ocean waters. The SOA is capable of recognizing the presence of anomalous conditions and of performing bio-optical retrievals in these more-difficult coastal waters.

Earlier work attempted to modify the SOA in order to allow for atmospheric correction and subsequent bio-optical retrievals in case 2 waters. Prior to the beginning of this project we tested the standard SOA algorithm on 20 different days of SeaWiFS imagery. We found that the performance was poor in case 2 inland waters and only partially successful in case 2 coastal waters. Since then the algorithm has been further developed and it has shown considerable improvement in case 2 waters using the same SeaWiFS images. We are currently investigating how well these modifications work with in situ measurements.

Research Performance Measure:
Our objective is to produce an algorithm that reliably retrieves accurate ocean color information in coastal waters. The development is on schedule and we are currently acquiring in-situ data to compare with our algorithm results. The final performance measure will be an algorithm that produces values that agree with in-situ data.

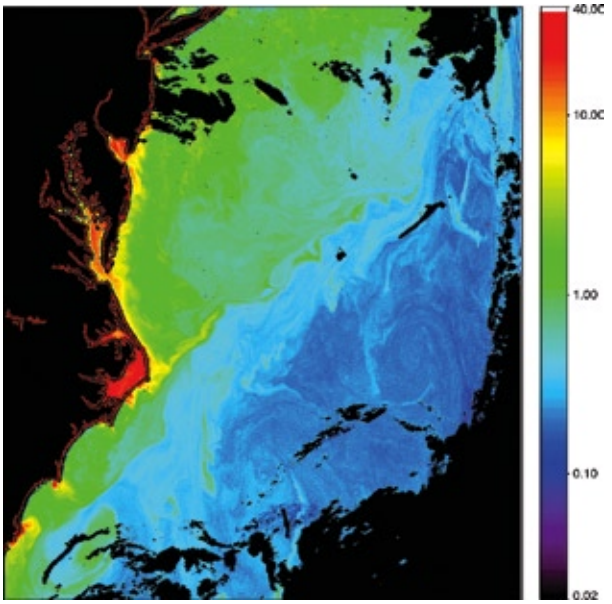


Fig. 1- Chlorophyll concentration (mg/m^3), Spectral Optimization Algorithm, Day 139, 1998 (SeaWiFS)

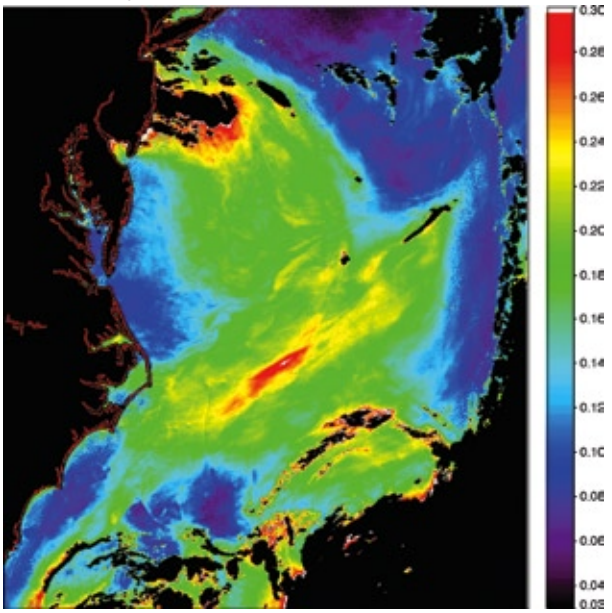


Fig. 2- Aerosol optical depth (865 nm), Spectral Optimization Algorith, Day 139, 1998 (SeaWiFS)

Developing Site Fidelity and Essential Habitat Assessment Tools for Juvenile Snappers in Western Sambo Ecological Reserve, Florida Keys National Marine Sanctuary

Project Personnel: Samantha Whitcraft (UM/RSMAS); Bill Richards; John Lamkin (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the life-history habitat-protection requirements for a recreationally and commercially important reef-associated snapper species, *Ocyurus chrysurus*. **Strategy**: To carry out a micro-acoustic tagging study using customized acoustic arrays and micro-tagging technology to focus on tracking small juvenile yellowtail snapper in the Western Sambo Ecological Reserve (WSER) and in habitat areas in Florida Bay.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Snapper are one of the most heavily fished species in the Florida fishery. In order to properly manage this fishery, we need to have a better understanding of the life cycle of snapper so that protective policies can be put into effect with minimal impact on the fishery. In order to characterize the effectiveness of coral reef marine protected areas (MPAs), it is essential to understand the site fidelity, home-ranges, and habitat-use patterns of these juvenile fish both within fully protected areas and in non-protected areas. It is also necessary to identify the habitat types associated with healthy coral reefs and coral reef-dependent fish-populations, such as seagrass and mangroves, which may need further protection in the future. We are focusing on WSER because it is the only FKNMS marine reserve that protects all three juvenile snapper habitats – coral/patch reefs, sea-grass beds, and mangrove along the shoreline. This unique configuration allows us to investigate the effectiveness of marine protected areas from a multi-habitat, ecosystem-level perspective. Extensive mangrove habitat, in association with coral reefs, can enhance the biomass of fishes on reefs because these tropical coastal ecosystems are ecologically linked. Therefore, in order to understand and quantify the effectiveness of coral reef MPAs, as well as design parameters for MPA linkages and optimal size, we must understand the influx of fishes to those areas from their nursery and juvenile habitats.

The program focuses on the tagging of the smallest-caught juvenile yellowtail snapper, those under 80 mm. In the initial phase of the study these will be tagged using site-specific colored elastomer tags to begin to identify site fidelity with fish size in seagrass areas in Florida Bay and around patch reefs in WSER. We are also developing methodologies, using no-cost "dummy tags" and captive, juvenile snappers to determine the most efficient tagging protocol – external attachment or internal insertion of micro-tags in order to target the smallest possible juvenile snappers for acoustic tagging and tracking. (Figure 1.). We are also developing micro-acoustic tags which can be surgically implanted in fish. When the tag-

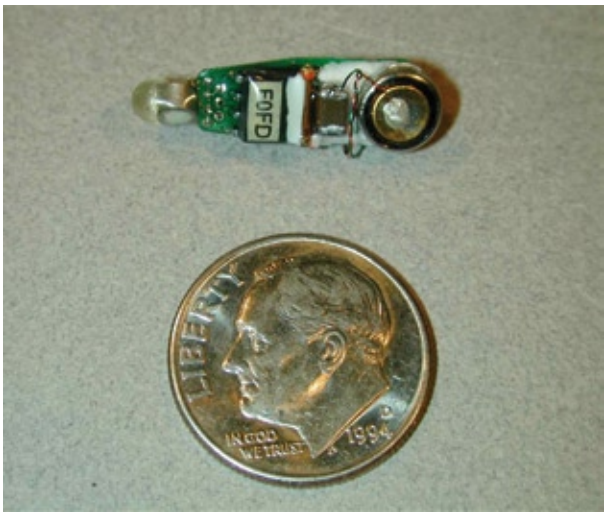


Fig. 1- Sample micro-acoustic tag (Battelle-PNNL Labs, Portland, OR) to be used in tracking the movements of juvenile snappers in the Western Sambo Ecological Reserve, Florida Keys National Marine Sanctuary.

ging program is implemented we will set up an acoustic array that will allow us to track juvenile snappers in shallow, near-shore obstruction-rich environments such as shallow patch reefs, channels within and between mangrove stands, and seagrass beds.

Research Performance Measure:
This pilot project is in its initial stages including the development of tagging technology. The program is proceeding on schedule.

Relative Importance of Threats Facing Florida Keys *Acroporids*

Project Personnel: Dana E. Williams (UM/RSMAS); Margaret W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To document the various threats facing the *Acropora palmata* and *A. cervicornis* populations in the Upper Florida Keys. **Strategy**: To track the fate of individual randomly selected colonies.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Caribbean *acroporid* species have experienced extreme declines since the 1970s. In some areas this has resulted in local-to-regional extirpation and led to their identification as candidates for endangered species listing. Population level recovery will depend on re-colonization by juveniles or fragments, which are particularly vulnerable to threats such as predation and disease.

Photo-monitoring of juvenile *Acropora cervicornis* and *A. palmata* colonies was undertaken to determine the progression and fate of various conditions on the growth and survivorship of recruits. Both healthy colonies and those displaying signs of recent predation were selected randomly among several sites in the Florida Keys (USA). Colonies were tagged, photographed and measured for size and condition. These were subsequently reassessed every 3 to 4 months.

The results of this ongoing monitoring suggest that among A. cervicornis, predation by the gastropod *Coralliophila abbreviata* decreases growth and live cover substantially more than the polycheate *Hermodice carunculata*. However, preliminary incidence data suggest that *H. carunculata* affects far more colonies among the sites sampled. Similar effects of *C. abbreviata* were seen among A. palmata juveniles.

A rapidly progressing die-off of *Acropora cervicornis* (staghorn coral) was recently observed over a wide geographic range (>200 km) in the Florida Keys. Original observations made at White Bank Dry Rocks revealed that one-third of *A. cervicornis* colonies showed evidence of tissue rapidly sloughing from multiple areas. Random surveys suggested that this syndrome was clumped and spreading among the colonies at the rate of 5% per week. Field experiments demonstrate that the syndrome causing the die-off is transmissible not only via direct contact between affected and healthy staghorn coral tissue but also via a predator vector (the corallivorous snail, *Coralliophila abbreviata*). The condition was also transmissible, though less effectively so, to the congener *A. palmata* (elkhorn coral). No transmission was observed in indirect contact treatments designed to simulate diver interaction/touch. Transmissibility implies that the condition is indeed a biotic disease and the demonstration of effective vector transmission suggests that predation may exacerbate disease outbreaks in remnant Caribbean acroporid populations so as to further impede their recovery.

Research Performance Measure:
Our objective was to monitor *Acropora* populations in the upper Florida Keys to determine the relative importance of various threats over time. This project is successfully progressing as planned and the program will continue because the threats addressed in our monitoring act on a wide range of time scales.

Microfauna as Tracers of Sediment Transport: Ft. Pierce Dredge Spoils Sediment Study

Project Personnel: Pat Blackwelder, Carlos Alvares Zarikian, Terry Hood (UM/RSMAS); Charles Featherstone, John Proni, Jules Craynock (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To monitor sediment transport in coastal waters so as to assess human impacts such as dredging. **Strategy**: To develop a method in which microfaunal indicator species can be used as tracers of sediment sources.

Link to NOAA Strategic Plan Goal:
Goal 1: Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
This study facilitates the use of particular indicator species of microfauna (foraminifera and ostracods) as natural tracers of transported sediment. Samples were collected offshore of Ft. Pierce, Florida, from sampling sites prior to and after dredging operations. Microfaunal populations were assessed from samples collected from 19 sites pre-dredging (2000) and subsequently collected post dredging in 2001, 2002, and 2003. These sites include nearshore, harbor and shelf localities. Total and relative *foraminifera* and *ostracod* abundance and diversities (Shannon-Weiner) were assessed. In addition, we characterized the total taphonomic and living population as well as the richness, evenness or individual indicator species.

This work provides a data set on microfaunal community characteristics in the study area before sediment movement induced by dredging. Sample locations included the sediment source (harbor), the planned dumping sites, and a location removed from the impacted sites. Subsequent reoccupations of the sites will enable us to identify sediment movement. Individual species of *formaminifera* and *ostracods* demonstrated potential as indicators of channel and harbor sediments. Q-mode cluster analyses indicated distinct faunal clusters for fresh water, lagoonal and continental shelf assemblages were present.

Results indicate that during initial re-sampling there was no evidence of inshore sediment spe-

cies at the continental shelf population sites. The last phase of the work will complete the analyses of collected samples to examine the potential re-distribution of these sediments over the three year sampling interval.

Research Performance Measure:
The initial objective - the collection and species assemblage characterization of samples - has been completed as planned. The conclusion as to whether the assemblages will be useful as indicators of dredged sediment will depend on the outcome of the continuing studies carried out as dredging progresses.

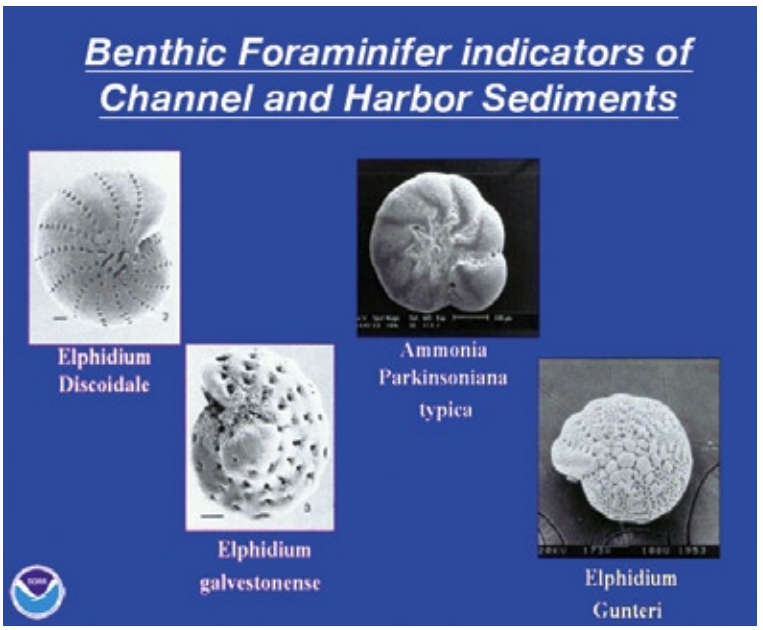


Fig. 1- Benthic *Foraminifer* Species Indicative of Channel and Harbor Sediments

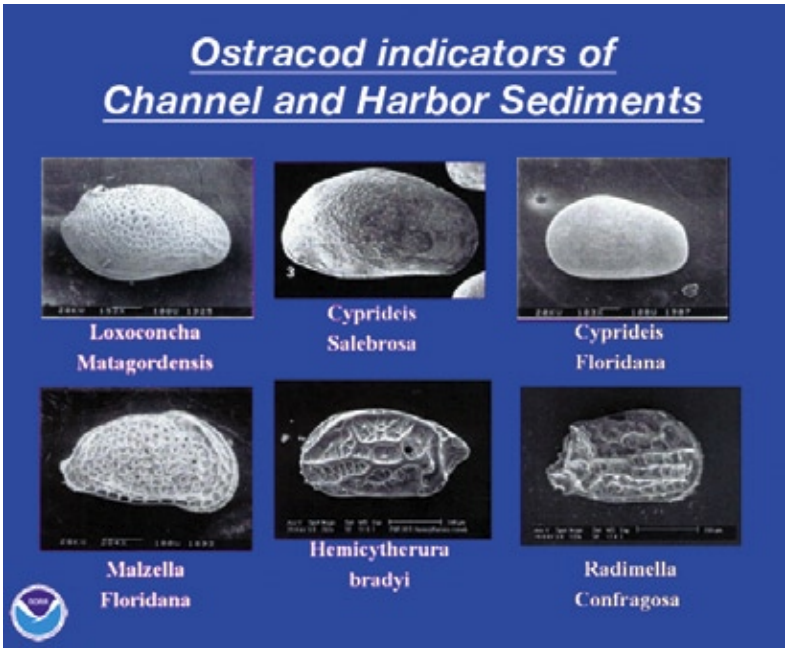


Fig. 2- *Ostracod* Species Indicative of Channel and Harbor Sediments

Remote Biosensing for Improved Protection of Coastal Resources and Public Health

Project Personnel: Michael J. LaGier, Jack W. Fell (UM/RSMAS); Kelly Goodwin, Peter Ortner (NOAA/AOML); Joseph Wang (New Mexico State University); Alderon Biosciences Inc. (North Carolina); Chris Scholin (Monterey Bay Aquarium Research Institute, CA)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To increase the social and economic value of marine resources by improving the monitoring capabilities for harmful organisms in coastal waters. **Strategy**: To develop remote biosensing instruments capable of simultaneously monitoring coastal areas for harmful algae, human pathogens, invasive species, and microbial indicators of pollution.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:
Our coastal areas and oceans generate 54 billion dollars annually in goods and services. The protection of these assets requires strategies founded in scientific efforts to better understand aquatic ecosystems and the processes that affect them. Biosensors use advances in biotechnology to identify microorganisms relevant to the economy, environment, and public health. The identification of aquatic microbes by means of biosensors, combined with physical and chemical data, will contribute to a better understanding of processes that impact aquatic ecosystems such as the initiation of algal blooms, the spread of invasive species, and the introduction of pollutants.

Standard methods for testing seawater for human pathogens are labor-intensive, costly, and take 48 hours to get results. Therefore, basing coastal management decisions on indicators for human pathogens monitored 2 days prior does not adequately protect society from exposure. In contrast to standard methods, biosensors provide local governments and coastal managers with the real-time, species-specific data needed to make rationale decisions about the closings of fisheries and recreational beaches.

Our program uses DNA sequences as markers to indicate the abundance of specific species in an environmental sample. We are developing marine biosensors to measure DNA via cutting-edge electrochemical detection methods. Unlike other molecular methods, electrochemistry offers technology that is small, inexpensive, and can readily be integrated into existing NOAA marine vehicles, moorings and instrumented platforms.

The first challenge of our research is the adaptation of proven DNA isolation and detection methods to complex environmental samples. Our initial efforts have made progress in addressing this challenge by using fecal-indicator bacteria (coliforms) and harmful algae (*Karenia brevis*) as models for the development of electrochemical techniques with the features necessary for remote, DNA-based microbial sensing. The most

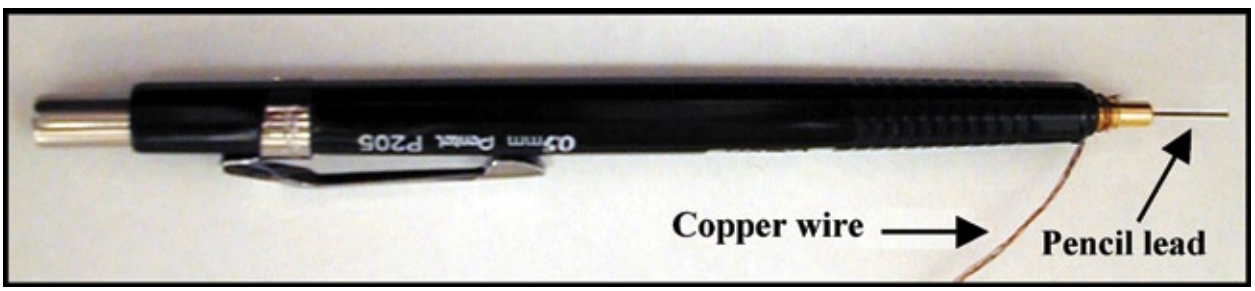


Fig. 1- DNA captured by molecular probes are detected by a carbon electrode (modified mechanical pencil).

promising methods are currently being tested in seawater samples. In addition, DNA probes are being developed for simultaneous detection of harmful algae, invasive species, fecal-indicator bacteria and human pathogens from a single water sample.

Research Performance Measure:
Our first objective was to incorporate cutting-edge electrochemistry technology into the laboratory. The second was to advance this technology for detection and characterization of economically-important aquatic microorganisms. These objectives were accomplished and have paved the way for integration of our assays into marine sensing platforms.

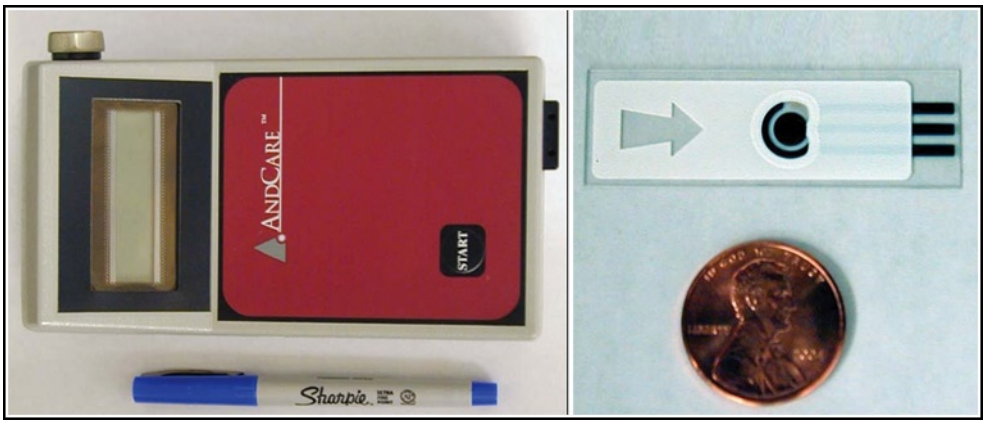


Fig. 2- Hand-held instrument and disposable sensors for detection of fecal bacteria and harmful algae (www.alderon.com)

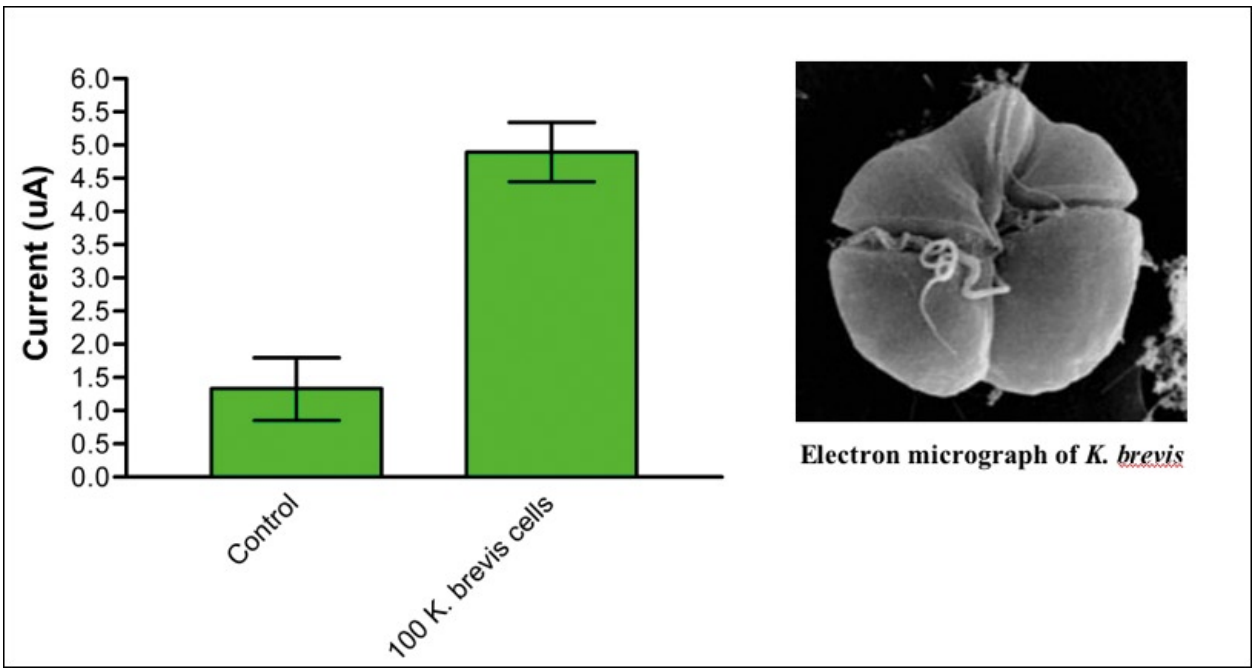


Fig. 3- Sensitive electrochemical detection of the red tide organism *Karenia brevis*

Air-Sea Interactions in Tropical Cyclones

Project Personnel: Eric W. Uhlhorn (UM/RSMAS); Peter Black (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: Characterize air-sea interactions in tropical cyclones. **Strategy**: Make measurements of the mean and turbulent structure of the atmospheric surface layer in tropical cyclones using an aircraft-based experimental strategy.

Link to NOAA Strategic Plan Goal:
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
The prediction of hurricane intensity remains a major issue confronting meteorologists. This is due to the considerable uncertainty in many of the physical processes that control hurricanes. One such aspect concerns the exchanges of heat and momentum at the air-sea interface. Hurricanes derive their energy from the ocean; thus understanding these processes is crucial to accurately predicting a cyclone's intensity. Due to a lack of data at the sea surface in high-wind conditions, these exchanges are currently not well understood.

Figure 1 shows a photo of the sea surface under surface winds of around 30 m/s (minimal hurricane force), photographed by Kerry Emanuel during one of the flights last year. The streaky nature of the foam at the sea surface indicates possible langmuir-type circulations within the ocean mixed layer. Also, the darker bands may be the sea surface signature of atmospheric boundary layer rolls which may play a part in energy and momentum transfers in tropical cyclones.

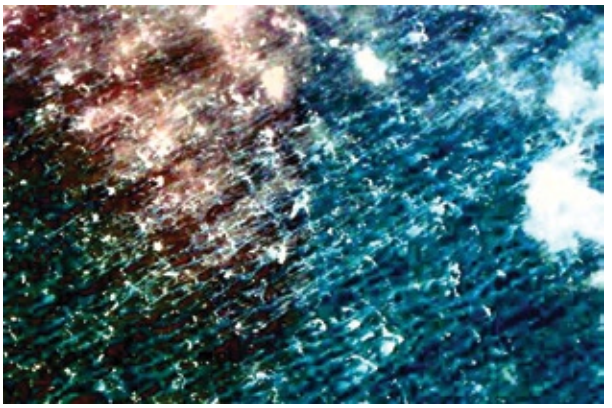


Fig. 1

Recent research activities include an investigation of the quality of surface wind measurements (upon which fluxes depend) from NOAA's Stepped-Frequency Microwave Radiometer (SFMR). We continue our program of verifying these remotely sensed wind speed estimates through comparisons with winds measured by Global Positioning System (GPS) dropwindsondes, the current standard for estimating the maximum wind in hurricanes.

An example of the wind structure in Hurricane Isabel is shown in Figure 2. These analyses document boundary layer structure in the inner-core of an intense tropical cyclone (Isabel) at unprecedented horizontal and vertical resolution. These observations will ultimately be used to analyze the kinetic and thermodynamic energy balances within the TC boundary layer to asses air-sea fluxes in extreme wind regimes.

During the past year we developed normalized mean profiles of temperature, moisture, and winds from GPS sonde measurements deployed during "stepped-descent" flight patterns. We also were involved with a major effort to analyze tropical cyclone eyewall structure by generating radius-height cross-sections based on GPS sonde high-density deployments.

We also continue to study the radial distribution of the azimuthal average surface momentum, heat, and moisture fluxes in a hurricane. A number of flux parameterization schemes currently employed by mesoscale numerical models are being tested. It is found that the variability of the computed maximum surface fluxes based on the choice of parameterization scheme is extremely large. This uncertainty represents a severe flaw in models of hurricanes, and is one major reason that numerical models are unable to predict changes in intensity.

In conclusion, observations of the atmosphere and ocean at the air-sea interface in hurricane conditions are now becoming increasingly available. With this new data, scientists should be able to begin to understand the exchange processes that ultimately fuel tropical cyclones.

Research Performance Measure:
Our first objective was to obtain a unique set of measurements of mean and turbulent quantities in various regions of tropical cyclones. The second was to produce preliminary analysis of these data. These objectives were accomplished.

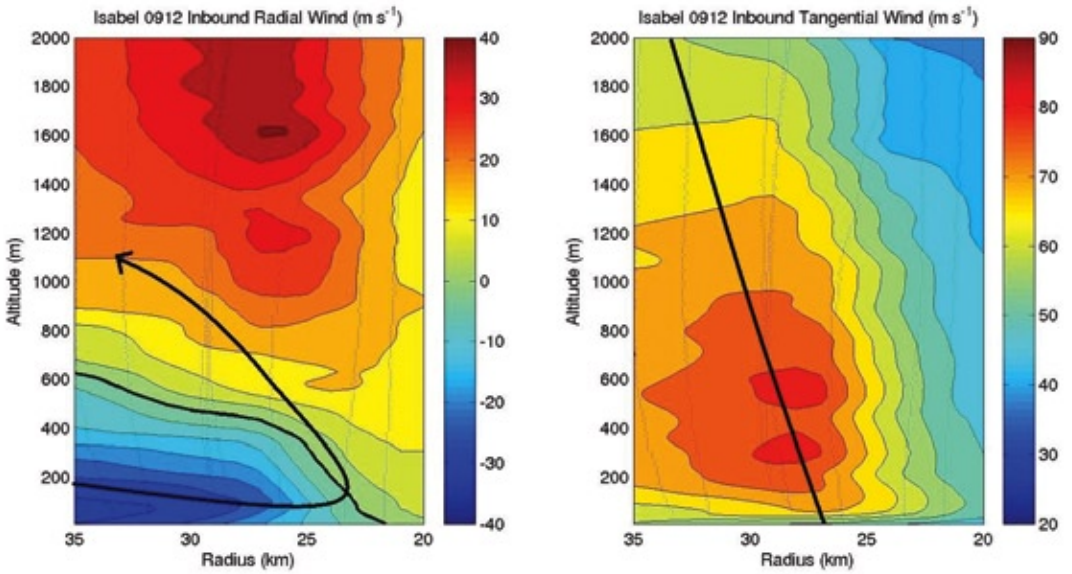


Figure 2

Investigating Tropical Storm Characteristics with Near Real Time Space – Borne Synthetic Aperture Radar Images

Project Personnel: Susanne H. Lehner, Mark A. Donelan, Hans C. Graber (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve numerical modeling and forecasting of sea surface wind fields in hurricane conditions. Strategy: Use SAR imagery to obtain data on surface conditions in hurricanes.

Link to NOAA Strategic Plan Goal:
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
Synthetic aperture radar (SAR) imagery offers a unique capability to observe features associated with hurricanes. In this project we show how recently developed methods for SAR measurements of ocean wind fields enable the study of ocean wind fields during hurricanes. For this study we used SAR data acquired during hurricanes from the European Remote Sensing Satellite ERS-2 and from the Canadian satellite RADARSAT-1.

In the past decade several satellite borne SAR systems have been put in orbit to help monitor the environment. Because SAR data-gathering is not affected by light conditions or cloud and because of the high resolution and large spatial coverage of SAR, they are a valuable tool for measuring and observing geophysical parameters like the surface wind field. In the past it has been shown that SAR imagery offers a unique opportunity to observe features associated with hurricanes.

At the UM RSMAS CSTARS (Center for Southeastern Tropical Advanced Remote Sensing) facility, RADARSAT images are acquired and processed on an operational basis. These images can be calibrated and converted into wind fields in near-real-time. In Figure 1 we show a RADARSAT image obtained during the passage of a front along with the respective wind field using wind field directions obtained from the meteorological model MM5. More recently we have acquired data from hurricane Charley at CSTARS.

Ideally we would like to obtain additional information on wind direction directly from the SAR

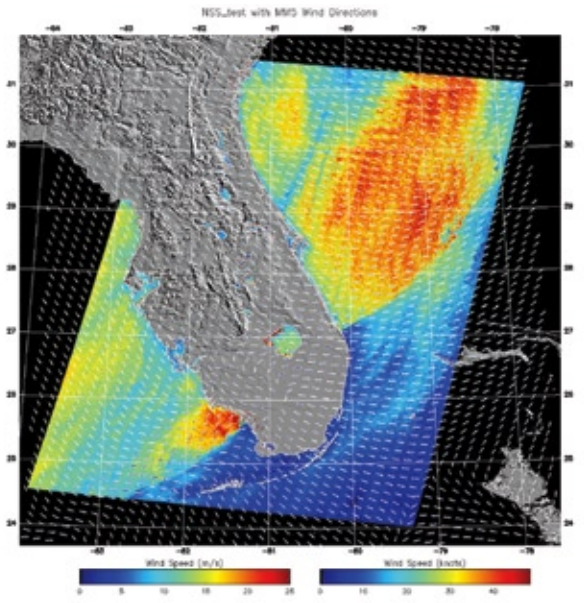


Fig. 1- RADARSAT image of wind fields during the passage of a front compared with winds from MM5.

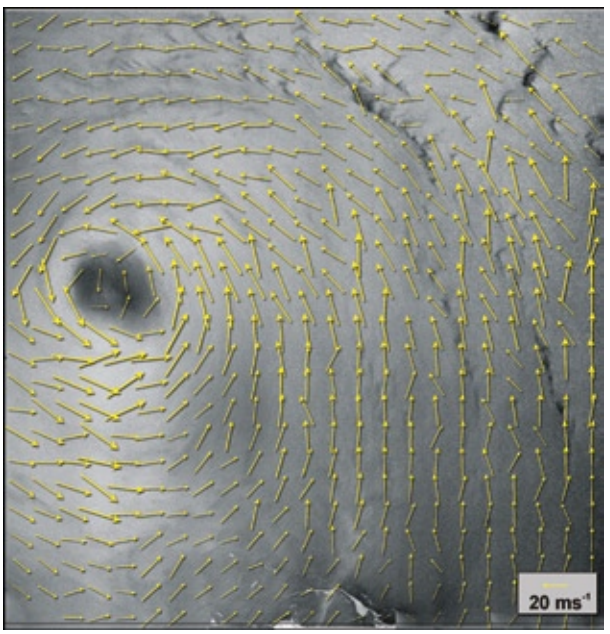


Fig. 2- The cyclonic structure and the eye are clearly defined in the wind field data. Wind field at 10 meter height derived from a RADARSAT SAR image of hurricane Floyd

image. To this end we have been developing a new algorithm which has been successfully tested using historical data of Hurricane Floyd. The recovered wind field structure in Floyd is shown in Figure 2.

Research Performance Measure:
The project is attaining its objectives in the planned timeframe.

Real-Time Hurricane Wind Analysis

Project Personnel: Nicholas Carrasco, Nirva Morisseau-Leroy, Sonia Otero, Russell St. Fleur (UM/RSMAS); Dr. Mark Powell (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve our understanding of tropical cyclones. **Strategy**: Implement state-of-the-art advances in computing technology.

Link to NOAA Strategic Plan Goals:
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
The HRD Real-time Hurricane Wind Analysis System (H*Wind) is a distributed system that ingests real-time global tropical cyclone observations measured by land-, sea-, space-, and air-borne platforms adjusting them to a common framework, 10m marine exposure. These observations are stored in an object-relational database, and then graphically displayed via an interactive Java application where scientists can quality control, objectively analyze, and visualize the information. The H*Wind system consists of five sub-components: data collection, the database, the quality control interface, the analysis package, and the product generation package.

Data collection is accomplished through a suite of Unix scripts and C programs. The current platforms being ingested include Air Force and NOAA reconnaissance, Dropwindsondes: GOES, SSM/I, TM/I and QSCAT satellites; METAR, C_MAN, Buoys, Ships and mobile Towers. All observations are stored in an object-relational database system consisting of several database schemas and a series of PL/SQL and SQLJ components.

The H*Wind Quality Control (QC) Client is the focal point of the H*Wind system. The QC Client allows scientist to interact with the data stored in the database. QC graphically displays the data and allows close inspection, editing or removal of data from the analysis, by the scientist. The QC Client can be launched over the web via Java Web Start or executed via an applet.

The analysis algorithm consists of a process of estimating the continuous spatial field of a physical variable from a set of discrete observational data. For our purposes, the physical variables of concern are wind, pressure (or geopotential height above surface), temperature and relative humidity. Analyses are customizable via filter wavelength and mesh sizes. The product of this analysis is a colored and annotated wind contour plot.

Research Performance Measure:
Our program called for a number of improvements of the data system and quality checking, all of which were achieved.

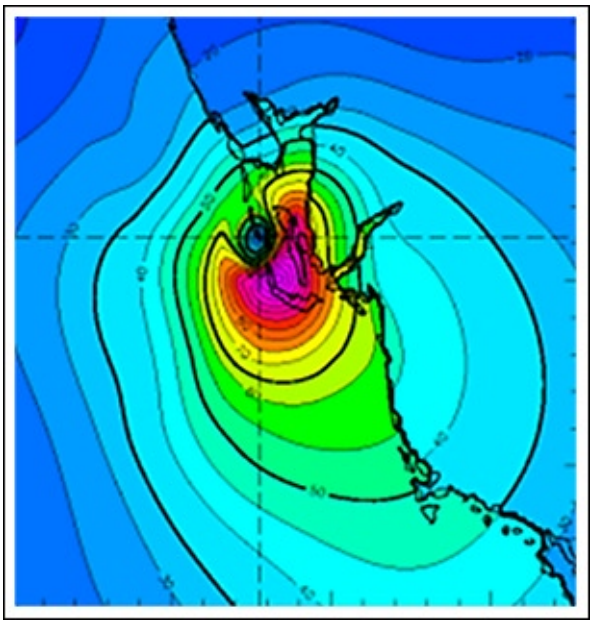


Fig. 1- Hurricane Charley at landfall, August 13, 2004, 19:46 UTC

Air-Sea Flux Estimation in High Wind Boundary Layers

Project Personnel: William Drennan (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve forecast accuracy for hurricanes and tropical systems. **Strategy**: To provide direct measurements of the air-sea fluxes of momentum, heat and moisture in hurricane conditions.

Link to NOAA Strategic Plan Goals:
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
Latent heat fluxes are a critical air-sea interaction parameter, one that is particularly important with respect to the development of tropical storms. Accurate fluxes are needed as input parameters to coupled hurricane forecast models. Hurricane reconnaissance flights routinely monitor latent heat fluxes. It is important to have an instrument that is accurate and has a fast response rate.

In the prior year of this program, supported in part by the ONR sponsored CBLAST initiative, my objective was to design and build fast-response humidity sensors to extend the turbu-lent flux package on the NOAA P3 aircraft. A prototype sensor was designed, built and delivered to NOAA-AOC for testing. Flight testing commenced during August 2003. The instrument performed well in prelimi-nary tests. Comparisons of the humidity data with those from other sensors were made and found to be excellent. The instrument was deployed during the 2003 CBLAST-hurricane experiment.

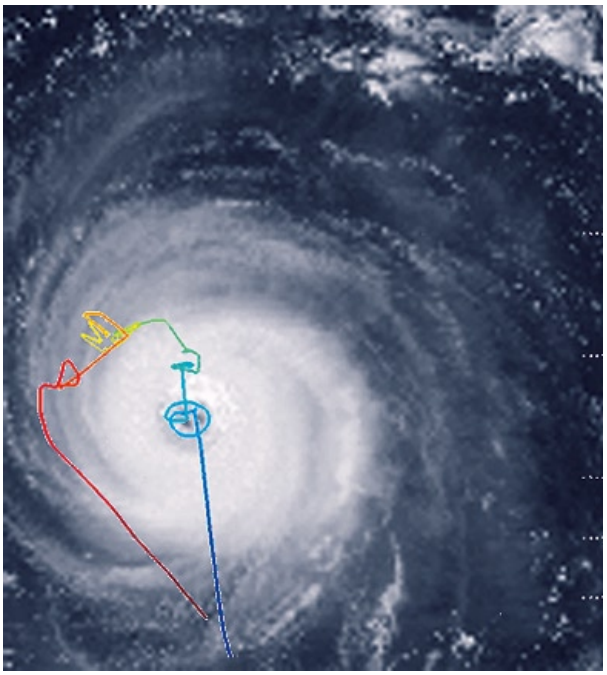


Fig 1- 14-September-2003 flight track of Hurricane Hunter aircraft N43 superimposed on a GOES visible image of Hurricane Isabel. The stepped descent segments for fluxes are visible on the left and upper left.

The fast-response hygrometer was deployed P3 aircraft during hurricanes Fabian and Isabel. The humidity instrument worked well on all flights and data analysis is in progress. The humidity data along with turbulence and supporting measurements will enable the calculation of latent heat fluxes with increased accuracy and precision and lead to improved hurricane forecasts. Analysis of the data is continuing and further data are being collected during the 2004 hurricane season.

Research Performance Measure:
All objectives were attained on schedule.

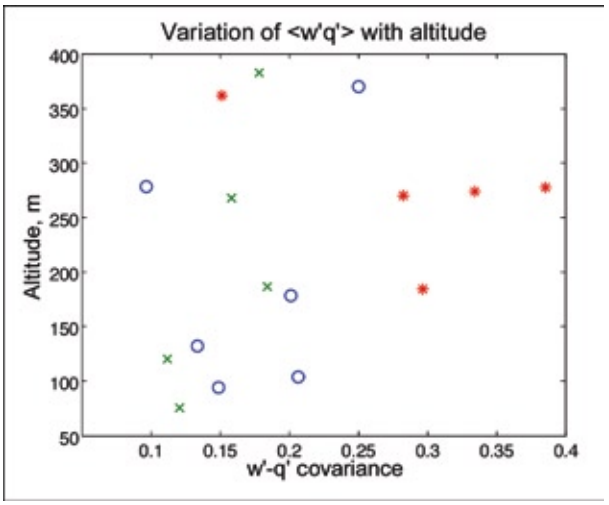


Fig 2- Variation of humidity flux <w'q'> with elevation during Hurricane Isabel stepped descents of 14-September. Circles and crosses are from along-wind descents; stars are from a cross wind descent, where the along track variations of wind speed and humidity are significant.

Evaluation of Upper Ocean Mixing Parameterizations

Project Personnel: Lynn K. Shay, George R. Halliwell (UM/RSMAS); S. Daniel Jacob (University of Maryland Baltimore County)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve hurricane intensity forecasting. **Strategy**: Use coupled ocean-atmosphere models which will be better able to predict ocean-atmosphere heat and water vapor transfers to the hurricane environment.

Link to NOAA Strategic Plan Goals:
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
Previous studies have shown that tropical cyclone intensity is sensitive to the upper ocean heat content relative to 26°C isotherm in the directly-forced region of the storm. Investigation of ocean response during hurricane Gilbert in the western Gulf of Mexico suggested that the oceanic heat and mass budgets strongly depend on the entrainment mixing scheme. One of the major uncertainties in a coupled hurricane ocean forecasting model is the choice of mixing scheme as oceanic mixed layer cooling and deepening during a storm passage is usually dominated by entrainment mixing.

In support of NOAA's Joint Hurricane Testbed (JHT), our program seeks to improve hurricane intensity forecasts in coupled ocean-atmosphere models currently under development at NOAA's National Center Environmental Prediction (NCEP). Central to this objective is using the Hybrid Coordinate Ocean Model (HYCOM) with several vertical mixing parameterization schemes. These are used to simulate the response to hurricanes Gilbert, Isidore and Lili and to compare these simulations to observed current, temperature and salinity profiles.

As an example of model differences we show in the Figure 1), a snapshot of mixed layer temperatures obtained in five mixing schemes in the directly forced region for 06 UTC 16 Sept 1988. Although all the simulations used the same initial conditions, clear differences appear in the domain. While maximum cooling of the mixed layer occurs in the right rear-quadrant of the storm, magnitude of the cooling significantly differs between the five cases. In particular, in one case (Fig. 1b), the oceanic mixed layer cools significantly compared to the other four cases. By contrast, minimal cooling is found in case a bulk treatment (Fig. 1c). This finding is consistent with our earlier Miami Isopycnic Coordinate Ocean Model study (Jacob and Shay 2003).

During the past year, we have improved the configuration of numerical model domains based on geographic coverage and vertical structure representation. We also derived more realistic initial conditions for hurricanes Gilbert and Isidore using a combination of in situ and remotely sensed data and we obtained more realistic boundary layer forcing by blending in situ and aircraft derived quantities with basin-scale model fields. We also simulated the ocean response to Gilbert forcing using various state-of-the-art ocean-mixing parameterizations. The models are tested by comparing simulated ocean temperatures and currents during hurricane Gilbert with those obtained with profiler observations in the hurricane. During the first phase of the project, our focus has been on deriving realistic initial conditions where boundary-layer forcing is crucial to simulating the upper ocean response accurately during hurricanes. Realistic conditions for the Gilbert case have been evaluated with respect to observations and were found to be appropriate. However, for hurricane Isidore the initial conditions evaluated against profiler data revealed a systematic bias in the temperature structure. These conditions are being revised for actual ocean response simulations.

Research Performance Measure:
The model development has proceeded as planned and all goals are being realized.

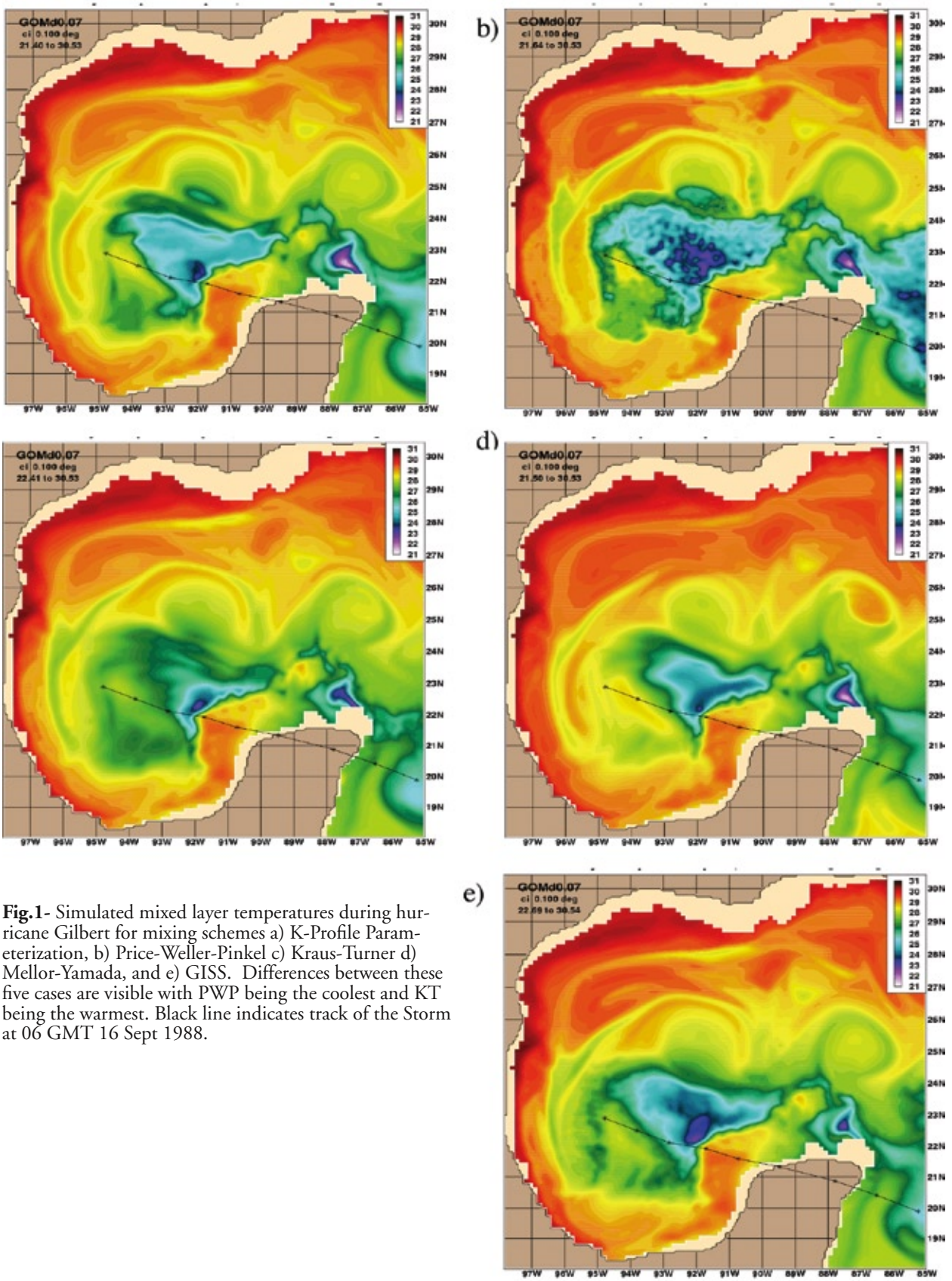


Fig.1- Simulated mixed layer temperatures during hurricane Gilbert for mixing schemes a) K-Profile Parameterization, b) Price-Weller-Pinkel c) Kraus-Turner d) Mellor-Yamada, and e) GISS. Differences between these five cases are visible with PWP being the coolest and KT being the warmest. Black line indicates track of the Storm at 06 GMT 16 Sept 1988.

Initial Steps Towards a Global Surface Water pCO_2 Observing System

Project Personnel: Frank J. Millero (UM/RSMAS); Rik Wanninkhof, Steven Cook (NOAA/AOML); Nick Bates (BBSR, Bermuda); Richard Feely (NOAA/PMEL); Taro Takahashi (LDEO/Columbia University)

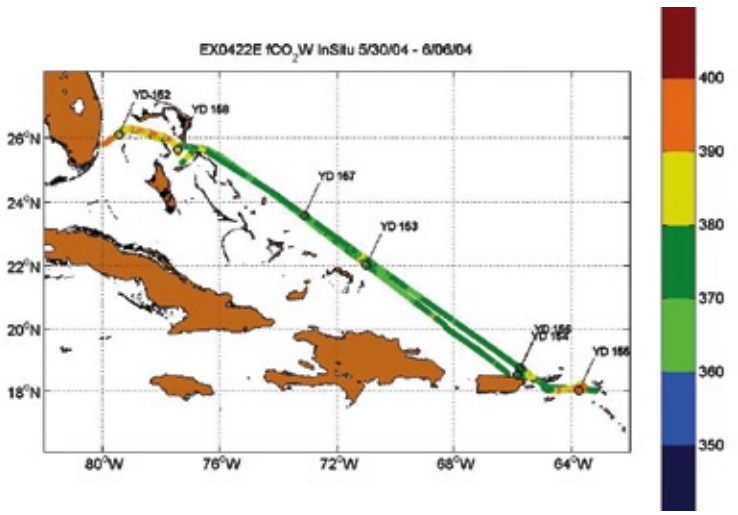
Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To monitor the uptake of fossil fuel CO_2 by the oceans over time. **Strategy**: Systematically measure changes in the pCO_2 in the Atlantic and Pacific Ocean waters using volunteer observing ships (VOS).

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
Because of the role of CO_2 in global warming, it is critically important to understand the global carbon cycle and to determine the regional sources and sinks of carbon. Such information is needed as the basis of international policy decision making as well as for forecasting long term climate trends. Projections of long-term global climate change are closely linked to assumptions about feedback effects between the atmosphere, the land, and the ocean. In this effort NOAA is outfitting research and commercial vessels with autonomous carbon dioxide sampling equipment to analyze the seasonal variability in carbon exchange between the ocean and atmosphere. This task is coordinated at national level with the U.S. Global Carbon Cycle Science program and its subcommittee on Ocean Carbon and Climate change (OCCC) and also with international groups.

The surface water pCO_2 programs support climate services by providing knowledge and quantification of climate forcing of the radiatively important gas, carbon dioxide. The near term (< 5-year) focus is on completion of the Northern Hemisphere ocean carbon observing system to assist in determining carbon dioxide sources and sinks over the coterminous United States in partnership with the atmospheric CO_2 observing system.

Our effort, henceforth called "The Underway pCO_2 Observing Program", is a partnership of AOML, AOML/GOOS, PMEL, LDEO of Columbia University, RSMAS of the University of Miami, and the Bermuda Biological Station for Research (BBSR). A central website for the efforts is under development: (http://www.aoml.noaa.gov/ocd/pco2/)



A major component of the VOS pCO_2 work revolved around designing, building and testing a new pCO_2 system for ships of opportunity. Four systems were built by a contractor with extensive input from the NOAA sponsored partners. The system was compared against several other units at an intercomparison study in Japan in May 2003. The performance of the system was such that it is rapidly becoming "the gold standard" and duplicate systems have been ordered by many other groups throughout the world. In addition, the VOS group has built a gas standard referencing system

Fig. 1- East track of the *Explorer of the Seas*.

and a system intercalibration laboratory such that all systems that will be deployed will have documented performance characteristics. The efforts of the NOAA VOS pCO_2 group thus have met the important monitoring principle of uniform instrumentation with a quantifiable accuracy.

We have placed a pCO_2 system aboard The *Explorer of the Seas*, a cruise ship of the Royal Caribbean Cruise line that follows routine tracks through the Caribbean. These data provide an excellent way to study the feasibility of creating flux maps using remote sensing because of both the high density of in situ measurements and the high quality of the remotely sensed data in the region. The cruise tracks are repeated on a bi-weekly basis alternating from an eastern track from Miami to St. Maarten (Figure 1) and a western track between Miami and Mexico (Figure 2). Large variations can be seen in CO_2 fluxes (color-coded values) across the region.

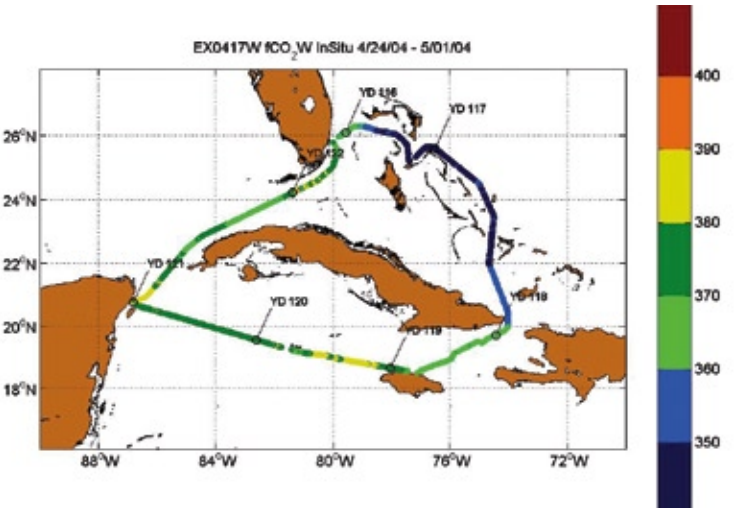
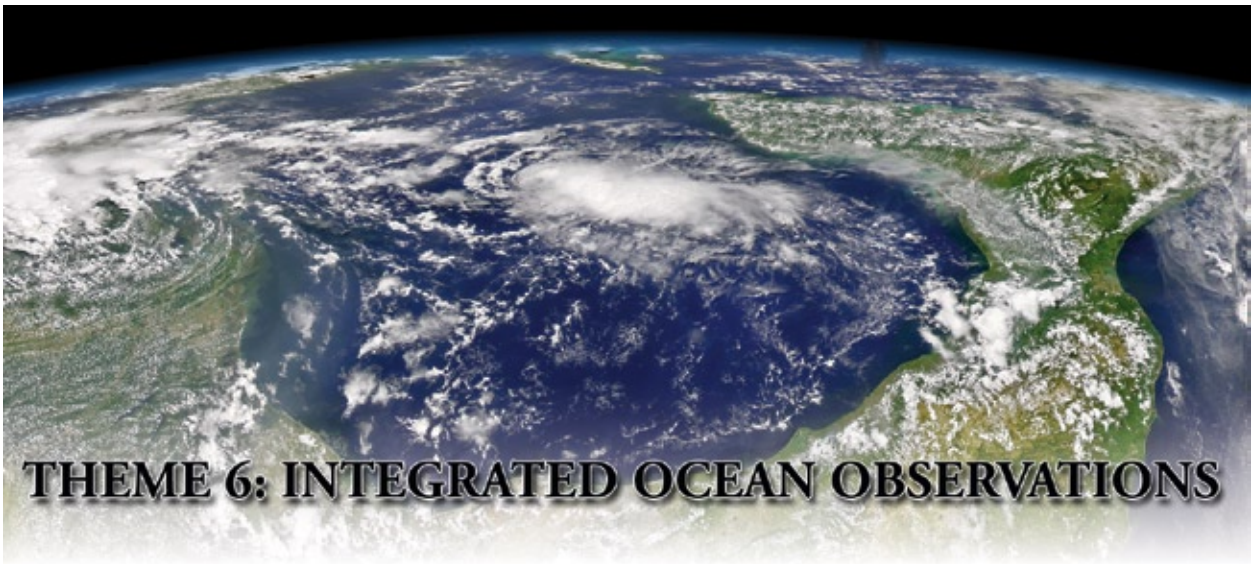


Fig. 2- West track of the *Explorer of the Seas*.

Research Performance Measure:
Our primary objective was to implement in situ, autonomous pCO_2 measurements on a number of NOAA VOS ships. These objectives were achieved as planned.



Western Boundary Current Climate Time Series: Windward Passages Experiment

Project Personnel: Carlos A. Fonseca (UM/RSMAS); Molly Baringer (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To understand the movement of water and heat around the global ocean and to determine ways in which these transports affect climate. **Strategy**: Use a wide range of observations, including satellite, hydrographic, and moored instruments as well as high resolution numerical models.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
Climate models have shown that variations of the transport of the Western Boundary Current in the Atlantic Ocean have significant impacts on the climate at both the national and global level. We carry out many studies on this current. As a part of the overall program, we use these cruises to improve instrumentation and data handling procedures. The participation in The Windward Passages Experiment gave us the opportunity to test the quality-control algorithms that were developed to improve the quality of the CTD data collected. Data from past cruises of this project were used to develop and to evaluate the new methods and algorithms to calibrate CTD data using water samples. The choice of these two cruises was excellent because it gave us the opportunity to develop algorithms for different oxygen sensors (the SBE 43 series and the SBE 13 series). In this way we now have a package that covers all the sensors available at AOML. The new algorithms allows us to retain a larger amount of data and to make the regression between sample data and CTD data. The final result shows average residuals smaller than that specified in the WOCE manuals.

Research Performance Measure:
The major objective was to develop a new package to facilitate the calibration of CTD profilers and the quality control of CTD data and to use the package on CTD data obtained on two cruises. This has been accomplished.

Upper Ocean Transports in the Atlantic Ocean

Project Personnel: Qi Yao (UM/RSMAS); Gustavo. J. Goni, Molly O. Baringer (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To study the upper ocean thermal structure of the Atlantic Ocean. **Strategy**: Use high density XBT transects to characterize these flows that define this thermal structure.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
In this program we investigate the interbasin mass exchange between the Indian and Atlantic Ocean, the meridional heat transport at 30°S and 30°N, and the zonal current system in the tropical Atlantic. These are all important components of the Meridional Overturning Circulation in the Atlantic Ocean, which is driven by temperature, salinity and wind variations. To this end we established high density XBT transect lines in the North and South Atlantic Oceans (Figure 1). The high density XBT lines provide real time high resolution temperature profiles spaced 30-50 km apart along five important lines in the Atlantic Ocean. Data obtained from these lines (AX25, AX18, AX08, AX10 and AX07) cab be accessed on the web at: http://www.aoml.noaa.gov/phod/hdenxbt/.

These XBT sections are critical to investigate the upper ocean circulation since they offer the only means to measure subsurface temperature fields on the spatial and temporal scales necessary to map the mean and fluctuating components of the ocean thermal structure. In the South Atlantic, AX18 also provides information on major boundary currents and their associated rings, such as the Brazil, Agulhas and Benguela currents.

These lines also provide data to the community for analysis of the thermal structure of the subtropical gyre, to investigate the seasonal to interannual variability in upper ocean thermal energy, to monitor and understand the role that the ocean plays in climate fluctuations, and to improve the ability to predict important climatic signals such as the North Atlantic Oscillation.

Research Performance Measure:
The major objectives - establishment of XBT transects - have been accomplished and the data acquisition is on schedule.

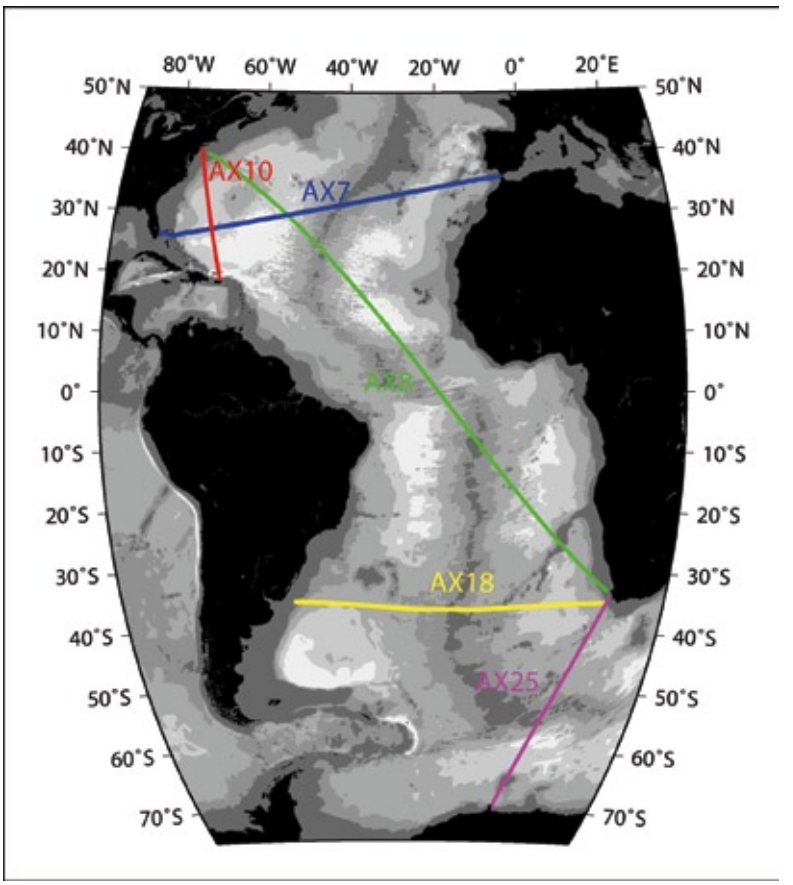


Figure 1

Coral Reef Early Warning System (CREWS) Project

Project Personnel: Jeff Absten, Louis Florit, Derek Manzello (UM/RSMAS); James Hendee, Michael Shoemaker, Jules Craynock (NOAA/AOML); Jeff Judas (NOAA Corps); Erik Stabenau (NOAA/NRC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To facilitate measurements in coral reef areas so as to better understand the physical processes that might be affecting the health of the reef system. **Strategy**: To construct meteorological and oceanographic monitoring platforms near coral reef areas, and to provide data archiving and artificial intelligence tools that can facilitate the acquisition of high-quality data and enable the rapid assessment of the physical environment at these areas.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
In order to improve and sustain coral reef health it is neccessary for researchers to have access to near-real-time data and information products. The water quality in many of the coral reef areas can change quite rapidly in response to changes in weather and to variations in the transport of materials (because of both natural and anthropogenic processes) from nearby land areas. In order to identify those factors that are most important from the standpoint of deleterious impacts on the near-coast environments, we need to have high-quality, high-frequency data on critical water parameters. Of particular importance is the measurement CO_2, and light in the water column, factors that are important in understanding coral bleaching processes. Ours is the first program to attempt to measure the long-term baseline data of these parameters on such a high frequency and over such a large area.

Research Performance Measures:
All objectives were obtained.

Fig. 1- shows a photograph of the most recent installation of a CREWS monitoring station near the Carribean Marine Research Center on Lee Stocking Island, Bahamas.

Fig. 2- shows the SAMI pCO2 sensor attached near the base of the spar.

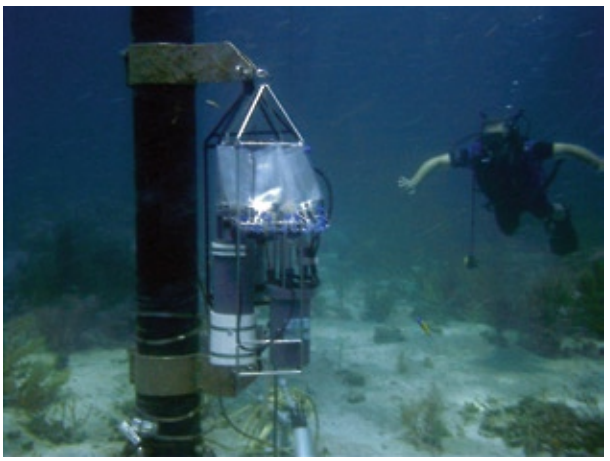


Fig. 3- shows the Aqua monitor water-sampling device.

Coastal Storms Initiative Project Number 5: Data Access and Standards

Project Personnel: Miguel Angel Izaguirre (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To increase the amount of data available to forecasters and community decision makers so as to support accurate forecasts and response scenarios. **Strategy**: Bring together data from a wide range of non-traditional monitoring systems and make it readily available to the community.

Link to NOAA Strategic Plan Goals:
Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
Large quantities of environmental data are collected by a wide range of groups that are not directly connected to NOAA data systems. In this program, we bring these data into the NOAA system. The project worked closely with data providers on data processing and data documentation to ensure quality control and that Federal Geographic Data Committee (FGDC) and other applicable standards are maintained for all data delivered.

In order for the NOAA/AWIPS to accept and make available to forecasters weather observation collected from nontraditional sources, the information must be properly coded. The weather observations arrive via email contained in different file formats or embedded in email messages. The relevant information is extracted with the help of computer programs or manually, codified, and transferred to the AWIPS server. The arrival of new data sources represents an increase in the diversity in the formatting of the information. With this in mind, distribution software has been generated. This program captures the observation, codes it, and sends an email directly to a NOAA server which, after authenticating the source, transfers the information to the AWIPS system. The intention is to minimize the time delay between data collection and data transfer.

Two input forms allow the user(s) to input meteorological information. One has been customized for Crowley Maritime Co. and allows for multiple vessel observations. The second application has been customized for single vessel input and internally translates the information according to the MAROB protocol. Both forms have an internal mailer that automatically emails the collected information as an attached file back to CSI-NOAA. In order to generate a MAROB report from Crowley's information, an Excel routine has been implemented; this routine processes the file and sends the resulting MAROB report to the CSI ftp site, from where it is ingested into AWIPS.

A third application has been designed to extract information embedded in an email message and to create a MAROB report which in turn gets transferred to the CSI ftp site. These applications are executable programs that operate under the windows operating system, which is the most common platform and which can be easily recompiled for UNIX and Linux operating systems.

Research Performance Measure:
The project continues to collect meteorological observations and imports them into the AWIPS as planned.

US Argo Project: Global Ocean Observations for Understanding and Predicting Climate Variability

Project Personnel: Xiangdong Xia, Elizabeth Forteza, Huiqin Yang (UM/RSMAS); Robert L. Molinari, Claudia Schmid, Reyna Sabina, Yeun-Ho Chong Daneshzadeh (NOAA/AOML)

Long Term Research Objectives and Strategy:
Objectives: To improve our understanding of interannual to multidecadal ocean variability and its role in climate. **Strategy**: To monitor ocean parameters over large areas of the ocean through the deployment of 1500 profiling floats as a part of a global array of 3000 floats.

Link to NOAA Strategic Plan Goal:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Summary:
The Argo array is part of the Global Climate Observing System/Global Ocean Observing System (GCOS/GOOS). ARGO profilers provide measurements of temperature, salinity and currents to depths of 2000 meters. Data collected from the floats are used by researchers in many scientific disciplines, including meteorology, climatology and oceanography. The ARGO array will eventually consist of a total of 3000 profilers.

The ARGO Data Center at AOML is responsible for acquiring and processing the data from 1500 profilers. The Center has developed and maintained an automatic system for decoding, quality control, and distribution of data obtained from US ARGO floats in real-time. The system runs in a 24/7 mode. These data are made available to scientists working on climate models and on the analysis of oceanographic data. More information on the ARGO Data Center can be found at this web site: http://www.aoml.noaa.gov/phod/ARGO/HomePage/home.html

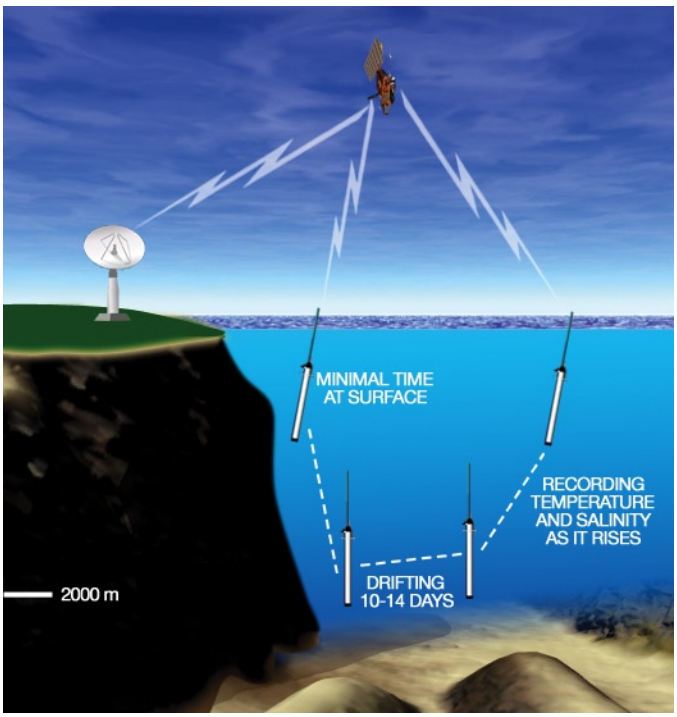


Fig. 1- Diagrammatic depiction of how the profilers function.

Data from ARGO floats are being used to derive the upper ocean heat budget in the tropical and North Atlantic. To achieve this, the data from the ARGO profilers were combined with data from other hydrographic observations. A comparative study of these independent datasets showed that they can be combined without any problems. These data are providing valuable insights on the critically important heat budgets in the Atlantic.

Research Performance Measure:
This program has attained all objectives and has met all time schedules. It continues to operate as planned.

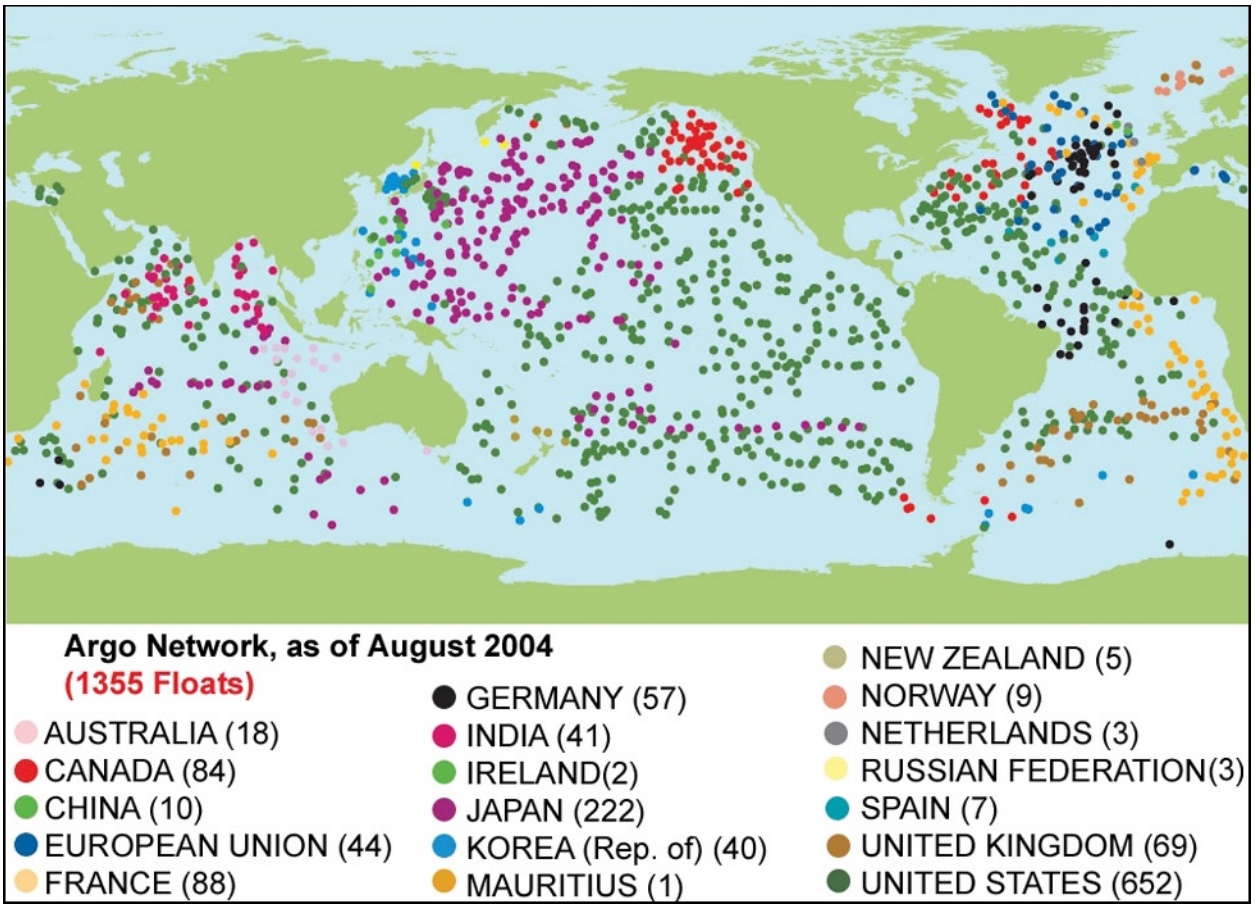


Fig. 2- shows the current disposition of profilers in the global ocean.

Western Boundary Current Time Series: Processing And Analysis Routines

Project Personnel: Chrisotpher S. Meinen, Rigoberto F. Garcia, Carlos Fonseca (UM/RSMAS); Molly Baringer (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To quantify the long-term transport of water and heat through the Straits of Florida. **Strategy**: Develop data acquisition and analysis routines to process data from the Straits of Florida communication cable that monitors flow through the region; derive a long record of flows by processing archived cable voltages that are at hand.

Link to NOAA Strategic Plan Goals:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

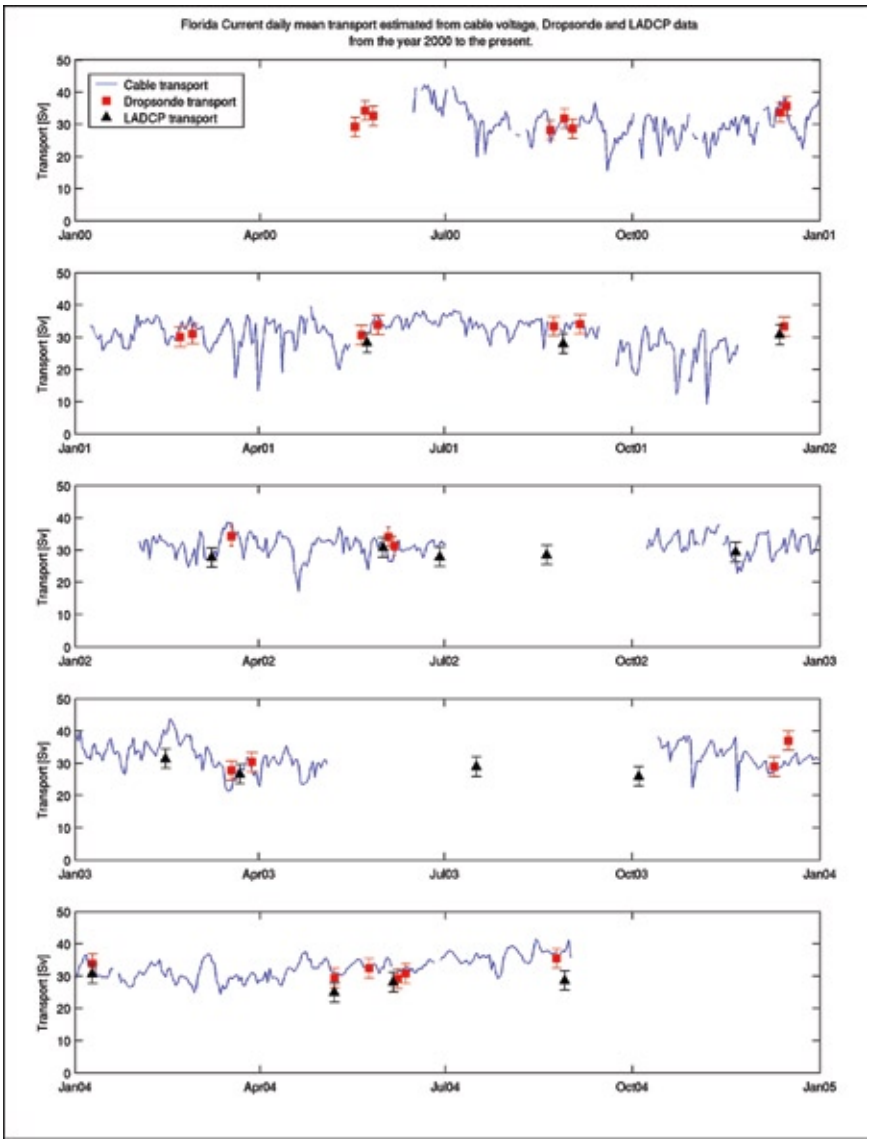


Fig. 1- The time record obtained over 2003-2004. In addition to the continuous record from the cable, the figure shows current measurements obtained by dropsondes and by a Doppler current profiler.

Research Summary:
The Florida Current represents the upper limb of the Atlantic Ocean Meridional Overturning Circulation (MOC). Variations of the MOC transport have been shown by a variety of numerical models to have significant impacts on climate both on a regional and a global scale. We study the variations in the MOC by measuring the changes in the voltage induced in a submarine telephone cable that spans the Straits of Florida. The induced voltages are interpreted in terms of water mass flow by comparing them to actual physical measurements of mass flow obtained from dropsonde profiles made across the Straits. My participation in the Western Boundary Time Series Project has been devoted to assisting with the development of processing and analysis routines for the interpretation of the induced voltages. Our group has nearly completed programs that will allow us to interpret the voltage measured on this cable as a time series of transport for the Florida Current. We have analyzed cable data from the year 2000 to the present, and we have also developed programs to analyze section data from 1991 to the present.

Research Performance Measure:
The major objectives were fully attained.

NOAA-AOML Instrument Support and Development: The XBT Monitoring Program

Project Personnel: Ben Kates (UM/RSMAS); David S Bitterman (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To provide technical support for NOAA-AOML field operations and to develop new instrumentation techniques and systems; to improve the observational capabilities of the laboratory.
Strategy: To carry out routine high-density XBT monitoring transects and coastal surveys using advanced sensors and data acquisition and processing routines.

Link to NOAA Strategic Plan Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management; Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:
Monitoring the thermal structure and heat transport in the ocean is critical to understanding the processes that affect long term climate variability. To this end we carry out routine high-density XBT monitoring transects to characterize the upper ocean thermal structure over large ocean scales. We have also installed improved instrumentation systems on our coastal research vessel and participated in numerous hydrographic surveys of Florida Bay in support of the long term study of the Florida Bay Ecosystem. We also assisted in the design, development, fabrication, and deployment of autonomous monitoring and real-time telemetering sites in the Florida Bay.

This research provides the results of field observations of these parameters in critical areas of the world's oceans. Similarly, multi-parameter monitoring of the Florida Bay ecosystem provides much-needed information on the ecological health of the coastal ocean and provides a scientific basis for better management strategies and environmental decision-making. In addition, by providing observational data in real time, investigators are better able to react quickly to unexpected events and to take corrective action if necessary. These data also allow for the development of improved sampling strategies for future field programs.

Research Performance Measure:
The primary goal of this work is to make field measurements and collect high quality data sets for use in NOAA-AOML scientific projects. All field operations were completed successfully and the data sets are available for use in the data analysis and interpretation.

Research Reports: Subcontracted Programs

Southeast Climate Consortium (SECC)

Climate Information System for Agriculture and Water Resources Management in the Southeastern USA: The Southeast Climate Consortium (SECC)

PROJECT PERSONNEL:
University of Miami: D. Letson, N. Breuer, K. Broad, V. Cabrera, and G. Podestá (UM/RSMAS); F. Miralles-Wilhelm (UM/School of Engineering)
University of Florida: J.W. Jones, C.W. Fraisse, S. Jagtap, C. Porter and K.T. Ingram (Agricultural and Biological Engineering); P.E. Hildebrand (School Natural Resources and Environment)
Florida State University: J.J. O'Brien and D. Zierden
University of Georgia: G. Hoogenboom, D. Stooksbury, L. Guerra and A. Garcia y Garcia.

LONG TERM RESEARCH OBJECTIVES & STRATEGY TO ACHIEVE THEM:
Objectives: To use advances in climate sciences, including improved capabilities to forecast seasonal climate, to provide scientifically sound information and decision support tools for agriculture, forestry and water resources management in the Southeastern US. Strategy: Functioning as a multi-disciplinary, multi-institutional team - the Southeast Climate Consortium (SECC) - to carry our climate research that will produce products for a broad community of potential users.

CIMAS RESEARCH THEMES:
Theme 1: Climate Variability
Theme 4: Human Interactions with the Environment

LINK TO NOAA STRATEGIC PLAN GOALS:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.
Goal 3: Serve Society's Needs for Weather and Water Information.

INTEGRATED RESEARCH SUMMARY:
The SECC involves close collaboration and integrated research among four universities, led by the University of Miami. The goal of the SECC is to develop a climate information and decision support system for the Southeastern US that will contribute to an improved quality of life, increased profitability, decreased economic risks, and more ecologically sustainable management of agriculture, forestry and water resources. Toward this goal we have the following objectives:

1. To improve understanding of seasonal climate variability and climate predictability at local to regional scales across the Southeastern US.
2. To characterize the contributions of climate variability to risks in management of agricultural, forestry and water resources.
3. To develop information and decision aids based on the use of seasonal climate forecasts, historical climate data and other climate analyses that help decision-makers identify management options to reduce risk and increase profits while sustaining the ecosystems of the Southeastern US.
4. To design and disseminate climate and decision support information, including an internet-based learning and decision support system.
5. To seek partnerships needed to build socially equitable extension and outreach programs for farmers, forest managers, water resource managers, homeowners and policy makers; to enhance users' familiarity with these seasonal climate forecasts and decision aids; and to provide ways for users to give feedback to researchers.

The groups at the University of Florida, Florida State University, and the University of Georgia operate under subcontracts to the University of Miami. In the following sections we present the research summaries of each of the four universities.

COMPONENT PROGRAMS

University of Miami:

We have developed and adopted some common methodologies in our approach to identify climate variability patterns in temperature and precipitation associated with ENSO events and the assessment of related agricultural and water resource impacts. We use nested, coupled, regional climate models to explore the process of using an ENSO forecast system to provide tailored output for various socio-economic sectors in small regions, primarily the Southeastern US and Southeastern South America. However, these models only have skill in predictions of seasonal climate anomalies. We are working with our collaborators to resolve the complete spectrum of anomalous climatic behavior required for agricultural and climate study purposes including the development of "downscaling" the model results to useful region sizes.

Additional research includes: the integration of weather generators with climate models; the assessment of agricultural impact through the analysis of historical crop yields and simulated yield potentials; understanding forestry risk and its minimization; water quality assessment and policy analysis; and the development of crop management optimization toolkits and programs to explore optimal management options under different ENSO conditions and optimization criteria.

University of Florida:

The focus is on improving downscaled climate forecasts. Climate forecasts may be downscaled for a region by using nested models within the cells of a global circulation model (GCM). These downscaled results, however, have relatively poor skill at a 20 km _ 20 km grid size. A statistical method based on nearest-neighbor analogue technique was developed to downscale global climate model outputs given by the coupled Atmospheric-Oceanic General Circulation Model developed by FSU/COAPS to local surface temperature, solar radiation, and rainfall in Southeastern US.

One objective is to understand how crops respond to climate variability under different phases of the El Niño Southern Oscillation (ENSO) phenomenon. To this end we are using crop simulation models for tomato, peanut, and potato in combination with historic weather data and daily data generated through resampling. We obtain a series of probability distribution functions to show crop response. Simulations were run under a range of crop establishment dates, fertilizer application rates, and irrigation regimes. A Visual Basic program was written that allows extension agents, farmers, and other to explore this database so that they can see how crops are likely to respond under different ENSO conditions, including under current climate forecast conditions. This program will allow agricultural extension agents and farmers incorporate climate information, including climate forecasts, into their decision-making processes.

In order to increase access of decision makers to the decision support tools developed by the SECC, UF has led the development of a web site that will eventually be open to the general public. Personnel from UM, FSU and UGA have also made important contributions to this web site. A beta-test version of the web site may be viewed at: http://www.agclimate.org/

Florida State University:

We have shown that different phases of ENSO have unique, quantifiable impacts on the Southeastern US and the rest of the world. We apply this research, using historical climate data, to understand these impacts and identify areas where they can be expected. We are working to improve downscaled climate forecasts by using nested models within the cells of a global circulation model (GCM) using the University of Florida statistical method described above. The downscaling procedure uses the global climate outputs from the FSU/COAPS coupled Atmospheric-Oceanic General Circulation Model to generate local surface temperature, solar radiation, and rainfall in Southeastern US. Downscaled

outputs significantly improved the skill of raw GCM forecasts of temperature, radiation, and precipitation. Crop yields forecast using downscaled climate data as inputs to crop simulation models have higher skill (~0.60 or better) than traditional GCM forecast climate data.

University of Georgia:
The calibration and evaluation of crop models requires good data for crop growth and development, yield and yield components, and management practices. However, the dynamics of the agricultural technology, such as new varieties that are released, is not matched with the frequency by which field experiments can be carried out to obtain the required data set for calibrating crop models. As a result, there is a lack of cultivar coefficients describing new and recently released varieties. Further, crop models should be evaluated with field data for a wide range of environmental conditions and management practices to provide credibility prior to applications for decision making. An accurate simulation of irrigation water use is needed to help improve yield predictions and contribute to the resolution of the tri-state (Alabama, Florida and Georgia) water dispute.

We used an optimization procedure to estimate the cultivar coefficients for widely-grown peanut varieties in southeastern USA as well as for new and recently released varieties. At the same time, we evaluated the performance of the DSSAT Cropping System Model in simulating irrigation applications and its impact on yield in farmers' fields in southwest Georgia. Crop growth and development variables and farmers' management practices such as irrigation applications were collected during the 2003 and 2004 growing seasons.

Long-term daily weather data are required for many applications of decision support systems in agricultural and natural resource management. The availability of daily solar radiation has been limited until recent years, restricting the application of crop and natural resource management models when long-term solar radiation data are required. We used a computer program, WGENR, to generate daily solar radiation data for selected counties in Alabama, Florida and Georgia using locally observed maximum and minimum temperature and precipitation data as input.

Research Performance Measure:
The goals in the development of models and forecast-information systems have been met on schedule.

The Rosenstiel School and CIMAS are active in education and outreach at the undergraduate and high school level. We are also involved with outreach to the general public. Many of these activities take place in cooperation with the local NOAA laboratories. Here we present a brief overview of outreach activities at the School in which CIMAS is involved. We only list those activities that describe on-going activities that follow a specific theme. There are many other outreach activities that are one-time events such as presenting talks to students, to groups of special-interest adults (e.g., fisherman), conducting tours, preparing articles for various media, etc. We do not list those here.

White Water to Blue Water Conference

White Water to Blue Water Conference (WW2BW) was held in Miami, 21-26 March 2004. The meeting was sponsored by the US Department of State and NOAA and it was hosted by the University of Miami and the Rosenstiel School which played a key role in helping to develop this conference. WW2BW was designed to promote the practice of integrated watershed and marine ecosystem-based management in support of sustainable development throughout the Intra-Americas Sea (IAS) region. The conference focused on the balance between the socio-economic changes occurring throughout the IAS and the problems that these impose on the region's environment and coastal ecosystems. The keynote address was delivered by VADM Conrad C. Lautenbacher, Jr., Under Secretary of Commerce for Oceans and Atmosphere The University of Miami hosted the meeting and RSMAS, with CIMAS participation, played a role in helping to develop the conference and in forming partnerships. Research programs in RSMAS and CIMAS are heavily focused on the IAS region and thus provided valuable insights and contacts for the conference. The conference was highly successful. More than 250 persons from countries around the IAS attended including representatives from NGOs, government agencies, universities, and corporations. A number of follow-up activities are underway.

The First "Bonefish Census"

Bonefish are fast-moving predators that dwell in the clear, shallow tropical waters of South Florida. They are regarded as a premier game fish because of their elusiveness and because when hooked they put up a fierce fight. They may be found in tropical waters worldwide but thrive in the Florida Keys where most of the world records have been set. Bonefishing is economically important to the Florida tourist industry. Sport fishing contributes more than $2 billion to the Florida economy and a large fraction of that comes from bonefishing. But little is known about the status of bonefish populations. Evidence suggests that populations has declined sharply in recent decades.

In order to learn more about bonefish, the first-ever census was made throughout the Florida Keys on October 2003. The objective was to establish a population baseline in support of conservation efforts. The census was a joint project of Bonefish and Tarpon Unlimited, the Florida Keys Fishing Guides Association, and RSMAS/CIMAS. It was endorsed by the Florida Keys National Marine Sanctuary and the National Park Service. Jerry Ault, Professor of Marine Biology and Fisheries at RSMAS and a CIMAS scientist, leads the university's Bonefish-Tarpon Conservation Research Project. The bonefish census activity is complementary to the intensive reef fish census activities that are carried out jointly by CIMAS and SEFSC scientists. Organizers of the bonefish census employed volunteer boaters, anglers, and guides to help cover the 150-mile stretch from Key Biscayne to the Marquesas on October 7. The census was a great success and organizers are planning to repeat the census twice annually.

Adopt-a-Billfish Program

The Adopt-a-Billfish program was established as a mechanism to enable science communication which would also facilitate partnerships with interested fishermen in joint research efforts. The program is led by Robert Cowen, RSMAS/CIMAS. The program initially focused on RSMAS billfish pop-up satellite tagging efforts along the Pacific coast of Central America. Main partners included individuals affiliated with the Presidential Challenge Central America (a group promoting catch-and-release fishing tournaments and other billfish conservation efforts), the National Marine Fisheries Service (SEFSC and SWFSC), the Bermuda Department of Environmental Protection, and the University of Miami RSMAS/CIMAS. To date, the program has successful tagged over 30 billfish along the Central American Pacific coast. This partnership has now expanded its geographical coverage to include Atlantic waters, and added another partner, The Billfish Foundation. An additional 50+ billfish (including sailfish, blue and white marlin) have been successfully tagged as a result of this program. Results of the movement trajectories of electronically tagged animals are made available to the participants and other interested parties, and presentations of the study are regularly made to fishing clubs that operate from Panama, Puerto Rico, Dominican Republic, Bahamas, and throughout the United States. For details, see:
http://www.preschallenge.com/aab/aab.html

Explorer of the Seas:

The Rosenstiel School and Royal Caribbean Cruise Lines (RCCL) with support from NOAA and NSF, and with the close cooperation of NOAA and CIMAS scientists are engaged in a unique collaboration to study the ocean and atmosphere during routine cruises of the RCCL ship Explorer of the Seas.
http://www.rsmas.miami.edu/rccl/

Explorer is a new state-of-the-art cruise ship (142,000 tons, 1020 feet LOA, 157.5 ft beam;

Research labs aboard *Explorer of the Seas*

3114 passengers; cruising speed, 23.7 kts) which started operations out of Miami in October 2000. Each week the Explorer cruises across the Gulf Stream to ports in the Caribbean and the Bahamas. RCCL provides free-of-charge two science laboratories to RSMAS and AOML, an atmospheric sciences laboratory and an oceanographic laboratory. Laboratory instrumentation was obtained with funds provided by RCCL, NOAA, and NSF. All data are made available to the general scientific community and to the public. A number of research programs supported through CIMAS make use of the Explorer.

The ship carries a wide range of instrumentation that allows continuous unattended measurements of a wide range of ocean and atmospheric properties. Data is returned via various communication links to data centers at RSMAS, National Weather Service, NOAA's National Data Buoy Center at Stennis Space Center, and the GLOBE (Global Learning and Observations to Benefit the Environment) program. The program is encourages the participation of scientists outside the UM and NOAA communities as described on the Explorer web site where data is displayed in real time: http://www.rsmas.miami.edu/rccl/obs/ex-rt-obs.pl

In addition, the ship's research facilities were designed to facilitate observation by passengers who also have access to interactive computer educational modules. Furthermore all scientists who participate on the one-week cruises must present at least one lecture to the passengers. Educational materials are provided to passengers as well. The web site also serves as an educational outreach mechanism to students.

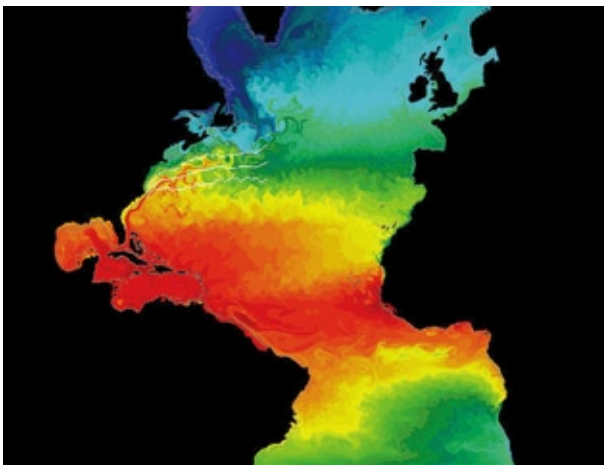
The MAST Academy

Starting in 1984 the Rosenstiel School and CIMAS have participated in a high school apprenticeship program made possible through NOAA funding. Students participate in summer internships at AOML and SEFSC. This activity is carried out through a Miami-Dade County "magnet" school, the MAST Academy (Maritime and Science Technology High School) which is located on Virginia Key, only a few hundred meters from CIMAS and the NOAA laboratories. http://mast.dade.k12.fl.us/

The MAST Academy curriculum is organized around a marine theme. The school has been recognized by the U. S. Department of Education with a Blue Ribbon School of Excellence and by Business Week magazine as one of seven most innovative schools of choice in the nation. The total enrollment is 550. The school has a broad cultural-ethnic mix of students: 36% Caucasian; 32% African American; 29% Hispanic; 3% Asian. Approximately 94% of the students eventually enroll in college. MAST students excel according to traditional measures of student performance, exceeding national averages on the PSAT, SAT, and ACT.

RSMAS participates in education-related activities at MAST by providing faculty and graduate students to teach courses. Every summer, 12-18 students are selected to participate in the summer program supported through CIMAS. The students assist in programs at AOML and SEFSC as well as at RSMAS. In addition to the summer program, CIMAS hires MAST students during the course of the year. As a result of these activities MAST students have co-authored papers with RSMAS and NOAA scientists; students have attended national conferences and presented the findings of their research. They have participated in field programs, for example in a comprehensive study of Biscayne Bay. In this way, we have developed a solid working and teaching relationship with the MAST Academy

In 2003, the MAST Academy won the Florida Regional Competition of the National Ocean Sciences Bowl which was held at Mast Academy and hosted by RSMAS.



The HYCOM Consortium Web Outreach
HYCOM is a multi-institutional effort funded by the National Ocean Partnership Program (NOPP) as part of the U. S. Global Ocean Data Assimilation Experiment (GODAE). It's goal is to develop and evaluate a data-assimilative hybrid isopycnal-sigma-pressure (generalized) coordinate ocean model (called HYbrid Coordinate Ocean Model or HYCOM A strong component of the RSMAS HYCOM initiative is web outreach.

A critical problem in ocean modeling and data assimilation is making both the observational data and model output available to (a) the members of our consortium for HYCOM and data assimilation code development, (b) the wider oceanographic and scientific communities, including climate and ocean ecosystem researchers; and (c) the general public. We are making a special effort to create modules that appeal to students in elementary and high school. The real-time global and basin model outputs are being made available to the community at large within 24 hours via the U.S GODAE and Miami Live Access Servers (LAS). A web-based reference site on ocean currents intended for students has been constructed and is accessible at http://oceancurrents.rsmas.miami.edu).

University of Miami, a Minority Serving Institution
The National Oceanic and Atmospheric Administration (NOAA) has established research and education centers to advance the community of under-represented minority scientists in the US and, especially, in the NOAA workforce. The four centers address different thematic areas of research in support to NOAA: environmental sciences, marine sciences, remote sensing, and atmospheric sciences. The Rosenstiel School is partner with two of these centers, led by Florida A&M University (FAMU) and the University of Maryland Eastern Shore (UMES).

The FAMU-led center is called the Environmental Cooperative Science Center (ECSC), and consists of partner institutions FAMU, Delaware State University, Jackson State University, Morgan State University, South Carolina State University, and UM-Rosenstiel. The central research themes of ECSC focus on the human-environment interactions involving the coastal environment and the development of conceptual models of those interactions.
The objectives of the ECSC are:
• to develop the next generation of MS and PhD-level scientists in the environmental sciences from under-represented minorities, especially African-Americans, Hispanic-Americans, and American Indians;
• to develop research activities on coastal environmental issues, focused on a set of NOAA National Estuarine Research Reserve (NERR) sites, plus the Florida Keys National Marine Sanctuary (FKNMS); and
• to conduct institutional capability building in the partner Historically Black Colleges and University (HBCU) institutions (e.g., graduate degree programs).

The Rosenstiel School's roles are:
• to provide two full fellowships for minority students for MS and PhD studies at RSMAS in environmental science and policy fields;
• to provide ship and other field experiences for undergraduate students;
• to assist in developing distance-learning classes in environmental sciences;
• to assist in the capacity building at partner institutions; and,
• to serve as the linkage to Florida Keys Sanctuary.

The UMES-led center is the Living Marine Resources Cooperative Science Center (LMRCSC). The mission is similar to the ECSC, but the focus is on marine sciences, including fisheries and aquaculture. Funding from LMRCSC provides for two minority graduate fellowships at RSMAS.

Project IMPACT

IMPACT is a summer partnership program between the Rosenstiel School and the Miami Museum of Science and Miami-Dade County Public Schools. This on-going Upward Bound program serves at-risk high school students in a six-week, hands-on, field oriented science experience. Selected students typically participate every summer during high school, earning high school science credit and a stipend as they learn science content in a marine context. In July-August 2003 about 45 students in grades 9-11 engaged in laboratory and computer-based activities at RSMAS, the Biscayne Nature Center, and various field sites under the direction of trained mentors. RSMAS faculty, including persons involved with CIMAS programs, made presentations in various areas of marine science. The program formally ended with a presentation of all student projects in the RSMAS auditorium.

Project INSTAR

INSTAR (Investigating Nature Through Science Teacher Active Research) http://mgg.rsmas.miami.edu/groups/instar/index.htm is an Earth Systems Science Teacher Institute focused on marine science education and technology training. Project INSTAR is funded by the Miami-Dade County Public School system with support from NOAA.

INSTAR provides an innovative approach to teacher professional development. The Institute, developed by a team of scientists and educators, began in 1998 at RSMAS. The INSTAR mission is to enhance the geoscience knowledge of middle school and high school teachers by offering laboratory, field, and technology training in coastal marine science themes. Teachers can directly use a majority of these activities and lessons in their classrooms. Training takes place during an 8-day summer program. Two more follow-up days are schedule during the following academic year. The program is built around four themes:

- Coral Reefs and Nearshore Ecosystems
- South Florida Hydrogeology
- Marine Microorganisms
- Quantifying Marine Animals and the Ecosystems Around Us

CIMAS participates in this program by providing opportunities through the many research programs in study areas.

Undergraduate Employee Program

CIMAS hires undergraduate students from the University of Miami and other local universities who work part time on projects at AOML and SEFSC. This program has been effective in exposing bright students to the scientific working environment. Some of these students have subsequently gone on to graduate school at RSMAS and other institutions and some have been eventually hired as full time employees.

CIMAS FELLOWS

Fellow	Affiliation
Dr. Bruce Albrecht	UM/Meteorology and Physical Oceanography
Dr. James Bohnsack	NOAA/Southeast Fisheries Science Center
Dr. David J. Die	UM/Marine Biology and Fisheries
Dr. Nelson Ehrhardt	UM/Marine Biology and Fisheries
Dr. David Enfield	NOAA/AOML/Physical Oceanography
Dr. Rana A. Fine	UM/Marine and Atmospheric Chemistry
Dr. Silvia Garzoli	NOAA/AOML/ Physical Oceanography
Dr. Kevin D. Leaman	UM/ Meteorology and Physical Oceanography
Dr. Frank Marks	NOAA/AOML/Hurricane Research Division
Dr. Robert L. Molinari	NOAA/AOML/ Physical Oceanography
Dr. Christopher N.K. Mooers	UM/Applied Marine Physics
Dr. Donald B. Olson	UM/Meteorology and Physical Oceanography
Dr. Joseph E. Powers	NOAA/Southeast Fisheries Science Center
Dr. William J. Richards	NOAA/Southeast Fisheries Science Center
Dr. Claes G.H. Rooth	UM/ Meteorology and Physical Oceanography
Dr. Sharon S. Smith	UM/Marine Biology and Fisheries
Dr. Rik Wanninkhof	NOAA/AOML/Ocean Chemistry Division
Dr. Rod Zika	UM/ Marine and Atmospheric Chemistry
Ex Officio	
Dr. Otis B. Brown	UM/Dean
Dr. Peter B. Ortner	NOAA/AOML/Ocean Chemistry Division
Dr. Nancy Thompson	NOAA/Southeast Fisheries Science Center

Jerald S. Ault
Excellence in the Research and Application of Advanced Computing and Internet Technologies to Further NOAA's Service to the Nation, NOAA TECH 2004.

Elizabeth Forteza
Member of the ARGO Data Management Team at AOML which received the NOAA Administrator's Award.

Elizabeth Forteza
Received a cash award from the University of Miami in recognition of her research as a part of the Argo Data Management Team at AOML.

Michael La Gier
Nominee (AOML) for 2004 Presidential Early Career Award for Scientists and Engineers.

Monica Lara
Nominated for the Coral Reef Task Force Award.
Category of Nomination: Outstanding Scientific Advancement of Knowledge.

Jenny Litz
Awarded a grant by Harbor Branch Oceanographic, Inc., from proceeds collected from the sale of the Protect Wild Dolphins license plate as authorized by the State of Florida Statute 320.08058(20).

Frank Millero
Carnegie Mellon 2003 Alumni Distinguished Achievement Award.
Sigma Xi, President-Elect, 2004-2006.

Nirva Morriseau-Leroy
Nirva Morriseau-Leroy received the "Woman of Achievement" award from the USBE & Information Technology magazine, Hispanic Engineer Information Technology magazine, and Women of Color Conference Magazine in recognition of her research on advanced methods for distributed scientific analysis and the use of cutting-edge technologies to address hurricane research challenges.

Nirva Mourisseau-Leroy
Was selected to participate in the IBM Residency Redbook Development Team. The team of residents, chosen through a competitive nomination process, produced a book, Implementing Web Applications With CM Information Integrator for Content and OnDemand Web Enablement Kit, W. J. Zhu, J. Almaraz, G. Campbell, H. Hammad, N. Morisseau-Leroy, and B. Paton.

Joseph M. Prospero
Inducted as a Fellow of the American Association for the Advancement of Science (Section on Atmospheric and Hydrospheric Sciences) in February 2004 in recognition of "a lifetime of aerosol measurements in remote regions of the oceans and for determining the role of aerosols in climate forcing and ocean chemistry".

Joseph M. Prospero
Inducted as a Fellow of the AGU (joint, Ocean Sciences and Atmospheric Sciences Sections) in May 2004, "For his outstanding research and international leadership in understanding mineral aerosols and their role in atmospheric and oceanic processes".

Mei-Ling Shyu
Excellence in the Research and Application of Advanced Computing and Internet Technologies to Further NOAA's Service to the Nation, NOAA TECH 2004.

Sharon Smith
Inducted as a Fellow of the AGU (Ocean Sciences Section) in May 2004 "For her leadership in the understanding of how, through evolution, zooplankton life cycles are intimately adapted to particular physical regimes and how these unique physical-biological couplings affect the broader marine ecosystem, including the oceanic carbon cycle."

Lesley Stokes
Received a NMFS cash award for her contribution to the NOAA Fisheries, Reduction of Sea Turtle Bycatch and Bycatch Mortality in the Atlantic Pelagic Longline Fishery, June 2004.

Xiandong Xia
Member of the ARGO Data Management Team at AOML which received the NOAA Administrator's Award.

Xiandong Xia
Received a cash award from the University of Miami in recognition of his research as a part of the Argo Data Management Team at AOML.

POSTDOCTORAL FELLOWS AND GRADUATE STUDENTS

A total of 19 Postdoctoral Fellows are involved with CIMAS-related programs. Of these, 8 are directly associated with CIMAS and two are supported under a subcontract through CIMAS to the University of Georgia. The nine remaining postdocs are working on CIMAS-related programs but they are supported by funding that come from other sources.

A total of 44 graduate students are associated with CIMAS-related programs. The support structure for the graduate students is rather diverse. Of the total of 44, six are University of Miami graduate students supported directly through CIMAS and seven are supported on subcontracts to other universities through CIMAS. In addition four CIMAS Research Associates/Assistants are pursuing graduate work at the University and three at other local universities while carrying out their normal employment duties. Many of these are using research carried out in their work as a part of their thesis or dissertation.

Here we list all postdocs and graduate students associated with CIMAS activities. We group them according to the source of support. We also list in a separate category those employees who are pursuing a degree while working as full-time employees. All remaining graduate students associated with CIMAS programs are listed under "Other Sources of Support".

Postdoctoral Fellows

University of Miami - CIMAS
Panagiota Apostolaki
Shaji Chithrabhanu
HeeSook Kang
Michael J. LaGier
Sang-Ki Lee
Larry Perruso
Mark Vermeij
Dana Williams

University of Georgia - subcontract
Alex Garcia
Larry C. Guerra

Other Sources of Support
Valerie Garnier
Terry Hood
Christopher Kuchinke
Denis Pierrot
Erik Stabenau
Javier Zavala

Graduate Students

University of Miami - CIMAS Students
Scott Chormanski
Monica Esquivel-Valle
Mariana Framinan
David L. Jones
Candace Nachman
Quian Li

University of Miami- CIMAS Employees
Nicholas Carrasco
Christopher Kelble
Traci Kiesling
Jenny Litz
Nirva Morisseau-Leroy
Jesse A. Wicker
Samantha Whitcraft

University of Florida - subcontract
Victor Cabrera
Viki Keener
Carlos Messina
Nitesh Tripathi

Postdoctoral Fellows and Graduate Students

University of Georgia - subcontract
Cecilia Tojo
Nittaya Phakamas

Imperial College - subcontract
Avi Shemla

Other Sources of Support
Celeste Diaz-Consul
William Forsee
Trika L. Gerard
Taylor Graham
William Hiscock
Lyza Johnston
Kristin Kleisner
Indika Priyantha Kuruppu-Appuhamilage
Hongli Liu
Hongli Luo
Derek Manzello
Mary Radlinski Tem
Maththondage Chamara Ranasingha
Patrick Rice
Kanoksri Sarinnapakorn
Avtar Singh
Christina Smith
Carlos Traveria
Phoebe A. Woodworth
XiaoBiao Xu

CIMAS RESEARCH STAFF

Abercombrie, Debra	Research Associate
Absten,Michael	Research Associate
Carrasco, Hector	Research Associate
Cotton, Sara	Research Associate
Dunion, Jason	Senior Research Associate
Fasano, Charles	Research Associate
Florit, Louis	Research Associate
Fonseca, Carlos	Research Associate
Forteza, Elizabeth	Research Associate
Garcia, Rigoberto	Research Associate
Gurnee, Monica	Research Associate
Hall, Jeremy	Research Associate
Izaguirre, Miguel	Research Associate
Kates, Benjamin	Research Associate
Kelble, Christopher	Senior Research Associate
Lara, Monica	Assistant Scientist
Litz, Jenny	Research Associate
Lumpkin, Claude	Assistant Scientist
Meinen, Christopher	Assistant Scientist
Melo, Nelson	Research Associate
Mestas-Nunez, Alberto	Associate Scientist
Morisseau-Leroy, Nirva	Assistant Scientist
Otero, Sonia	Research Associate
Rawson, Grant	Research Associate
Redman, Jessica	Research Associate
Sullivan, Kevin	Senior Research Associate
Stokes, Lesley	Research Associate
Stone, Holly	Research Associate
Uhlhorn, Eric	Senior Research Associate
Wicker, Jesse	Research Associate
Whitcraft, Samantha	Research Associate
Xia, Xiangdong	Research Associate
Yao, Qi	Research Associate
Yang, Huiqin	Research Associate

VISITING SCIENTISTS - YEAR 3

Dr. Daniel Jaffe
Professor
University of Washington-Bothell
Interdisciplinary Arts and Sciencies
Bothell, WA
9/17-18/03
"Long-Range Transport of Asian Pollutants to the West Coast: Does it Matter for Air Quality?"

Dr. Dennis J. McGillicuddy, Jr.
Associate Scientist
Department of Applied Ocean Physics and Engineering
Woods Hole Oceanography Institution
Woods Hole, MA
1/19-25/04
"Influence of Mesoscale Eddies on Biochemical Cycling in the Open Ocean"

Dr. Michael Wallace
Director
The Joint Institute for the Study of the Atmosphere and Ocean (JISAO)
University of Washington
Seattle, WA
11/22-25/03
"Looking at the Big Picture: Exploiting Global Datasets in Climate Research"

Dr. Fritz Schott
Abteilung Regionale Ozeanographie
Institut für Meereskunde an der Universität Kiel
Kiel, Germany
4/1-30/04
"Subtropical Cells and their Climate Relevance"
"Atlantic Western boundary circulation at 5-10S"

Dr. Michael Scoullos
Professor of Chemistry and Oceanography
University of Athens
President of the Mediterranean Information Office for Environment, Culture and Sustainable Development
Athens, Greece
11/2-8/04
"Fresh Water Problems in the Mediterranean"

In this section we cite publications in various categories during 2003-2004. During that period, CIMAS scientists participated in the publication of 80 papers in peer-reviewed scientific journals. They were lead authors on 36 of these. They also participated in 79 papers that appeared in non-peer reviewed publications, including books. A breakdown of publication statistics for the first three years of the Cooperative Agreement is shown in the table. The publications are listed in three categories: Papers where the CIMAS scientist was lead author, where a NOAA scientist was a lead author, and where a scientist from organizations other than CIMAS or NOAA was the lead author.

	CIMAS Lead Author			**NOAA Lead Author**			**Other Lead Author**		
	FY01	FY02	FY03	FY01	FY02	FY03	FY01	FY02	FY03
Peer Reviewed-	54	60	36	0	7	14	--	--	30
Non Peer-Reviewed	7	8	34	0	3	17	--	--	28

Refereed Journal Articles

Arimoto, R., X.Y. Zhang, B.J. Huebert, C.H. Kang, D.L. Savoie, J.M. Prospero, S.K. Sage, C.A. Schloesslin, H.M. Khaing and S.N. Oh, Chemical Composition of AtmosphericAerosols from Zhenbeitai, People's Republic of China, and Gosan, South Korea, during the ACE-Asia, in press, *J. Geophys. Res.*, 2004.

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