COOPERATIVE INSTITUTE FOR MARINE
AND ATMOSPHERIC STUDIES

CIMAS

Seventh Year Annual Report
NOAA Cooperative Agreement NA17RJ1226

2007 - 2008

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Hurricane Ike, September 04, 2008

TABLE OF CONTENTS

I. EXCUTIVE SUMMARY

The Cooperative Institute for 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 jointly sponsored by the University and the National Oceanic and Atmospheric Administration (NOAA). CIMAS works especially closely with two co-located NOAA laboratories: the Atlantic Oceanographic and Meteorological Laboratory (AOML) and the Southeast Fisheries Science Center (SEFSC). CIMAS carries out research under six Themes all of which are linked to NOAA's Strategic Goals.:

> *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*

CIMAS activities during Year 7 (Y7)of the Cooperative Agreement (CA) continued at a high level. Total expenditures in Y7 were $9.9M, comparable with those of the previous year, $10.6M. The high expenditures in Y6 and Y7 reflect the growth of activities in CIMAS under the CA. The average expenditure of the past two years is approximately $4M greater than the first two years, an increase of 78%. Task 2 expenditures in Y7, which supports CIMAS employees who conduct research primarily within AOML and SEFSC, continues at the high level of the previous year, totalling $4.1M, almost triple that in Y1.

Other research funding (Task 3 and Task 4) in Y 7 was $4.7M. This is an increase of $0.8M (20%) over Y 6. In contrast to Task 2 funding, research funding has remained relatively unchanged over the past five years of the CA with an annual average of $4.0M. Nonetheless, this rate is substantially greater than that in the first two years which averaged $2.5M. The largest portion of Task 3 and Task 4 expenditures is in Theme 6, Integrated Ocean Observations, which accounts 33% of the total. The smallest expenditures were in Theme 2, Fisheries Dynamics, 9%. Expenditures in the remaining four themes were roughly comparable, ranging from 12 to 15%.

During Y7 a total of 121 persons were involved with CIMAS in various capacities. Of these, 90 received over 50% of their support from NOAA sources. Of the 90 who receive over 50% NOAA support, 56 are associated with AOML and 34 with SEFSC.

The employees in the Research Associate and Research Scientist ranks have a rather diverse demographic profile. Our population is 36% female. Foreign-born individuals make up 54% of the personnel. Of these, Hispanics make up 31% of the ranks; Asian and Pacific Islander, 19%. The population of CIMAS is also relatively young with an average age of 38

CIMAS continues to be highly productive. In Y7 CIMAS employees were the lead authors on 39 peer-reviewed publications and co-authors on 67 other peer-reviewed papers. Their research has yielded many exciting results. Here we highlight some of our achievements. These are selected to be representative of the wide range of activities carried out in CIMAS. A more detailed description of these and other research activities can be found in the body of the Report under the Themes.

RESEARCH HIGHLIGHTS

Past and Future North American Drought: The tropical Pacific has played an important role in North American (and Global) hydroclimate for the past 1000 years; periods of persistent "mega-droughts" coincide with cooler La-Niña- like SSTs..

Climate Noise and Climate Predictability: We have designed and implemented a set of novel numerical experiments to examine the relative importance of ocean initial condition uncertainty versus "weather noise" as the forecast evolves in limiting ENSO predictability and ENSO prediction skill. We find that the current limiting factor is initial condition uncertainty, a factor that will complicate USNWS climate forecast efforts.

Intra-Americas Sea Climate Variability During Boreal Spring and Summer: We find that when the Pacific - North American climate pattern and the El Nino-Southern Oscillation act in concert the Intra-Americas Sea (IAS) shows a distinctive SSTA dipole structure whose strength is indicative of larger-scale circulation anomalies that affect precipitation in the US and South America.

Assessment of Decadal Variability in the Tropical Radiation Budget: The horizontal and vertical structure of the covariance between water vapor and temperature in the tropical troposphere, measured using the Atmospheric Infra-Red Sounder (AIRS), show large spatial gradients in the local covariance between water vapor and temperature, an important factor in the radiation budgets.

Climate Impacts of the Western Hemisphere Warm Pool on the Americas:
Observations over the past 153 years show that that global warming of the sea surface is associated with a secular increase of tropospheric vertical wind shear in the main development region (MDR) for Atlantic hurricanes. The increased wind shear coincides with a weak but robust downward trend in U.S. land-falling hurricanes.

Monitoring Coral Reef Fish Populations in the Florida Keys: A team of 38 research divers from the University of Miami, NOAA, and various federal and state agencies successfully completed a 20-day biennial census of protected areas in the Florida Keys and Dry Tortugas as part of a long term effort to document the recovery of the region after decades of overfishing and environmental changes.

Acoustic Seabed Classification and Quantification of Reef Fish Habitat: Using acoustic seabed mapping technologies, we found that drowned outlier reefs were a feature comon to all six fish spawning aggregation (FSA) sites mapped in the upper Florida Keys. This pilot effort demonstrates that acoustic seabed mapping technologies can provide fisheries managers an objective and relatively inexpensive method for identifying likely locations of FSA sites.

Coral Ecological Restoration in the Florida Keys National Marine Sanctuary: Experiments during the 2007 spawning season, showed that coral larvae that settled on clean artificial substrates survived at much greater rates compared to resettlement on natural reef rubble. Adopting this alternative procedure will markedly improve coral reef restoration.

Climate Information System for Agriculture and Water Resources Management in Southeastern USA: Research carried out by the Southeast Climate Consortium (SECC) has shown that different phases of ENSO have unique quantifiable impacts on the Southeast United States. SECC products and decision support tools were provided to water, agricultural and forest managers enabling them to better assess climate-related risks

A Study of African Dust and Dry-Air Outbreaks and Their Effect on the Atlantic: Using satellite data, we identified large-scale coherent signals between African dust and Atlantic precipitation. These data are being used to verify and diagnose climate models to improve our understanding of the modulating effects of dust on cloud and precipitation.

Documenting Everglades Restoration Impacts on Biscayne Bay's Shallowest Benthic Habitats: We have established direct links between the salinity patterns in western Biscayne Bay and the abundance and distribution of seagrasses and macroalgae. These relationships highlight the potential impact of future changes in hydrology and freshwater deliveries expected as a part of the South Florida restoration.

Application of Satellite Surface Wind Data to Ocean Surface Analysis and Numerical Weather Prediction: While the incorporation of QuikSCAT data has a minor influence on operational global model forecasts of tropical cyclones, these data have a much more significant impact on high-resolution research model forecasts that use an advanced data assimilation framework.

Investigating the Boundary Layer in Hurricanes using Unmanned Aircraft Systems: Aerosonde data were analyzed to assess their performance in characterizing the low-level structure in Tropical Storms Ophelia and Noel. In each of the two storms, the wind speeds measured by Aerosonde were significantly higher than those measured by manned aircraft and other systems.

Ship of Opportunity Program: The analyses of concurrent with CTD and ARGO float observations indicate that there is a systematic difference in temperature profiles which may be due to an error in the XBT fall-rate equation. Uncorrected this error introduces a warm bias in the global XBT data base which would result in significant errors in heat transport estimates.

Global Drifter Program: The first global analysis of hourly-resolution drifter data shows clear patterns of tidal, inertial and super-inertial motion in the Atlantic, Pacific and Indian Ocean basins.

Surface Water pCO_2 Measurements from Ships: The estimated variability of air-sea CO_2 uptake is 0.2 Pg C/year with an annual average of 2 Pg C/year. Most of the variability is observed in the equatorial Pacific and shows a strong inverse correlation with the ENSO index indicating that natural climate variability has a significant effect on air-sea CO_2 fluxes.

The CLIVAR CO_2 Repeat Hydrography Program: .We have been able to accurately quantify the changes in the water column carbon in the Atlantic, Pacific, and Indian Oceans by comparing data from recent cruises with those from WOCE cruises that occupied the same transect lines in the late 80's and early 90's. The largest uptake is in the North Atlantic and corresponds with a downwelling component of the Meridional Overturning Circulation (MOC) that enhances tranport of carbon into the deep waters.

II. CIMAS MISSION AND ORGANIZATION

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 OAR Cooperative Institutes nationwide.

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.*

The CIMAS Mission:

- *To conduct research in the terrestrial, ocean, and atmospheric environment within the general context of 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 promotes synergisms between University scientists and those in NOAA. Most CIMAS research is supported by the OAR and the National Marine Fisheries Service (NMFS). CIMAS partners primarily with the Atlantic Oceanographic and Meteorological Laboratory (AOML) and the Southeast Fisheries Science Center (SEFSC) which are co-located on Virginia Key adjacent 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 its objectives:

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

CIMAS facilitates 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 involvement of University scientists and educators in NOAA mission-related research.

The Link between CIMAS Research and NOAA Goals

CIMAS research and its scientific objectives are currently guided by the NOAA's *Strategic Plan for FY 2005-2010*. NOAA has identified 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.

The Administration and Governance of CIMAS

The organization of CIMAS reflects the joint interests of the University and NOAA in carrying out the CIMAS Mission. In accordance with the MOU, the Director of CIMAS must be a faculty member of the University. Many aspects of the governance of CIMAS are dealt with in consultation with the CIMAS Fellows who act much like a Board of Directors. Fellows are scientists of established national or international standing who hold regular teaching or research faculty appointments in the University or who are NOAA employees. The Fellows play an important role by providing guidance to the Director of CIMAS in matters regarding the promulgation of research programs.

CIMAS activities fall into four Task categories. The administrative functions of CIMAS are carried out under Task I with funding provided by both the University and NOAA. Many research activities are carried out under Task II wherein CIMAS provides highly specialized research scientists to work on research projects carried out in NOAA's Miami laboratories. The expertise of these CIMAS employees complements that already present in NOAA and the University.

Other research in CIMAS is carried out under Task III and Task IV. These Tasks provide funds to University scientists to conduct research on CIMAS themes. Support for specific projects under these tasks is based on proposals submitted to specific NOAA units or programs in response to a general announcement of opportunity. Task 3 encompasses activities of CIMAS scientists that are carried out in close cooperation with NOAA laboratories in Miami and elsewhere. Task 4 includes projects that support or complement the NOAA mission but are not directly linked to the NOAA laboratories or collaboratively conducted with NOAA scientists.

III. PERSONNEL

Distribution of Personnel

CIMAS personnel participate in a wide range of NOAA-related activities. During Y7 a total of 121 persons were involved with CIMAS in various capacities. Of these, 90 received over 50% of their support from NOAA sources. Table 1 shows the distribution of personnel by category and by their association with the local NOAA laboratories. Of the 90 who receive over 50% NOAA support, 56 are associated with AOML and 34 with SEFSC.

Table 1: CIMAS Personnel 2007 – 2008

Category	Personnel number	BS	MS	Ph.D.
Research Associate/Scientist	47	20	16	11
Part Time Research Associate/Scientist	3	1	1	1
Postdoctoral Fellow	7			7
Research Support Staff (temp)	33	7		1
Total (> 50% NOAA support)	**90**	**28**	**17**	**20**
Administrative (<50% NOAA Support)	5			2
Undergraduates Students	9			
Graduate Students	17		5	
Visiting Scientist	4			4

Location of Lab	56-AOML 34-SEFSC
Obtained NOAA employment within the last year	0

Research Associates and Research Scientists are Task 2 employees working closely with and primarily with and primarily within the local NOAA laboratories. A total of 47 persons were employed under Task 2 in Y7. There had been a steady growth in Task 2 personnel in the middle and late 1990s. During the first three years of the current Cooperative Agreement, Task 2 personnel levels had remained relatively steady – about 34. In Y4 the number increased sharply to 44 followed by 43 in Y5 and 45 in Y6. CIMAS Task 2 seems to have stabilized at this new level of about 45 personnel.

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 required for the support of research activities at the University. 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 be equivalent to those of the research faculty at the University (i.e., Assistant Research Professor, Associate Research Professor, Research Professor).

There are a total of seven Postdoctoral Fellows. Postdocs have become an important part of CIMAS with numbers usually in the range of six to nine.

Research Support Staff are temporary employees, hired for the duration of specific projects. These also include persons from a variety of backgrounds (including local high schools) as a part of CIMAS outreach 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 School academic divisions. These faculty (including the Director and Associate Director) are not counted in the listing of CIMAS personnel. Graduate students who work on CIMAS programs also have their primary affiliation with an academic division which has the ultimate responsibility for overseeing the students' academic performance and the granting of degrees, but if fully supported by CIMAS are included in Table 1.

CIMAS Fellows
Many faculty participate in CIMAS as Fellows who play a role in the governance of the Institute. At present there are 22 CIMAS Fellows. In addition to the regular members of the Fellows, there are three *ex officio* members, the Dean of RSMAS (O. Brown) and the directors of the two co-located NOAA laboratories (R. Atlas, AOML; B. Ponwith, SEFSC). A list of the CIMAS Fellows membership is shown in the *Fellows* section of this report along with their affiliation. At present 13 Fellows are from RSMAS, 7 from the local NOAA laboratories, 1 from the National Hurricane Center and 1 from Florida International University.

CIMAS Staff
CIMAS staff consists of the Director, Dr. Joseph M. Prospero, and the Associate Director, Dr. Peter Ortner, and three administrative personnel. Not included in the listing of personnel is Dr. David Die, the Director of the Cooperative Unit for Fisheries Education and Research (CUFER). CUFER plays an active role in many CIMAS activities and is located within CIMAS but it functions as an independent office.

Transition to Federal Positions
Since the start of the current Cooperative Agreement a total of 13 CIMAS employees have assumed Federal positions in the local laboratories. During the past year no CIMAS employee assumed a position as a Federal Employee.

Demographics of CIMAS Employees
The employees in the Research Associate and Research Scientist ranks have a diverse demographic profile. The CIMAS population is 36% female. Foreign-born individuals make up 54% of the personnel; of these Hispanics make up 31% of the ranks; Asian and Pacific Islander, 19%. Only one African-American has been recruited, despite our efforts to expand this demographic. The population of CIMAS is relatively young with an average age of 38. The largest age group is the 30s decade, a total of 23. Our population is both younger and more diverse than that at the co-located NOAA laboratories.

CIMAS and Students
There are currently 17 graduate students supported through CIMAS, the largest number ever supported in any one year under the current Cooperative Agreement. In addition nine undergraduates are supported. Many high school students are employed as temporary hires (in the category Research Support Staff). Many of these are enrolled in the Miami – Dade MAST Academy, a magnet school located adjacent to the NOAA laboratories (see Outreach).
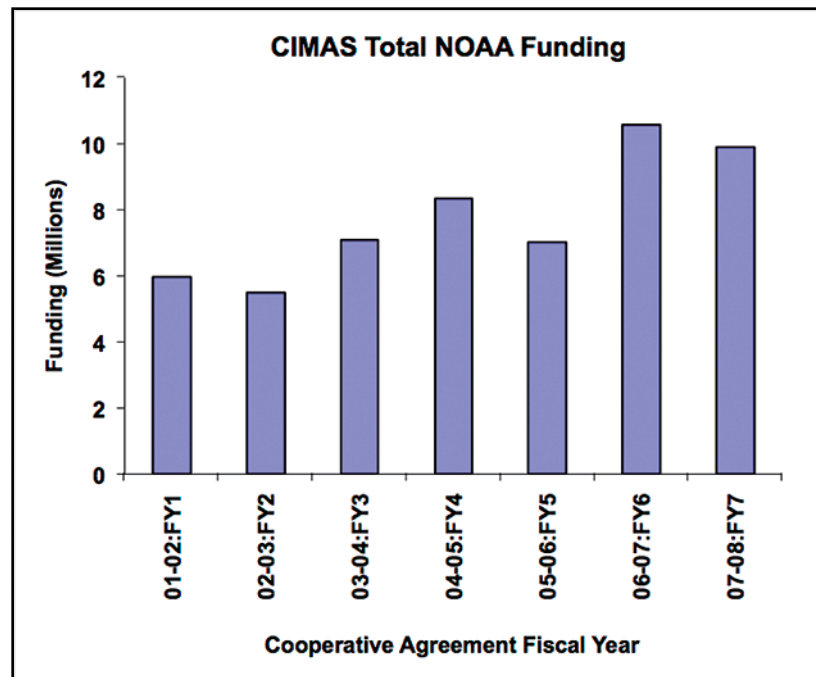
IV. FUNDING

General Funding Trends

Expenditures during Year 7 of the Cooperative Agreement (CA), were very similar to the preceding year. In Y7, funds from all NOAA sources totaled $9.9M compared to 10.6M in Y6. A summary of CIMAS funding under the four Tasks in Y7 is shown in Table 1 along with the funding under the prior six years of the CA.

Table 1: CIMAS Funding from NOAA Sources (Thousands of Dollars)

	Task I	Task II	Task III	Task IV	Total
Year 1	1620	1434	2604	320	5979
Year 2	1381	2059	1444	625	5509
Year 3	700	2435	3548	413	7096
Year 4	1847	2701	2853	945	8345
Year 5	1133	2527	2683	675	7018
Year 6	2343	4301	3360	580	10584
Year 7	1043	4148	4011	709	9911

The history of NOAA funding through CIMAS is shown graphically in Figure 1. Total funding in Y6 and Y7 was substantially greater than in the first five years of the CA and reflects the steady growth of CIMAS. The average expenditure of the last two years of the CA is approximately $4M greater than the first two years, an increase of 78%.


Figure 1: CIMAS funding from NOAA sources

The NOAA line-office sources of funding in CIMAS are shown in Table 2. The major source of funding is OAR which provides 55% of the total. NMFS and NOS are second at 13% and 14% respectively. Over the course of the CA about 85% of CIMAS funds has come from two NOAA sources: OAR and NMFS. Of total OAR funding, $3.54M (65%) comes from the Climate Program Office (CPO), a competitive grants program in OAR. Funding from CPO has increased sharply in Y7, from $1.4M in Y6. The "Other" sources of funding include DoD ($1.0M, from the Army Corps of Engineers in support of the South Florida Restoration program) and a small amount from NASA ($71K).

Table 2: NOAA Funding by Source FY 7

1 July 2007 – 30 June 2008		
Line Office	**Funding $M**	**% Total**
OAR	5.37	55%
NMFS	1.31	13%
NOS	1.41	14%
NWS	0.48	2%
NESDIS	0.24	5%
Other	1.09	11%
Grand Total	9.91	

The trends in the principal sources of CIMAS funding over the lifetime of the current CA are shown in Figure 2. Funding through OAR has grown considerably over the past seven years. The other major sources of funding, NMFS and NOS,
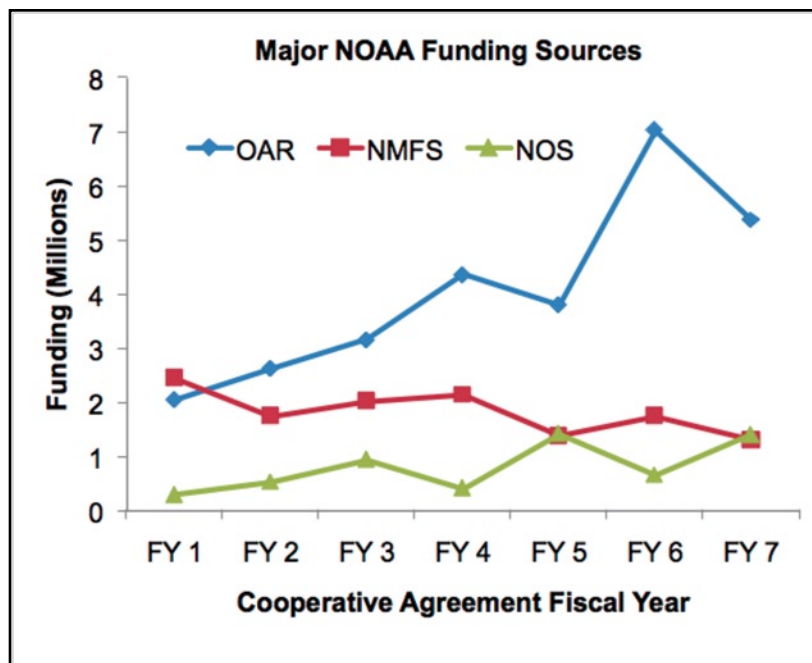
Figure 2: Trends in funding from the major sources under the current Cooperative Agreement

are relatively small compared to OAR. NMFS funding suggests a slight downward trend whereas NOS funding has been growing, the sum of the two holding relatively constant over the CA.

Funding Trends by Task
CIMAS activities are administratively grouped under four distinct Tasks encompassing different aspects of the CIMAS mission.

- **Task 1** provides the administrative structure for the Institute and includes support for graduate students and limited-term visiting scientists from outside Miami. The University contributes to the administrative support of CIMAS in its role as a Division in the School. The indirect cost rate for Task 1 is 0%

- **Task 2** provides support for highly specialized research scientists who are employed by CIMAS to complement existing expertise at NOAA and the University in conducting research upon the collaborative research themes of the Institute. Support for limited-term postdoctoral research associates is also included in this Task. The indirect cost rate for Task 2 is 26%.

- **Task 3 and Task 4** encompass the directed research programs of CIMAS. These provide support for research on CIMAS themes by University faculty, scientists and students. Task 3 encompasses activities of CIMAS scientists that are carried out in close collaboration with NOAA personnel in the local NOAA laboratories and elsewhere in the United States. In Task 4 are those projects that explicitly contribute to NOAA goals but fall outside the scope of Tasks 1, 2 and 3. The indirect cost rate for Task 3 is 40% and Task 4 is 52%. The different rates for these two tasks are in recognition of the direct funding support that CIMAS receives from the local NOAA laboratories under Task 1.
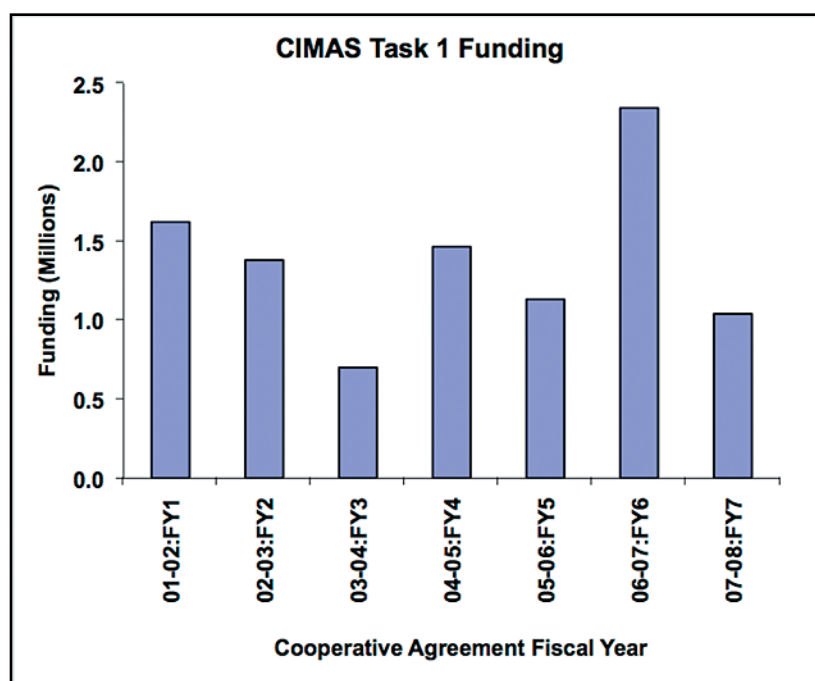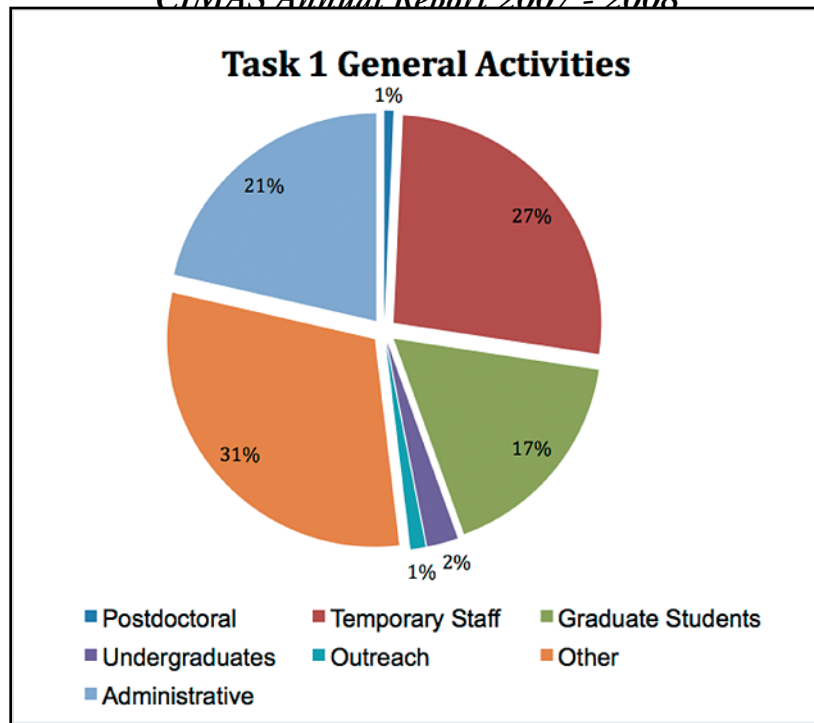

Figure 3: History of Task 1 Funding

The history of Task 1 funding under the CA is presented in Figure 3. Funding in Y7 is down sharply from Y6, which was anomalously high. The relatively low value in Y7 is due to a number of factors. One is related to the policy change initiated in Y5 with regard to Postdoctoral Fellows; these were previously funded under Task 1 but they are now being employed under Task 2.

The distribution of NOAA Task 1 expenditures is shown in Figure 4. The total NOAA-supported Task 1 budget is $1.04M. The category "Administrative Staff" covers a portion of the salary of CIMAS staff including the Director and Associate Director. In addition, the University of Miami contribution for Y7 was $0.241M to Task I.

The category "Other" (31%) includes: travel for Postdoctoral Fellows, students, visiting scientists and temporary staff in support of research activities; relocation expenses for new hires including research personnel on Task II; new hire expenses (drug tests, background searches); advertisements for new positions; visa costs; consulting agreements, other supplies (computer equipment, peripherals, etc.). Temporary Staff (27%) covers persons hired on a temporary basis to support research. The budget for Postdoctorals is very small (1%) because, as stated above, they are now funded through Task 2 except for a small carry-over of grandfathered personnel.

Task 1 General Activities

Figure 4: Distribution of Task 1 Funding

The history of funding under Task 2, which supports CIMAS employees who work closely with NOAA scientists (i.e., the Research Associate and Research Scientist program) is shown in Figure 5. In Y7, Task 2 totaled $4.15M, essentially unchanged from Y6. There has been significant growth in funding for Task 2 over the CA, essentially tripling from Y1 to Y7. In contrast, as we show below, the rest of the research budget (Tasks 3 and 4) has been relatively stable. The growth in Task 2 accounts for much of the sharp growth in the overall budget of CIMAS.
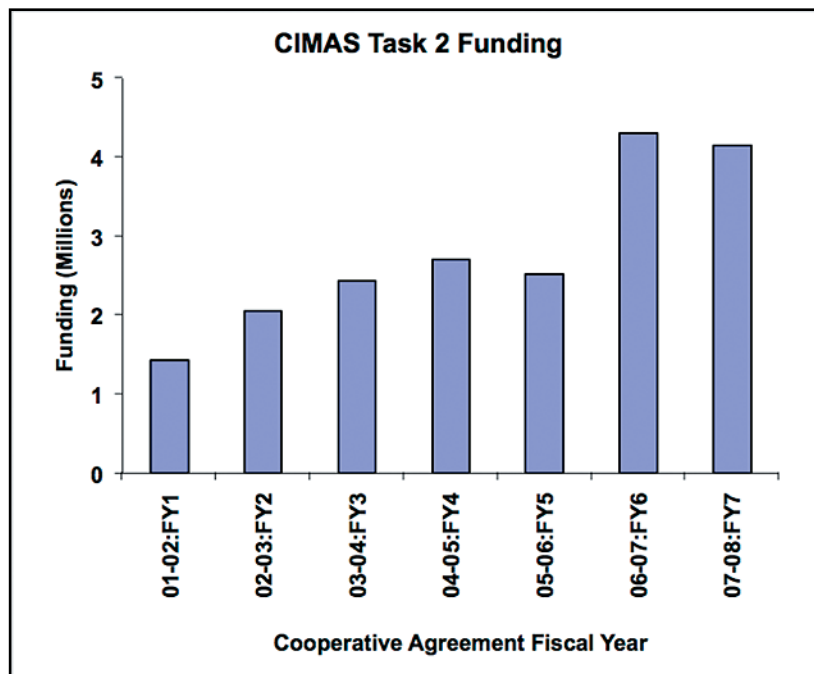
*Figure 5: History of Task 2 Funding over the Cooperative Agreement*

The history of NOAA-supported research funding (Task 3 and Task 4 combined) is shown in Figure 6. This has remained relatively unchanged over the past five years of the Cooperative Agreement with an annual average of $4.0M. Nonetheless, this rate is substantially greater than that in the first two years which averaged $2.5M and than that under the previous CA.

Funding By Theme

Figure 7 shows the percentage of Task 3 and Task 4 funding that is expended in each of the CIMAS Themes. Theme 6, Integrated Ocean Observations, accounts for the largest portion of the funding - 33%. The least funding were in Theme 2, Fisheries Dynamics - 9%. Funding in the remaining four themes was roughly comparable, ranging from 12 to 15%.

The distribution of funding by Theme as shown in Figure 7 is based on the scientists' own assessments of the major focus of their research. Some research could reasonably be assigned to more than one Theme, e.g., much research under Theme 1: Climate Variability also could be assigned to Theme 5: Air-Sea Interactions and Exchanges. Indeed, many scientists reported more than one Theme for their research.

Note that this figure only shows the distribution of research funding under Theme 3 and Theme 4; it does not show the funding that supports Task 2 personnel doing research in the local NOAA laboratories in programs that fall under the six CIMAS Themes but which are budgeted directly by NOAA.
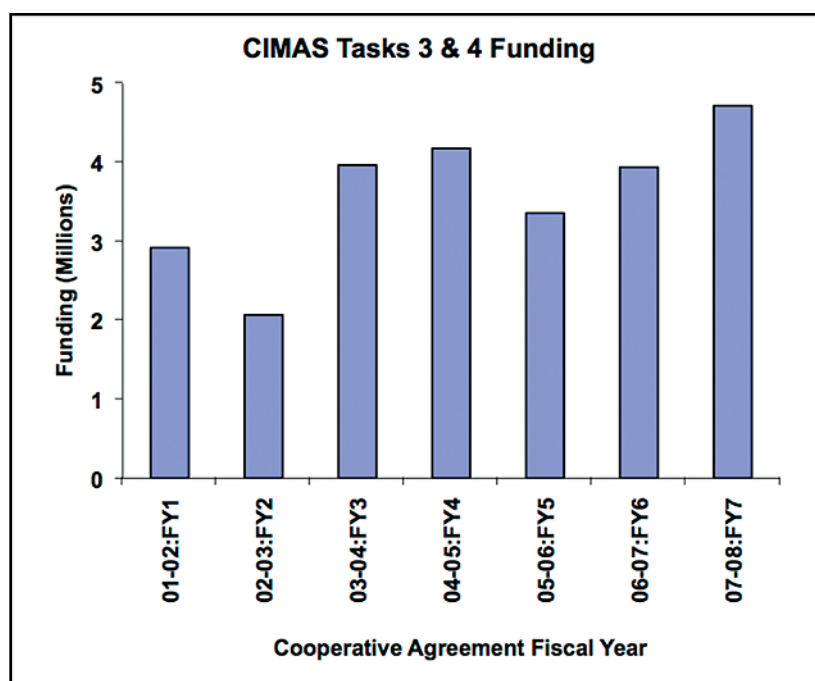
Figure 6: CIMAS Research Funding (Task 3 and Task 4)
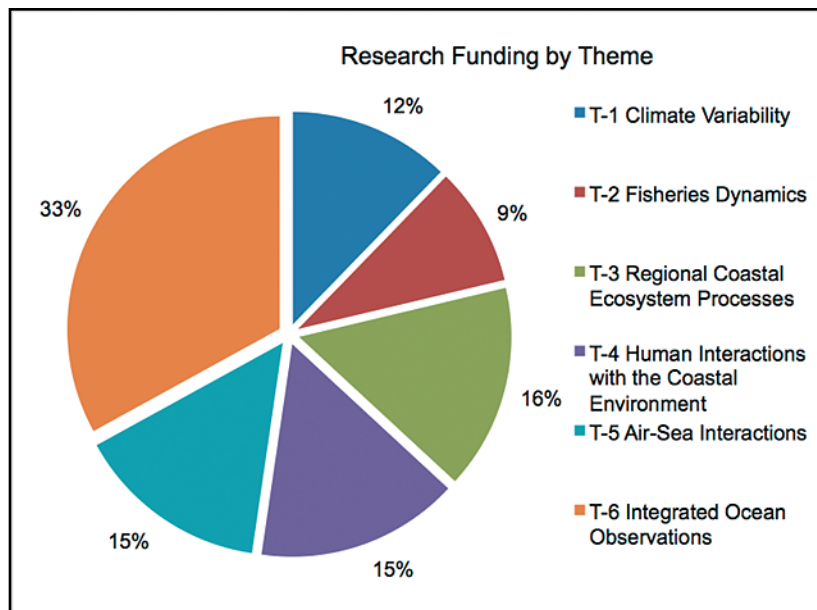
Figure 7: Percentage of Task 3 and Task 4 (Research) funding in the CIMAS Themes

Conclusion

In this report we have detailed only research and education expenditures made through CIMAS. We emphasize once again that there are a substantial number of research programs carried out by RSMAS faculty that are complementary to the NOAA-supported CIMAS-linked programs but supported by other agencies and some supported by NOAA outside CIMAS. The grants obtained by these faculty are credited not to CIMAS but to the academic division in which they reside. Consequently there is considerable leveraging of NOAA funds across the campus which does not appear in the present accounting. An example of such an activity 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 NOAA's 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. The concept of the CIE was developed in CIMAS and it was initially funded through the CIMAS CA. For legal reasons the CIE was removed from the CA and since 2002 it has been funded by a separate contract with NOAA/NMFS. It still resides within CIMAS and is administered by a CIMAS Fellow. Since 2002, the CIE has expended $2,978,373. These expenditures do not appear in any CIMAS budget data.

V. RESEARCH THEMES OVERVIEW

Organization of CIMAS 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. The Themes and their 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 in climate research 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 ranges includes: involvement in process-oriented field programs involving ships, aircraft, and satellite systems; making climate-oriented long-term observations of oceanic transport processes; the systematic analysis of environmental data sets; modeling of weather and climate. These efforts 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 with a strong focus on tropical cyclones and hurricanes.

Because climate and climate variability are fundamentally global-scale phenomena, CIMAS research activities often involve 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.*

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 a major factor. 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 the 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 fishery 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.*

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 in the past decade has already allocated over ten 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.*
- *Special integrated studies of critically-stressed or keystone components of the South Florida coastal ecosystem.*
- *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.*

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 Mission Strategies dealing with 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. Studies of these human 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. 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 -*** 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*** - to quantify the impact of human exploitation of fisheries and marine

ecosystems so that these can be better managed.

- *Urbanization of the Coastal Zone* - to assess coastal zone impacts and to identify the dominant ecological risks including habitat alteration, hydrological alteration, and the over-exploitation of natural resources. Half the nation's population lives on coastal lands which comprise only 17% of the total land area. This research 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. Moreover the oceanic biogeochemical cycles can play a role in climate forcing: e.g., CO_2, halocarbons, aerosols. Air-sea exchange processes control the amount of these materials transported to the atmosphere and thus the degree to which these species can affect radiative processes and climate.

In CIMAS research on air-sea interactions focuses on processes in the atmosphere and the surface waters of the ocean including the oceanic mixed layer; this interaction is critically important in driving hurricane intensity changes. Our research also extends into maritime cloud climatology and to maritime weather system prediction including tropical cyclones 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 test physical-chemical models of the atmosphere and ocean and the processes that couple them.

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. Remote sensing techniques are playing an increasing role in studies of the marine boundary layer and the upper ocean including the interface.

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.**

The development of integrated observing systems such as the Integrated Ocean Observing System (IOOS) 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 is to develop the criteria for the acquisition of oceanic data needed to determine and document the role of the ocean in climate change and to monitor these changes.

Observational evidence indicates that the coupled air-sea system is undergoing dramatic changes - for example, increasing surface temperatures and the melting of the Arctic and Greenland ice caps. 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 and space-scales of the factors that control Atlantic basin-scale and coastal ocean circulation. This requires continued observations in the Atlantic open ocean and coastal ocean and atmosphere coupled with numerical modeling.

The optimal observing 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 emergency and ecosystem-based management with physical transport estimates; and it must provide initialization, validation, and verification data for climate and ocean circulation forecast models. The design of ocean observing systems depends on the scale of the domain which ranges from global to regional to coastal, the processes of interest, and the application of the data that is to be obtained. The current direction of design studies is to carry out Observing System Simulation Experiments - OSSEs which can yield the optimal mix of *in situ* (Eulerian and Lagrangian) sensors, satellites, and other remote sensing observations. CIMAS and RSMAS scientists are currently involved in the development of OSSEs in conjunction with scientists in AOML.

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 REPORTS

THEME 1: CLIMATE VARIABILITY

Climate Noise and Climate Predictability
B. Kirtman (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To understanding of how *noise* due to internal oceanic and atmospheric dynamics impacts climate variability and predictability on interannual to decadal time scales.
Strategy: To develop new technique for controlling the amplitude of the atmospheric stochastic forcing within the context of state-of-the-art coupled general circulation models (CGCM).

CIMAS Research Theme:
Theme 1: Climate Variability

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

NOAA Funding Unit: CPO   **NOAA Technical Contact:** James Todd

Research Summary:
Impact of Internal Atmospheric Dynamics and Air-Sea Interactions in the Tropical Intraseasonal Oscillation
The relative roles of coupled air-sea feedbacks and internal atmospheric dynamics in tropical intraseasonal variability were investigated using an interactive ensemble coupling technique applied to the NCEP climate forecast system. Results demonstrate that while the overall intraseasonal and interannual variability of sea surface temperature is reduced in the interactive ensemble simulation, the variability of precipitation is increased on both timescales. Additionally, the simulation of the tropical intraseasonal oscillation (TISO) in the interactive ensemble simulation has characteristics of both a fully coupled and an uncoupled simulation of the TISO using the same model. The interactive ensemble simulation demonstrates that both air-sea feedbacks and internal atmospheric dynamics are involved in the simulation of the TISO in this model. These results are reported in Pegion and Kirtman (2007b).

**Noise in the Initial Condition vs. Noise as the Forecast Evolves**

Stan and Kirtman (2008) have performed a set of identical twin ENSO experiments that are specifically designed to examine how uncertainty in the oceanic initial condition versus uncertainty (or internal atmospheric noise) as the forecast evolves limits ENSO predictability. These experiments were performed with the NOAA CFS model using the operational coupling strategy and the interactive ensemble coupling strategy. Based on these experiments Stan and Kirtman (2008) conclude that:

1. The idealized limit of ENSO predictability is considerably longer than suggested by the actual forecast error.
2. Excessive noise as the forecast evolves is a significant contributor to the loss of predictability at all lead times; but,
3. uncertainty in the ocean's initial condition leads to rapid initial error growth that exceeds the growth due to excessive noise in the evolution.

Kallummal and Kirtman (2008) have also examined how noise impacts ENSO predictability within the context of the interactive ensemble and theoretically motivated linear models.

Interactive Ensemble Version of CCSM

We have applied the interactive ensemble coupling strategy (Kirtman and Shukla 2002; Kirtman et al. 2005) in a preliminary
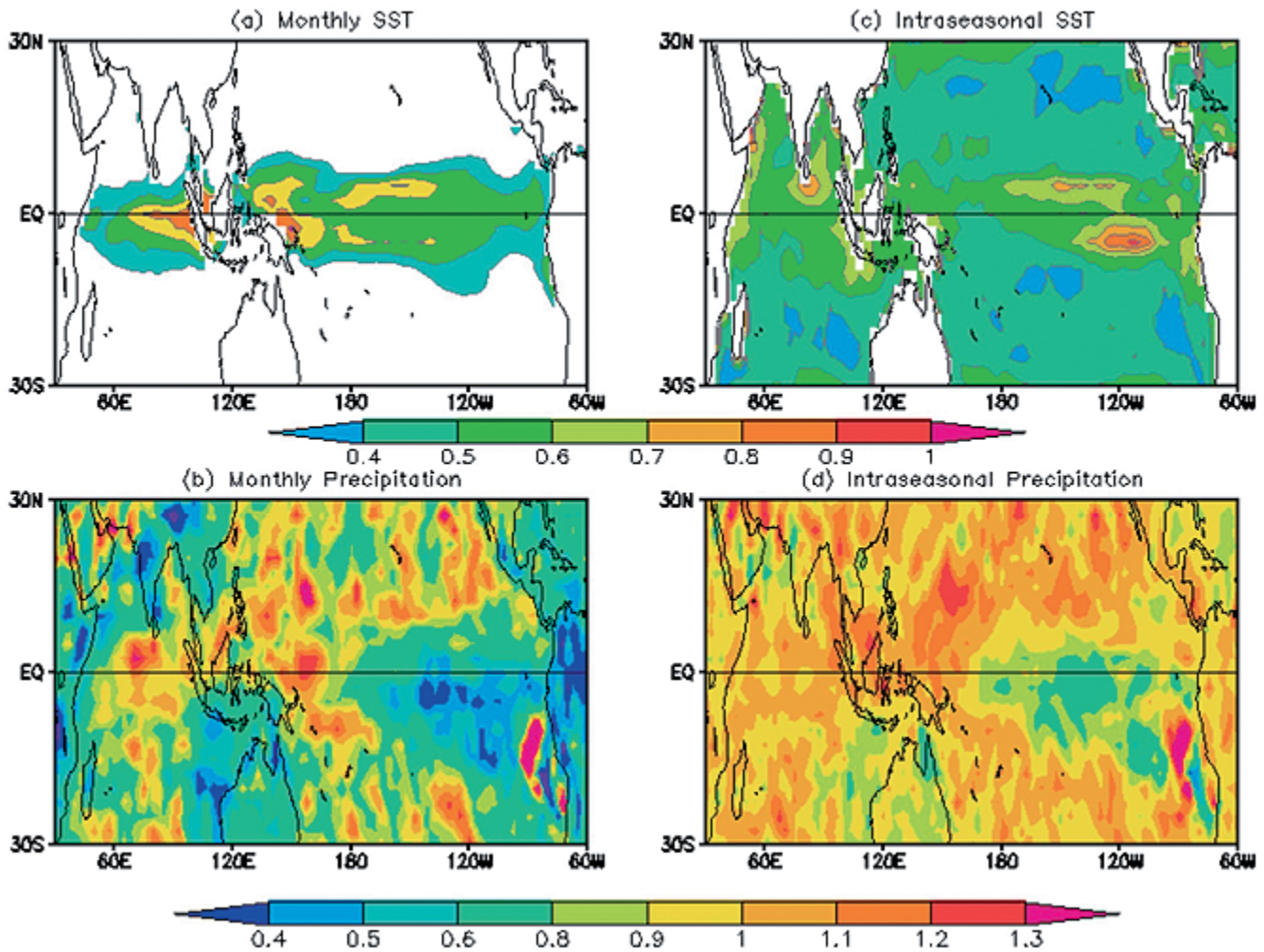

Figure 1: Ratio of the variance of the interactive ensemble simulation to the coupled control simulation for (a) monthly SST and (b) precipitation and for (c) intraseasonal (30-100 day) SST and (d) precipitation.

assessment of how the atmospheric noise reduction associated with the interactive ensemble impacts the ENSO variability

(Figure 2). Here we have plotted equatorial Pacific SST anomaly.   Overall there is only a modest reduction of the ENSO amplitude compared to the standard versions of CCSM3.0. This suggests that a Markov model with additive noise cannot completely explain the behavior of ENSO in this model. The most interesting aspect of this result is the fact that the low frequency (i.e., decadal) component of the tropical Pacific variability is amplified relative to the ENSO component. This can be easily seen by noting the distinct active and inactive periods. This large amplitude modulation is not detected in the control version of CCSM.

Research Performance Measure:
We have met our objectives: we developed interactive ensemble versions of the NOAA Climate forecast system (CFS) and the NCAR Community Climate System Model (CCSM); we published several papers documenting the impact of climate noise on ENSO predictability and prediction skill, intra-seasonal variability and decadal modulation of ENSO; we quantified the limit of ENSO prediction skill due to uncertainty as the forecast evolves versus uncertainty in the initial condition.
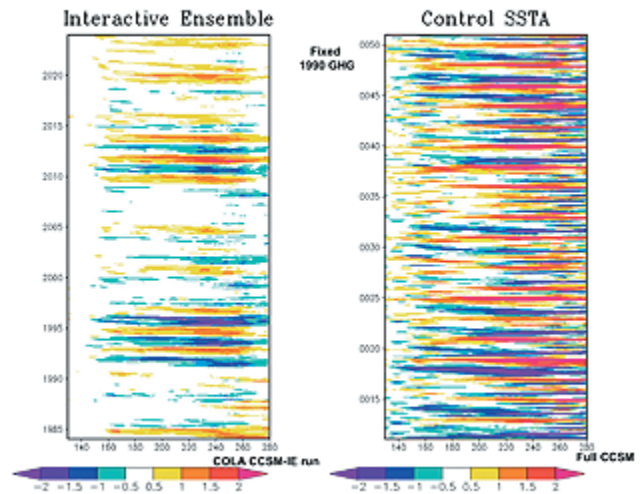
Figure 2: Time-longitude cross-section of equatorial Pacific SSTA from the (left panel) interactive ensemble version of CCSM and (right panel) the control version of CCSM.

Past and Future North American Drought

R. Burgman and A. Clement (UM/RSMAS); R. Seager (LDEO, Columbia University)

Long Term Research Objectives and Strategy to Achieve Theme:

Objectives: To understand the role of tropical Pacific SST's in forcing persistent North American drought in the past, present, and future.

Strategy: To use paleo-proxy data from the equatorial central Pacific Ocean to created SST boundary conditions of the tropical Pacific for extended periods over the past 1000 years and to use these to force the NCAR AGCM (CAM3) and analyze North American/ global hydroclimate. To analyze AR4 coupled model output to understand the role of tropical Pacific SST's in North American drought in state of the art coupled models.

CIMAS Research Theme:

Theme 1: Climate Variability (*Primary*)
Theme 2: Air-Sea Interactions and Exchanges (*Secondary*)

Link to NOAA Strategic Goals:

Goal 3: Serve Society's Needs for Weather and Water Information

NOAA Funding Unit: CPO   **NOAA Technical Contact:** James Todd

Research Summary:

Recent research has shown that low frequency changes in tropical Pacific SSTs can influence persistent drought in North America and other regions around the globe by influencing the large-scale atmospheric circulation. Figure 1 shows this pattern and the atmospheric response for the most recent inter-decadal climate shift. Paleo-proxy records of tropical Pacific SST's and global hydroclimate indicate that this relationship may have lead to extended periods of severe drought in
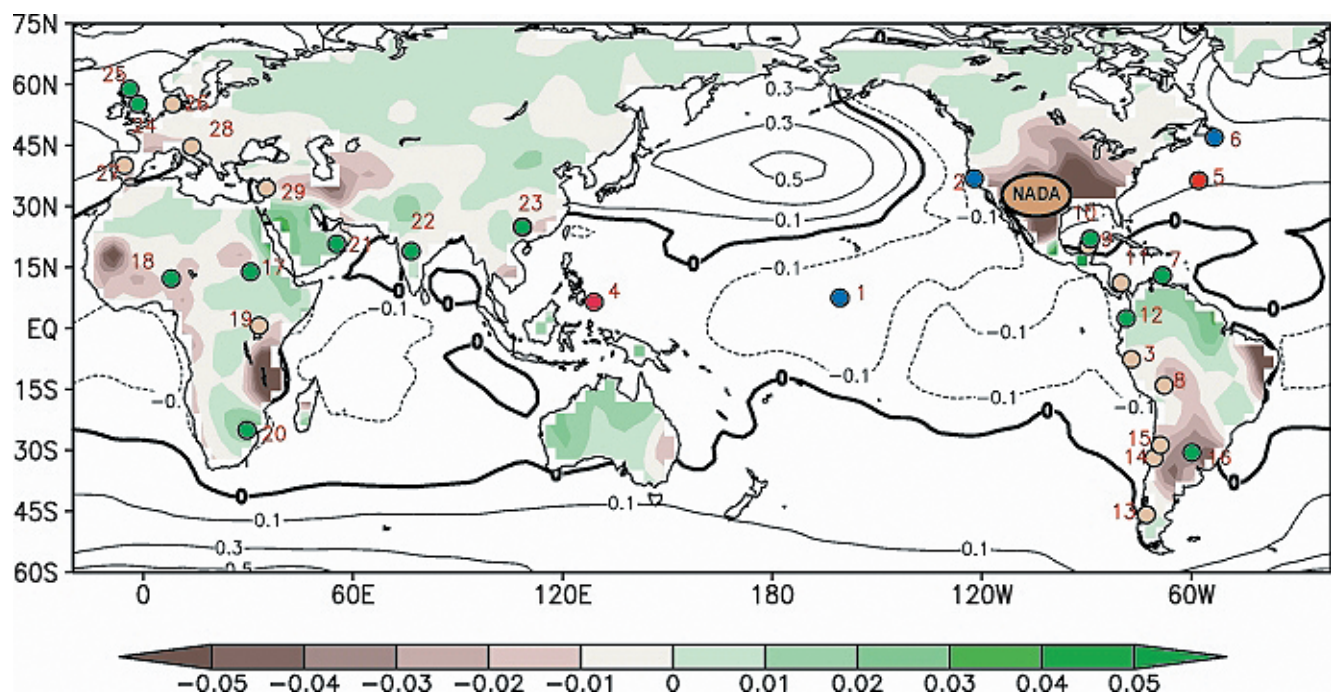
Figure 1: Spatial patterns generated by regressing the global (a) SST field upon a time series of Pacific Decadal variability [not shown]. Contour interval 0.1_C (STDV)_1. (b) As in Figure 2a for SLP. Contour interval 0.1mb (STDV)_1. (c) GPCP precipitation. Contour interval 0.2 mm/day (STDV)_1. (d) SSM/I wind speed. Contour interval 0.1ms_1 (STDV)_1. (e) SSM/I atmospheric WV. Contour interval 0.4mm (STDV)_1. (f) HIRS outgoing longwave radiation. Contour interval 1Wm_2 (STDV)_1. (g) ICOADS cloud amount. Contour interval 0.05 oktas (STDV)_1. (h) As in Figure 2g for period January 1970 to December 2003.

North America in the past. The goal of our research was to examine this relationship between tropical Pacific SSTs and hydroclimate in the context of observations and state of the art climate models.

To understand the role of tropical Pacific SST's on medieval hydroclimate we created tropical Pacific SST boundary conditions for several periods over the past 1000 years and used these to force ensembles of atmospheric general circulation models. We compared model results with paleo-proxy data from North America and other regions around the globe. Figure 2 shows the difference between the ensemble mean SST (contours) and soil moisture (shaded) from the paleo simulation forced by tropical Pacific SST's derived from proxy records and a simulation forced by global estimates of SST for the past 150 years. Results show dryer conditions in North America associated with cooler tropical Pacific SSTs.

It is a more difficult undertaking to understand the relationship between low frequency changes tropical Pacific SST and climate variability in state-of-the-art coupled models because of systematic differences in the model components among the models in the AR4 simulations. To undertake this study in a more consistent manner we have developed a new coupled modeling strategy where we "intervene" in the coupling process and stimulate the model atmosphere with the PDV forcing pattern derived from observations and allow the coupled model to adjust to a new equilibrium state.

Research Performance Measure:
All analysis of observed atmospheric response to PDV were completed and resulted in one publication. All Paleo model simulations have been completed resulting in two publications. All analysis of AR4 model simulations are complete, leading to a new coupled modeling strategy with one publication currently submitted.
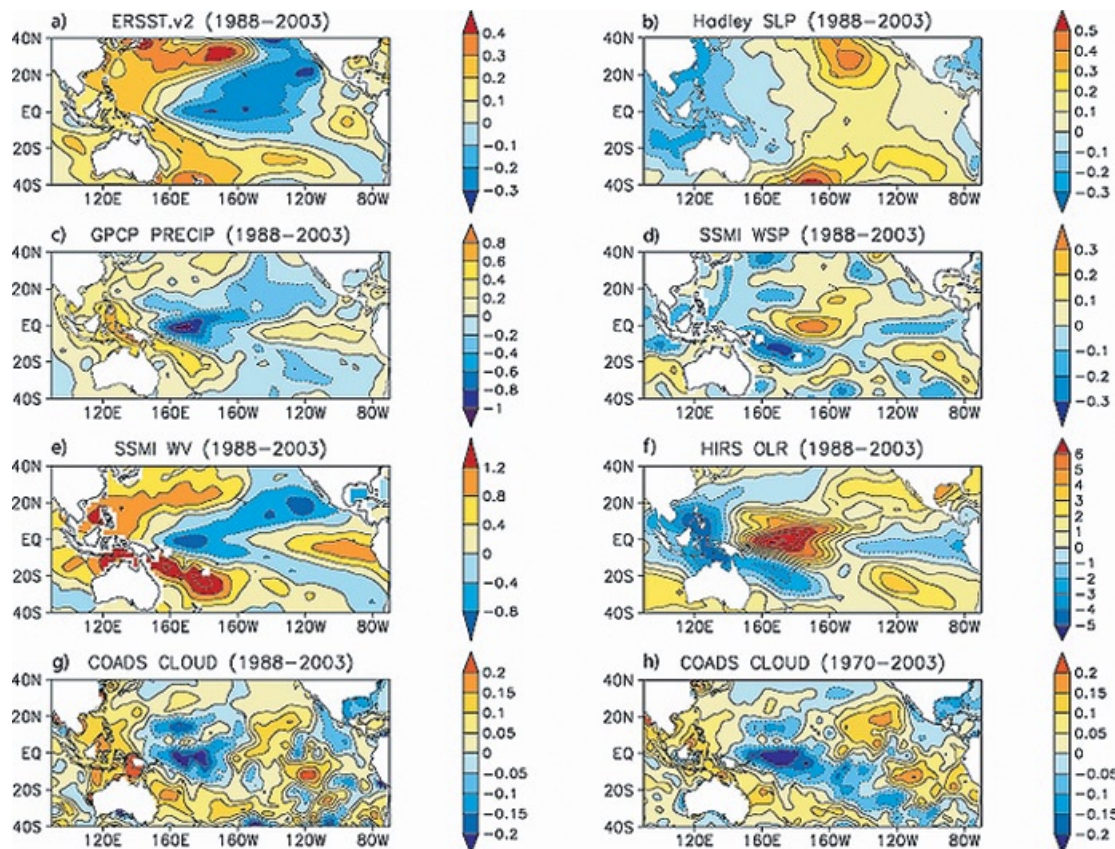
Figure 2: Long term mean differences of vertically integrated soil wetness (shaded) and SST (contour, 0.10 C) between Pacific Ocean Global Atmosphere with 1 layer ocean outside of tropical Pacific (1320-1462AD) and Global Ocean Global Atmosphere simulation (1856-2005 A.D.) overlaid with records of medieval hydroclimate and SST. Four SST records are plotted as red or blue dots depending on whether they show the medieval period to be warm or cold relative to succeeding centuries. Green and brown dots over land indicate a proxy record of wet or dry medieval hydroclimate. The numbers cross-reference the records to the references in the text and Appendix 1. The medieval period is taken to be, approximately, from 800 A.D. to 1400 (Adapted from Seager et al., 2007).

Intra-Americas Sea Climate Variability During Boreal Spring and Summer

E. Muñoz (UM/CIMAS); C. Wang and D. Enfield (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To understand the forcing mechanisms of Intra-Americas Sea (IAS) climate variability. To acquire prognostic understanding of the IAS springtime anomalies which extend to summertime.
Strategy: To use available gridded observational datasets and reanalyses and to simulate the IAS variability with numerical models.

CIMAS Research Theme:
Theme 1: Climate Variability (*Primary*)
Theme 5: Air-Sea Interactions and Exchanges (*Secondary*)

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

NOAA Funding Unit: AOML/PHOD
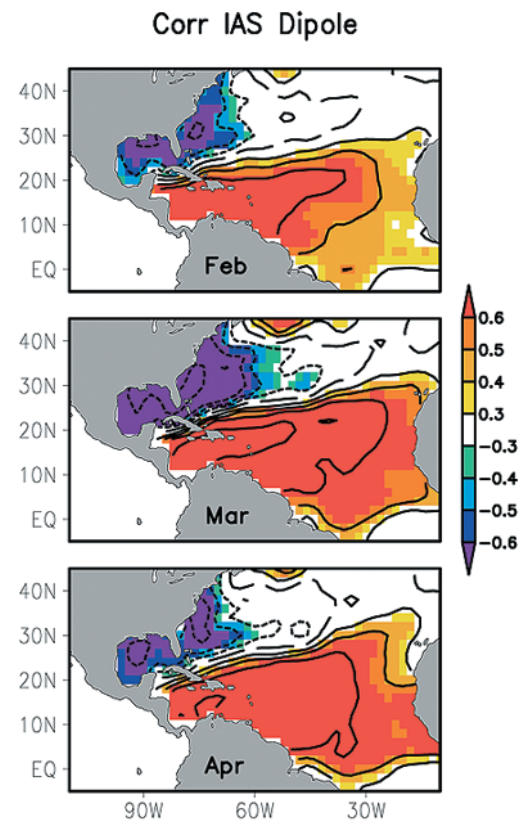**NOAA Technical Contact:** Chunzai Wang

Research Summary:

The influence of teleconnections on the Intra-Americas Sea (IAS; Gulf of Mexico and Caribbean Sea) has been mostly analyzed from the perspective of the El Niño Southern Oscillation (ENSO) on the Caribbean Sea (the latter being an extension of the tropical North Atlantic). This emphasis has overlooked: 1) the influence of other teleconnections on the IAS and 2) which of these teleconnections affect the Gulf of Mexico climate variability. We analyze the different fingerprints that the major teleconnection patterns have on the IAS during boreal spring. Our approach is to utilize available gridded data sets that are based on observations (such as reanalyses and COADS data) to accomplish our objective. We find that the Pacific teleconnection patterns that influence the IAS do so by affecting the Gulf of Mexico in an opposite manner to the Caribbean Sea. For example, during a warm ENSO event the Caribbean warms, whereas concurrently the Gulf of Mexico cools.

The influence of the Pacific Decadal Oscillation (PDO) on the IAS is similar to that of the Pacific North American Pattern (PNA). The North Atlantic Oscillation (NAO) is related to a lesser degree than the Pacific teleconnection patterns. The dipole forms mostly in response to changes in the air-sea heat fluxes. In the Gulf of Mexico the dominant mechanisms are the air-sea differences in humidity and temperature. The changes in shortwave radiation also contribute to the dipole of net air-sea heat flux. The changes in shortwave radiation are linked, in part to increased cloudiness triggered by the air-sea differences in humidity, and also by the changes in the convection cell that connects the Amazon basin to the IAS. This study contributes to a greater understanding of how the different Pacific and Atlantic teleconnections affect the Intra-Americas Sea.

Figure 1: Correlation between IAS SSTA dipole index in spring and SSTAs for the North Atlantic. The Pacific region has been masked. Contour interval is 0.2 starting at ±0.3.

Research Performance Measure:

We have accomplished our goal: we analyzed and characterized the relation of different teleconnections to the Intra-Americas Sea. The next steps are to simulate (via numerical models) the teleconnection influence on the IAS and perform further numerical experiments.

A Study of the MJO-ENSO Problem: Phase II

C. Zhang and A. Kapur (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To improve ENSO prediction by quantifying the contribution to ENSO from the MJO as a source of stochastic forcing and by understanding the mechanism for the MJO-ENSO relationship.
Strategy: To use numerical models to quantify effects of the MJO on ENSO and ENSO prediction.

CIMAS Research Theme:
Theme 1: Climate Variability

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

NOAA Funding Unit: CPO
NOAA Technical Contact: James Todd

Research Summary:
Both the El Niño – Southern Oscillation (ENSO) and the Madden–Julian Oscillation (MJO) have an impact on climate. In our research we seek to improve ENSO prediction by quantifying the contribution to ENSO from the MJO as a source of stochastic forcing and by understanding the mechanism for the MJO-ENSO relationship. The stochastic components of the surface wind were derived from both NCEP reanalysis and the Bureau of Meteorology Research Center (BMRC, Australia) atmospheric model – coupled (BAMC) simulations. The simulated stochastic winds by BAMC shows the main features of the observed winds, but there are also discrepancies. Both were then used in the Cane-Zebiak (CZ) model to simulate stochastically driven ENSO. Most interestingly, some ENSO warm events in the BAMC were reproduced in the CZ model regardless of its coupling strength. This evidently demonstrates that some ENSO warm events in BAMC were produced by stochastic forcing. It was found that ENSO driven by stochastic forcing from BAMC has an unrealistic seasonality. The lack of a seasonal cycle of the MJO in BAMC is proposed as a reason for this problem. We also explored the effect of multiplicative noise on ENSO through parameterizing the MJO under various SST influences. The results suggest that SST feedback to the MJO may introduce a new instability mechanism due to the coupling between stochastic forcing of the MJO and ENSO.

Research Performance Measure:
We are making satisfactory progress toward our goal of assessing the role of stochastic forcing in ENSO in coupled model BAMC.
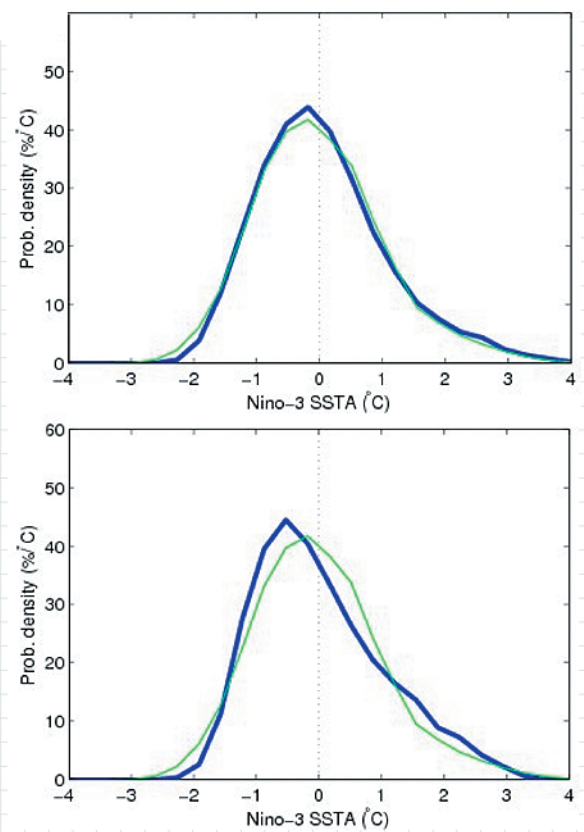
Figure 1: Probability distribution function (blue curve) of Nino-3 SSTA time series obtained from intermediate model driven by stochastic forcing derived from BMRC coupled model. Green curves are the PDF derived from BMRC coupled simulations. The x-axis is Nino-3 SSTA and y-axis is probability density (expressed in percentage). The coupling coefficients are 0.95 (slightly damped) in the upper panel and 1.15 (unstable) in the lower panel. This figure demonstrates that ENSO in the BAM coupled simulation can be better reproduced in the intermediate model with stochastic forcing when the coupled system is slightly stable and unstable.

Climate Impacts of the Western Hemisphere Warm Pool on the Americas

S.-K. Lee (UM/CIMAS); C. Wang and D. Enfield (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:

Objectives: To understand the climatic impacts (rainfall and Hurricanes) of Western Hemisphere warm pool on the Americas.

Strategy: To use both data and a model (NCAR Community Atmospheric Model: CAM3) to elucidate relationships.

CIMAS Research Theme:

Theme 1: Climate Variability (*Primary*)
Theme 5: Air-Sea Interactions and Exchanges (*Secondary*)

Link to NOAA Strategic Goals:

Goal 3: Serve Society's Needs for Weather and Water Information
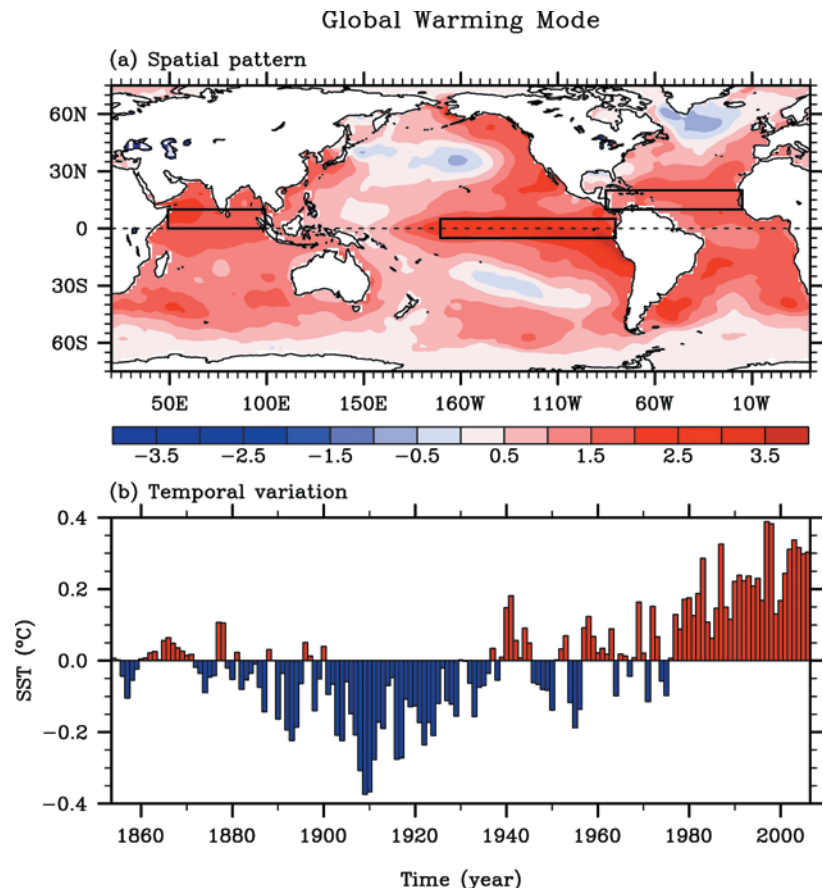
NOAA Funding Unit: AOML   **NOAA Technical Contact:** Chunzai Wang

Research Summary:

One of the tasks that we address is to understand the relationship between El Niño and tropical Atlantic (TNA) SST – specifically, why some El Niños have no impact on the regional SST while others do. To this end we carried out multiple sets of ensemble model experiments using the NCAR atmospheric general circulation model coupled to a slab mixed layer ocean model. We show that if an El Niño does not extend through the months of January, February and March, the atmospheric bridge connecting the tropical Pacific to the TNA is not persistent enough to force the TNA. To further our understanding of the linkage we also developed a simple atmospheric model of the local and teleconnection responses to tropical heating anomalies. We demonstrated the use of this minimal complexity model to describe both the local and remote stationary responses of the atmosphere to tropical heating.

We examined the role of the Atlantic Warm Pool (AWP) acting as a link between the Atlantic Multidecadal Oscillation (AMO) and Atlantic tropical cyclone activity. The multidecadal variability of Atlantic tropical cyclone activity is observed to relate to the AMO. In this study, we demonstrate that the influence of the AMO on Atlantic tropical cyclone activity operates through the mechanism of AWP-induced atmospheric changes.

Figure 1: The spatial pattern and temporal variation of global ocean warming.

We also examined the Tropical Atlantic decadal oscillation and its impact on the equatorial atmosphere-ocean dynamics. We carried out a model study using simple coupled atmosphere-ocean models to show that a strengthening (weakening) of the Atlantic SST dipole mode corresponds to a weakening (strengthening) of the equatorial Atlantic thermocline slope.

We also investigated the potential impact of global warming on landfalling hurricanes on the United States. We used observational data to show that global warming of the sea surface is associated with a secular increase of tropospheric vertical wind shear in the main development region for Atlantic hurricanes. The increased wind shear coincides with a weak but robust downward trend in U.S. landfalling hurricanes, a reliable measure of hurricanes over the long term.

Research Performance Measure:

We achieved our main objective: to investigate the impact of the AWP on the summer climate of the Western Hemisphere using the NCAR community atmospheric model and observational data. We also investigated other climate related links.
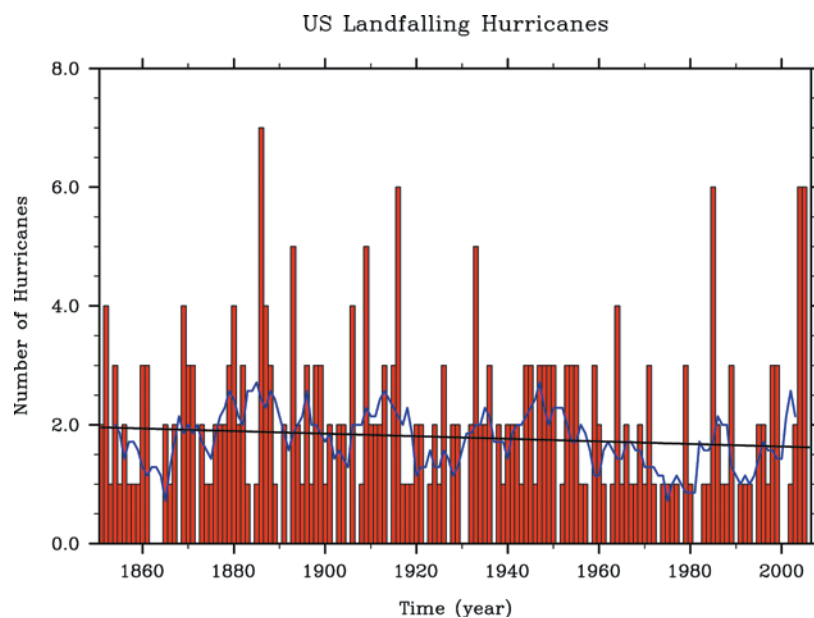
Figure 2: The number of U.S. landfalling hurricanes from 1851 to 2006. The black straight line is the linear trend that is fitted to the U.S. landfalling hurricane time series. The blue line is the seven-year running mean of U.S. landfalling hurricanes.

Assessment of Decadal Variability in the Tropical Radiation Budget

B.J. Soden (UM/RSMAS); D.L. Jackson (NOAA/CIRES)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To assess the decadal scale variability of the tropical radiation budget.
Strategy: To compare satellite observations with empirical analyses and climate model simulations to evaluate the veracity and cause of decadal variations in the net radiation at the top-of-the-atmosphere.

CIMAS Research Theme:
Theme 1: Climate Variability

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

NOAA Funding Unit: CPO/CCDD   **NOAA Technical Contact:** Chris Miller

Research Summary:
Currently there is a key disagreement between Global Climate Models (GCMs) and satellite observations regarding the decadal-scale variations in the Earth's radiation budget. Observations from the Earth Radiation Budget Experiment (ERBE) over the period 1984- 2001 indicate a decadal shift towards increased longwave emission and solar absorption over the tropics. At present no GCM can reproduce this shift (Wielicki et al., 2002). Current operational retrievals from TOVS conflict with the ERBE observations in that they reveal no such trend. However, the quality of the operational TOVS retrievals is suspect because these products were never intended for decadal-scale climate applications. Therefore it is unclear if the ERBE trend is real or not, and if it is real, whether it is associated with a trend in clouds or water vapor or both. However, this uncertainty does not stem from an inherent limitation in the data. The TOVS radiance record contains the necessary measurements to resolve this discrepancy, but they have not been analyzed in a sufficiently disciplined manner to enable the scientific community to assess their consistency with model projections or ERBE measurements.

Our research aims to fill this void by performing a detailed, radiance-based comparison of the reprocessed TOVS (level 1-b) archive with GCM simulations. The latest version of the GFDL GCM is forced with observed SSTs, trace gas concentrations, and aerosols during the period of satellite record (1978-2006). Output from the GCM is then used to simulate directly the corresponding TOVS spectral radiances which would be observed under the model-simulated conditions. The asynchronous sampling of each NOAA polar satellite is then exactly matched in the model, enabling us to emulate the drift in the satellite observation times on the operational radiance record. This provides, for the first time, a direct and consistent comparison between a GCM and TOVS satellite observations free of retrieval uncertainties and sampling biases. Such attention to detail is required in order to accurately asses the decadal variability in spectral radiances. If the decadal variations are substantiated, the analyses
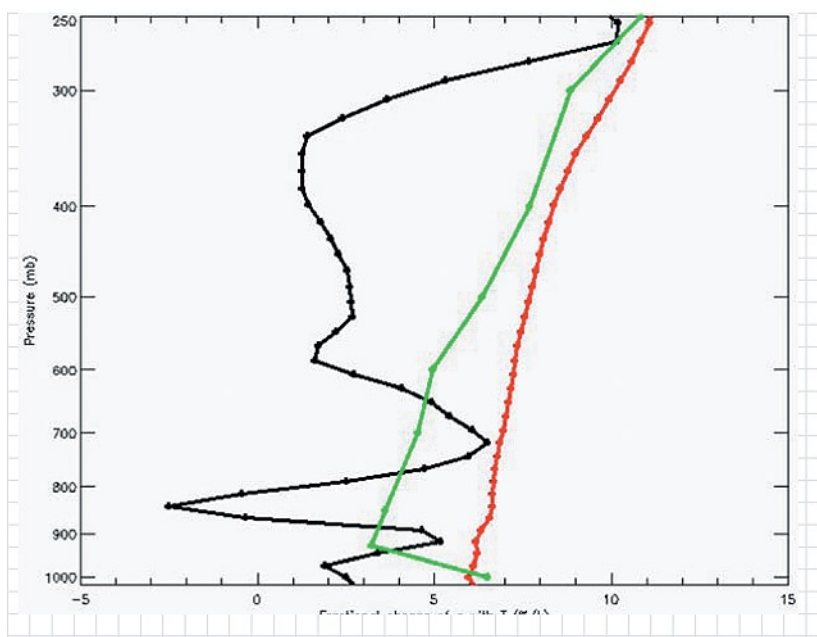
Figure 1: The vertical profile of the regression of fractional changes in specific humidity against the corresponding temperature change for tropical-mean interannual variations. The results are shown for the AIRS observations (black), GFDL GCM simulations (green) and a constant relative humidity constraint (red).

performed here will contain the spectral information necessary to shed light onto their cause (e.g., water vapor, clouds) as well as their implications for climate modeling. This is critical both to understanding the observed trends and to the evaluation (and improvement) of the model simulations. Without this analysis, the veracity of the decadal variations in the radiation budget and the credibility of climate model simulations on decadal time-scales will remain suspect.

Research Performance Measure:
The following research performance measures were accomplished on schedule: 1) Developed an intercalibrated and orbital-drift corrected set of HIRS radiances for 1979-2006. 2) Compared observed decadal trends in HIRS spectral radiances to that simulated from prescribed SST and coupled ocean atmosphere GCMs under natural and anthropogenic forcing scenarios. 3) Identified anthropogenic signatures in HIRS spectral radiance trends. 4) Submitted manuscripts documenting these results to *J. Climate*.

The Nutrient Measurement in Repeat Hydrography Program
N. Amornthammarong (UM/CIMAS); J.-Z. Zhang (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To measure changes in the storage and transport of chemical oceanographic parameters in the ocean system.
Strategy: To use an auto analyzer system to measure nutrients (Silicate, Ammonia, Nitrate, Nitrite and Phosphate) in seawaters collected during Repeat Hydrography Program cruises.

CIMAS Research Theme:
Theme 1: Climate Variability

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

**NOAA Funding Unit:** OAR/AOML   **NOAA Technical Contact:** Joel Levy

Research Summary:
The NOAA/NSF Repeat Hydrography Program is a collaboration between NOAA and NSF to study changes in storage and transport of climatically important parameters in response to natural and human activity. Data from the cruises will be compared to data from previous cruises and posted on the public data sites at the Carbon Dioxide Information Analysis Center (CDIAC) and the Scripps Institute of Oceanography. These data will lead to improved forecasting skill for the ocean response to global climate.

A hydrographic cruise (CLIVAR/Carbon P18) was carried out on the NOAA Ship Ronald H. Brown from December 2007 to February 2008 in the eastern Pacific. The cruise track shown in Figure 1 started from San Diego, CA on 15 December 2007. The ship anchored at Easter Island, Chile, 18-21 January 2008 for changing personnel between Leg 1 and Leg 2. The cruise ended in Punta Arenas, Chile, on 23 February 2008. Natchanon Amornthammarong participated on Leg 2 from Easter Island, Chile to Punta Arenas, Chile for nutrients measurement.

Research Performance Measure:
All objectives are being met on schedule.
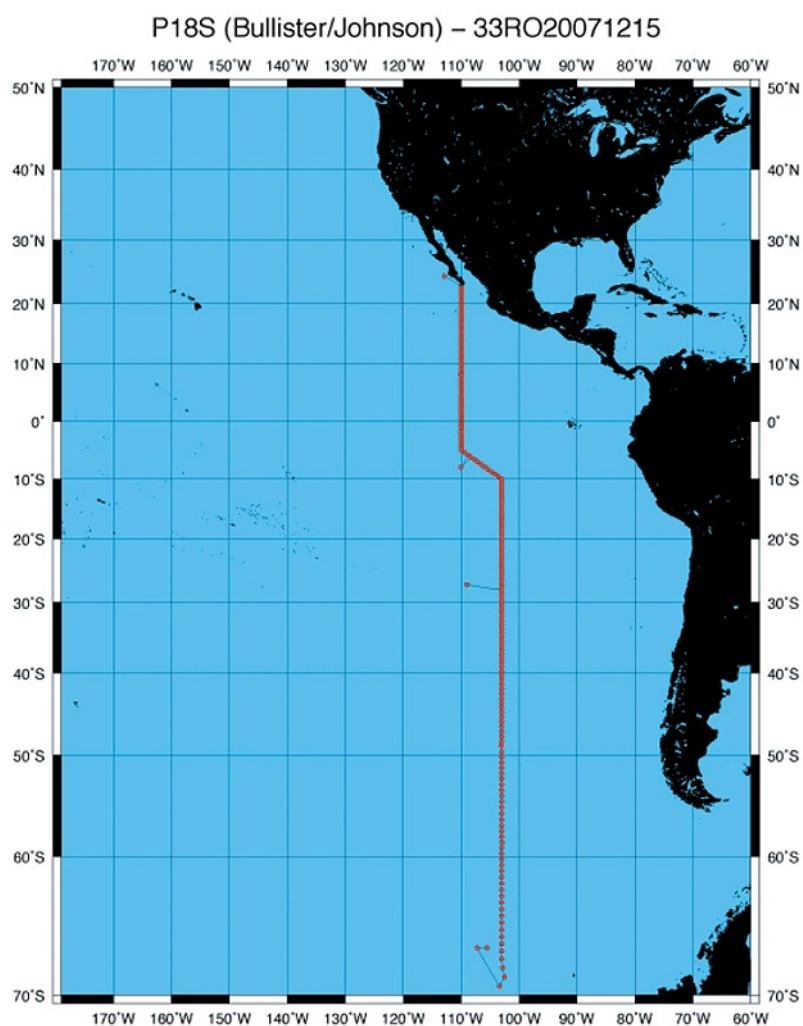
Figure 1: Cruise track beginning in San Diego, CA on 15 December 2007 and ending in Punta Arenas, Chile on 23 February 2008.

NAME (North American Monsoon Experiment Climate Process Team)
B. Mapes and P. Kelly (UM/RSMAS); J Schemm (NOAA/CPC)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To improve simulation and prediction of the North American Monsoon.
Strategy: To compare models and observations, identifying process deficiencies.

CIMAS Research Theme:
Theme 1: Climate Variability

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

NOAA Funding Unit: CPO/CPPA   **NOAA Technical Contact:** Jae Schemm

Research Summary:
The UM-CIMAS portion of this project involves NAMAP-2, a model intercomparison project informed by field observations from the NAME-2004 field campaign. Student Patrick Kelly studied land-atmosphere interactions in columnar datasets from field sites and models. Significant discrepancies were found, so models can be improved. In particular, he documented model process discrepancies including mean surface albedo, net radiation, and partitioning of energy flux into sensible and latent. These discrepancies were found to affect diurnal boundary layer evolution over the land in a way that parallels seasonal-mean model errors. This finding is important because it suggests that results from field programs of short duration can indeed address model errors on climate time scales. Results were disseminated both as a large Web atlas (of interest to particular model developers) as well as a journal article (in preparation) describing larger lessons and conclusions from the whole multi-model evaluation.

Research Performance Measure:
The project successfully linked processes to seasonal model simulations, as proposed.

This Table shows a summary of findings about model land processes in the NAM area.

Model	Albedo	Incoming SW	Seasonal Net Rad.	EF-rain relationship	Diurnal Thickness	Seasonal High Range
CAM-N	Little too high	Too much	Too much, largest bias	Very sensitive	Too high	Much too large
CFS	Too high	Too much	Too much	Moderately sensitive	Too high	Too large
GFS	Too high	A little too much	Closest to obs., but too much	Insensitive	Too high	Too large
RSM	Little too high	Too little	Too much	Insensitive	Too high	Too large
NARR	Much too high	Too much	Closest to obs., but too much	Insensitive	Too high	Closest to obs.

THEME 2: FISHERIES DYNAMICS

Investigation of the Movements of Adult Billfish in Potential Spawning Areas

R.K. Cowen, J.P. Hoolihan and J. Luo (UM/RSMAS); E.D. Prince, D. Snodgrass
and Eric Orbesen (NOAA/SEFSC); J.E. Serafy (NOAA/SEFSC and UM/RSMAS)
Dr. Phil Goodyear (Contractor, Niceville, FL); D. Schultz (UM/Medical School)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To characterize the horizontal and vertical movements of Istiophorid billfish and other pelagic fishes in potential spawning areas in a large marine ecosystem context.

Strategy: To use electronic tags, plankton nets, and biological samples to describe habitat utilization and spawning state; to describe effective depths of pelagic long-line gear using electronic monitors and to relate the distribution to oceanographic information.

CIMAS Research Theme:

Theme 2: Fisheries Dynamics

Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: NMFS/SEFSC   **NOAA Technical Contact:** Eric Prince

Research Summary:

Over this last year, we used a combination of recreational and commercial fishing vessels to:

1. Catch pelagic fish caught by pelagic long-lines.
2. Attached pop-up satellite archival technology (PSAT) sensors to them, and
3. Re-released them, allowing us to record their (horizontal and vertical) movements for periods up to 120 days.

A total of over 300 fish were implanted with PSATs and about 78% of the deployed PSATs reported via the Argos satellite system. The data is currently undergoing quality control and analysis. In addition, we recovered 18 PSAT tags that had

previously transmitted a data summary through the Argos Satellite System. As PSATs have non-volatile memory, these tags produce large volumes of extremely high resolution data that is now being carefully analyzed and compared to the corresponding data summaries.

During April 2005, a pelagic long-line research cruise was conducted in the Gulf of Mexico. Forty-three instrumented long-line sets were deployed from the NOAA research vessel Oregon II (i.e. hook strike timers and time-depth recorders on every hook) to assess gear behavior under various oceanographic conditions. Hook time-at-depth and water temperature data were recorded.
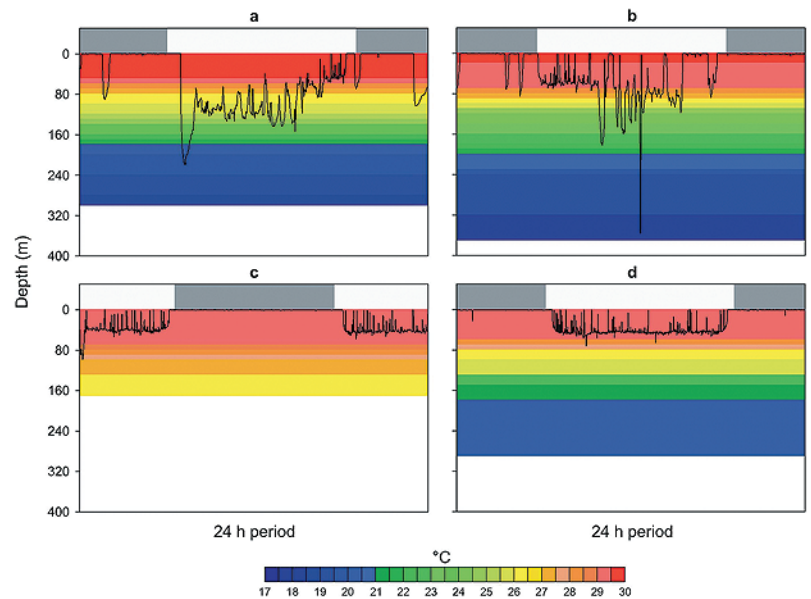
Comparable data is being collected in the N. Atlantic and Gulf of Mexico through the Cooperative Research Program (CRP) employing commercial long-line vessels by equipping fishing gear monitoring electronics (i.e. TDRs and hook strike timers) and experimental hook types to assess impacts on catch composition, catch rates and fish condition. These data are being analyzed to characterize gear movement and hook distribution in the water column and, ultimately, to determine

Figure 1: Excerpt from a time series (12 October–20 November 2003) of temperature and depth measurements by a PSAT 27825 affixed to a blue marlin. The shaded/white area above the zero depth value on the y-axis denotes dark and daylight periods respectively. Excerpts from the full data set illustrate (a) the deepest dive (340 m) measured; (b) quiescent (dormant) activity during nocturnal period; and, (c) restricted daytime diving activity. From Goodyear *et al.* (in press).

degree of overlap with pelagic animal habitat. Preliminary results indicate that hooks on long-line gear generally fish shallower than predicted by presently used depth equations (see Figure 1).

Marlin and sailfish vertical habitat use data in the Western and Eastern Atlantic sectors will contribute to the second of a series of papers on hypoxia-based habitat compression. This will provide a mechanistic basis for employing habitat standardization techniques in analyzing Atlantic long-line catch rates. Last, preliminary white marlin seasonal migration studies have been made and will be continued in the coming year.

The numerous peer reviewed publications that have resulted from this project can be found at
 http://www.sefsc.noaa.gov/fisheriesbiology.jsp.

Research Performance Measure:
All objectives are being met on schedule: We obtained a high recovery rate for data collected by popup satellite tags indicates that fish tagging protocols and deployment durations are appropriate. We successfully acquired high resolution data on pelagic long-line gear "behavior" and the effects of gear modifications on animal interactions with pelagic long-line fishing gear. We submitted a manuscript authored by Rice et al. entitled "Predicting Hook Depths Using Catenary Geometry for Shallow Experimental Pelagic Long-line Fishing in the Windward Passage in 2003" has been accepted in the *N. American J. Fisheries Management.* The editors are featuring this paper in the AFS series *Fisheries.*

Monitoring Coral Reef Fish Populations in the Florida Keys

J.S. Ault and S.G. Smith (UM/RSMAS); J.A. Bohnsack (NOAA/NMFS)

Long Term Research Objectives and Strategy to Achieve Theme:

Objective: To provide a comprehensive quantitative evaluation of trends in the Florida Keys coral reef ecosystem, in particular the open and "no-take" zones of the Florida Keys National Marine Sanctuary (FKNMS -- Sanctuary Preservation Areas SPAS; Tortugas Ecological Reserves TERs) and Dry Tortugas National Park (DTNP -- Research Natural Area RNA).

Strategy: To carry out regional multispecies reef fish assessments, map coral reef habitats and to conduct spatially-based monitoring of coral reef fish composition, occurrence, abundance, and size structure on the Florida Keys reef tract. To use these data to assess population changes, ontogenetic habitat associations, and ecosystem responses to fishing, recreational use, pollution, MPA zoning and, eventually, Everglades restoration.

CIMAS Research Themes:

Theme 2: Fisheries Dynamics (*Primary*)
Theme 3: Regional Coastal Ecosystem Processes (*Secondary*)

Link to NOAA Strategic Plan Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: SEFSC   **NOAA Technical Contact:** James A. Bohnsack

Research Summary:

The primary research emphasis has been upon quantifying effectiveness and impact of no-take marine reserves and other resource management measures taken by Biscayne National Park, the FKNMS, and DTNP to meet their living marine resource management goals. No-take marine reserves (NTMRs) in the National Marine Sanctuary (FKNMS) and Dry Tortugas National Park of the Florida Keys 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 approximately 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

Figure 1: Jerald Ault of the University of Miami measures a red grouper as part of a 2-day study of marine life in the Florida Keys.

Ecological Reserves, 206 and 312 km^2, are were added in 2001 west of the Tortugas, Florida. The NPS Service implemented a 100 km^2 Research Natural Area (RNA) in the western half of Dry Tortugas National Park in January 2007.

We regularly monitor and evaluate the performance of the SPAs and TERS in the FKNMS. Although still early in the recovery process, our results for the Dry Tortugas and Florida Keys are encouraging and suggest that NTMRs in conjunction with traditional management, can potentially help rebuild sustainable fisheries while protecting the Florida coral reef ecosystem. This is a win-win scenario; good for the fish, the ecosystem, the fishermen, and for Florida's economy!

In late Spring 2008, a team of 38 research divers from the University of Miami (UM) Rosenstiel School of Marine and Atmospheric Science, NOAA Fisheries Service, the Florida Fish and Wildlife Conservation Commission, the National Park Service, REEF, and the University of North Carolina at Wilmington completed a successful 20-day biennial census to measure how the protected status of the Florida Keys National Marine Sanctuary's Tortugas Ecological Reserve and Dry Tortugas National Park's Research Natural Area are helping the regional ecosystem rebound from decades of overfishing and environmental changes. The unprecedented collaboration allowed the team to complete more than 1,700 scientific dives, sufficient to establish a rigorous with respect to reef fish stocks and coral reef habitats. We were very encouraged to see that stocks have slowly begun to recuperate since the implementation of 'no-take' marine protected areas in the region. We noted particular improvements in the numbers of snapper, grouper, and coral recruits. We are currently analyzing the data to advise the managers as to what adjustments may need to be made to address the issues of biodiversity protection and restoration of ecological integrity. Our team was also able to document changes in fish abundance and habitat quality in an area hit by six major hurricanes since 2004 (see Figure 1). By statistically comparing these data with our previous survey information collected, we will be able to determine what if any long lasting effects this intense hurricane activity had on reef tract and its fisheries.

Research Performance Measure:
We accomplished our primary objective: to carry out an extensive monitoring and assessment program which has provided data which will be factored into management decisions being made by federal (NOAA/FKNMS and NOAA/NMFS and DOI/NPS) and state (FWCC) agencies. Based in a large part upon our data and testimony, ecological research reserves are being established in the Dry Tortugas despite federal and state litigation over jurisdictional mandates.

Monitoring Coral Reef Fish Utilization of MPAs and Recruitment Connectivity Between the Florida Keys and Meso-American Reefs

E. Malca, A. Shiroza, M. Lara, D.L. Jones and A. Morgan (UM/CIMAS);
B. Richards and J. Lamkin (NOAA/SEFSC); R. Smith and L. Johns (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To provide a baseline study of the oceanography and larval distributions of fisheries species in the western Caribbean during winter spawning to provide a basis for anticipated fisheries management decisions.
Strategy: To carry out large scale synoptic larval and hydrographic surveys to map the larval transport and recruitment pathways in the Mesoamerican reef system upstream of the Florida Keys.

CIMAS Research Theme:
Theme 2: Fisheries Dynamics

Link to NOAA Strategic Goals:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management
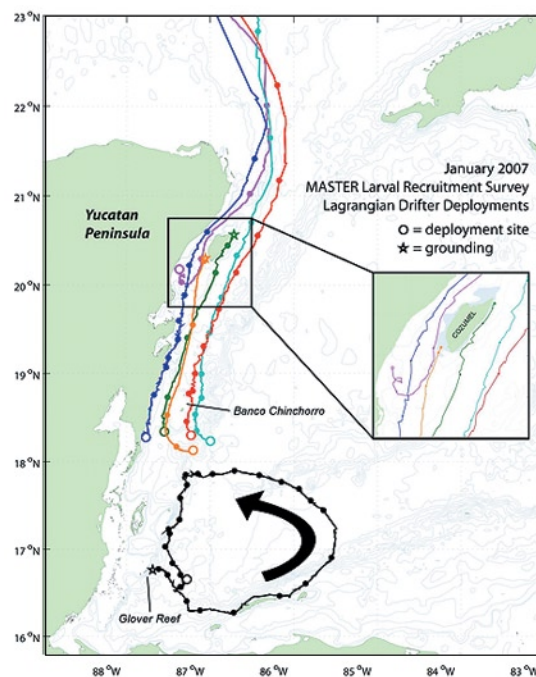
NOAA Funding Unit: SEFSC
NOAA Technical Contact: John Lamkin

Research Summary:
This research project began during the prior year during which the first survey was conducted. The second large-scale larval and hydrographic survey was carried out from January 8 – February 5, 2007 aboard the NOAA R/V Gordon Gunter from Yucatan Channel to southern Belize. MOCNESS and juvenile trawls were used to collect ichthyoplankton emphasizing sites with known snapper and grouper spawning aggregations. Oceanographic data including currents, temperature, salinity, and oxygen measurements were collected with a lowered CTD and LADCP and shipboard ADCP and flow through system. We also deployed satellite-tracked Lagrangian drifters to measure current flow and identify gyre circulation patterns. In addition, inshore sampling took place, simultaneously, with light trap, settlement trap, and tidal net samplers deployed both in the coastal marine reserves at Xcalak and also at the offshore atoll Banco Chinchorro, Quintana Roo, Mexico. To date, sorting of ichthyoplankton samples from the 2006 research cruise and inshore collections has been completed and identification to the taxonomic level of family has begun. Highest larval abundances (1,000 m³) were found in the upper 50 meter strata with mean abundance values ranging from 113 to 218 larvae/1000m³. Sorting of the 2007 research cruise samples has recently been initiated and family identification is proceeding collaboratively with our colleagues at ECOSUR in Chetumal, Quintana Roo, Mexico.

Figure 1: Satellite tracked drifter tracks which along with the currents indicates a consistent strong northern flow along the Yucatan coast with transport times from 4-days to two weeks, well with the larval period of grouper and snapper.

Figure 2: Grouper larvae collected with light traps during sampling

Research Performance Measure:
The program is in progress and proceeding on schedule. The primary measure of the success of this newly initiated program will be the extent to which the physical and biological data complement each other and enrich the analysis and the degree to which the results obtained factoring into management decisions being made by NOAA/NMFS and the corresponding Mexican agency. The research program integrates many types of activities; this collaboration will markedly enhance the probability of success.

Juvenile Snapper Acoustic Tagging & Tracking Project (J-SATT)
S. Whitcraft (UM/CIMAS); J. Lamkin (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To clarify and quantify the foraging and movement patterns of recreationally and commercially important reef-associated juvenile snappers between their nursery, juvenile and adult habitats in South Florida.
Strategy: To surgically implant small acoustic tags in juvenile snappers and, over a one-year period, acoustically track their movements within and between specific nursery habitats, including oyster reefs, mangroves, and seagrass beds in the Loxahatchee Estuary and adjacent coastal habitats.

CIMAS Research Theme:
Theme 2: Fisheries Dynamics (*Primary*)
Theme 3: Regional Coastal Ecosystem Processes (*Secondary*)

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

NOAA Funding Unit: Coral Reef Conservation Pm and SEFSC
NOAA Technical Contact: John Lamkin

Research Summary:
In February, the VEMCO acoustic tags in 44 juvenile mangrove or gray snappers (*Lutjanus griseus*) terminated transmission after nine-months of transmission for continuous movement-monitoring on the Loxahatchee River and estuary, as programmed. This marked an end-point of the initial broad-scale movement study comparing up-stream vs. estuarine movement patterns of these fish. These data are currently being analyzed and compared with the movement patterns of adult gray snapper on the offshore reef. In November 2007, a paired array of six additional receivers was deployed to compare site fidelity between 1) man-made/dock versus natural/mangrove island habitat, and 2) between a restored oyster reef and a non-restored oyster reef. At each array of three receivers, 6 fish juvenile gray snapper were surgically tagged with transmitters to determine their site fidelity to the happen associate with the array. Initial results suggest much stronger site fidelity for juvenile fishes at the remnant mangrove habitat than at the dock habitat. This was exemplified by a clear nocturnal/diurnal movement pattern present at the mangrove island location which is absent from the dock location
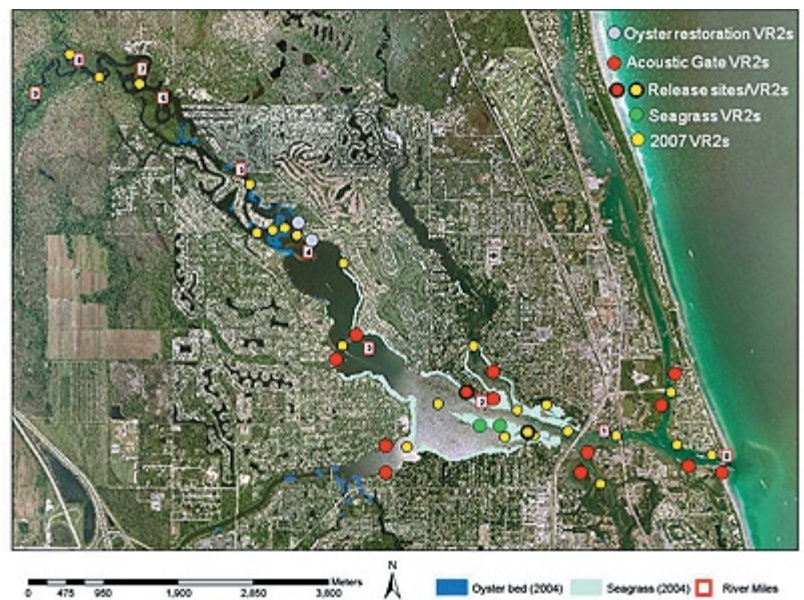
Figure 1: Vemco VR2 acoustic receivers in the Loxahatchee River and Estuary including both the original broad-scale – up-stream to down-stream – movement array (yellow dots), acoustic gates (red dots), and oyster reef monitoring (purple dots).

In May 2008, 15 VEMCO VR2 acoustic receivers were added to the existing monitoring array of 21 receivers already in place in the Loxahatchee estuary covering approximately 8 river and estuary miles (Fig. 1). These 15 additional receivers are configured to form acoustic monitoring gates at migration/movement choke-points in the flow of the river and estuary in order to determine downstream and seaward movements of tagged fishes. Range-testing of the receivers along the salinity

gradient and in differing habitats is underway, via the deployment of six permanent "sentinel" tags that determine efficiency and range within each monitoring gate, when these data are analyzed in post-processing. Forty-four sub-adult mangrove snappers were caught and successfully tagged and released in the array. Twenty-two of the snappers were caught and released at the only sub-tidal mangrove habitat in the main estuary and 22 were caught and released around man-made structure/docks along the shore of the estuary. The surgically implanted tags are expected to transmit for approximately 400 days. Additionally two tagged fish were caught and reported by local anglers.

We are also actively partnering with other regional PIs deploying acoustic receivers to track various fish species along the east coast of Florida. This developing partnership, the Florida Atlantic Coast Telemetry (F.A.C.T) Array (http://www.adoptafish.net/lox/factProject.cfm) (Fig. 2) allows for broader scale tracking of individual fishes and more comparisons of movements between habitat types within the overall coastal ecosystem. Because each individual project is using compatible equipment we can markedly increase the data obtained by exchanging fish-tag-code data. Additional species being tagged and tracked on this extended array include lemon sharks, various species of rays, sea turtles, and red drum.

Research Performance Measure:
We accomplished our objectives for the past year: to deploy an additional 15 receivers and six sentinel tags to form acoustic "gates" and to catch, tag and release 22 sub-adult snappers in sub-tidal mangrove habitat and 22 in man-made habitat. Additionally, we downloaded the entire array (36+ receivers covering 8+ miles) for every month for on-going data analyses. Objectives were met and exceeded in that all tagging, deployments were completed on schedule and as a result of establishing a remarkably successful federal, state, local and academic partnership fish movements are now being continuously and successfully tracked across multiple habitats both in and offshore of the Loxahatchee estuary and along the east coast.
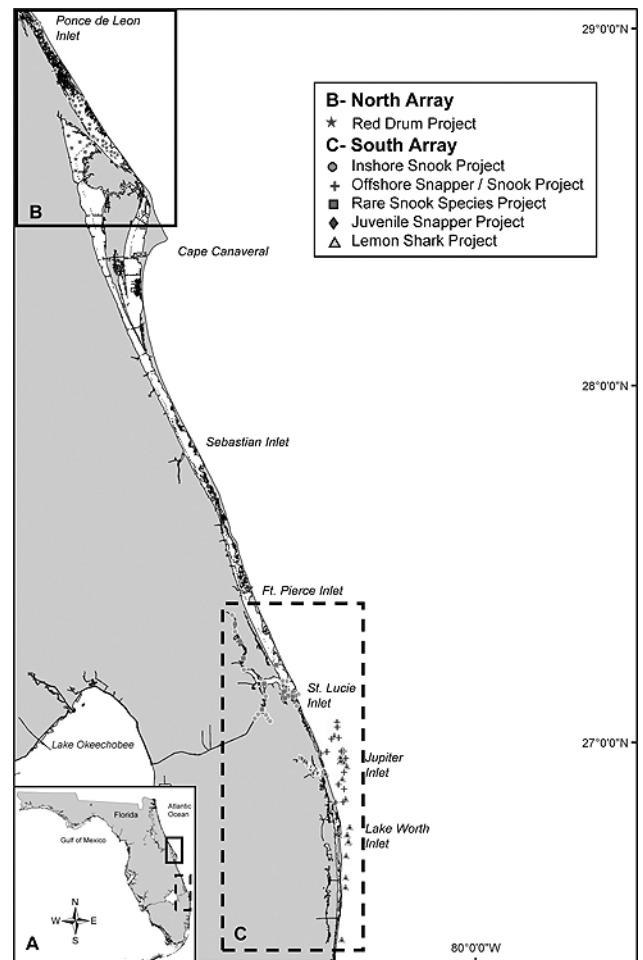
Figure 2: Florida Atlantic Coast Telemetry (F.A.C.T.) Array.

US Virgin Islands Larval Distribution and Supply Research

E. Malca, A. Shiroza, N. Melo, A. Morgan, D. Ovando, S. Hartman, C. Quigley,
A. Hoover, and G. Rawson (UM/CIMAS); J. Lamkin, T. Gerard (NOAA/SEFSC);
R. Smith and L. Johns (NOAA/AOML); F. Fuenmayor and N. Davis (NOAA Core);
B. Muhling (NOAA/FATE Program)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To provide essential information required for coral reef ecosystem assessment and a scientifically-based ecosystem approach to fisheries management in the Caribbean region.

Strategy: To carry out large-scale larval and hydrographic surveys with complementary inshore larval collections to map the larval distribution, transport, and recruitment pathways.

CIMAS Research Theme:

Theme 2: Fisheries Dynamics
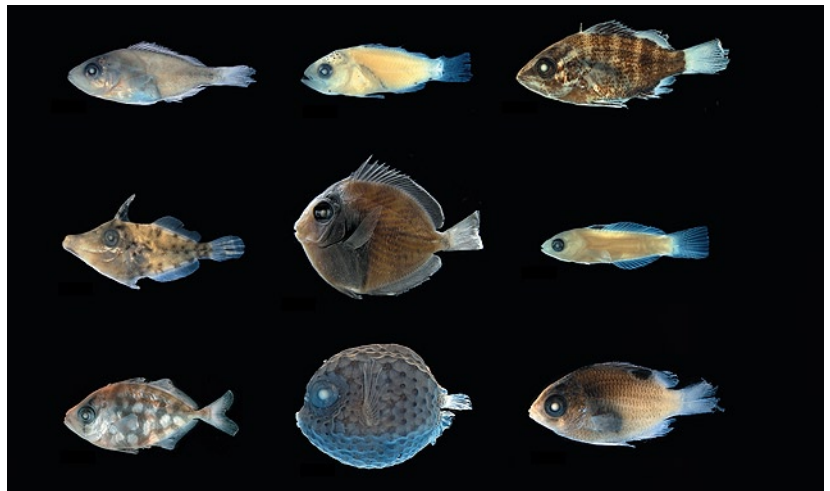
Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: Coral Reef Conservation Program
**NOAA Technical Contact:** Trika Gerard

Research Summary:

This uniquely collaborative fisheries oceanography endeavor combines the expertise of fisheries biology, oceanography and local knowledge from managers to focus on the long-term sustainability of coral reef fish populations in the Virgin Islands. Surveys of water properties, currents, and dispersal and transport of settlement-stage larvae provide data on and a further understanding of the biological and physical processes that drive production on the Grammanik and Red Hind Banks, which are protected sites of multi-species spawning aggregations for economically important coral reef fish. Additionally, surveys of inshore settlers yield an understanding of the spatial variation in the supply of settlement-stage fishes in coastal waters. We are presently conducting a three-year interdisciplinary research project utilizing the NOAA Ship NANCY FOSTER to conduct biological and physical

Figure 1: Larval and Juvenile Fish collected from the Virgin Islands using light traps in 2008.

oceanographic surveys of the Virgin Islands' (VI) bank ecosystems and surrounding regional waters. One cruise was taken late in 2007 and another in March 2008.

Data analysis has only begun. Operational success is evident in that oceanographic cruise data from 52 stations has been collected and processed and the larval fish collections from the 2007 cruise which included the use of MOCNESS, and Bongo tows have been sorted obtaining 23,177 fish larvae the family identification of which is well underway. Inshore samples using light traps have also been sorted and 1,878 fish have been collected. Data from the first cruise will be analyzed and family identification of larval fish will be completed. In addition, we completed the second cruise aboard the R/V
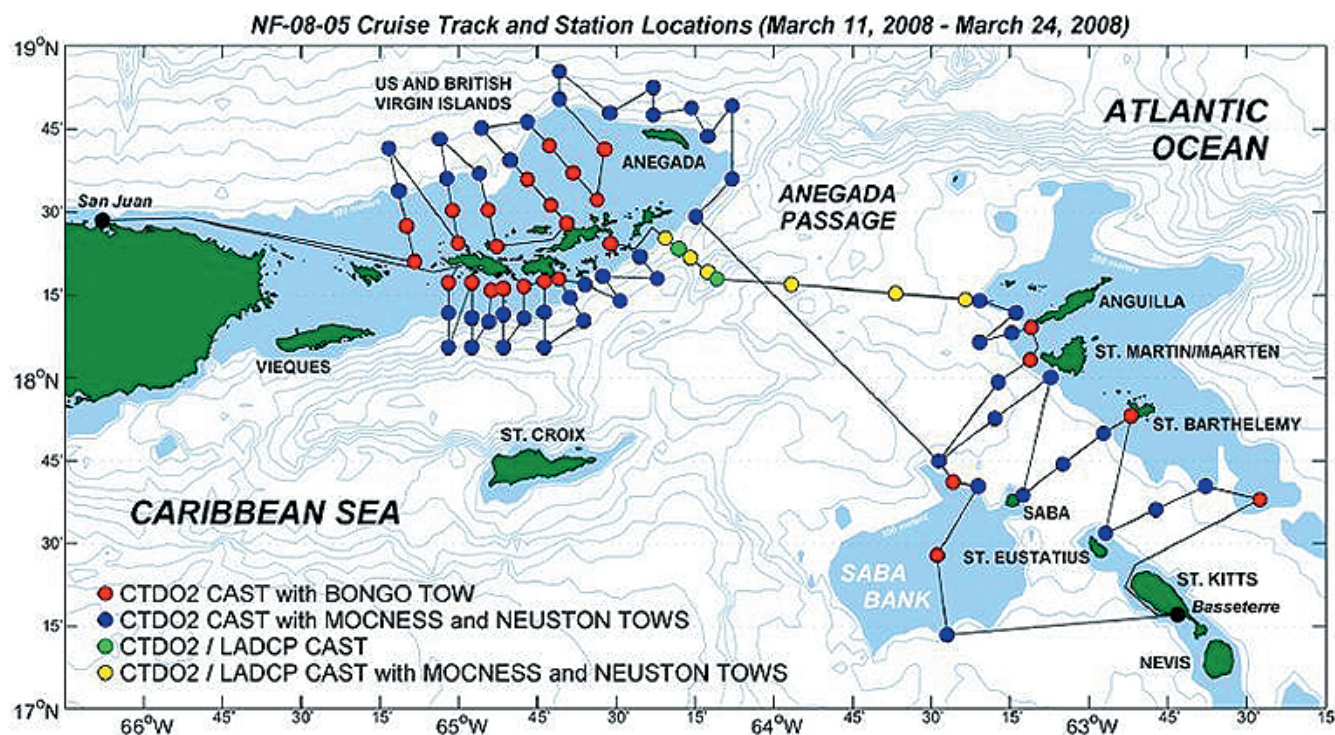
Figure 2: Cruise track showing collection gear and sampling location in 2008.

Nancy Foster this past March 11 – March 24, 2008 and inshore light trap collections April 1 – 10, 2008 in St. Thomas, USVI.

Research Performance Measure:
The research program is on schedule. This goal requires a comprehensive understanding of regional spawning aggregations, larval transport, and overall larval recruitment in the study area. The primary measure of the success of this program will be the extent to which the physical and biological data complement each other and enrich the analysis and the degree to which the results obtained are factored into management decisions being made by NOAA/NMFS. This study, when completed, will contribute to the long-term sustainability of fisheries in the Virgin Islands and surrounding regions.

Shallow-Water Grouper Distribution, Habitat Characteristics and Spawning Behavior

D.J. Die and V. Koch (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To quantify habitat preferences for black groupers
Strategy: To use an array of self-contained autonomous acoustic devices to triangulate the position of individual tagged fishes and to track them for periods up to several months.

CIMAS Research Theme:
Theme 2: Fisheries Dynamics

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

NOAA Funding Unit: SEFSC/NMFS   **NOAA Technical Contact:** Todd Kellison

Research Summary:
This research is designed to substantially augment our limited knowledge of black grouper ecology, and thus our ability to effectively manage this ecologically and economically important species. In particular it is intended to facilitate development of a sampling strategy and design that can monitor the success of the management measures adopted.

This project is a multi-year study designed to assess the distribution and abundance patterns of shallow-water groupers in the Florida Keys. In 2006, efforts focused on habitat utilization studies for black grouper utilizing acoustic telemetry. In particular, we were interested in assessing whether black grouper habitat utilization patterns varied seasonally. Data
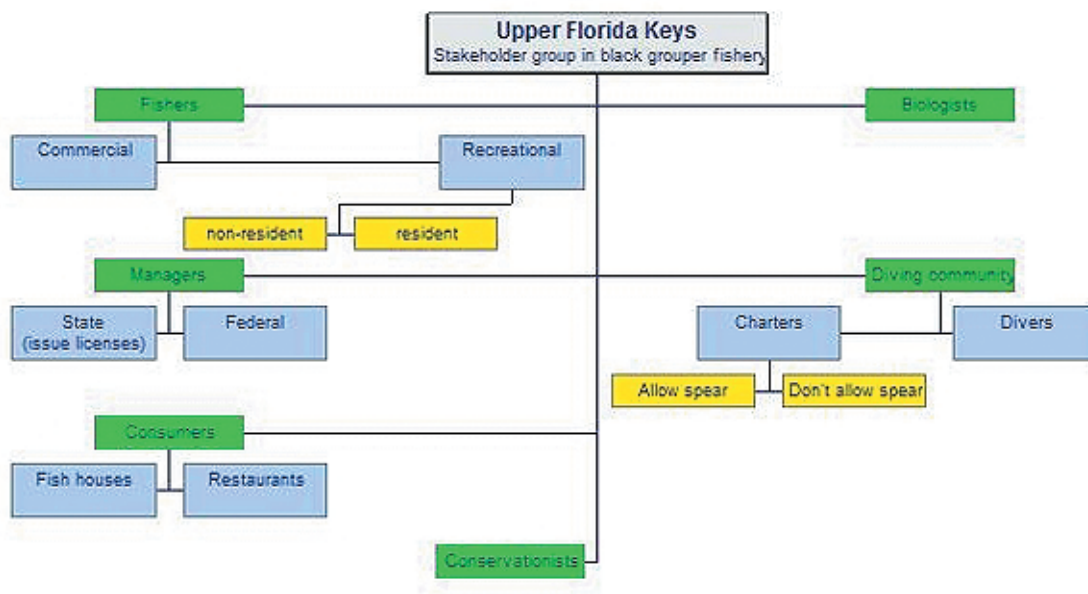
Figure 1: Schematic representation of the Florida Keys stakeholder groups considered in this study.

collection for this component ended in February 2007 and preliminary analyses have now been completed. In 2007 representative marine stakeholders were interviewed in the Upper Florida Keys to gather their knowledge about grouper habitat and conservation (Figure 1).

The tracking study was successfully completed at Conch Reef. Sixteen individual black groupers (*Mycteroperca bonaci* Poey 1860) were tagged in order to obtain presence/absence data from them as they swam freely in a no-take/research only reserve of Conch Reef in Key Largo, Florida around the Aquarius habitat. Tracking of fish movement behavior was conducted by 25 self-contained data logging receivers deployed on the seafloor. The objective was to characterize site fidelity and movement behavior around the Aquarius underwater habitat and its surroundings, out to Davis and Pickles reefs. Results from just under one year of data show seasonal patterns of movement, with the greatest number of detections occurring in the spring. Furthermore, the majority of signal detections for individual fish were recorded at the three receivers located closest to the Aquarius habitat. Only on one day did any fish visit another reef (Davis). It is also important to note that individual fish had different detection frequencies and "time at liberties" (length of time detected), with some being detected throughout the study and some disappearing earlier on.

Research Performance Measure:
Currently we are completing analyses and preparing publications. Preliminary analyses of interviews with stakeholders suggest that additional interviews will have to be conducted to provide the information originally intended to be collected. It is likely that these interviews will not be completed in the current year because of the impending departure of the graduate student. It is therefore likely that this part of the project will not achieve all its original goals. The measure of our success will ultimately be the implementation of a management strategy permitting a sustainable black grouper fishery.

Reef Fish Recruitment Dynamics: Integration and Analysis of Long-Term Visual Fish Surveys to Examine Environmental Influences

D.L. Jones (UM/CIMAS); J.F. Walter and J.E. Serafy (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Theme:

Objectives: To establish the nature and extent of the linkage between fish populations on the Florida Keys reef tract and those in adjacent inshore mangrove nursery habitats.

Strategy: To construct predictive models of recruitment dynamics that incorporate ontogenetic habitat shifts (i.e., mangrove to reef), account for environmental variation, and allow estimation of adult reef fish stock size. To develop an annual, abundance-based index of recruitment that will allow identification of essential fish habitats and provide a quantitative basis for stock assessment and fishery management.

CIMAS Research Theme:

Theme 2: Fisheries Dynamics

Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: NMFS/SEFSC
NOAA Technical Contact: John F. Walter

Research Summary:

Connectivity between mangrove forests and coral reefs, mediated by ontogenetic migrations of reef fishes that use mangroves for juvenile nursery habitat, may be crucial for the replenishment of adult populations on the reef. However, direct evidence of this kind of linkage and an understanding of the influence variability of juveniles within mangrove nurseries has on the dynamics of nearby adult reef fish populations is lacking for many species. Our goal is to establish the nature and extent of the linkage between mangrove and reef habitats by synthesizing data from two long-term monitoring efforts: 1) in the inshore mangrove nursery habitats in Biscayne Bay (J. Serafy, Univ. of Miami/NOAA Fisheries) and 2) upon the adjacent Florida Keys reef tract (J. Bohnsack, NOAA Fisheries). The challenge is to construct of predictive models that incorporate ontogenetic habitat shifts (i.e., mangrove to reef), account for environmental variation, and allow estimation of adult reef fish stock size.

Length and abundance data for fishes collected during 981 mangrove visual survey transects conducted over nearly a decade (1999–2007) form the basis of our current work. Based on their presence and abundance in both the mangrove and reef surveys, 10 target species from seven families were identified as having
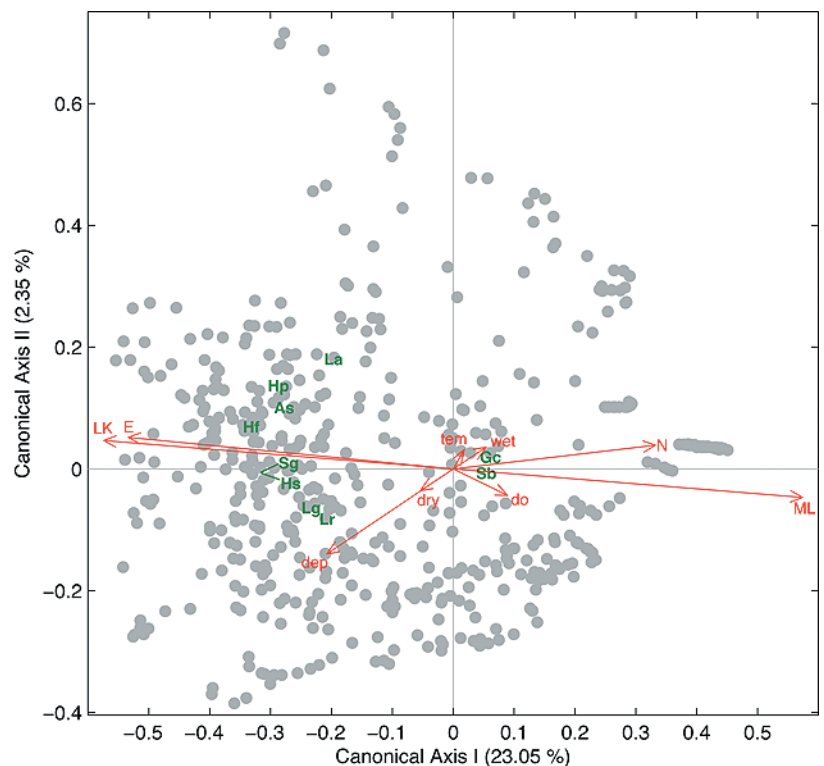
Figure 1: Bray-Curtis distance-based redundancy analysis; circles depict transect sites (n = 709); weighted averages species scores: As = *Abudefduf saxatilis*, Gc = *Gerres cinereus*, Hf = *Haemulon flavolineatum*, Hp = *H. parra*, Hs = *H. sciurus*, La = *Lutjanus apodus*, Lg = *L. griseus*, Lr = *Lagodon rhomboides*, Sb = *Sphyraena barracuda*, and Sg = *Scarus guacamaia*; arrows depict magnitude and direction of the environmental, temporal, and spatial gradients that substantially influenced species distribution and abundance: LK/ML = Leeward Key/Mainland habitat, E = UTM Easting, N = UTM Northing, dep = depth, do = dissolved oxygen, dry/wet = season, tem = water temperature.

potential to exhibit ontogenetic shifts between the two habitats. Large-scale spatial trends in utilization of mangrove nursery sites within Biscayne Bay highlight the importance of Leeward Key mangroves in providing essential nursery habitat as 90% of the target species immature stages were significantly more abundant here than along the Mainland. Juveniles and/or sub-adults of all target species showed greatest abundances in the mangroves during the wet season, ostensibly coincident with seasonal peaks in reproduction and the subsequent timing of habitat shifts made by early juveniles that initially settled in sea-grass beds. Life history stage data provide evidence suggesting habitat shifts from the mangroves occur between the juvenile and adult stages in 9 of the 10 species examined. Patterns of habitat utilization among closely related species indicate alternative life history strategies exist to minimize competition. For example, French grunt and schoolmaster snapper inhabit the mangroves at earlier stages and for shorter durations than their generic counterparts, blue-striped grunt and gray snapper.

The data were partitioned according to spatial (latitude and longitude, habitat) and temporal (year, season) treatments and multivariate analysis was used to establish the influence of these along with several other environmental predictors (temperature, dissolved oxygen, salinity, depth, freshwater discharge) on the community of juvenile mangrove fishes inhabiting Biscayne Bay (Figure 1). Habitat had the greatest influence on the distribution and abundance of these fishes. Most of the target species showed an affinity for Leeward Key sites, which were farther from the influence of freshwater canal discharge than sites along the Mainland and closer to offshore waters where the adults reside and larval input originates.

Research Performance Measure:
Work developing a year class-based index of recruitment for fishes from Biscayne Bay is in progress and on schedule. Construction of predictive models of adult reef fish stock size will follow when these juvenile-based recruitment indices are validated. The results of our spatial, temporal, and multivariate analysis of the mangrove survey data were presented in July 2008: *Contribution of mangrove nursery habitats to replenishment of adult reef fish populations in southern Florida*, 11th International Coral Reef Symposium, Ft. Lauderdale, FL. and well received.

Preliminary Evaluation of Larval Fish Assemblage and Distributions in the Waters of Kuwait

A. Shiroza (UM/CIMAS), J. Lamkin (NOAA/SEFEC)

Long Term Research Objectives and Strategy to Achieve Theme:

Objectives: To describe the early life history stages of fishes in Arabian Gulf and determine of available data are indicative of over-fishing or pollutant impacts in Kuwaiti waters.

Strategy: To trace the development of larval fish species, thereby to enable the identification at various life stages; subsequently, to develop and conduct local courses on larval fish identification.

CIMAS Research Theme:

Theme 2: Fisheries Dynamics

Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: SEFSC

NOAA Technical Contact: John Lamkin

Research Summary:

This project is part of the 15 survey cruises carried out between July 2002 and June 2005 at 24 locations off the Kuwait coast. Neuston samples were taken from Arabian Gulf bi-monthly from April 2004 to June 2005 on 7 cruises at 8 spatially separated stations. The surveys were carried out under a PAAC (Public Authority for the Assessment of Compensation for Damages Resulting from Iraqi Aggression) Marine and Coastal sampling program, implemented by CIC (Consortium of International Consultants), and under the technical supervision of KISR. This collaboration is a measure of the success achieved and instrumental to the useful application of the results obtained.

Six samples were collected per station; three tows before sunset and three tows after sunset for total of 336 samples. Of these, 322 samples contained fish larvae and total of 43,893 fish were collected; 12079 yolk-sac larvae and 1,066 damaged larvae were left unidentified
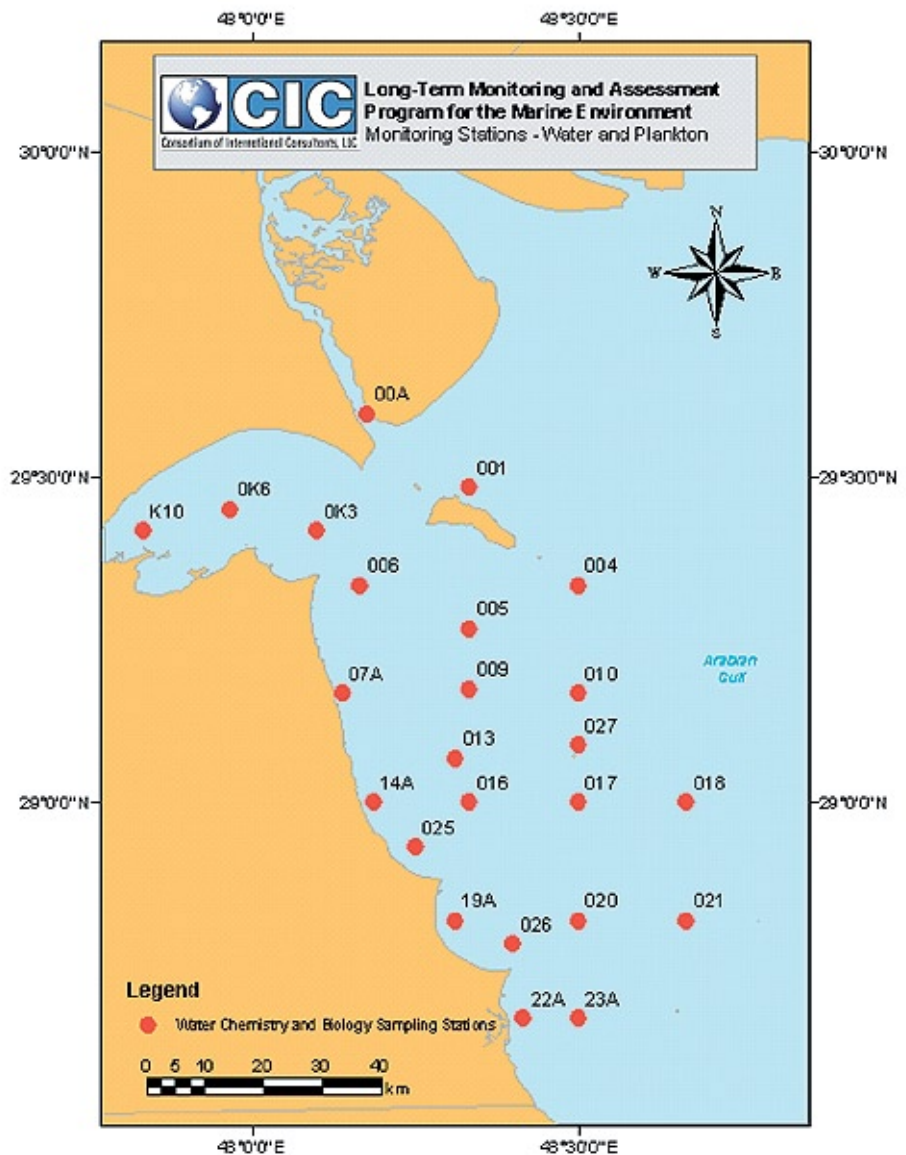
Figure 1: Map of the plankton sampling stations.

along with 140 unidentifiable fish larvae. The remaining 30,608 larvae were identified to 35 different families; and, whenever practicable samples were also classified to lowest possible taxonomic level.

The purpose of the research is to assess the recovery of ichthyoplankton from the environmental damage during the Gulf War in 1991 when the largest oil spill in history (approximately 1.7 million tons of oil) and toxins were released in the atmosphere. Since the
the details of the early life history of fishes in Arabian Gulf are currently unknown the data resulting will in turn assist in monitoring the impacts of over-fishing of in the region

Many of the larvae collected were too small to be identified, or were yolk-sac larvae that have not yet fully developed larval characteristics. A few of the larvae were identified to species but the ichthyoplankton of this region is poorly known with few complete larval descriptions of species. Whenever possible, larvae were sorted into 'types' within families. Future work on these specimens should allow better genera and species identifications.

Research Performance Measure:
All objectives were met. In addition, by preparing and conducting courses on larval fish identification, the project has also served an important educational purpose. The report from this project will supplement William J Richard's book, *Guide to Arabian Fish*.

Coastal Fisheries Logbook Program

J. Diaz (UM/CIMAS); S. Turner, M. Judge, N. Baertlein and J. Hall (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To determine the fishing effort of federally-permitted commercial fishers in the South Atlantic and Gulf of Mexico.
Strategy: To collect fisheries dependent catch data by providing trip report logbooks to all federal South Atlantic Snapper/Grouper, Gulf of Mexico Reef Fish, Shark, King Mackerel, Spanish Mackerel, and Dolphin/Wahoo permit holders in the U.S. Atlantic and Gulf of Mexico.

CIMAS Research Theme:
Theme 2: Fisheries Dynamics

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

NOAA Funding Unit: NMFS/SEFSC   **NOAA Technical Contact:** Patrick Cope

Research Summary:
The Coastal Fisheries Logbook Program is an ongoing fisheries-dependent data collection program that collects statistics for the commercial fisheries found in the South Atlantic (SA) and Gulf of Mexico (GOM). Over the past 18 years, fishers in the SA and GOM who possess federal commercial fishing permits (SA Snapper-Grouper, GOM Reeffish, King Mackerel, Spanish Mackerel, Shark, & Atlantic Dolphin/Wahoo) have been required to submit a trip report form which primarily aims to collect landings and fishing effort data (NOAA Form 188-186, OMB No. 0648-0016, Expires 3/31/2010). Development of an annual, abundance-based index of recruitment, based on the juvenile survey data, enables the identification of essential fish habitat and provides information necessary for adequate stock assessment and proper management of the fishery. Data collected in this program is used for various statistical analyses and for permit compliance purposes. It is also used in conjunction with other fisheries-dependent, and independent, data sets for stock assessments and fisheries management decisions.

Research Performance Measure:
Our objective, the monitoring of compliance by fisherman by the timely submission of data, has been successfully accomplished.

RESEARCH REPORTS

THEME 3: REGIONAL COASTAL ECOSYSTEM PROCESSES

Documenting Everglades Restoration Impacts on Biscayne Bay's Shallowest Benthic Habitats

D. Lirman (UM/RSMAS); J. Serafy (NOAA/NMFS);
G. DeAngelo (NOAA/National Geodetic Survey)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To quantitatively characterize the seasonal abundance and distribution of the submerged aquatic vegetation (SAV) of western Biscayne and monitor these communities as changes to freshwater flow are implemented as part of the Comprehensive Everglades Restoration Plan (CERP).

Strategy: To conduct seasonal SAV surveys with a Shallow Water Positioning System (SWaPS,) that collects geo-referenced images of the bottom with sub-meter spatial accuracy.

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: NMFS/SEFSC
NOAA Technical Contact: Joe Serafy

Research Summary:

This research project is focused on the shallow, near-shore benthic habitats along Biscayne Bay's western margin (< 1 m in depth, < 500 m from shore) where changes to freshwater flow resulting from CERP activities are likely to be the strongest. We carried out SAV surveys with a Shallow Water Positioning System (SWaPS,) that collects geo-referenced images of the bottom with sub-meter spatial accuracy (Figure 1).


Figure 1: Image of the survey skiff used to collect geo-referenced images of the bottom at near-shore benthic habitats of Biscayne Bay

To date, we have conducted surveys of > 400 sites in the area between Matheson Hammock and Manatee Bay. These surveys revealed that sea-grasses are the principal component of the near-shore SAV community during the dry season (mean cover = 25.5 %) (Figures 2 and 3), while macro-algae dominated during the wet season (33.4 %). The distribution and abundance of SAV are directly related to the tolerance of each taxon to salinity patterns. Species with high tolerance to low and variable salinity such as *Halodule wrightii* and *Ruppia maritima* are found only in canal-influenced areas and increase in abundance and spatial distribution in the wet season when freshwater inflow is highest. *T. testudinum*, the most abundant sea-grass species, is found throughout the study region, but decreases in abundance in the canal-influenced areas during the wet season when lower, more variable salinity results in lowered productivity. These initial findings support the use of SAV as appropriate indicators of changes in water quality resulting from future restoration projects associated with CERP, which will modify the delivery of freshwater into littoral habitats with unknown ecological consequences.

Figure 2: Geo-referenced image of a sea-grass bed collected during the 2008 Dry Season.
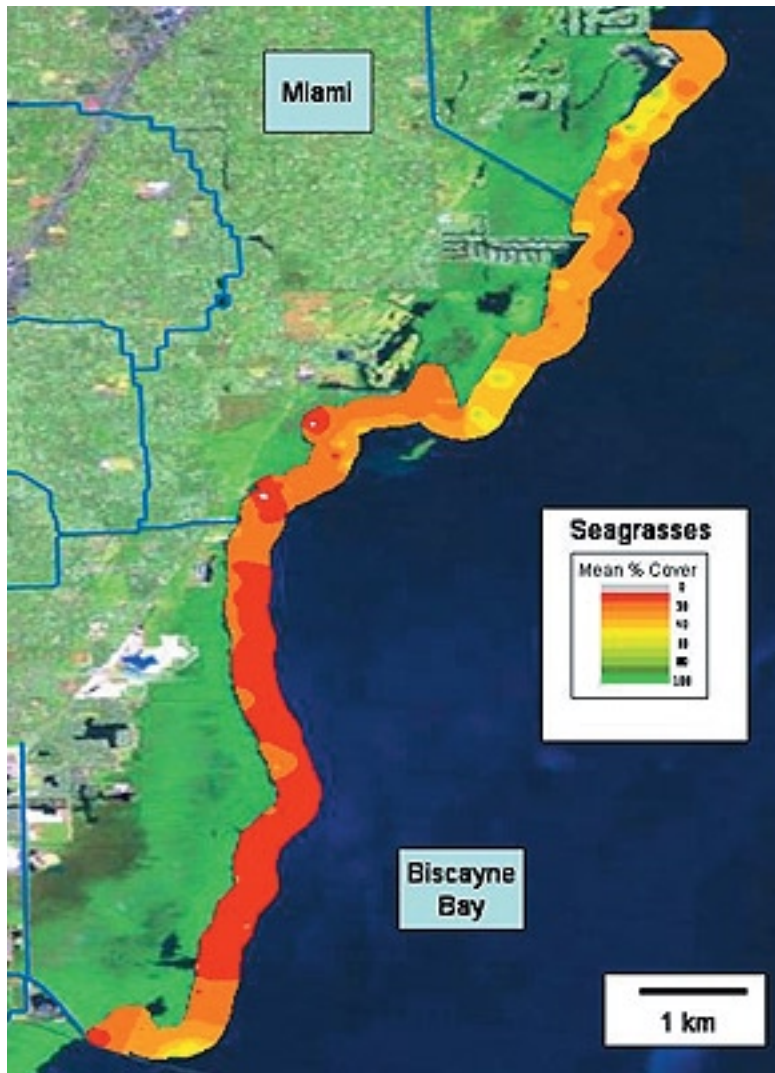
Figure 3: Percent cover of sea-grasses in near-shore habitats of southern Biscayne Bay in Feb-March 2008.

Research Performance Measure:
All major objectives have been met for the report period and the approach tested is now being considered for application in other similar CERP domains. Our research demonstrates that SWaPS is particularly suitable in the very near shore which is difficult to sample with other approaches.

Acoustic Seabed Classification and Quantification of Reef Fish Habitat

P. Reid (UM/RSMAS); T. Kellison (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To assess the utility of a commercial acoustic seabed classification system for mapping coral reef habitats.

Strategy: To test the capability of the Quester Tangent QTCView Series 5 (QTC5) with respect to three questions. First, what physical properties of the seabed dominate the QTC5 classification in carbonate reef environments? Second, are the QTC5 results consistent from site to site in deep water, and can they be made to conform to habitat classes defined from optical mapping data in shallow water? Third, are there geomorphological similarities among reef fish spawning aggregation sites in the upper Florida Keys that can be mapped with this system?

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: Coral Reef Conservation Program
**NOAA Technical Contact:** Todd Kellison

Research Summary:

In 1998 a large (~100 individuals) black grouper (*Mycteroperca bonaci*) aggregation was observed less than 100 m outside the Carysfort Sanctuary Preservation Area within the Florida Keys National Marine Sanctuary. Thus far, efforts to understand why this aggregation occurred in this location have been hampered by the fact that there are no benthic habitat maps of the area, which is too deep to be mapped with conventional optical methods (airphotos/satellite imagery). One result of this project will be an assessment of whether the commercial acoustic seabed mapping system Quester Tangent QTCView Series 5 (QTC5) could be a useful tool for rapidly mapping areas under consideration for protected status to determine if there are deep habitats that could be protected (Figure 1).

The benefits to management of a cost-effective acoustic seabed mapping system are clear; over 50% of the FKNMS has not been mapped with sufficient detail to distinguish hard bottom from sediment habitat (Figure 2). Acoustic technologies must fill this gap, and the QTC5 system thus far has proven to be an accurate and cost effective method for doing so. Accurate and detailed seabed maps benefit other aspects of coral reef ecosystem research/use as well. Understanding how groupers relate to their habitat (this study) is one example, but others include: delineating protected areas, stratifying sampling for coral/fish population surveys, identifying new sites for recreational diving, assisting commercial/recreational fishing, etc.
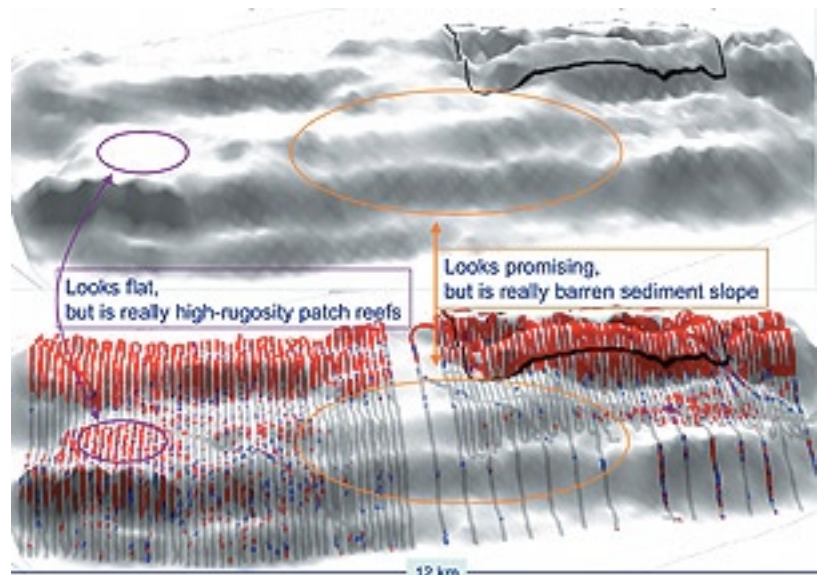
Figure 1: Top: Oblique view of a shaded three-dimensional surface created by interpolating acoustic soundings offshore of Carysfort and Watsons Reefs, Florida. Bottom: Seabed type derived from the acoustic soundings draped over the same bathymetry as the top panel. Red is hard bottom (reef), grey is sediment, and blue is mixed hard bottom / sediment. Note how information on the substrate complements bathymetry for habitat mapping.
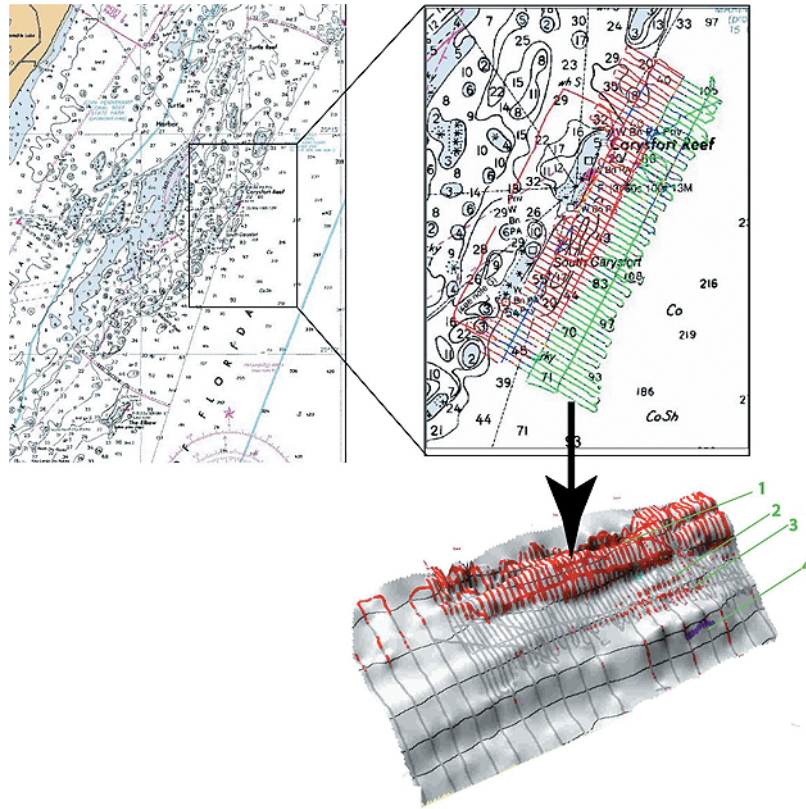
Figure 2: Top left: Portion of NOAA nautical chart 11451 showing the area around Carysfort Reef, FL (soundings in feet). Note lack of bathymetric detail for areas greater than approximately 20 feet deep. Top right: Survey track lines color coded by acoustically-derived substrate: red is hard bottom (reef), green is sediment. Bottom: Oblique view of a shaded three-dimensional surface created by interpolating acoustic soundings with seabed type draped on top: red is hard bottom (reef), gray is sediment. A series of four parallel rocky ridges, numbered 1-4, are apparent on the acoustic data but are not visible on the NOAA charts. These ridges provide important habitat and appear to be associated with grouper and snapper spawning aggregations in the upper Florida Keys.

Research Performance Measure:

The performance metrics for this report period were to complete data collection and analysis for the three components of the project (described under research strategy, above) and to begin drafting results for peer-reviewed publication. All data collection was completed on schedule. One manuscript has been prepared and submitted for publication directly related to this performance goal. Two additional relevant manuscripts that were not specific performance goals were also published this year.

Assay and Sensor Development to Identify, Detect, and Quantify Microbial Contaminants

D. Wanless and C. Sinigalliano (UM/CIMAS); K. Goodwin (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

*Objectives***:** To improve detection of microbial contaminants in coastal waters and to implement these new or modified technologies along with traditional approaches to better characterize microbial contaminants of Florida coastal receiving waters impacted from treated wastewater outfalls, septic field discharge, terrestrial runoff, and other anthropogenic sources.

*Strategy***:** To develop and/or test novel detection methodologies for fecal indicator bacteria, alternative fecal indicator bacteria, human-source microbial markers, and selected pathogens of public and coastal ecosystem health interest, to assess their effectiveness for environmental monitoring of microbial contaminants in coastal waters, and to deploy those molecular technologies found effective along with traditional methods for the assessment of microbial water quality in conjunction with ongoing NOAA water quality monitoring programs.

CIMAS Research Theme:

*Theme 3***:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

*Goal 1***:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: OAR/AOML   **NOAA Technical Contact:** Kelly Goodwin

Research Summary:

Currently, microbial water quality standards are judged by assessing the abundance of Fecal Indicator Bacteria (FIB). The FIB traditionally assayed include enterococci and *Escherichia coli*, according to EPA standard methods 1600 and 1603, respectively. However there is wide and growing consensus in the scientific community that these current indicator organisms and the culture-based methodology currently used to detect them may be inaccurate and inappropriate indicators of human fecal contamination in subtropical and tropical coastal waters and that more rapid and sensitive molecular-based assays need to be employed in the monitoring of these indicators and alternative indicators that may better represent the actual public health risks in these environments. The US EPA has been mandated to update their water quality criteria from traditional culture-based methods to include new molecular based methods for rapid detection of FIBs, and to develop water quality critieria utilizing alternative FIBs and to establish new exposure limits for these FIBs in recreational and coastal waters by the year 2012. In addition, there is a need to determine not just the presence of fecal indicator bacteria, but also their origins, in particular the determination of human-origin indicators, as human-source fecal contamination may pose the greatest public health risks.

Figure 1: NOAA Hollings Scholar Rene Boiteau conducts test for presence of fecal enterococci contamination in coastal waters during a research cruise aboard the R/V F. G. Walton Smith as part of a wastewater treatment dye tracer study by the NOAA FACE program, July 2008.

Our research has focused on developing and evaluating new rapid molecular-based detection methodologies for both traditional fecal indicator bacteria and for alternative fecal indicator bacteria, and for source-tracking bacteria indicators that can discriminate human and animal sources of fecal contamination. In the past year we have moved away from Luminex flow cytometry technology and chromogenic microplate hybridization assays to further concentrate on adaptation and development of rapid molecular assays based on real-time quantitative Polymerase Chain Reaction.

We have further optimized and deployed molecular qPCR-based assays for the rapid environmental detection of traditional indicators such as enterococci and *E. coli*, alternative human source-track indicators such as *Bacteroides* spp., dog-specific source-track *Bacteroides* indicators, human-source enterococci, and human-source *Bifidobacterium* spp. indicators, as well as molecular assays for selected actual pathogenic bacteria, including multi-antibiotic resistant *Staphylococcus aureus*, toxic *E. coli* strain O157:H7, *Salmonella* spp., *Campylobacter jejuni*, and for select indicator and pathogenic viruses including human adenovirus, noroviruses, and enteroviruses. The *Lactococcus lactis* extraction control methodology has been further optimized and implemented in a wide range of field assay projects. We have transferred this extraction control methodology to other collaborators and colleague laboratories. We have also further optimized and tested the dog-specific Bacteroides assay we developed in house, converting it to a exonuclease-probe-type format (i.e. Taqman-type qPCR assay), and are now participating in cross-laboratory validation of a suite of molecular assays with collaborating laboratories associated with our sister Cooperative Institute (the Northern Gulf Institute).

In this past year we have successfully employed these new molecular assays and controls in conjunction with traditional culture assays to characterize environmental microbial contamination for a variety of collaborative water quality research monitoring studies, including the Florida Area Coastal Environment program (investigating coastal impact of wastewater outfalls and terrestrial runoff), the B.E.A.C.H.E.S. epidemiological study of bathers at a South Florida recreational beach in collaboration with the University of Miami Oceans and Human Health Center, NOAA-AOML water quality studies of the Boynton-Delray area, water quality studies of the Florida Keys National Marine Sanctuary, and a large scale EPA water quality modeling project (the EPA-STREAMS virtual beach project. Future work will involve adaptation of additional microbial water quality assays to the quantitative qPCR assay format to allow for both rapid detection and abundance measurements of these microbial contaminants, and further cross-laboratory testing of molecular microbial source-tracking assays both developed in house and shared by our collaborators.
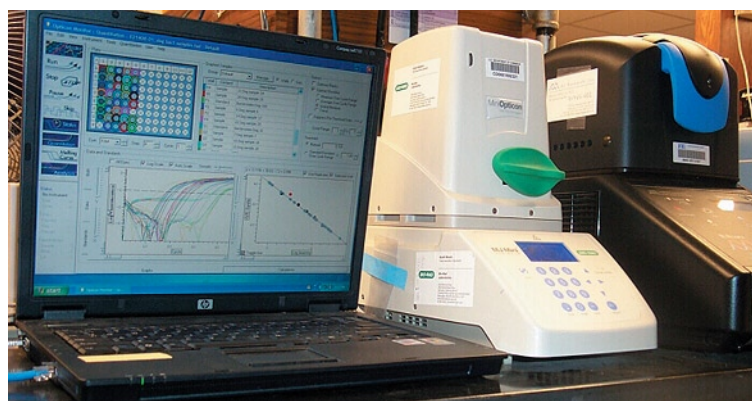
Figure 2: Real-time quantitative PCR instrumentation displaying positive detection of dog-specific bacteroides fecal bacteria from recreational beach water.

Figure 3: Collecting water samples from a recreational beach for molecular microbial water quality testing as part of the B.E.A.C.H.E.S. epidemiology study.

Figure 4: Dave Wanless, a CIMAS researcher, demonstrates how to set up molecular assays during a water quality training workshop.

Research Performance Measure:
We have accomplished our primary objectives: the complete development and/or adaptation of molecular assays for detection and quantization of traditional enterococci indicator bacteria, source tracking markers and pathogens in coastal waters; and the assessment of their effectiveness in deployment of field monitoring with comparisons to traditional culture based methods. The follow-up program to field-test assays is on schedule.

We have also meeting our third objective: to integrate those molecular assays that are effective environmental indicators of pathogens into ongoing NOAA-led water quality research and monitoring programs. The follow-up program to field-test assays is also on schedule.

Figure 5: Training University of Miami undergraduate students in both traditional culture methods and molecular microbial water quality methods.

Coral Reef Fish-Habitat Modeling to Support Ecosystem-Based Management

J.S. Ault and S.G. Smith (UM/RSMAS); G.T. Kellison (NOAA/NMFS)

Long Term Research Objectives and Strategy to Achieve Them:

Objective: To improve our understanding of the relationships between habitat characteristics and coral reef fish community structure to facilitate the transition to Ecosystem Based Management (EBM), including determining the optimal sizes, numbers, and locations of Marine Protected Areas (MPAs).

Strategy: To use newly available benthic habitat and marine topography data to assess habitat complexity over multiple scales; to incorporate spatially-explicit reef fish data into predictive numerical models relating seascape variables, habitat complexity, and biophysical processes to coral reef fish community structure.

CIMAS Research Themes:
Theme 3: Regional Coastal Ecosystem Processes (*Primary*)
Theme 2: Fisheries Dynamics (*Secondary*)

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

NOAA Funding Unit: SEFSC   **NOAA Technical Contact:** Todd Kellison

Research Summary:

Our research into habitat suitability models will allow fishery managers to: (1) identify fundamental relationships governing fish community structure, dynamics, and responses to environmental changes and anthropogenic impacts; (2) devise cost-effective sampling strategies to assess the effects of exploitation and management actions; and, (3) predict optimal areas for management actions (e.g., establishment of MPAs). These models are an essential component of successful ecosystem-based fisheries management. Our work utilizes, builds on, and complements ongoing state and federal monitoring efforts in the Florida Keys coral reef ecosystem. It will provide output that will be used to improve sampling design for these monitoring efforts, which in turn will lead to improved data quality to support ecosystem-based management (EBM). Thus, our work will begin a positive feedback loop that will continually improve our ability to perform wise and effective EBM in the Florida Keys coral reef ecosystem.

Our research work supports multiple projects, goals and objectives identified in Local Action Strategies under the Southeast Florida Coral Reef Initiative (SEFCRI) and the FKNMS. From an perspective MPA design and assessment, our work is integral to FKNMS resource management for evaluating likely effectiveness and ecosystem impact of existing marine protected areas (i.e., MPAs or Sanctuary Preservation Areas SPAs in FKNMS) relative to alternate types of traditional management scenarios. Our work is also of considerable value to resource managers in the National Park Service (i.e., Biscayne National Park and Dry Tortugas National Park).

Figure 1: A school of permit glide over a coral reef in the Florida Keys.

Figure 2: A school of masked gobies and purple reef fish associate with black coral and white star coral in the Dry Tortugas region of the Florida Keys.

Research Performance Measure:
Our program is in its early stages and progress is on schedule. Although model development is still underway, Biscayne National Park is already using results from this research to assist the analysis of establishment of MPAs as part of their General Management and Fisheries Management Plans.

Epifaunal Communities of Biscayne Bay Near-shore Waters
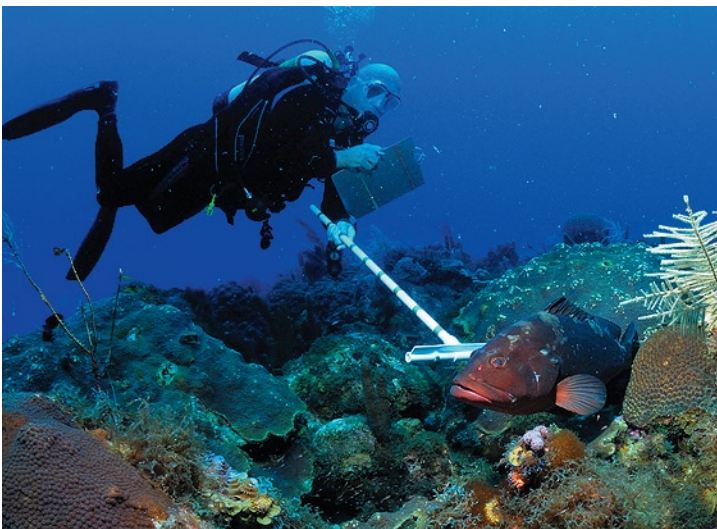
G.A. Liehr, E. Buck, J. Tomoleoni, H. Cardenas, D.R. Johnson and D. Cox (UM/CIMAS); J.A. Browder and T. L. Jackson (NOAA/SESFC); M.B. Robblee (USGS/CWRS)

Long Term Research Objectives and Strategy to Achieve Theme:

Objectives: To characterize the epifaunal community of near-shore Biscayne Bay and relate distribution, abundance, and community structure to salinity, bottom vegetation, and other relevant environmental factors.

Strategy: To carry out twice-yearly (dry season and wet season) spatially intensive sampling activity along the western shoreline of South Biscayne Bay; and to statistical analyze the data with respect to relationships to environmental factors.

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes

Link to NOAA Strategic Plan:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: NMFS   **NOAA Technical Contact:** Joan Browder

Research Summary:

Biscayne Bay on the lower east Florida coast is one of several coastal systems affected by changes in the quantity, quality, timing, and distribution of freshwater inflow brought about by a series of wetland drainage projects started before the end of the 19th century that culminated in the Central and Southern Florida Project (C&SFP). The Comprehensive Everglades Restoration Plan (CERP) includes the Biscayne Bay Coastal Wetlands (BBCW) project, which will redirect freshwater flow from canals into coastal wetlands in an attempt to reestablish the positive salinity gradient characteristic of estuaries.

This project was initiated to characterize the near-shore epifauna and to acquire information for the development of ecological indicators, performance measures, and targets needed to help guide restoration planning, predict ecosystem responses to alternative designs, and monitor and assess the effects of the BBCW and other CERP projects after implementation.

Because of its clear, shallow waters, Biscayne Bay's benthic community is a primary source of its productivity and diversity. The epifaunal community, consisting of small forage fish, juvenile game fish, and invertebrates such as pink shrimp, is particularly well developed in the shallow near-shore zone adjacent to the mainland and may be dependent, either directly or indirectly, upon freshwater inflow to the Bay. Many small forage fish such as rainwater killifish, goldspotted killifish, and code goby are found more abundantly in the shallow nearshore waters than in the deeper waters of the bay. The commercially important pink shrimp and blue crab use the western nearshore area as a nursery ground. Caridean shrimps form another important

Figure 1: Results of multi-dimensional scaling (MDS) to group species according to their patterns of geographic distribution.

component of the epifauna. The epifaunal community is a direct food source for gray snapper, spotted seatrout, and great barracuda. Further, it is an important link in the food web that leads to higher trophic level species such as crocodiles.

This community will be the first to change when the Biscayne Bay Coastal Wetland Project of the Comprehensive Everglades Restoration Program is implemented. The analysis addresses faunal distributions in relation to salinity, ignoring other possible influences on their distribution. The wide variation in salinity along the shoreline and near uniformity of other variables such as water depth and bottom cover made this approach feasible.

We have collected to date three years of data, each from two seasons, dry (January-February) and wet (July-August). The data are collected with a 1-m² throw-trap. Using the multivariate analysis techniques of similarity dendrograms and non-metric multi-dimensional scaling (MDS), we addressed (1) whether species with similar salinity requirements, as suggested by the literature, would have similar geographic distributions and (2) whether sites nearest to each other would have more similar species compositions when the coherence of salinity patterns along the coastline was less disrupted by freshwater inflow.

The MDS analysis, which is based on relative distances in multi-dimentional space, demonstrated that pink shrimp consistently (across all years and seasons) formed a central cluster with several other species, including some species pre-classified as estuarine. We cannot entirely explain the significance of the central position; however, we tentatively conclude that, of all the species included in the analysis, pink shrimp best represents the distribution of the estuarine species with respect to halo-habitat (Figure 1).

Our other analysis examined pair-wise similarity of sites according to species composition. We expected to see better correlation of similarity with geographic nearness during the dry season, when salinity patterns at the coast would be less affected by point-source outflows of fresh water.

The geographic distance analysis required a judgmental step in delineating the site clusters in the Bray-Curtis similarity dendrograms. We determined that the designation of clusters was even-handed across the six dendrograms, and the pair-wise similarity of species composition was more similar within these identified clusters than across them. Although not

| Species	Dry 2005	Dry 2006	Dry 2007	Wet 2005	Wet 2006	Wet 2007
Clown Goby			X			X
Code Goby	X	X				X
Goldspotted Killifish			X		X	X
Gulf Pipefish	X	X	X			X
Gulf Toadfish	X			X	X	X
Rainwater Killifish	X	X	X	X	X	X
Blue crab	X	X				X
Blue Crab sp.			X			
Hermit Crab	X			X	X	
Caridean Shrimp	X	X	X	X	X	X
Pink Shrimp	X	X	X	X	X	X

Figure 2: Overview of central clusters of species in the MDS graphs (X indicates that the species was found in the central cluster of a given collection).

significant, the regression of average distance (deg Lat) on median salinity (psu) explained 36% of the difference among sites. Nevertheless, the direction is as expected, and further exploration of this concept may lead to the development of an index of change in species composition across sites brought about by CERP. Added data points from future years will clarify whether there is a meaningful relationship between pair-wise within cluster geographic distance and salinity across the sampling sites.

Research Performance Measure:
We met our primary objective: to carry out preliminary analyses to describe and explore the epifaunal community. These results suggest that it may be possible to characterize species based on halo-habitat, and to develop a framework for a community approach to assessment of CERP effects.
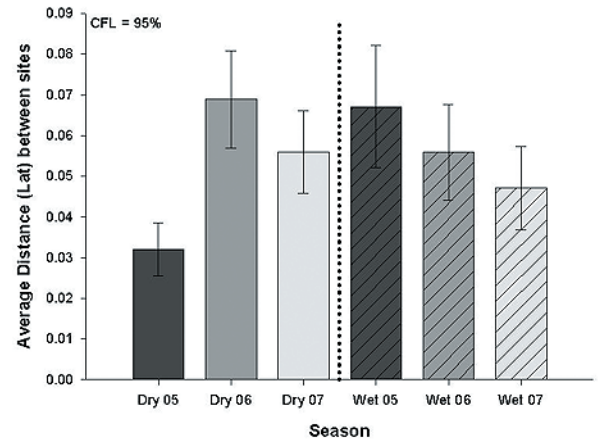
Figure 3: Average within-cluster pair-wise geographic distance between sites and 95% confidence intervals (clusters were based on Bray-Curtis similarity of species composition).
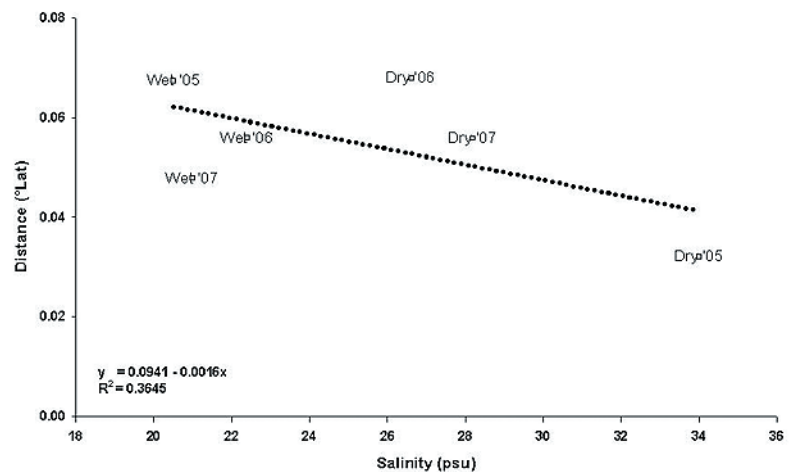
Figure 4: Average within-cluster pair-wise geographic distance between sites vs. median measured salinity at faunal sampling sites.

Monitoring Shoreline Fish Assemblages of Biscayne and Florida Bays

J. Luo, D. Johnson, B. Teare and X. Serrano (UM/RSMAS);
D.L. Jones (UM/CIMAS); J. Serafy (UM/RSMAS, NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To facilitate improved living-resource conservation measures by advancing our understanding of the processes that determine near-shore habitat utilization by economically and ecologically important fishes.

Strategy: To continue our seasonally-resolved, more-than10-year visual mangrove-fish monitoring effort; to develop species-specific fish habitat suitability index models based on field data; to perform analyses that evaluate the variability of fish communities and variation in salinity; and to examine the osmo-regulatory capabilities and behavioral preferences of an exploited, coral reef fish, the gray snapper.

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes

Link to NOAA Strategic Plan:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: NMFS/SEFSC **NOAA Technical Contact:** Joseph E. Serafy

Research Summary:

This project supports two major programs: the US Army Corps of Engineer's Comprehensive Everglades Restoration Plan (CERP) and NOAA's Coral Reef Conservation Program (CRCP).

1. Habitat Suitability Models -- This year's efforts used a delta approach to generate a triad of habitat suitability index (HSI) models per species, sampling technique, and habitat combination. The approach allowed for the testing of three HSI models per combination because three "abundance metrics" are considered: frequency of occurrence, concentration (density when present, exclusive of zeros) and "delta-density" (occurrence x concentration). In the present project, we fit 150 HSI models for 13 fish and invertebrate taxa (i.e., 12 fishes and pink shrimp) and provide results in both graphic and mathematical form. This was achieved via scrutiny of data sets from 16 studies which were conducted from 1976 to the present and involved five distinct sampling techniques: visual census, trawling, seining, throw-trapping and drop-trapping. Six of the data sets were products of studies conducted in Biscayne Bay and 10 were from studies in Florida Bay.

2. Community Analyses -- A multivariate, community-level analyses of Biscayne Bay visual census data was conducted using cluster and canonical correlation techniques (the latter are also known as redundancy analyses). Both analyses suggested that 20 psu as a "pivot point" with respect to community composition and structure, with the occurrences of snapper and grunt species diminishing at salinities below 20 psu and those of snook and small mojarras increasing. We found few significant relationships between salinity and taxonomic richness; the strength and direction of these relationships were not consistent within or among Bays. Multivariate community-level analyses were restricted to the Biscayne Bay visual census data using cluster and canonical correlation techniques (the latter are also known as redundancy analysis). Both analyses suggested that 20 psu as a "pivot point" with respect to community composition and structure (Figure 1).

3. Salinity Variability Analyses -- To more directly evaluate the importance of salinity variability along the Biscayne Bay mainline, the shoreline was divided into 31 segments and an index of salinity variability (salinity range across years) was developed for each of the segments. The three abundance metrics of the selected species were calculated for each segment of shoreline and plotted against the salinity range index. A trend line (linear or parabolic) was assessed for each metric. In addition, digital maps of the three abundance indices were made for the seven most abundant species to identify spatial patterns of fish and salinity variability. Wet and dry season GIS maps were developed for each metric for each species. *H. sciurus, L. griseus*, and *L. apodus* showed negative relationships with salinity range. *Eucinostomus* mojarras concentration was

positively correlated with salinity range and no relationship was found for *S. barracuda, F. carpio*, and *G. cinereus*.

4. Gray Snapper Laboratory Studies -- The physiological capabilities and salinity preferences of gray snapper were examined via controlled salinity challenges and behavioral trials. Fish were challenged in the laboratory with six different salinity treatments (0, 5, 30, 50, 60 and 70 ppt, including control) for 192 hours. Results indicate that physiological stress to salinity changes is unlikely to occur at a salinity range of 5 to 50 ppt. At salinities of 0 and 60 ppt significant but transient changes in plasma osmolality and/or blood haematocrit were observed, but are corrected after an initial adjustment period of approximately 96 hours. At the highest salinity treatment (70 ppt) resulted in death for all fish within 48 hours of exposure. Overall, these findings demonstrate the strong euryhalinity and extraordinary tolerance of this species to both extreme hypo- and hypersaline environments. Behavioral preferences trials revealed that gray snapper preferred slightly hyperosmotic isosmotic salinities that may minimize the physiological costs of osmoregulation compared to extreme salinities.

Research Performance Measure:

We successfully achieved our primary research objectives, which were to: (1) preserve the continuity of the visual survey of mangrove-associated fishes data set; (2) develop species-specific habitat suitability models; (3) perform community-level analyses to examine relationships between fish assemblages, salinity and salinity variation; and (4) examine the physiological capabilities and salinity preferences of a reef fish that occupies nearshore habitats when immature. Several peer-review articles and technical reports have resulted from this effort as well as a graduate student thesis.
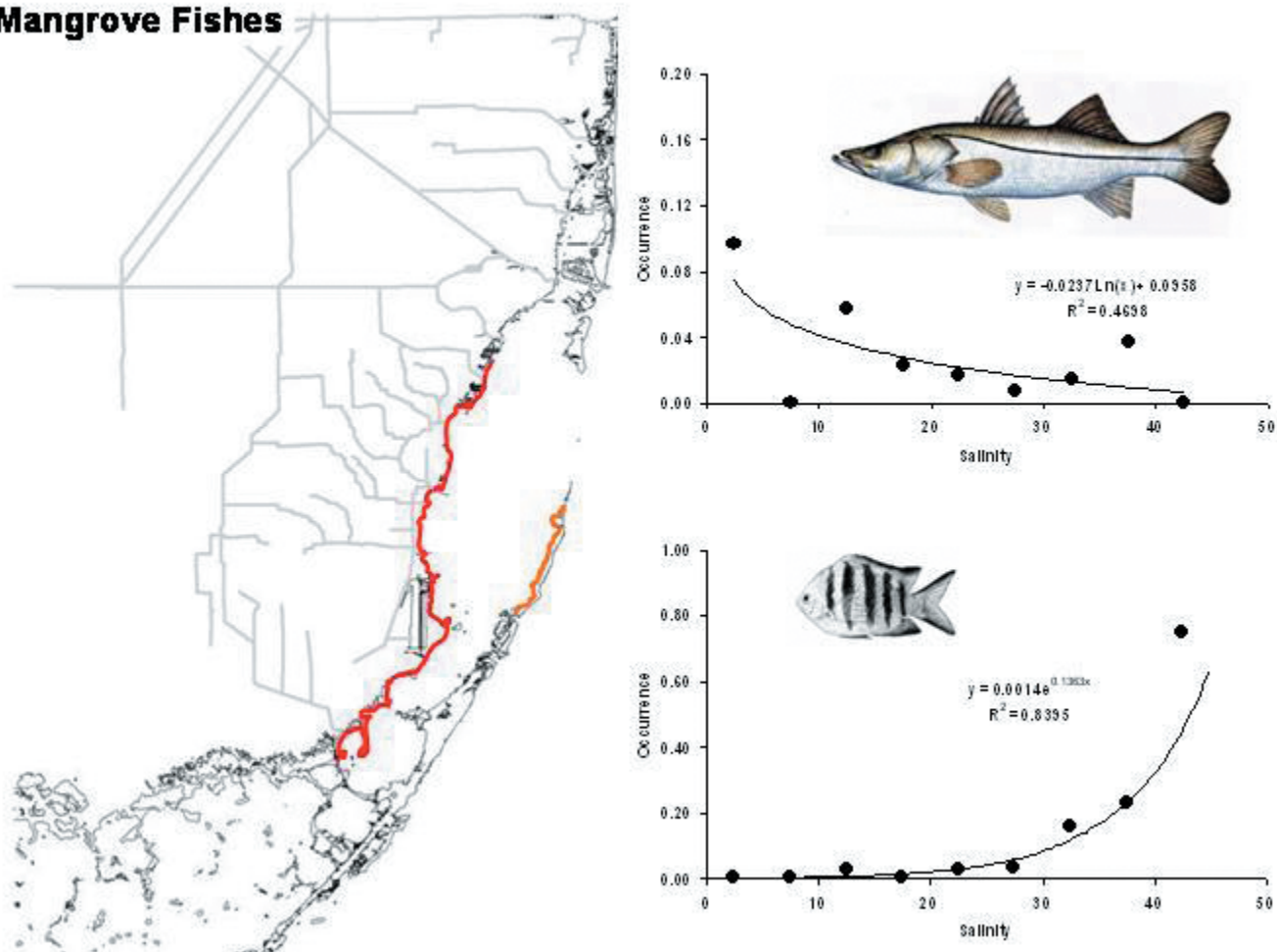
Figure 1: Examples of habitat suitability models which are based on empirical data collected via visual fish surveys conducted along Biscayne Bay's mainland mangrove shoreline. Shown are contrasting salinity-relationships for snook, an estuarine species, and sergeant major, a reef-associated species.

Modeling Connections Between Life Stages and Habitats of Pink Shrimp in South Florida

H. Cardenas (UM/CIMAS); M.M. Criales (UM/RSMAS);
J.A. Browder and T. L. Jackson (NOAA/SEFSC); M.B. Robblee (USGS/CWRS)

Long Term Research Objectives and Strategy to Achieve Theme:

***Objectives*:** To develop a pink shrimp (*Farfantepenaeus duorarum*) simulation model and performance measure (an indicator) of the impact of Greater Everglades ecosystem restoration related upstream water management changes upon the Florida Bay ecosystem.

***Strategy*: To** carry out coordinated field experiments on different life history stages of pink shrimp in conjunction with water quality and circulation measurements so as to improve our understanding of the recruitment process of this important fishery species.

CIMAS Research Theme:

***Theme 3*:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Plan:

***Goal 1*:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: SEFSC   **NOAA Technical Contact:** Joan Browder

Research Summary:

Our previous results indicated that postlarvae use flood-tide transport (FTT) to enter Florida Bay. To achieve this horizontal transport postlarvae ascend from the bottom into the water column during the nocturnal flood tide, remain swimming there until current reversal with the ebb-tide when they return to the bottom (CIMAS report 2007). Intensive nightly sampling with channel nets (Figure 1) inside the Bay confirmed that postlarvae advance upstream using FTT and juveniles leave the Bay with an ebb-tide transport (ETT).
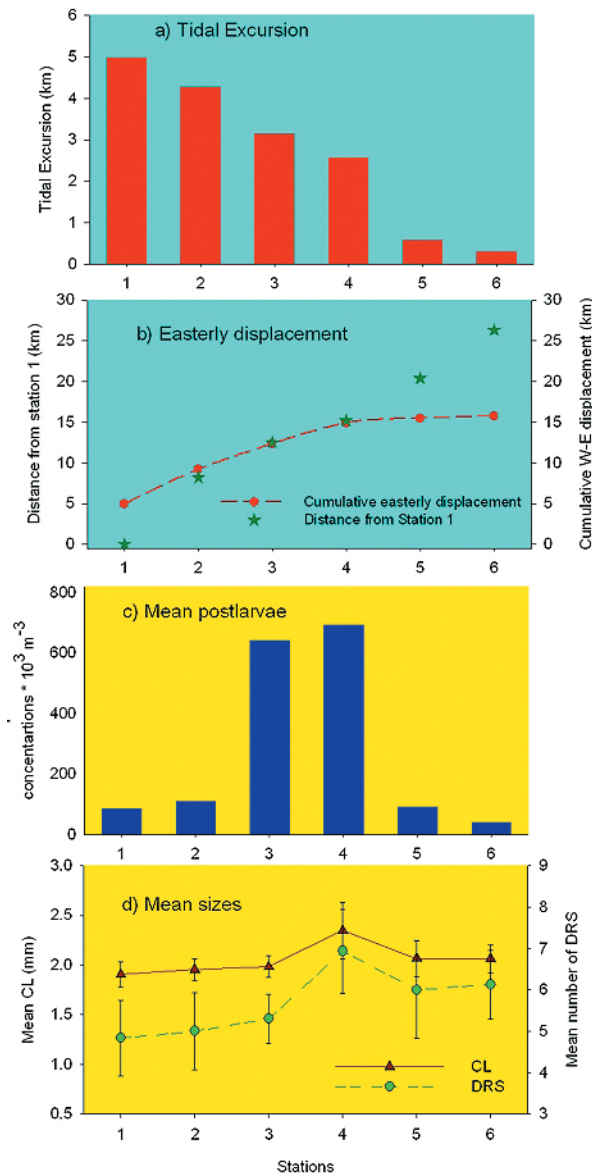
To address the question of whether the abundance of pink shrimp juveniles in the bay's interior is limited by post-larval transport or by water quality we collected pink shrimp post-larvae at six stations in northwestern Florida Bay along a west to east transect. Tides in Florida Bay are greatest at the bay's western boundary and attenuate with distance into the bay. We calculated the tidal excursion and the cumulative tidal displacement to estimate the distance that post-larvae could travel with the dominant semidiurnal M_2 constituent. Results indicated that the tidal wave moves 3 to 5 km per night to a maximum of 16 km eastward in three days (Figure 2a, b). This distance corresponds to the location of two interior stations where the highest concentrations of post-larvae were recorded (Figure 2c). The tidal displacement curve becomes almost flat at the two most interior stations, suggesting that the tidal excursion is not sufficient to generate transport as far as these stations (Figure 2b). The size of post-larvae also showed a west to east
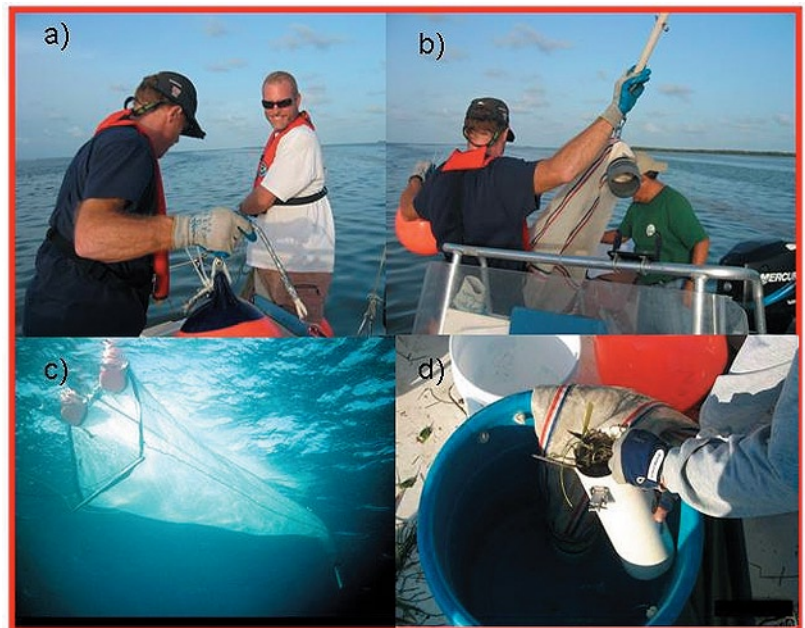
Figure 1: Deployment of channel nets in Florida Bay for capturing pink shrimp postlarvae (Tom Jackson, Eric Buck and Hernando Cardenas) (a-b); channel net fishing in the water (c); cod end with sample (d).

progression, reaching maximum size at the locations with highest concentration of postlarvae (Figure 2d). Our results suggested that postlarvae may advance eastward with the FTT in an accumulative process during successive nights until reaching appropriate seagrass habitat for settlement. This concentrating mechanism has been described for some crabs and shrimps that use FTT to advance into estuaries, but not previously for pink shrimp. The sharp decline of post-larvae by the two most interior stations seems to be related to the lack of sufficient tidal transport. Alternatively, declines in post-larval abundance may reflect the high salinities, often hypersalinity, commonly found in central Florida Bay during the latter part of the dry season.

We also observed that wind strength was positively correlated with post-larval concentrations (Figure 3). This result suggests that strong winds may bring post-larvae from the near bottom into the water column by a vertical turbulence in the shallow and non-stratified waters of Florida Bay. However we found no contemporaneous evidence of wind-driven surface currents carrying pink shrimp post-larvae into the bay. Strong, episodic winds, that occurring in south Florida during the recruitment peak of post-larvae may nonetheless act as a dispersion mechanism, having a significant impact on recruitment of this commercially important species.

Research Performance Measure:
The objectives have been accomplished. A unit model has been developed and continues to be refined and extended as we learn more about species behavior. Larval immigration pathways and transport mechanisms at the SWF shelf have been identified, and new and relevant results on postlarval transport inside Florida Bay are providing a solid basis to formulate new research hypotheses.

Figure 2: a) Tidal excursion of the dominant semidiurnal M_2 tidal constituent calculated for the six sampling stations (1-6); b) Cumulative easterly displacement (circles) in relation to distance from station 1 (starts). c) Mean concentration of pink shrimp postlarvae; d) Mean carapace length (mm) and number of rostral spines (DRS) measured at the six sampling stations. Station 1 is the most westerly and station 6 the most easterly station; sampling period summer-early fall 2004-2005.

Figure 3: Time series of postlarval concentrations of pink shrimp together with wind strength (upper figure) and wind vectors (lower figure) during summer-early fall 2004-2005. Cross-shelf (E-W) is component (*U*) and alongshore (N-W) is component (*V*), positive values are eastward and northward, and negative values are southward and westward.

Coral Ecological Restoration in the Florida Keys National Marine Sanctuary (F.K.N.M.S.)

D.E. Williams, K.L. Kramer and A.Valdivia (UM/CIMAS);
M.W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Theme:

Objective: To aid in the restoration and recovery of coral reef communities in the Florida Keys National Marine Sanctuary (F.K.N.M.S.).

Strategy: To culture larvae of reef-building coral species including *Acropora palmata* (E.S.A. Threatened) and *Montastraea faveolata*; to conduct experimental studies to elucidate factors affecting success of early life stages, and attempt to 'seed' larvae/spat onto damaged or depauperate reef areas of the F.K.N.M.S; and to characterize the benthic cover of restoration structures (i.e. artificial reefs) in the F.K.N.M.S. to evaluate the degree of recovery of these assemblages to resemble reference reefs.

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: SEFSC   **NOAA Technical Contact**: Margaret Miller

Research Summary:

During this last year we focused upon two aspects of our research. First, we continued ongoing research efforts to address recruitment failure by reef-building coral species via developing methods for larval culture and seeding. This activity included experimental studies on the early life history of corals to elucidate factors that may enhance or inhibit settlement and post-settlement survivorship. Specifically, experiments were conducted to: 1) determine if artificial inoculation with different strains of algal symbionts could enhance post-settlement survivorship, compared to previous procedures where settlers acquired symbionts from natural reef rubble (it did not); 2) determine settlement versus early survivorship on natural reef substrates (with 'mature' encrusting assemblages) compared to artificial 'clean' substrates (settlement rates were less, but survivorship much greater on the artificial substrates).

Second, we tried to evaluate the recovery of the benthic communities colonizing the artificial restoration structures constructed at grounding sites in the FKNMS. Generally, ecological restoration actions are intended to enhance or accelerate successional convergence with undisturbed habitats. To test this hypothesis, we conducted transect surveys to characterize benthic community development at four artificial restoration structures
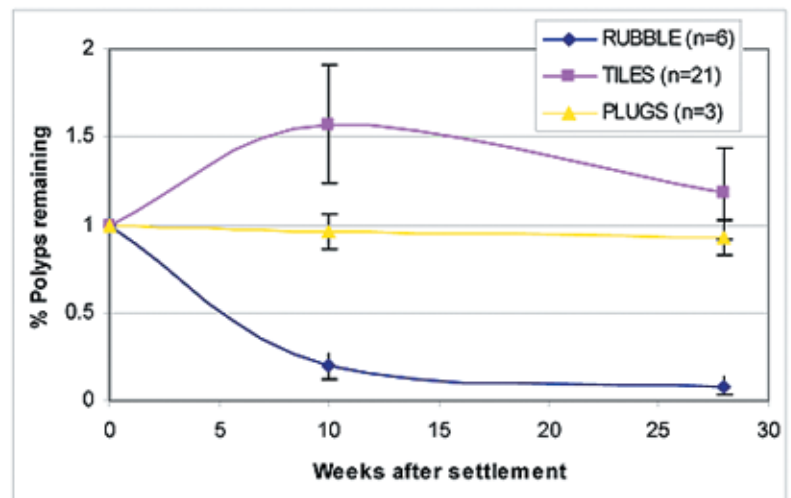

Figure 1: Rates of early survivorship (in aquarium; mean $\pm$ 1SE; n= # substrate units) for newly settled larvae of the reef-building coral species, *Montastraea faveolata,* on different substrates. Despite lower settlement preference, survivorship on 'clean' artificial substrates (marble tiles and ceramic plugs) was much higher than on natural reef rubble. This was artifactual. Initially, larvae settled in cryptic locations (e.g., nooks and crannies in the tile) and this settlement became readily apparent only several weeks later.

and four adjacent reference areas (REF) ranging in age from five to 12 years. Multivariate clustering indicated that benthic assemblages were significantly distinct between RS and REF substrates as well as among sites. Assemblage differences were primarily attributable to macro-algal and cyano-bacterial groups with fast growth and turnover, rather than to slow-growing corals and crustose coralline algae. This fact, together with a general lack of relationship between benthic assemblage structure and RS age, suggests that restoration structures are generally not progressing in successional convergence and may represent an alternate stable state.

Research Performance Measure:

All major annual objectives have been met and we are planning for additional restoration experiments in the upcoming year. Two manuscripts regarding the research activities in this project have been submitted and are currently under review, one on *Diadema* settlement and one on the evaluation of benthic communities on the reef restoration structures.
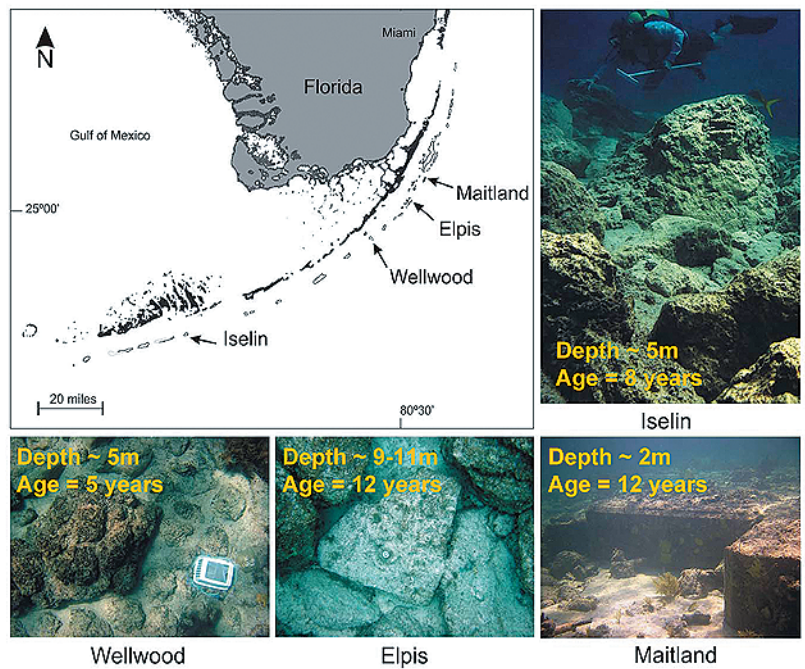
Figure 2: Map and appearance of four FKNMS reef restoration structures assessed in this study. The structures varied somewhat in depth and age (as given in each photo) but were largely similar in construction (combinations of locally quarried limestone and concrete), allowing us to test the hypothesis that the benthic communities developed on the restoration structures were undergoing successional convergence with their adjacent reference communities.

Assessment of Candidate Corals

D.E. Williams, A. Valdivia and K. Erickson (UM/CIMAS);
M.W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To document the threats (disease, predation etc.) to the remaining elkhorn (*Acropora palmata)* populations in the upper Florida Keys and determine the relative importance of each 'threat'. To document and identify demographic variables (recruitment, mortality, etc.) in the Florida Keys *Acropora* spp. population. To compare other populations of Caribbean *Acropora* spp. based on periodic surveys.

Strategy: To assess on a quarterly basis the status of individually-tagged colonies of coral at several sites in the upper Florida Keys and conduct periodic assessments of other Caribbean *Acropora* spp. populations.

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: NMFS/SEFSC   **NOAA Technical Contact:** Margaret W. Miller

Research Summary:

Since the 1980s, elkhorn and staghorn corals (*Acropora* spp*.)* have declined by more than 90% on reefs throughout the Caribbean. Because of its fast growth rates and structural complexity, it is ecologically irreplaceable on Caribbean reefs. Acroporid corals are listed as 'Threatened' species under the U.S. Endangered Species Act. NMFS is in the process of designating critical habitat and developing a recovery plan based on the current status and threats to these corals in U.S. waters. Data collected for this project are directly supporting the critical habitat designation and recovery plan development by NMFS.

The overall objectives of this project are to document the dynamics of the remaining Elkhorn populations in the upper Florida Keys and compare its performance to other Caribbean locations. The surveys also aim to determine the relative importance of the various 'threats' (disease, predation, etc.) present in those populations.

Individually tagged *Acropora palmata* colonies are surveyed periodically to document their condition. Based on these observations, we can estimate basic population parameters including recruitment, growth and mortality, along with the causes of mortality and the source of the recruitment (asexual or sexual). These data are directly used in a population model being developed by a colleague at Scripps Institute of Oceanography and the projections will assist in the development of a recovery plan by NMFS. Data from the Florida Keys population indicates continued decline of the adult *A. palmata* population, and an alarming failure of asexual and
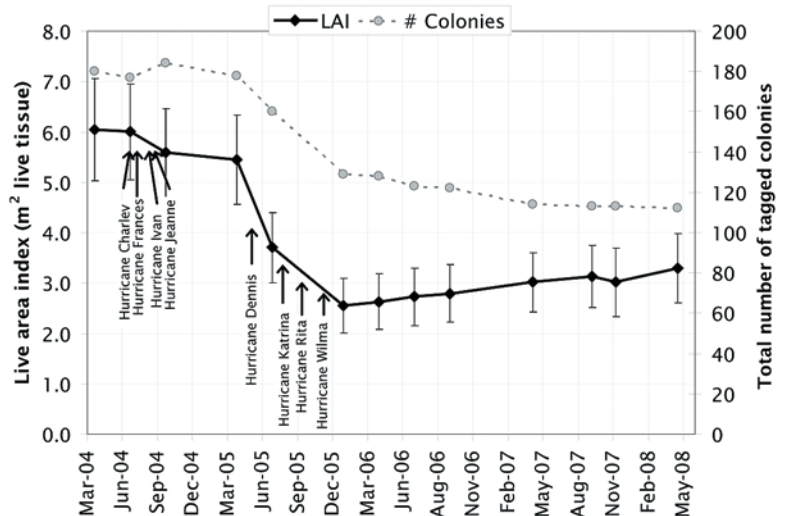
Figure 1: Change in the live *A. palmata* tissue estimated using a live area index (LAI) for the tagged *A. palmata* colonies summed for each plot, then averaged for all plots (n=15, mean $\pm$ 1 SE). LAI is calculated as the average dimension of a colony squared then multiplied by a visual estimate of the % live tissue cover on the colony. Although the LAI appears to be on a slight increasing trend, the total number of tagged colonies continues to decline due to the effects of disease and predation. The timing of hurricanes are shown by arrows.

sexual recruitment. This decline was the direct result of the 2005 hurricane season. Recovery from this disturbance has been slow and the population continues to suffer losses from disease and predation. *Acropora palmata* in our other survey areas not affected by the 2005 hurricane season appear to be stable and show evidence of greater inputs from recruitment.

Research Performance Measure:
All major components of this project are ongoing and on schedule. Three surveys of the Florida Keys sites were conducted. New survey sites were established around Puerto Rico in October 2007 and re-surveyed in April 2008. Annual surveys were conducted at previously established survey sites in Curacao, British Virgin Islands, Antigua and St. Vincent.

Sediment-Water Exchange of Dissolved Organic Phosphorus in Florida Bay

X. Huang (UM/RSMAS); J.-Z. Zhang (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To quantify the partitioning of organic phosphorus between sediment and water in Florida Bay.
Strategy: To carry out laboratory experiments to quantify organic P hydrolysis and P-exchange at the sediment/water interface.

CIMAS Research Theme:
Theme 3: Regional Coastal Ecosystem Processes

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

NOAA Funding Unit: COP   **NOAA Technical Contact:** Larry Pugh

Research Summary:
We have compared the sorption of different organic phosphorus compounds on sediments from selected stations in Florida Bay and found that the sorption behavior of organic phosphorus is quite different from inorganic phosphorus. It was found that a significant fraction of the phosphate ester can be hydrolyzed. We hypothesized that the processes was related to an iron catalyzed hydrolysis.

We have found hydrolysis of sugar phosphate in aged iron solutions with enzyme-like, pseudo-first-order reaction kinetics. The catalytic activity increases with the aging time of nanomolar iron solutions. The formation of diiron or polyiron with the μ-(hydr)oxo bridge through hydrolysis of iron during the aging process may contribute to the observed catalytic activity. We suggest that these aged iron solutions, void of protein, RNA, or any organic component, might serve as an inorganic phosphoesterase. We further demonstrated that the hydrolysis of sugar phosphate can be inhibited by tetrahedral oxyanions just as natural phosphoesterase is inhibited. Compared with natural phosphoesterase, aged iron solutions are primitive in that they are effective only in low concentrations of organic phosphate (low Michaelis-Menten constant) and have low selectivity (competitive behavior of all three tetrahedral oxyanions) and efficiency (maximum velocity of hydrolysis). We are currently investigating other factors that might influence our results including the possible contamination of our samples by microorganisms. We are repeating the experiments under sterile conditions.

In addition we developed a novel kinetic method for the determination of low concentrations of phosphate and explored the causes of low rates of phosphoantimonylmolybdenum blue complex formation in acidic persulfate digested sample matrices.

Research Performance Measure:
Our research program is on schedule. A manuscript describing the above results has been submitted for publication and is currently in review.
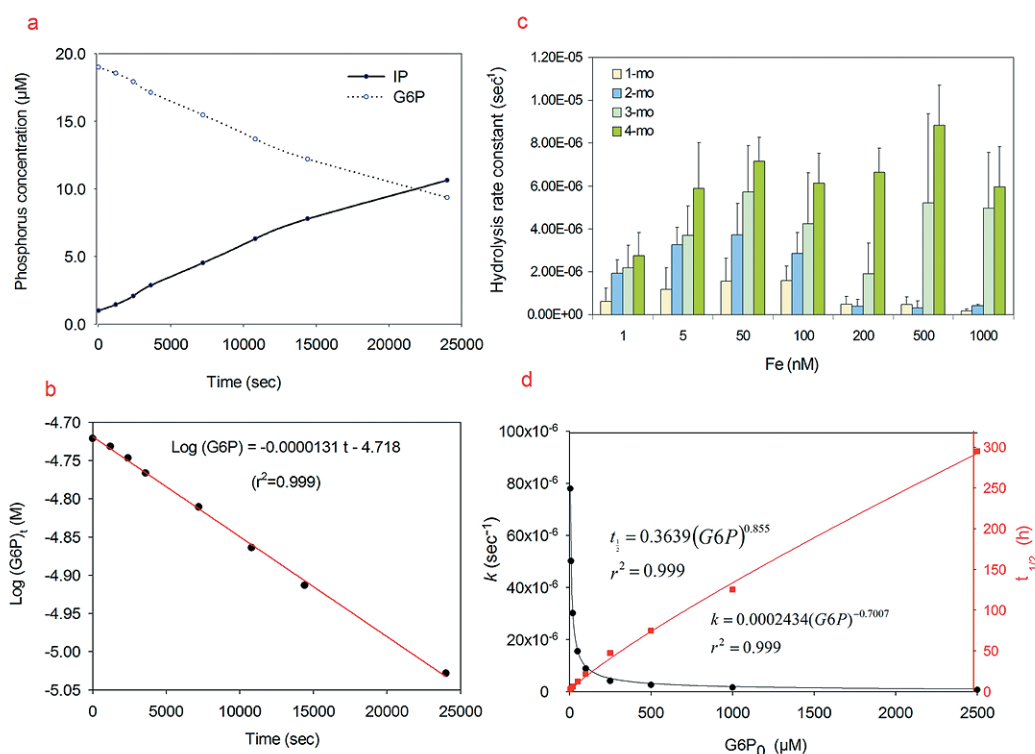
Figure 1: (a) Hydrolysis of 20 µM G6P in a 16.5 nM $Fe(NO_3)_3$ solution aged for 14 months at room temperature (22 ± 2°C). (b) The change of G6P follows the pseudo first-order reaction kinetics. (c). Hydrolysis rate constant (k) of 20 µM G6P as a function of aging time in solutions of different iron concentrations. (d) Effect of initial G6P concentration on the hydrolysis rate constant (k, sec^{-1}) and the half time (t ½, h) in an aged 14-month, 16.5 nM Fe solution at room temperature (22 ± 2°C).
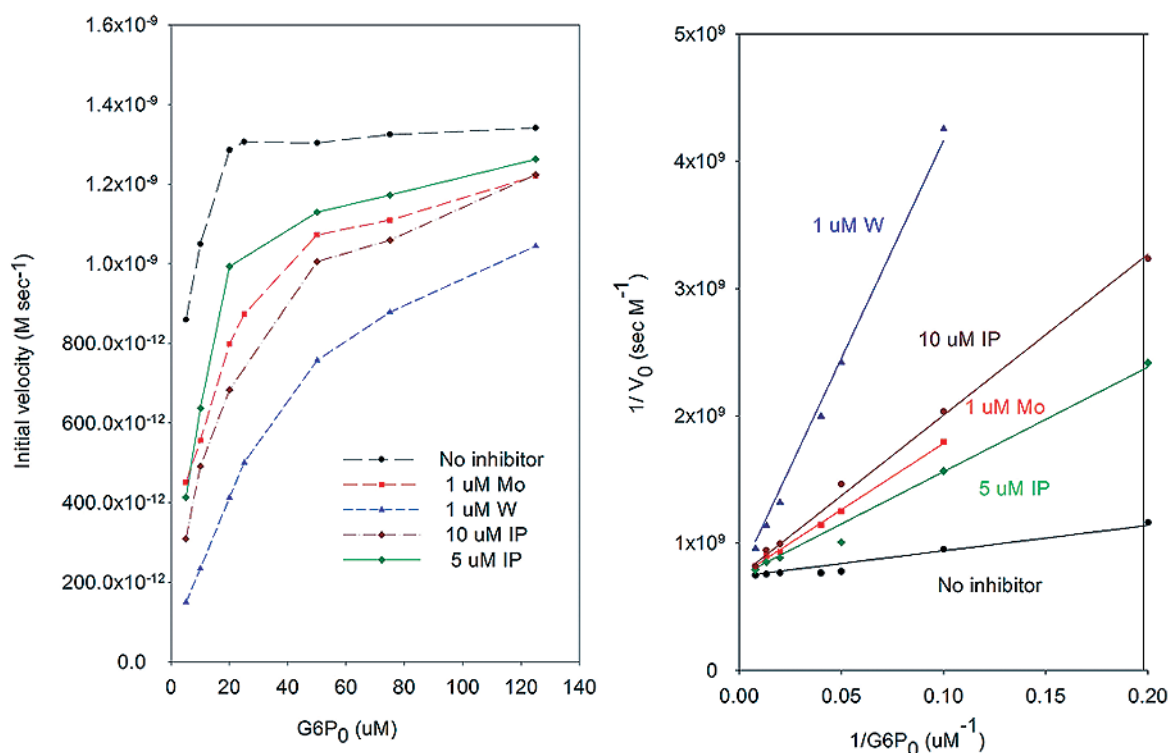
Figure 2:. Effect of different tetrahedral oxyanions on the initial velocity of Glucose-6-phosphate hydrolysis in the 10-month aged 1000 nM $Fe(NO_3)_3$ solution at room temperature (22 ± 2°C).

Bay Blind Pass Study: Petroleum Hydrocarbon Analyses of Sediment Cores

P. Blackwelder (UM/RSMAS); C. Featherstone and J. Proni (NOAA/AOML);
H. Al-Sayegh, T. Hood, C. Piela (UM/Geological Sciences);
D. McCorquodale (Florida-Spectrum Laboratories)

Long Term Research Objectives and Strategy to Achieve Theme:
*Objectives***:** To characterize the history of oil spill contamination in Blind Pass, Tampa Bay, Florida.
*Strategy***:** To analyze recovered cores for the concentration of petroleum hydrocarbons, and assess levels at sites at which dredging is contemplated.

CIMAS Research Theme:
*Theme 3***:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:
*Goal 1***:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: AOML   **NOAA Technical Contacts:** J. Proni, C. Featherstone

Research Summary:

In 1993 an oil spill resulted in contamination of areas within Tampa Bay, Florida. Our research has focused on Blind Pass petroleum hydrocarbon sediment characterization by analyses of 104 cores taken in the Pass by Dr. Ping Wang, University of South Florida (Figure 1). Characterization of levels of petroleum hydrocarbons in the sediment was conducted in anticipation of a future dredging project in the shoal area of Blind Pass. The C8-C40 concentrations of petroleum hydrocarbons ranged from below detection (10 ug/Kg) to over 300 mg/Kg. Averages in each region were, in general, less than 10 mg/Kg (Figure 2).

Characterization of individual petroleum hydrocarbons was accomplished using GC/MS for speciation analyses of every above-detection C8-C40 sample. The degree to which these petroleum hydrocarbons are similar to each other and to oil recovered during the 1993 oil spill in Tampa Bay was assessed utilizing the Brouchard 155 Tank #7 heating oil #6 reference sample taken at the time of the 1993 spill (Figure 3). Individual speciation studies indicated that many samples exhibited individual petroleum hydrocarbons in common with the Brouchard reference sample and

2007-2008 Blind Pass Vibracore

Figure 1: Blind Pass, Tampa Bay, Florida. Over 100 cores were collected for characterization of petroleum hydrocarbons by Dr. Ping Wang and map created by Tanya Beck (USF, 2008).
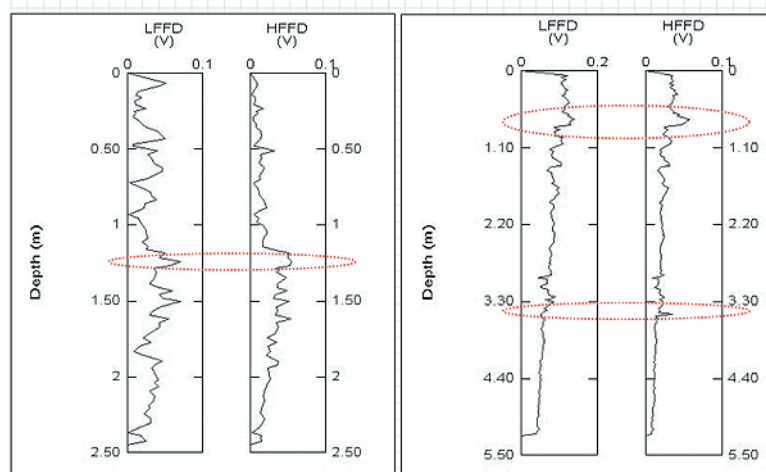
Figure 2: Blind Pass petroleum hydrocarbons average concentrations in 141 sediment core samples. An anomalously high value was evident the South Channel (*n = 25*) in which a single sample C8-C40 concentration was 330 mg/Kg. Averages from Shoal (*n = 35*), Outside the Pass (*n = 36*), Mid Channel (*n = 33*) and the North End Channel (*n = 12*) were less than 6 mg/Kg. For depiction purposes all sample concentrations below minimum detection level (10ug /Kg) were included as 0 values.

with each other. In some cases, usually at relatively shallow core depths, the petroleum hydrocarbon signal was clearly of lighter petroleum hydrocarbons not representative of those found in the heavier heating oil #6 Brouchard #155 reference sample. These results indicate that, although contamination levels were in general low or below detection, the heavier oils may persist in the Pass environment over long time periods.

Data from these results was applied to calibration studies of an FFD probe in which *in situ* petroleum hydrocarbon measurements may be made (Figure 4). Of the 104 samples analyzed, 35 samples or 25 % exhibited above detection values. The levels of C8-C30 were generally below detection or low. The distribution of above-detection level samples was in general localized, with a patchy distribution of above detection values evident in the Pass (Figure 5). In general, the most consistently above-detection levels were obtained at core depths between 200-300 cm. This study also employed scanning electron
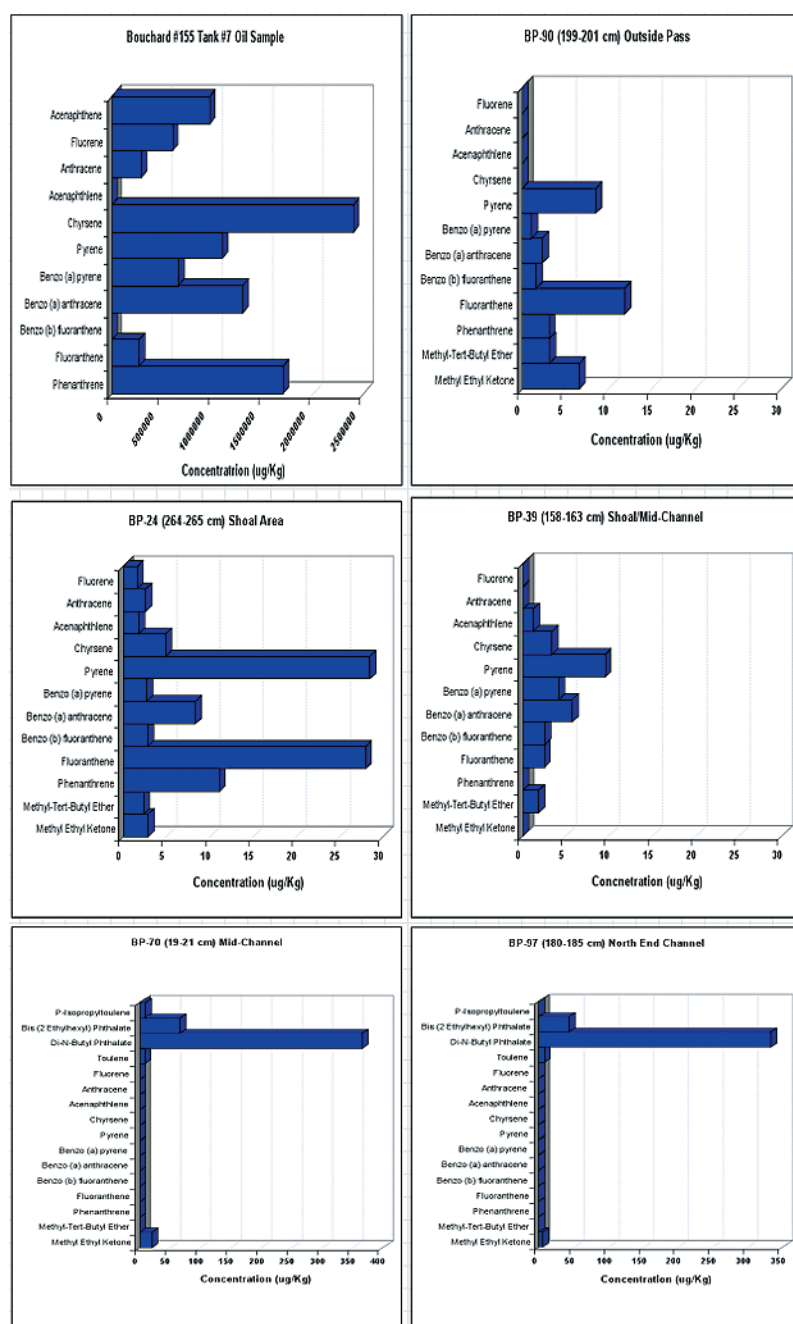
Figure 3: Brouchard #155, Tank #7, heating oil #6 recovered from the spill site compared with selected Outside Pass, Shoal, Mid and North Channel core sediment horizons. Note the samples exhibit profiles similar to, but of much lower concentration, then the reference sample. The bottom two figures depict two sample profiles from the Mid and North End Channel which were distinct from the reference sample. Note the Chrysene/Pyrene ratio in the reference sample compared to the field samples. These ratios will be evaluated as an indicator of the degree of weathering and degradation of the oil over time.

microscopy (SEM) to examine the distribution of sulfur in particulates from core samples exhibiting higher levels of petroleum hydrocarbons.

This research was valuable in the assessment of the FFD probe, a new analytical tool, with which petroleum hydrocarbons may be assessed *in situ,* in characterization of sources of environmental contamination, and in monitoring recovery of an area after environmental contamination.

Research Performance Measure:

The research program is on schedule and all performance objectives are being met. This research was valuable in the assessment of the FFD probe, a new analytical tool, with which petroleum hydrocarbons may be assessed *in situ,* in characterization of sources of environmental contamination, and in monitoring recovery of an area after environmental contamination.
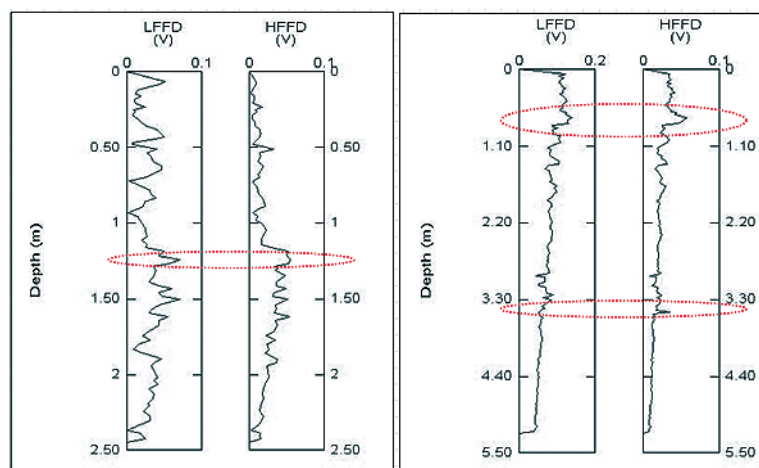
Figure 4: Blind Pass core BP-16 (left) BP-19 (right) FFD probe analysis. Red circles indicate horizons sampled for petroleum hydrocarbon analyses.

Figure 5: Blind Pass, Tampa Bay, Florida. Sediment cores petroleum hydrocarbon concentrations (C8-C40) at 200-299 cm core intervals. Note the number of samples below detection, with a few higher values resulting in a "patchy "petroleum hydrocarbon distribution. Over 100 cores were collected for characterization of petroleum hydrocarbons by Dr. Ping Wang and map created by Tanya Beck (USF, 2008).

Variations in Carbon and Oxygen Stable Isotopes in the Otoliths of Four Species of Juvenile Snapper (Lutjanidae) in Florida Bay

A. Morgan and E. Malca (UM/CIMAS);
W. Richards, J. Lamkin and T. Gerard (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:
***Objectives*:** To determine whether any of the four snapper species commonly found in Florida Bay can be used as proxies for the others in future stable isotope projects in order to alleviate the difficulty of obtaining a substantial sample size.
***Strategy*:** To measure the concentration of $\delta^{13}C$ and $\delta^{18}O$ stable isotopes in the otoliths of four snapper species found in Florida Bay and to use these as an indicator of environmental factors and metabolic activity of these fishes.

CIMAS Research Theme:
***Theme 3*:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:
***Goal 1*:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: SEFSC   **NOAA Technical Contact:** Bill Richards

Research Summary:
Species of snapper in Florida Bay are crucial components of the ecosystem and the fishing economy. This study examines the concentration of C:C and O:O stable isotopes in the otoliths of four snapper species found in Florida Bay as an indicator of environmental factors and metabolic activity of these fishes. Carbon isotopes reflect mostly metabolic factors while oxygen isotopes reflect the ambient water conditions including temperature and salinity. Interspecies and temporal analyses were performed on samples taken from seven sites over five years representing 133 km of representative habitat in Florida Bay. Results were inconsistent, with the most promising comparison occurring between schoolmaster and gray snapper found in Northeast Florida Bay. Further research with more comprehensive data is necessary to draw a strong conclusion, but initial results suggest that stable isotope projects involving snapper in Florida Bay should be species-specific to report any future findings with confidence. Sample collections in Florida Bay will continue to extend the temporal size of the study will take place in summer 2008.
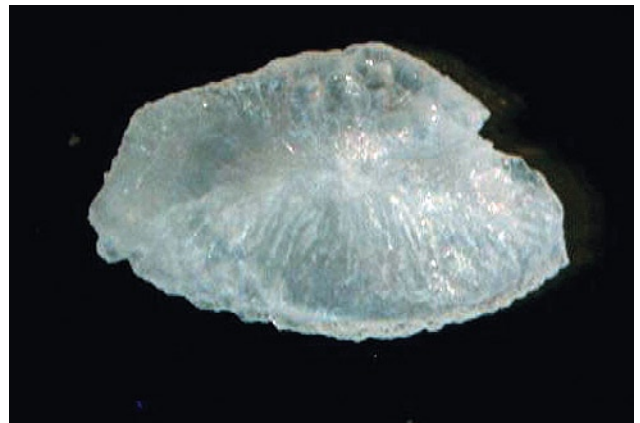
Figure 1: Sagittal Otolith (6 mm long) removed from a juvenile Snapper (SL 150 mm).

Research Performance Measure:
The program is meeting its goals on schedule. One of the goals of this study is to determine whether any of these species can be used as a proxy for another in future stable isotope projects in order to alleviate the difficulty of obtaining a substantial sample size. Initial results obtained suggest that stable isotope projects involving snapper in Florida Bay should be species-specific to report any future findings with confidence. This project was submitted as a Senior Thesis by Anne Morgan to the Biology Department at the University of Miami and will be presented in December at the next Florida Bay Science Conference.

Photo-Identification of Bottlenose Dolphins in Biscayne Bay, Florida

J.A. Wicker (UM/CIMAS); L. Garrison, J.P. Contillo,
J. Litz and A. Martinez (NOAA/NMFS/SEFSC)

Long Term Research Objectives and Strategy to Achieve Theme:

Objectives: **To** conduct research to understand and describe the parameters of bottlenose dolphin populations in Biscayne Bay and to monitor and observe their role in the south Florida ecosystem and the impacts of human activities on them. To advise and inform decision-makers and the general public on the condition of the bottlenose dolphin population in Biscayne Bay and the affects of human interactions on them.

Strategy: To develop and maintain a long-term database on bottlenose dolphin population parameters using photographic identification techniques which can be used to monitor the overall health of the Biscayne Bay ecosystem. To facilitate sharing of bottlenose dolphin photo-ID information and images among research groups in adjacent study areas in south Florida via the Internet.

CIMAS Research Themes:

Theme 3: Regional Coastal Ecosystem Processes

Link to NOAA Strategic Plan:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: SEFSC/PRBD **NOAA Technical Contact:** Lance Garrison

Research Summary:

The National Marine Fisheries Service (NMFS) is responsible for monitoring the populations of bottlenose dolphins (*Tursiops truncatus*) in the southeastern United States waters. The main goals of this monitoring are detection of large-scale changes in bottlenose dolphin abundance and establishment of archival databases for long-term trend detection. Biscayne Bay has been greatly influenced by development of the Miami area in the past 75 years. Information from 14 years of photo-ID surveys have 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.

Aside from 20 aerial surveys (40 survey hours), conducted by Odell in the mid-1970's, very little formal research had been conducted on the abundance and distribution of bottlenose dolphins in Biscayne Bay prior to 1990. From 1990-2006, a total of 409 photo-ID surveys comprising 2000 plus hours of sampling effort were conducted in Biscayne Bay. Sampling has continued uninterrupted into 2006. 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, an Oracle database application was developed. This database enables "Internet web-based" online data entry, update, categorization, search, and
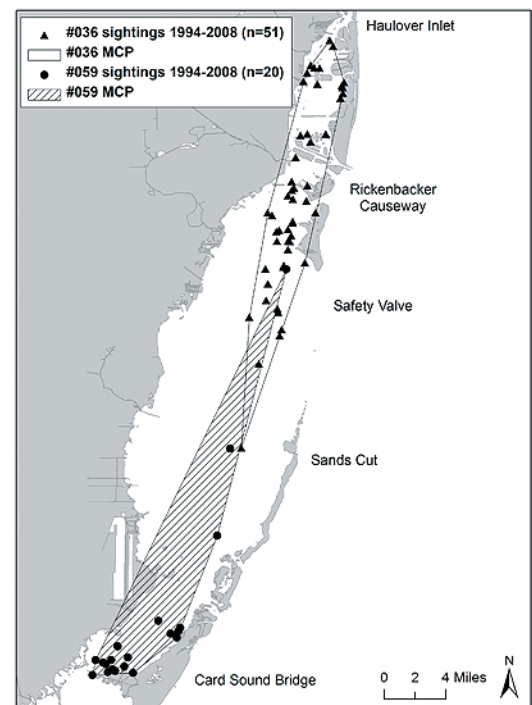
Figure 1: Sightings and minimum convex polygon home ranges of two different dolphins (059 and 036) for a fourteen year period.

download capabilities. The data resident on the system include scanned digital photos, associated collection information and meta-data, and allows 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. To date, a total of 70 skin and 50 blubber samples from 50 known individuals have been collected and are currently being processed and analyzed. Additional biopsy sampling is planned. Continuation of the established photo-ID sampling regimen and integration of photo-ID and genetic data will provide the framework for defining biologically based management units.

Research Performance Measure:
All major objectives have been met with the Biscayne Bay Photo-Identification project. As a result of this program Bottle Nose Dolphins are under consideration as an Indicator Species with respect to Biscayne Bay ecosystem health and water quality. We have assembled a data base that will enable future research to quantitatively characterize the consequences of anthropogenic contamination upon the well characterized bottlenose dolphin population in Biscayne Bay.

RESEARCH REPORTS

THEME 4: HUMAN INTERACTIONS WITH THE ENVIRONMENT

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

G.P. Podestá, D. Letson, N. Breuer, D. Solis and K. Broad (UM/RSMAS); J.W. Jones, C.W. Fraisse, C. Porter and K.T. Ingram, (UF/Agricultural & Biological Engineering); P. Hildebrand (UF/Food & Resource Economics); K.W. Migliaccio (UF/Tropical Research & Education Center); J.J. O'Brien, D. Zierden and T. LaRow (FSU/COAPS); G. Hoogenboom, D. Stooksbury, J. Paz, C. Roncoli and P. Knox (Univ. Georgia/ Biological & Agricultural Engineering); C. Roncoli (Univ. Georgia/Anthropology); J. Christy (Univ. Alabama-Huntsville)

Long Term Research Objectives and Strategy to Achieve Them:

Objective: 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 USA.

Strategy: To develop generic tools for the production and dissemination of relevant climate information (diagnostic and forecasts); to strengthen decision making in agriculture.

CIMAS Research Themes:

Theme 4: Human Interactions with the Environment (*Primary*)
Theme 1: Climate Variability (*Secondary*)

Link to NOAA Strategic Plan Goals:

Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond (*Primary*)
Goal 3: Serve Society's Needs for Weather and Water Information (*Secondary*)

NOAA Funding Unit: CPO
NOAA Technical Contact: Caitlin Simpson and Hannah Campbell

Integrated Research Summary:

The mission of the Southeast Climate Consortium (SECC) is 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 USA. As a multi-disciplinary, multi-institutional team, the SECC conducts research and outreach to a broad community of potential users and forms partnerships with extension and education organizations to ensure that SECC products are relevant and reliable.

The goal of the Southeastern Climate Consortium 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:
1. To develop an improved understanding of seasonal climate variability and climate predictability at local to regional scales across the Southeastern USA.

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 Southeast USA.

4. To design and implement appropriate vehicles for disseminating climate and decision support information, including an Internet-based learning and decision support system.

5. 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 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 "down-scaling" 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.

Component Programs
The groups at the University of Florida, the Florida State University, the University of Georgia, and the University of Alabama-Huntsville, operate under subcontracts to the University of Miami. In the following sections we present the research summaries of each of the five universities.

University of Miami:
Economic modeling of climate information use in the context of farm programs. To answer the question, "Can climate information raise farm incomes?" farm risk models must evaluate climate information in a context where farm programs matter. David Letson and Daniel Solís have introduced a framework of studying the value of the climate information under federal farm programs in the SE USA, in collaboration with SECC members at all locations. This framework integrates climate, biophysical, economic, and policy components in a comprehensive optimization and simulation model to study the impacts of government intervention in the use of ENSO-based climate forecast. This research aims to provide information

to growers and policy makers in order to improve economic well being and to reduce risk.

Conduct outreach surveys and gather feedback from farmers, extension agents, and other climate information users. We conducted assessments and evaluations to establish the value and impacts of SECC products. Norman Breuer and Peter Hildebrand have assessed potential use of seasonal climate forecasts by different groups of potential users. They also undertake case studies with particular groups of agricultural producers, including resource-limited or marginalized communities. An important step has been to assemble our baseline data on knowledge of climate variability, usefulness of forecasts, and potential adaptations in the states in which we operate.

Breuer works with Carla Roncoli of the University of Georgia to develop an Internet-based system for eliciting feedback from stakeholders. A survey embedded in the *AgClimate* website provides real time feedback from end users.

Breuer and Hildebrand continue to conduct open-ended, structured, personal interviews with extension agents and farmers with the aim of obtaining useful backwards flow information as a guide to producing more useful products. A learning community is has evolved from these continuous interactions, in which information flows both ways, with a view to constant cross fertilization in a framework of adaptive management, as follow-ups to *sondeos,* and in pursuit of new lines of inquiry.

Develop a systems-based approach to link models from different disciplines for applications of climate information in agricultural and water resources decision-making. Stochastic weather generators are powerful tools for translating ENSO forecasts into regional climate conditions. They may also give new insight into how an ENSO phase forecast helps us understand regional climate. Guillermo Podestá and a graduate student, Mr. William Forsee, have implemented a parametric-nonparametric hybrid stochastic weather generator to produce synthetic weather series for locations in the US southeast. The performance of this generator is currently being tested using a broad suite of graphic diagnostics. The output of the weather generator is an ensemble of synthetic daily weather sequences with statistical properties consistent with those of the historical record. These series can be used to drive process models (e.g., crop simulation models) for risk assessment and management. Podestá and Forsee have also compared four alternative approaches to estimate the boundaries between terciles (the 33% and 66% quantiles) of quarterly precipitation totals and mean surface temperatures for 197 cooperative weather stations in Alabama, Florida and Georgia. Forsee completed his M.S. degree and graduated in May 2008.

University of Florida:
Expand climate risk analysis products for different crops. Monthly climatic indices published by NOAA were correlated with observed cotton yields for all cotton producing counties in the southeastern USA. Multiple linear regression models were
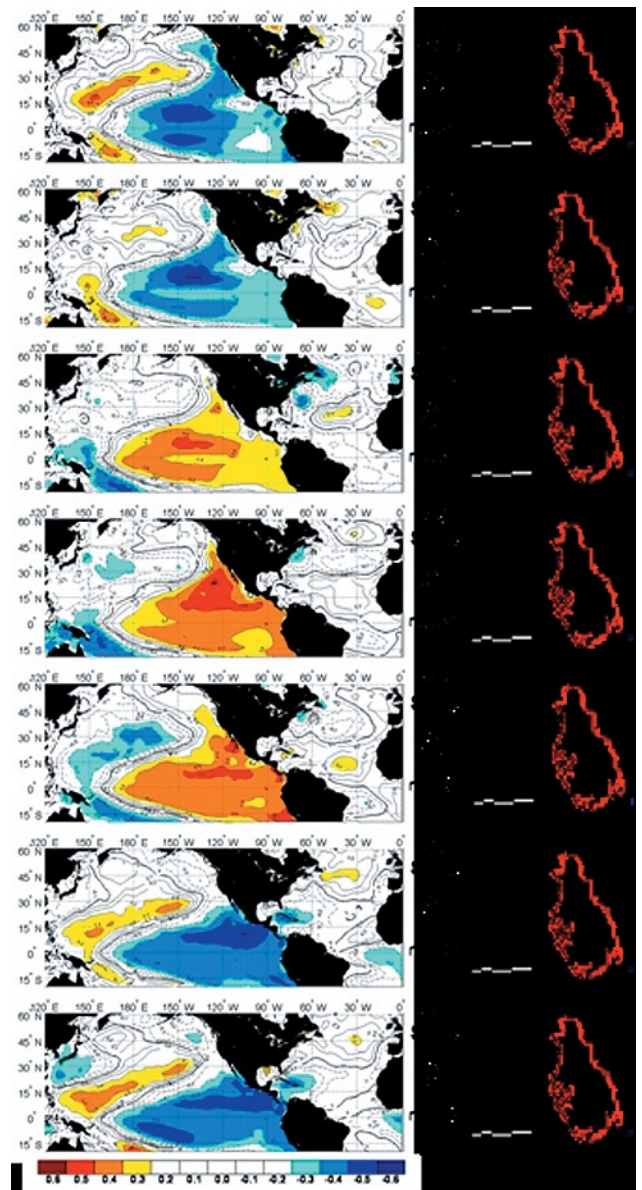
Figure 1: Pearson's correlation between July – January SSTs and rainfall in the Southwest Florida Water Management District. Changes in sign of the SST correlation are accompanied by a change in sign of rainfall station correlation and is an artifact of the SVD method. Also shown is the Pearson's correlation (r) and squared covariance fraction (SCF) of the leading SVD modes of the two fields.

developed for all the counties using only significant principal components. Models were evaluated using cross validation approach, leaving one observation out at a time. Skill level testing was done on predictions to evaluate the results. Earliest prediction of cotton yield was obtained in the month of April.

Online help has been developed and implemented in *AgClimate* for all decision support tools. In addition, an extension publication has been published explaining the use of crop yield risk tools available on *AgClimate*. In addition, we published the following to help *AgClimate* users: Fraisse, C.W., J.O. Paz, and C.M. Brown. 2007. Using seasonal climate variability forecasts: Crop yield risk. University of Florida IFAS Extension, Circular EDIS AE404.

In order to establish whether a weather generator captures inter-annual weather variability caused by ENSO phases, we utilized two recent SECC products – the Schoof weather generator and the Zierden modification to the JMA ENSO index. Statistical comparisons showed that, while the generated weather reproduced mean monthly rainfall by ENSO phase, the average number of days per year with freezing temperatures was consistently underestimated, particularly during the ENSO neutral condition. This may be particularly important in south Florida, since crops grown there can be very cold sensitive.

***AgClimate* enhancement and transition.** The main accomplishment related to *AgClimate* in 2007 was the transition to IFAS Extension. Main objectives under this activity included:

- To establish the personnel and infrastructure needed for the transition of *AgClimate* from Research to Extension;
- To create a mirror *AgClimate* site that will be maintained by Florida Extension Services;
- The transition of climate, crop yield, and forestry tools to the Extension *AgClimate* site.

All objectives were accomplished. *AgClimate* is currently operating in new servers maintained by the University of Florida computer network systems that are also shared by the Florida Agricultural Weather Network (FAWN) system.

Figure 2: Example graphic of a long-term temperature record (overnight minimum temperatures) for Arcadia, FL.

Support to InterRISA Project with CLIMAS. An initial assessment of stakeholders needs for climate information was done in Albuquerque, NM on December 03, 2007 at a meeting to introduce New Mexico State University (NMSU) Extension agents to *AgClimate* and its decision support tools. The main goal was to have Extension agents evaluating the system and identifying needs and adaptations that would be required for serving their clients in the region. Programmers from the University of Florida have also provided support to programmers at NMSU in the design and implementation of the climate database requirements to support a stand-alone version of *AgClimate* that will be implemented at NMSU.

Integrate agricultural and hydrological models. Working with UF staff, Soil & Water Engineering Technology, Inc. (SWET) staff developed a linkage between Watershed Assessment Model (WAM) and Decision Support System for Agro-technology Transfer (DSSAT) models. This linkage provides a model capable of simulating the effects of climate scenarios on water quantity, water quality, and plant growth and yields.

Using seasonal climate forecasts to reduce risk in regional water supply management. Water supply managers in Florida are increasingly turning to alternative sources in order to minimize the environmental impact of groundwater withdrawals. As part of a study to improve source allocation decision making in Southwest Florida, an evaluation of Pacific and Atlantic Ocean sea surface temperatures (SSTs) and monthly rainfall (1970-2006) was performed to identify coupled modes of variability. Field-significant correlations were found only for the leading singular value decomposition (SVD) mode. The leading SST expansion coefficients corresponded strongly with the eastern tropical Pacific ENSO signal. Significant coupling was found between SSTs and monthly rainfall between November and April. Coupling of
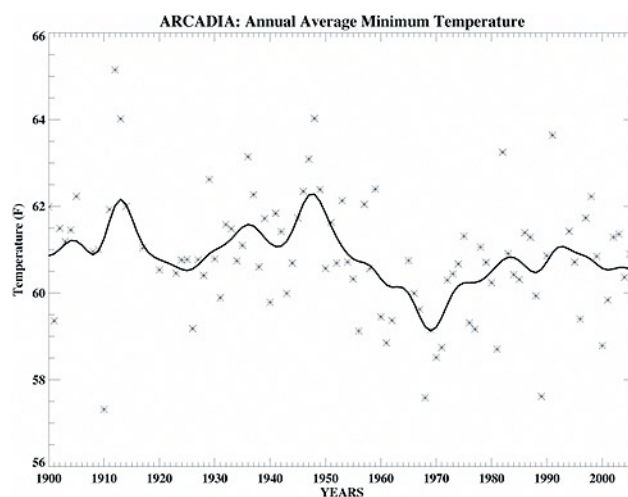
November, January, February, and March monthly rainfall with SSTs were found to be significant at 0- to 6-month lead times. Coupling of December rain was significant at 0- to 2-month lead times, and the coupling of April rainfall was significant at 0- to4-month lead times (Figure 1).

Developing a Water Deficit Index (WDI) for quantifying crop water stress. The proposed index, Water Deficit Index (WDI), is a function of actual to potential transpiration ratio: WDI = $1 - T/T_p$, where: T = actual crop transpiration, mm, and T_p= potential crop transpiration, mm. We estimated T_p using the FAO-56 model, T from water uptake coefficient and available soil water: T = $\alpha(\theta - \theta_{wp})$. Using historical weather data of four locations, daily WDI and LGMI values were computed for grass and DSSAT stress factors were computed for maize. These values then were used to calculate the departure of WDI from LGMI and DSSAT (Figure 1). Although LGMI and WDI showed similar trends of crop water stress, LGMI values were always greater because of LGMI uses unrealistically high estimates of evapotranspiration. Like LGMI, WDI is calculated from readily available weather data. Yet WDI has more realistic estimation of evapotranspiration than LGMI.

Florida State University:
Coupled climate-crop models and downscaling. In order to build a firm bridge between the numerical climate model and the crop model, we have investigated the performance of an advanced land model, the Community Land Model 2, in the seasonal dynamical downscaling of surface fields (maximum and minimum temperatures, precipitation, and solar radiation) through the FSU regional climate model) and explored the suitability of these surface fields for crop yield estimations using a state-of-the-art processed based crop model (e.g., DSSAT 4.0 family of crop models). These models are able to simulate between 2.5 and 10% of the observed yields when accurate data for crops, soils and weather are available. Ensemble simulations were used to characterize uncertainty in the forecast, using convective parameterizations. These ensembles are used to make probabilistic forecasts of crop yields at multiple sites.

Update, expand, and automate climate database operations. The latest raw weather data were collected by the state climate offices in Florida, Georgia, and Alabama and sent to Florida State University for quality control and compilation into a common format. The data have been rewritten into portable ASCII files and also into DSSAT format that is used by the crop models. The data was also resample using a technique known as bootstrapping, creating a data set of 1,000 "synthetic" years of monthly data for each weather station and for each ENSO phase. These bootstrapped values are used to generate smooth probability density functions for the climate variables, which drive the probability graphs displayed in the climate tool on *AgClimate* (AgClimate.org). All of these formats have passed final quality checks and are now used operationally. The data base is available to all SECC members and other interested parties at a common ftp site: ftp://secc.coaps.fsu.edu.

Research on ENSO variability in the Southeast US. We compared the definitions of ENSO phases according to two popular SST-based indicators: the Oceanic Niño Index (ONI) and the Japanese Meteorological Association (JMA) index. The ONI was designed by the US Climate Prediction Center, and is the main indicator used for their regular ENSO outlook. The JMA index (JMAI) has been used in many studies and has been the indicator chosen by the Southeastern Climate Consortium for their ENSO outlook.

Long-term trends and climate change. Analysis of historical weather and ocean observations reveals useful information on the average state and variability along with changes on time scales from seasonal, to interannual (1-5 years), decadal, and even long-term trends. Warm season precipitation has dropped 10% to 15% in recent decades around central and south Florida, whether caused by land use changes or by circulation changes in the Atlantic Ocean. Many Florida weather stations also exhibit long term trends in temperature and rainfall, whether caused by a changing global climate or by local changes in land use and urbanization (Figure 2).

Focus on variability of extremes and extreme events. The El Niño-Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), the Pacific Decadal Oscillation (PDO), and the Polar Vortex Oscillation (PVO) produce conditions favorable for monthly extreme temperatures and precipitation. We examined the worst and best case scenarios for each phase

and the combination of phases that produce the greatest monthly extremes. Data from Canada, Mexico, and the United States were gathered from the Historical Climatology Network (HCN), and data from these stations were bootstrapped in order to expand the time series. Magnitudes of temperature and precipitation anomalies were the greatest in the western Canada and the southeastern United States during winter, and these anomalies were located near the Pacific North American (PNA) nodes. Summertime anomalies were weak because temperature variance was low. The magnitudes of the anomalies and the corresponding phase combinations varied regionally and seasonally.

Refinement, development, and dissemination of climate forecast products. FSU led the development of new tools and climate variables for inclusion in the agricultural decision support system (*AgClimate*), including tools displaying ENSO climate variations in such quantities as chill accumulation, growing-degree days, absolute minimum and maximum temperatures.

Wildfire Risk Forecast System. COAPS produces a monthly wildfire risk forecast operationally for the traditional wildfire season of January through July of each year. The wildfire activity potential forecast is based on the Keetch-Byram Drought Index (KBDI), available through *AgClimate*.

University of Georgia:
Development of numerical tools for analysis of climatic time series. Several numerical tools were developed to provide a common platform for the systematic, reproducible, and statistical analysis of hydro-climatic data. These tools consist of a series of libraries of functions (packages) written in Python, a powerful, open-source, platform-independent scripting language. Our modifications have been included in the latest official release of Numpy (1.0.5). A second series of modules has been developed for the manipulation of time-indexed datasets and is also readily available as a specific Scipy package (scikits.timeseries).

Comparison of ENSO indicators. The Japanese Meteorological Association (JMA) index is used by the SECC for characterizing ENSO episodes. In its standard application, El Niño occurs when the 5-month averaged sea surface temperature anomalies recorded in the tropical Pacific Ocean are greater than +0.5°C for at least six consecutive months including October to December. In contrast, La Niña occurs when the temperature anomalies less than -0.5°C. The phase then lasts from October to the following September included. We investigated a modification to this method, where ENSO phase stops as soon as the temperature conditions are no longer met. We compared the two approaches by analyzing differences in mean and median average monthly precipitations recorded on 172 stations over Alabama, Florida and Georgia. The two methods gave equivalent results from September to March. For these months, the modified method yielded slightly more significant results. We applied the two methods to estimate the impact of ENSO variability on the low flows of seven streams in South Georgia. The modified JMA indexed tended to give more significant results than the original index.

We also compared the modified JMAI with the Oceanic Niño Index (ONI), designed by the US Climate Prediction Center, which is the main indicator used for their regular ENSO outlook. There was an apparent bias of -0.4°C for the ONI before April 1952, resulting in an overestimation of the number and strength of La Niña events, and an underestimation of El Niño events. After 1952, the two indicators gave similar results, with the ONI detecting 25% more episodes than the JMAI. Based on comparison of the two indicators for precipitation datasets from Alabama, Florida, and Georgia, we recommend the modified JMAI to assess the influence of ENSO phases on environmental data.

Weather data. Daily weather data for Alabama (44 locations), Florida (58 locations), and GA (62 locations), obtained from the Cooperative Observer Program (COOP) network and compiled by the Center for Oceanic-Atmospheric Prediction Studies (COAPS), are ready until 2006. The historical weather data include observed daily maximum and minimum air temperature and rainfall and generated daily solar radiation.

Lead-time climate and weather data forecasting. In this activity we focused on using pattern recognition for lead time forecasting daily weather data consisting of precipitation, maximum and minimum temperature, and solar radiation. An algorithm for daily weather data series prediction based on the k-NN approach was developed. To test our algorithm of

pattern recognition we used 10 different sites across the state of Georgia. This approach was verified across the world for 16 sites, with at least one site from each continent.

Simulated yield. The CSM-CROPGRO-Peanut and CSM-CROPGRO-Cotton models were run for all counties producing both crops in the three states during 1975 to 2006, as reported by USDA-NASS.

Pests and diseases. We examined the effects of El Niño-Southern Oscillation (ENSO) on the prevalence of tomato spotted wilt virus (TSWV) in peanut, and how a weather-based component can be integrated with the current TSWV risk index. Results indicate that the severity of spotted wilt in peanut was consistently lower during La Niña than during El Niño or Neutral years. In addition to the risk index component, average daily air temperature in April, mean daily minimum air temperature in March and April, ratio of rain/wet days in March, total rainfall for April, and water balance (rainfall minus evapotranspiration) for April, provided significant contributions in predicting the severity of spotted wilt in peanut.

Southeast-Water-Climate. A template for a new water management website was developed based on inputs from water managers and other stakeholders. The development focused on content and links requested by the managers rather than the final look and feel of the website, which will be designed at a later time with assistance from website development specialists. Water managers suggested several tools that the need for improved decisions. Reservoir managers most often requested estimations of evaporation to help them with water balance calculations. Another tool that was requested was the effect of ENSO on precipitation and temperature based on watersheds and counties.

Evaluating use and impact of *AgClimate* tools. To better understand what kind of information producers need and how to communicate it them, Roncoli and Crane conducted semi-structured interviews with South Georgia farmers from January to March 2007, including 38 farmers in 20 counties, which represented a broad cross-section of production systems found in Georgia. Most farmers are keen on receiving more climate information. Among other potential adaptive responses to climate forecasts, farmers mentioned: a) adjusting expenditures, insurance coverage, and chemical input application; b) modifying the timing of planting and harvesting; c) planting more or less in certain fields/soils; d) selecting crops and crop varieties; e) preparing irrigation equipment; f) implementing soil and water conservation. Our research also documented how some farmers have used the SECC's information system. In spring of 2006, the SECC forecasted a drier than normal summer. The extension agent in Irwin County received the SECC's forecast and included it in the column he normally writes for the local newspaper. He reported that this led many farmers to switch to peanut varieties that mature in 90 days, instead of the normal 120-day varieties.

Assessing the accessibility, relevance, utility of *AgClimate* tools. An assessment of the AgClimate website, based on multiple activities with a diversity of users, was conducted between Fall 2006 and Spring 2007 under Roncoli's direction. The assessment included seven hands-on classroom evaluations, twelve IT expert evaluations and evaluations by extension agents at three AgClimate training workshops. Qualitative feedback indicated that users most like the comprehensive collection of information in one place, the availability of historical yield data, the various crop tools, and the ability to make comparisons illustrating the effects of ENSO phase on all of these functions. During 2007 Roncoli and Crane worked closely with the AgClimate team to implement the user feedback and improve the display, the text, the structure, and the usability of the website.

University of Alabama – Huntsville:
Improvements to Lawn and Garden Moisture Index (LGMI). In this past reporting period we have updated the static evapotranspiration curve to be slightly more realistic in the LGMI. The LGMI was used extensively during the drought of 2007 in determining drought designations for the SE in the US Drought Monitor (P.I. Christy is the main information source for Alabama's Drought Monitor designations, for example)

Assimilation and use of high resolution insolation data. We testing of the use of an insolation product derived from NOAA GOES to include in the LGI to better capture the spatial evaporative loss part of the LGI. UAH in conjunction with NASA currently produces an hourly 4-km insolation product over the Southeast. The initial employment of the insolation

product will be used to calculate potential evaporation rates.

Development of a new drought index. Soil data in crop models coupled with the observed *in situ* weather data and weather interpolators developed under the SECC along with the radar derived rainfall and insolation data have the potential for producing a new type of agricultural drought index which is physically based and would have excellent spatial coverage. Initial DSSAT runs have been successful in discriminating crop health relative to irrigated and non-irrigated grid squares, and thus the crop-moisture condition of the soil, which is the variable we are quantifying. Tests have been completed on variable solar radiation input and the impacts on evapotranspiration which directly affects crop-moisture availability. Thus the model is near ready for the real-time implementation of the solar radiation ingestion.

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

Effort Response, Harvest, the Economy, and Climate
in the Gulf of Mexico Recreational Fishery

D. Letson (UM/RSMAS); D.W. Carter (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Theme:

Objectives: To predict the effect of climate, economic, and regulatory changes on the value of recreational fishing in the Gulf of Mexico.

Strategy: To develop and assess models that can be used forecast recreational fishing effort and the value per unit effort or species. The forecast models will be used to predict the changes in effort and value expected with changes in the climate, the economy, and fisheries policy.

CIMAS research themes:

Theme 4: Human Interactions with the Environment

Link to NOAA strategic plan goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: NMFS/SEFSC   **NOAA Technical Contact**: Jim Waters

Research summary:

We continued work on the econometric forecasting model of the Gulf of Mexico head boat fishery originally developed in 2004-05 (a head boat is a vessel that charges a fee per passenger "head" for recreational fishing trips). The 1986 to 2003 data series used to estimate the model were updated through 2007 and forecast simulations were conducted to examine forecast accuracy. The head boat angler days forecasted for each month from 2004 to 2007 were, on average, within fifteen percent of the actual values observed.

The forecasting model was used twice to evaluate the effects of policy changes in the Gulf of Mexico red snapper fishery. In the first case, we forecasted the changes in head boat angler days expected with the changes in the red snapper bag limit and season length proposed in Amendment 27 to the Gulf of Mexico Reef Fish Fishery Management Plan. In the second case, the changes in angler days expected with the early closure of the 2008 red snapper fishing season in the Gulf of Mexico were forecasted. Figure 1 shows the effect of that changing the date when the red snapper season closes could have on aggregate level of head boat effort in the Gulf of Mexico.
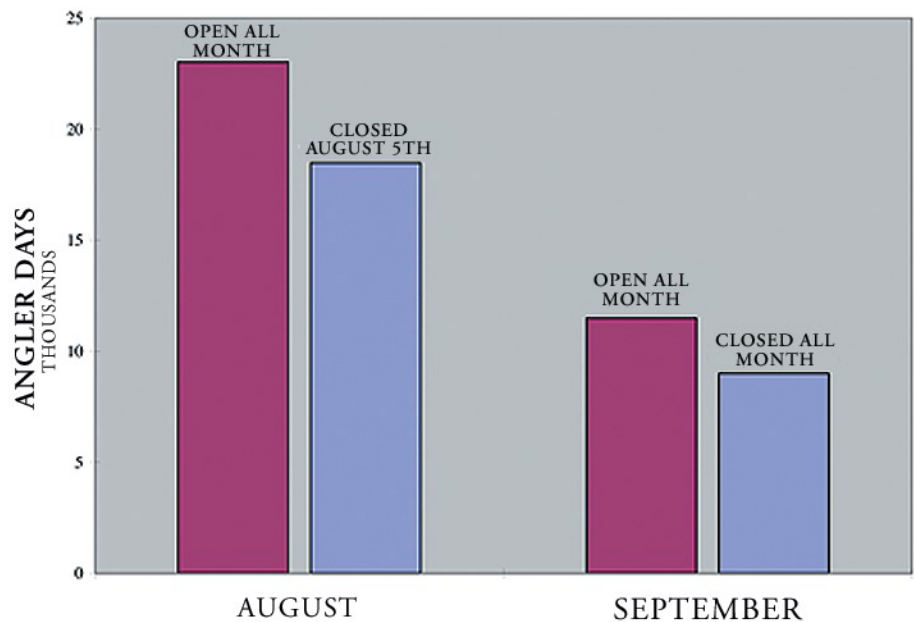
Figure 1: Forecasted Head Boat Effort in the Gulf of Mexico during the Red Snapper Season when the Season Ends on August 5th versus September 30, 2008.

Work began on estimating similar recreational effort forecasting models for the charter and private boat sectors in the Gulf of Mexico. Preliminary results suggest that climate signals and regulatory changes have effects on these sectors that are similar to those observed for the head boat sector.

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

RESEARCH REPORTS
THEME 5: AIR-SEA INTERACTIONS AND EXCHANGES

Investigating the Boundary Layer in Hurricanes Using Unmanned Aircraft Systems

S.J. Majumdar (UM/RSMAS); J. Cione and E. Uhlhorn (NOAA/AOML);
Guy Cascella (UM/RSMAS, NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To examine the role of data collected by the Aerosonde unmanned aircraft in modifying dynamic and thermodynamic analyses in the hurricane boundary layer.

Strategy: To use observational data from Aerosonde and other platforms collected during Ophelia (2005) and Noel (2007) to prepare objective analyses and surface analyses.

CIMAS Research Theme:

Theme 5: Air-Sea Interactions and Exchanges

Link to NOAA Strategic Goals:

Goal 3: Serve Society's Needs for Weather and Water Information

NOAA Funding Unit: AOML/HRD   **NOAA Technical Contact:** Bob Atlas

Research Summary:

The Aerosonde is a unique unmanned aircraft system that has been designed to fly into the core of hurricanes and subsequently return to base. It provides a continuous sampling of dynamic and thermodynamic variables while in the storm, in locations that are too dangerous for manned aircraft to fly. Such data are essential to advance the scientific understanding of the poorly-understood atmospheric boundary layer and of air-sea interaction processes in hurricanes. Additionally, the data are expected to be important for high-resolution numerical models that attempt to predict hurricane structure and intensity change.

The maiden flight by an Aerosonde into an Atlantic tropical cyclone was achieved on 16 September 2005 when it sampled Tropical Storm Ophelia, including its inner core, for 4 hours. A second Aerosonde mission took place on 3 November

2007 in Tropical Storm Noel (Fig. 1). Both storms were in the early stages of extratropical transition, a poorly understood process due to the lack of observations.

The quality control and post-processing of the data has been finished for the Aerosonde and multiple other platforms (NOAA P-3 and USAF aircraft flight-level data and dropwindsondes, buoys, AXBTs, Doppler Radar, Stepped Frequency Microwave Radiometer, SST). Much of the recent focus has been on Tropical Storm Noel. Global model and satellite analyses suggested that Noel was a warm core cyclone even as Noel hit Nova Scotia, yet Noel had been declared extratropical 36 hours earlier due to a lack of deep convection on its western side. The first science question was: What led to the abrupt decrease in convection, thereby curtailing Noel's status as a hurricane? While one may have expected that the intrusion of cool, dry air as is typical in late-season storms was the culprit, it was found from the data that the moisture generally remained high in the inner-core of Noel, but the air-sea surface enthalpy fluxes had dropped to near zero close to the storm center. Other questions include: Why did Noel intensify during extratropical transition?; Why did Noel maintain a deep warm core 36 hours after the onset of ET?; and What role did the inner-core observations play in the analysis? A preliminary analysis of the last question shows that the wind speed analysis was 25 kt stronger in the north-west part of Noel when the Aerosonde data were added (Fig. 1c) These and other questions are being addressed as part of Guy Cascella's M.S. thesis, with a parallel study being performed for Tropical Storm Ophelia.

Research Performance Measure:
The research objectives in Year 2 have been met.
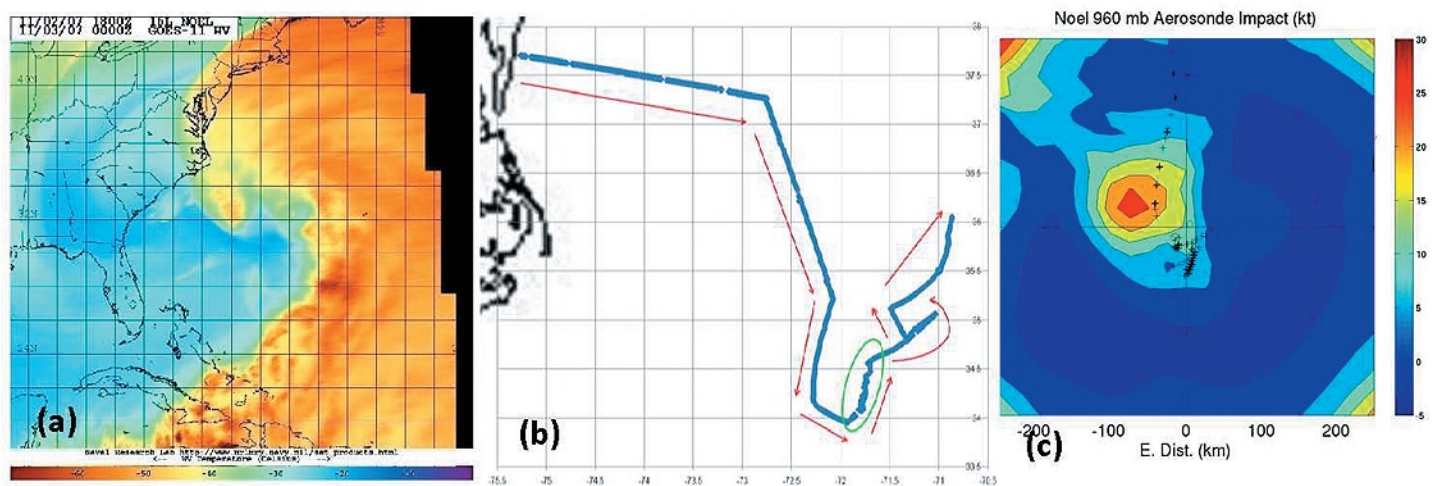
Figure 1: (a) GOES Satellite Water Vapor image of Noel at the time of the Aerosonde flight. (b) Aerosonde flight track into Noel. (c) Difference between two objective analyses of the wind field at 960 hPa, one of which is based on all aircraft data collected by manned aircraft, and the other which includes all these data plus Aerosonde data.

Characterization of Turbulent Energy in Hurricanes Using Doppler Measurements

S. Lorsolo (UM/CIMAS); J. Gamache, P. Dodge,
F. Marks and J. Zhang (NOAA/AOML/NRC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To estimate the distribution and evolution of hurricane boundary layers' turbulent energy for a better boundary layer parameterization in numerical weather prediction models

Strategy: To analyze Doppler radar and *in-situ* measurements from various instruments and to develop a method to estimate low-level turbulent energy that will provide an accurate assessment of hurricane turbulent energy to use in numerical weather prediction parameterization.

CIMAS Research Theme:

Theme 5: Air-Sea Interactions and Exchanges

Link to NOAA Strategic Goals

Goal 3: Serve Society's Needs for Weather and Water Information

NOAA Funding Unit: OAR/AOML   **NOAA Technical Contact:** John Gamache

Research Summary:

In order to improve hurricane forecasts we need to have a better understanding of the structure of tropical cyclones so that they can be better modeled. In particular a better knowledge of the hurricane boundary layer (HBL) is essential to improving the boundary layer (BL) parameterization in numerical weather prediction (NWP) models.

The goal of this research project is to estimate turbulent energy of the HBL and to evaluate how this energy is associated with small-scale HBL turbulent processes so that we can better understand their importance in the HBL flux transport.

The activities of the past year have focused on two aspects of the research project. First, we evaluated the capability of the high-resolution Imaging Wind and Rain Airborne Profiler (IWRAP) Doppler radar. IWRAP is the first high-resolution dual-band airborne Doppler radar designed to study the inner core of cyclones (TCs). We used IWRAP to resolve small-scale secondary circulations of the HBL that can affect the hurricane turbulent energy. We simulated IWRAP measurements using wind data from a NWP model (WRF) and compared the results with the original data to assess how well the IWRAP could measure secondary circulations in the wind field.

The second part of our work was to process tail Doppler radar data acquired from various past hurricanes to estimate hurricane turbulence. We developed a method that allows us to use radar data to calculate turbulent energy. We used this method to process data from Hurricanes Isabel, Katrina and Rita. Correlation analysis between turbulent data and other storm quantities (vertical wind gradient, reflectivity, distance from the center) have been conducted and vertical profiles of turbulent energy have been obtained.

Research Performance Measure:

The objective regarding processing and analyzing tail radar data was met. However, the analysis of IWRAP data has been delayed due to the current unavailability of the data which are being processed by a third party and should be available soon.

a)

b)
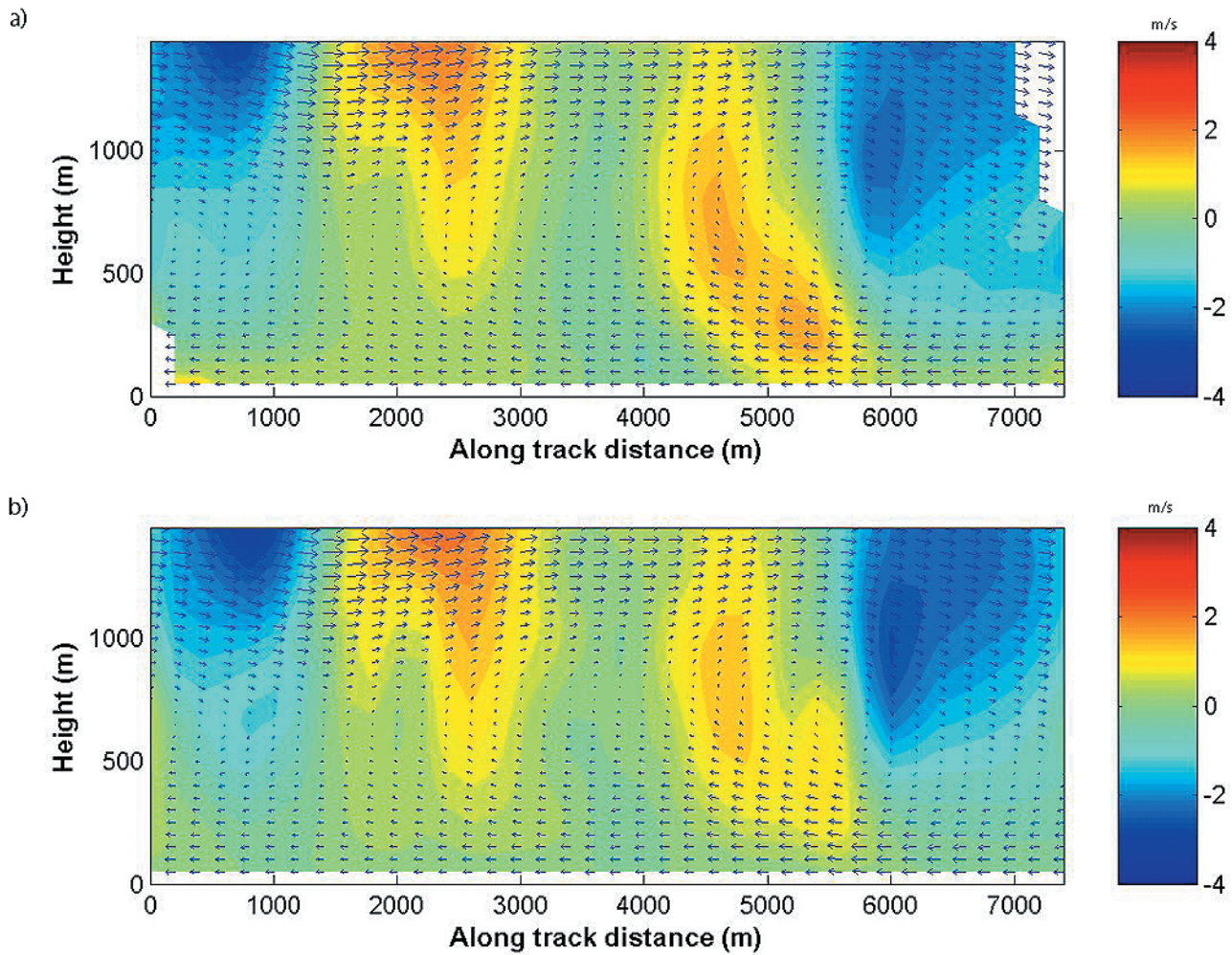
Figure 1: Vertical cross-section of vertical wind speed with overlaid wind vectors. Top panel displays the vertical wind resulting from processed simulated IWRAP data and bottom panel represents the original data.
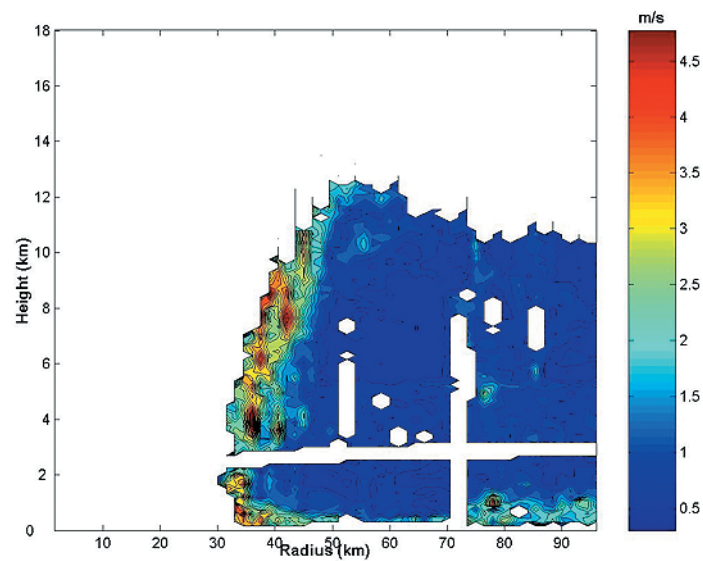
Figure 2: Vertical cross-section of turbulent energy for Hurricane Katrina on 28 August 2005.

Advanced Modeling and Prediction of Tropical Cyclones

K.-S. Yeh, X. Zhang, T. Quirino and V. Sainani (UM/CIMAS);
S.G. Gopalakrishnan (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To guide and accelerate improvements in hurricane intensity forecasts with emphasis on rapid intensity (RI) change and the reduction of false alarms.
Strategy: To improve hurricane forecast through the development and advancement of numerical modeling and data assimilation techniques valid for scales of motion down to about 1-km resolution.

CIMAS Research Theme:
Theme 5: Air-Sea Interactions and Exchanges

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

NOAA Funding Unit: OAR/AOML/HRD
NOAA Technical Contact: Sundararaman G. Gopalakrishnan

Research Summary:
There has recently been a dramatic improvement in tropical cyclone (TC) track forecasts brought about through advancements in high quality observations, high speed computers, and improvements in dynamical models. Similar advancements are now needed for improvements in tropical cyclone intensity, structure and rainfall prediction. The Hurricane Forecast Improvement Project (HFIP) is a unified NOAA approach to guide and accelerate improvements in hurricane intensity forecasts with emphases on rapid intensity (RI) change and the reduction of false alarms. Several preliminary studies indicate that, in order to improve the TC prediction, it is essential to capture motions on scales down to about 1 km. The Weather Research Forecasting (WRF) model is a general-purpose, multi-institutional, and multi-scale modeling system. A version of the WRF model, called the Nonhydrostatic Mesoscale Model (NMM), originally developed at the National Centers for Environmental Prediction (NCEP), was recently adopted for TC forecasting (Gopalakrishnan et al, 2006). The AOML Hurricane Research Division, in collaboration with the Cooperative Institute for Marine and Atmospheric Studies (CIMAS) at the University of Miami, along with other national and international collaborators, are further developing the WRF-NMM into the Hurricane Prediction System (HPS) for hurricane research and predictions (Figure 1).

We are improving WRF-HPS with: (1) a better vortex initialization by using modern techniques such as vortex reconstruction and vortex-scale data assimilation; (2) a better dynamical framework by creating high-resolution nesting grids capable of simulating multi-scale processes down to about 1-km resolution; (3) a better lower-boundary condition by incorporating the air-sea interactions; and (4) better physics by refining the parameterization schemes for tropics at about 1-km resolution. We are also developing the next-generation data analysis and visualization tools to better understand hurricane-scale processes and to provide a platform for doing model diagnostics to facilitate hurricane research. To advance our understanding of hurricane processes we are carrying out high-resolution numerical modeling of both idealized and real-world cases.

 The initial effort has focused on creating an end-to-end atmospheric component of the HPS capable of providing daily predictions over the tropical Atlantic. The system will run continuously on the AOML/HRD Ooyama Linux cluster throughout the 2008 hurricane season at *quasi*-operational resolutions of about 27 km with the moving grid at 9 km. This system should provide the basis for the high-resolution modeling effort discussed above. We have also developed an intelligent interface to automatically bring in the data to run and analyze these forecasts. We have also developed another visualization interface for advanced analysis of hurricane inner cores and also a platform for performing model diagnostics.

One of the most essential components of a hurricane modeling system is vortex initialization. We are exploring the

development of a baseline capability of vortex relocation and adjustment that is currently being used in several models including HWRF (but not available in the release version). We are also working with our ESRL partners to advance vortex initialization techniques valid for vortex scales at about 1-km resolution.

Because of the huge computational requirements in running a uniformly high-resolution, regional-scale domain for hurricane forecasting down to 1-km resolution, model nesting will be imperative for addressing the hurricane problem in the next 5-year time frame. To this end we are developing an advanced telescopic moving nest capability for the WRF-HPS system (project time lines 6 months). We are also exploring the possibilities of coupling at least a simple mixed-layer ocean model with the atmosphere model in the WRF-HPS system.

Finally we are developing an intelligent Java-based data mining and visualization tool capable of performing inter-model comparisons and producing quick and direct visualization of the inner core structure as well as the larger scale TC environment.

Research Performance Measure:
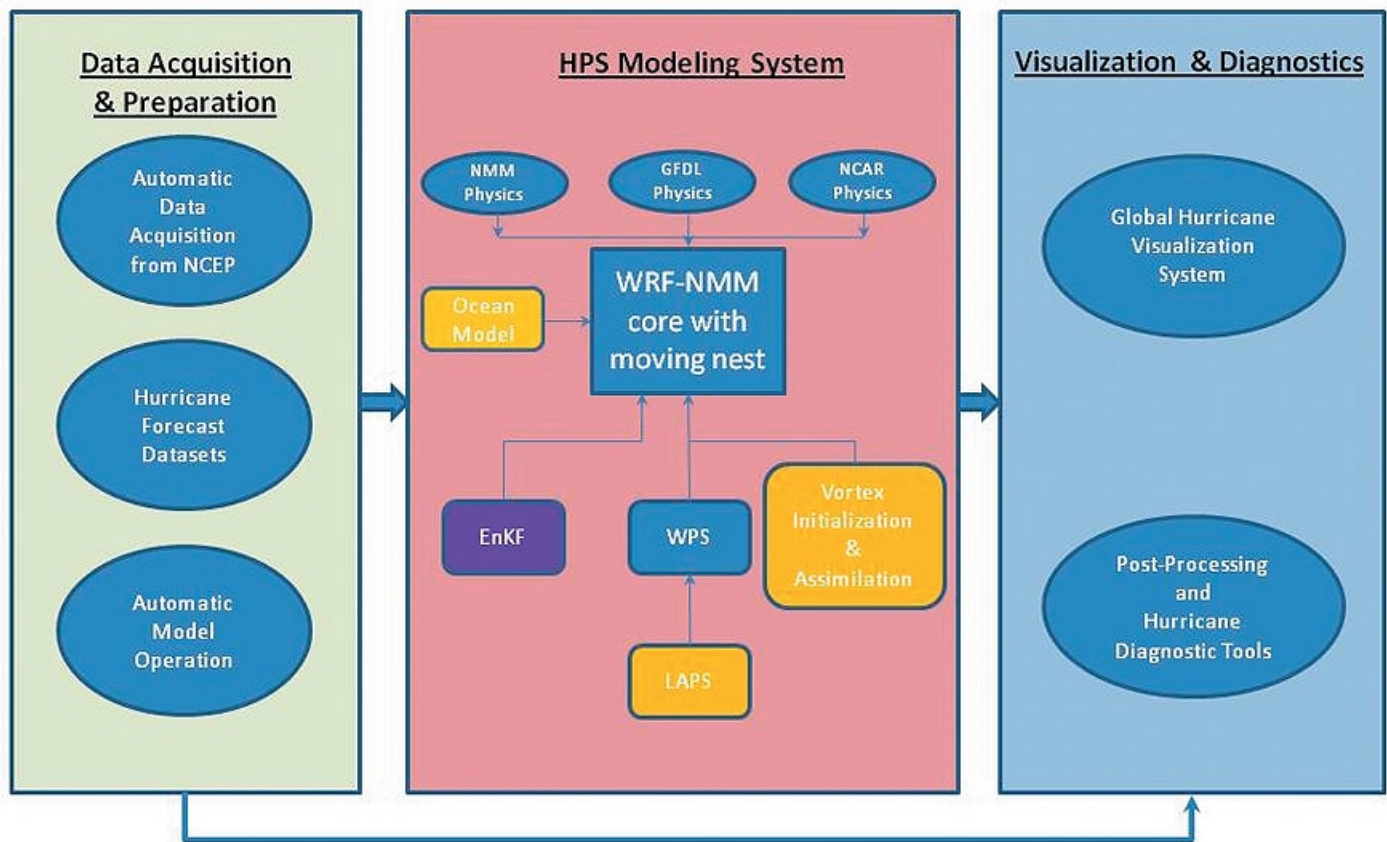All research objectives are being met on schedule.

Figure 1: WRF-NMM/Hurricane Prediction System.

Evaluation and Improvement of Ocean Model Parameterizations for NCEP Operations

L. K Shay and G. Halliwell (UM/RSMAS); C. Lozano (NOAA/NCEP/EMC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To evaluate and improves ocean model parameterizations in the NOAA National Center for Environmental Prediction (NCEP) coupled hurricane forecast models in collaboration with the NOAA Tropical Prediction Center (TPC) and NOAA/NCEP Environmental Modeling Center (EMC).

Strategy: To initialize the Hybrid Coordinate Ocean Model (HYCOM) with realistic ocean conditions, force it with realistic ocean fields, then evaluate model performance against high-quality ocean observations, emphasizing the impact of vertical resolution, horizontal resolution, vertical mixing, air-sea flux parameterizations (drag coefficients), and the accuracy of the ocean initialization.

CIMAS Research Theme:

Theme 5: Air-Sea Interactions and Exchanges

Link to NOAA Strategic Goals:

Goal 3: Serve Society's Needs for Weather and Water Information

NOAA Funding Unit: USWRP Joint Hurricane Testbed   **NOAA Technical Contact:** Jiann-Gwo Jiing

Research Summary:

The initial research effort focused on testing model initialization schemes primarily in the Gulf of Mexico (GOM) and processing data required for model evaluation. This dataset includes *in situ* Naval Research Laboratory Acoustic Doppler Current Profiler data from Ivan (Teague et al., JPO, 2007) and during Katrina and Rita (courtesy of Minerals Management Service) as well as measurements acquired during NOAA Hurricane Research Division Intensity Fluctuation Experiments (IFEX) in pre and post Rita in 2005 (Rogers *et al.*, BAMS, 2006).

HYCOM is used as the ocean model because it has been coupled to the WRF atmospheric model to form the next-generation coupled hurricane prediction model (HWRF). This coupled prediction model is being tested during the 2008 season at NOAA/NCEP/EMC, and the overarching goal of this work is to improve the performance of the ocean component of HWRF. The model evaluation completed to date has focused on hurricane Ivan in the GOM, where high-quality *in-situ* moored current measurements have been acquired, focusing on the impact of the Loop Current (LC) and associated warm and cold rings, along with the complex bathymetry of the continental shelf/slope region. Objectively analyzed fields from multiple space-based platform data such as radar altimeter measurements and SST fields are also used in the evaluation. Nine experiments have been performed to date emphasizing ocean model sensitivity to factors such as initialization, vertical and horizontal resolution, and vertical mixing. Based on these results, we provided guidance to NOAA/NCEP/EMC on the ocean model implementation for the summer 2008 HWRF tests, making sure that the latest version of the model code and optimal values of model input parameters were being used. We will contribute to the evaluation of HWRF performance in these tests.

Oceanographic features present during the Ivan simulation are illustrated in the simulated SSH field (Fig. 1). The LC path followed a medium-amplitude intrusion into the eastern GOM while a recently detached warm core ring (WCR) was located to the northwest. Two smaller significant cold-core eddies (CCEs) were also present, one located northeast of the WCR and the other to the southeast. The largest SST cooling occurred within the CCEs while little cooling occurred in the WCR, a pattern that was verified by microwave satellite sensors (Fig. 1) and by an analysis of AVHRR SST measurements by Walker *et al.* (GRL, 2005). The good pattern agreement was due in large part to the HYCOM-Naval Coupled Ocean Data Assimilation (NCODA) nowcast product that initialized the run with correctly-located ocean features. HYCOM has now been set up to simulate the response to hurricanes Katrina and Rita, and this work will be performed over the next few months.

Research Performance Measure:
The objectives of this program are being met on schedule.
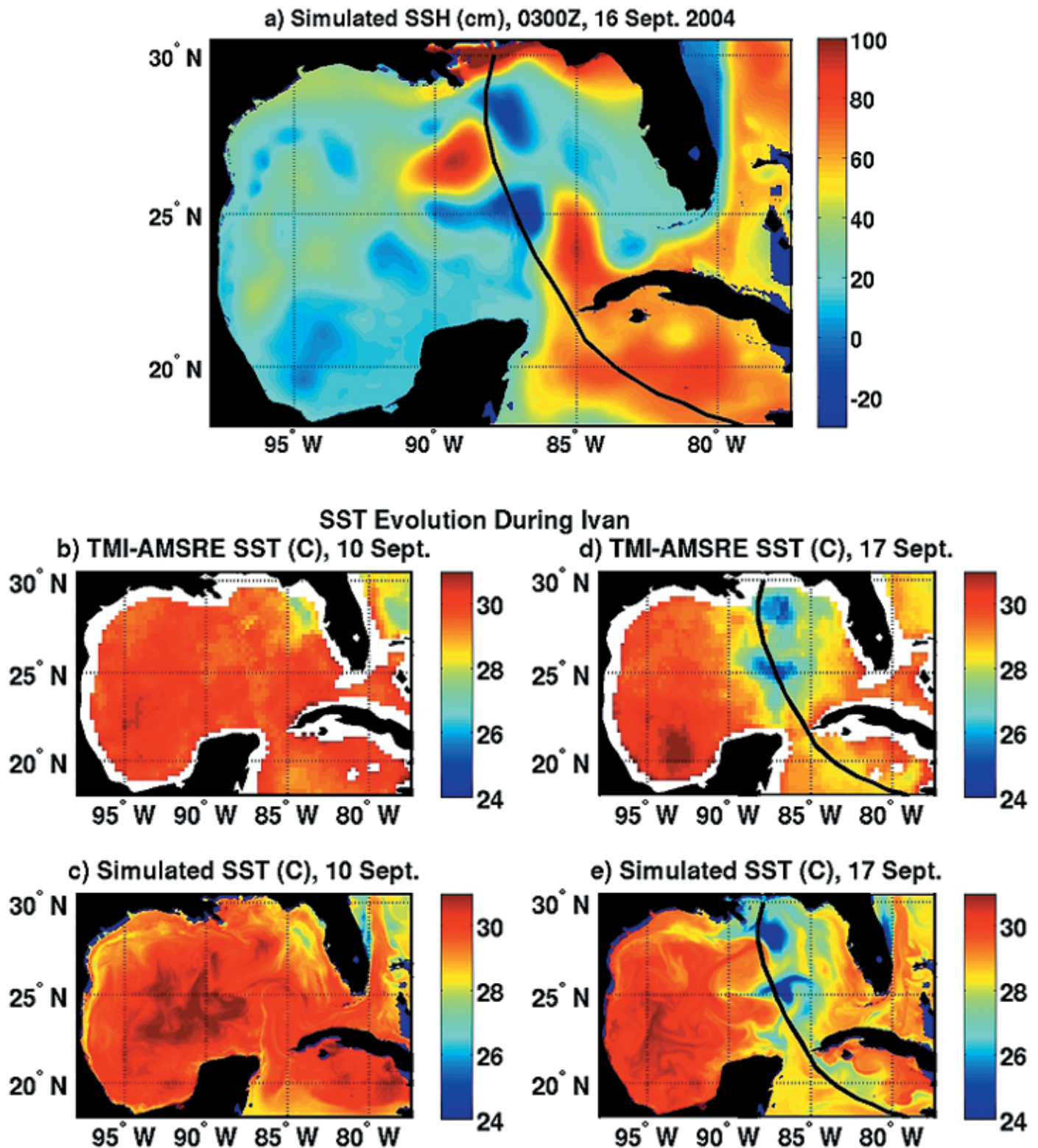
Figure 1: SSH from the free-running HYCOM simulation of the ocean response to hurricane Ivan at the time of maximum simulated coastal storm surge (0300Z, 16 September, 2005). Comparison of SST fields before and after Hurricane Ivan (10 and 17 September 2004) estimated from blended microwave satellite measurements from the TMI and AMSR-E instruments (middle panels) and simulated by free-running HYCOM (lower panels) (From Halliwell et al., MWR, 2008).

Application of Satellite Surface Wind Data to Ocean Surface Analysis and Numerical Weather Prediction

S.J. Majumdar and S.S. Chen (UM/RSMAS); B. Atlas (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
***Objectives*:** To understand the influence of assimilating scatterometer-based winds in global and mesoscale models of hurricanes in order to advise on optimal assimilation of future scatterometer data.
***Strategy*:** To assimilate winds derived from the QuikSCAT satellite into NCEP Global Forecast system (GFS) and into MM5/WRF to diagnose the role of these data in modifying hurricane forecasts.

CIMAS Research Theme:
***Theme 5*:** Air-Sea Interactions and Exchanges

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

NOAA Funding Unit: AOML/HRD   **NOAA Technical Contact:** Bob Atlas

Research Summary:
The primary data used in this study are two parallel NCEP GFS analysis-forecast cycles, run retrospectively by NCEP collaborators for periods during the 2005 and 2006 Atlantic hurricane seasons using the newest version of the global model and data assimilation cycle. The two cycles are identical except that one includes all QuikSCAT data in the assimilation, while the other excludes all the QuikSCAT data.

To date, three tropical cyclones in 2005: Dennis, Katrina, and Rita have been investigated with the NCEP GFS system. It is evident from Fig. 1 that the corrections to the surface wind analysis by the QuikSCAT assimilation are small, even in instances where the wind magnitude and direction of the most recent QuikSCAT pass are different from the first guess. Similarly, the difference in mean sea-level pressure is also small (not shown). In a few places close to the storm, it has been found that the difference between the first-guess wind and the QuikSCAT wind can be well over 10 m/s. The handling of these differences by the data assimilation scheme is under investigation. While the assimilation of QuikSCAT data often provides a minimal influence of the track forecast, one exceptional case yielded a difference in track forecasts of nearly 200 km, even with a minor modification to the initial conditions. This case provides evidence that the accurate assimilation of surface wind data may on occasion change the track forecast, even with current operational data assimilation schemes.

We speculate that the generally small impact of the QuikSCAT data on the analyses investigated to date may be due to a combination of several factors, including:

1. The QuikSCAT pass does often not encapsulate the tropical cyclone.
2. The NCEP GFS first-guess wind field is accurate in most of the environment.
3. There is abundant observational data of other types that are assimilated near the tropical cyclone.
4. Significant subsets of QuikSCAT data are rejected by the quality control scheme due to rain contamination or large differences from the first-guess field.
5. QuikSCAT data are averaged geographically prior to assimilation.
6. The NCEP GFS background error variance is relatively small compared with the QuikSCAT observation error variance.
7. The background error covariance may not project the influence of the QuikSCAT data significantly in the vertical.

None of these proposed factors have been tested to date. They will be explored in depth over the next year in collaboration with personnel at NOAA/NCEP and at NASA Goddard.

In contrast, the assimilation of a vortex based on QuikSCAT observations by Prof. Shuyi Chen's group has shown

considerable promise for the improvement of hurricane track and intensity forecasts. These results exemplify the promise of using scatterometer data to provide improved hurricane forecasts.

Research Performance Measure:
This project is new, only three3 months into the program. Nonetheless the results obtained thus far have been revealing and will shape the remainder of the project.
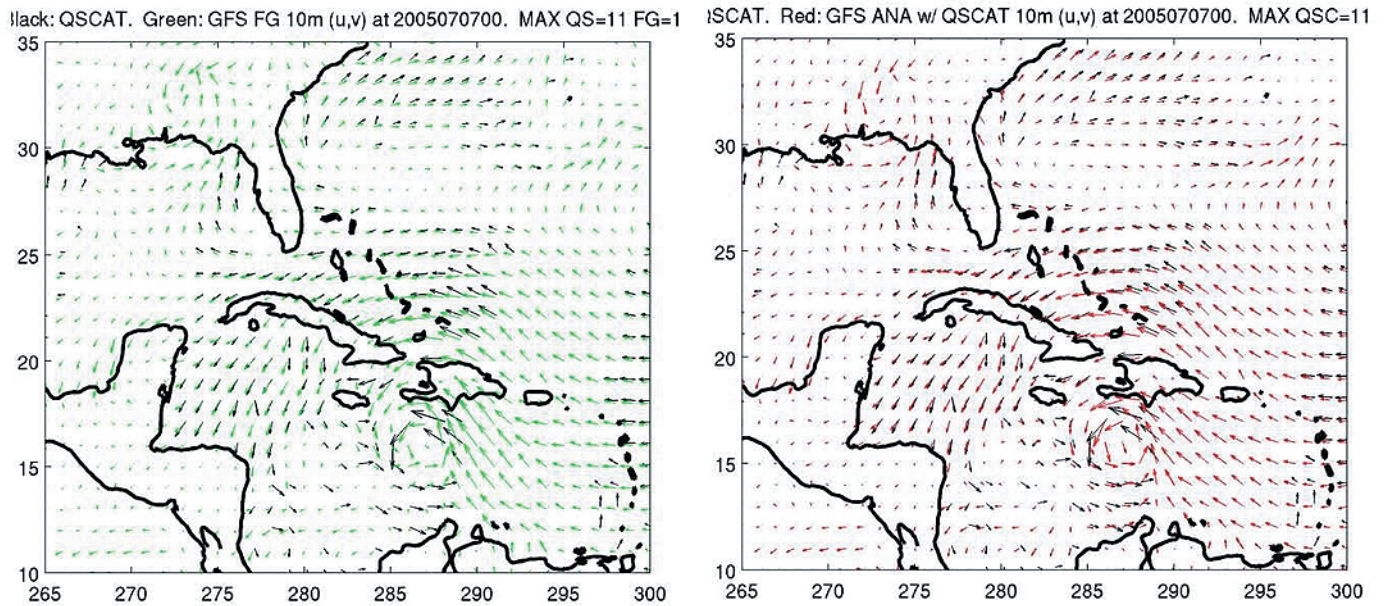
Figure 1: 1a) QuikSCAT wind vectors (Black) versus 6-h NCEP GFS first-guess of 10m winds (Green). 1b) QuikSCAT wind vectors (Black) versus NCEP GFS analysis (Red). Only those QuikSCAT wind vectors at each degree of lat/lon are plotted.

A Study of African Dust and Dry-Air Outbreaks and Their Effect on the Atlantic

J.M. Prospero (UM/CIMAS); C. Zhang and J. Huang (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To explore possible effects of African aerosol and dry air on the large-scale variability of precipitation in the Atlantic ITCZ.
Strategy: To use satellite data to identify coherent signals between African aerosol and precipitation.

CIMAS Research Theme:
Theme 5: Air-sea Interactions and Exchanges

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

NOAA Funding Unit: CPO   **NOAA Technical Contact:** James Todd

Research Summary:
We have verified the existence of large scale co-variability of African aerosol and precipitation in the Atlantic Marine ITCZ (AMI) and the West Africa Monsoon (WAM). We used multiyear satellite observations to document a relationship between the large-scale variability in precipitation over the tropical Atlantic and aerosol traced to African sources. We used both long term (TOMS vs. GPCP) and short term (MODIS vs. TRMM) satellite data.

We find that African aerosols substantially suppress precipitation in the AMI and the WAM, but there was considerable seasonal and spatial variability. During boreal winter and spring, there is a significant reduction in precipitation south of the Atlantic marine intertropical convergence zone; during these months aerosol concentrations are anomalously high over a large domain of the tropical Atlantic Ocean. This reduction cannot be attributed to known climate factors such as El Niño-Southern Oscillation, North Atlantic Oscillation, and zonal and meridional modes of tropical Atlantic sea surface temperature, or to meteorological factors such as water vapor. The fractional variance in precipitation related to aerosol is about 12% of the total interannual variance, which is of the same order of magnitude as that related to each of the known climate and weather factors.

The coherent variability of African aerosol and dry air outbreaks were statistically quantified using concurrent MODIS and AIRS datasets. Dust and smoke (differentiated by MODIS fine mode fraction) affect shallow/deep convective or stratiform rain (differentiated in the TRMM 3A25 product) differently. We also found systematical changes in the meteorological fields in vertical profiles across African dust front. A backward trajectory analysis confirms the African origin of aerosols that directly affect the changes in precipitation. The reduction in mean precipitation mainly comes from decreases in moderate rain rates (10 – 20 mm/day), while light rain (<10 mm/day) can actually be enhanced by aerosol. Our results suggest aerosols have a clearly identifiable effect on climate variability in precipitation in the Pan-Atlantic region.

Research Performance Measure:
We accomplished the first goal of the project by identifying an empirical relationship between African aerosol and large-scale precipitation over the tropical Atlantic Ocean and in the West African Monsoon. We accomplished the second goal by differentiating dust and dry air outbreaks, distinguishing their large-scale coherent patterns, and investigating the extent to which African dust and dry-air outbreaks are independent to each other.
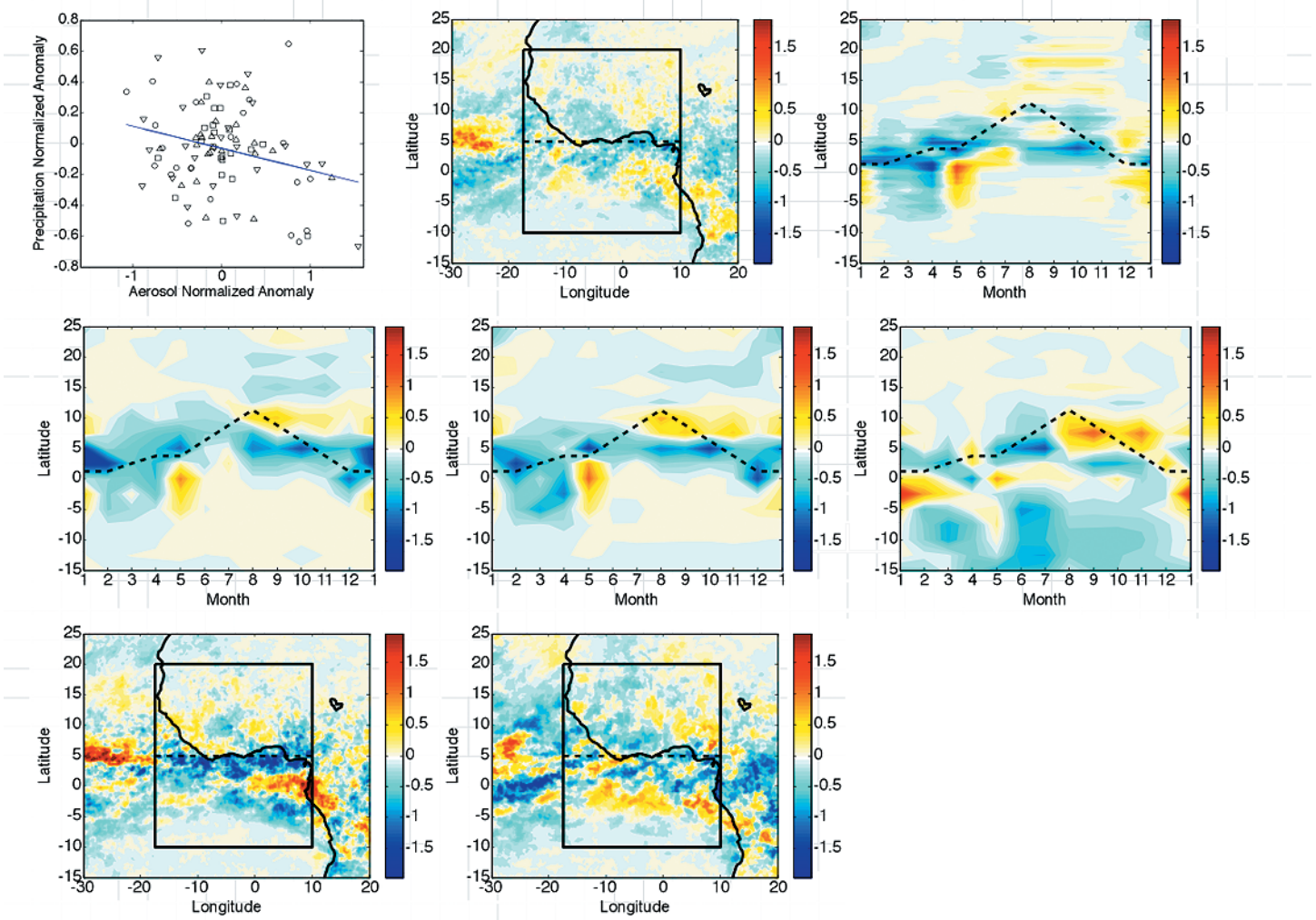
Figure 1: Difference composites of precipitation normalized anomalies between high and low terciles of aerosol normalized anomalies over the WAM region: (a) regressional between regional averages (R=-0.262, p=0.00992, N=96. Data for winter are in circles, spring in squares, summer in up-triangles, and autumn in down-triangles); (b) spatial pattern; (c) annual cycle (zonal averages for [17.5°W-10°E]); (d) same as (c), but for convective precipitation; (e) same as (c), but for stratiform precipitation; (f) same as (c), but for shallow precipitation; (g) same as (b), but between high and low dust terciles; (h) same as (b), but between high and low smoke terciles. Dashed lines mark the center of the West African Monsoon.

Shallow Meridional Circulation and Saharan Heat Low:
Their roles in the Tropical Atlantic Variability
C. Zhang (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To understand the seasonal cycle over West Africa, especially the West African monsoon.
Strategy: To diagnose *in situ* sounding observations from West Africa and compare them with global reanalyses; and to diagnose climate model simulations.

CIMAS Research Theme:
Theme 5: Air-Sea Interactions and Exchanges

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

**NOAA Funding Unit:** CPO   **NOAA Technical Contact:** James Todd

Research Summary:
The new analysis of the moisture transport into the continental West Africa has shown the role of the meridional shallow circulation that is distinct from that of the deep overturning circulation. During the onset and developing stages of the West African monsoon, moisture convergence associated with the deep circulation maximizes in the center of monsoon rainfall. In contrast, the peak of moisture convergence by the shallow circulation is located further inland north of the monsoon rainfall center. The role of the deep circulation is therefore to enhance monsoon rainfall. The shallow circulation, on the other hand, plays a crucial role in help northward advancement of the monsoon rainband.

Research Performance Measure:
The research has made progress as planned.
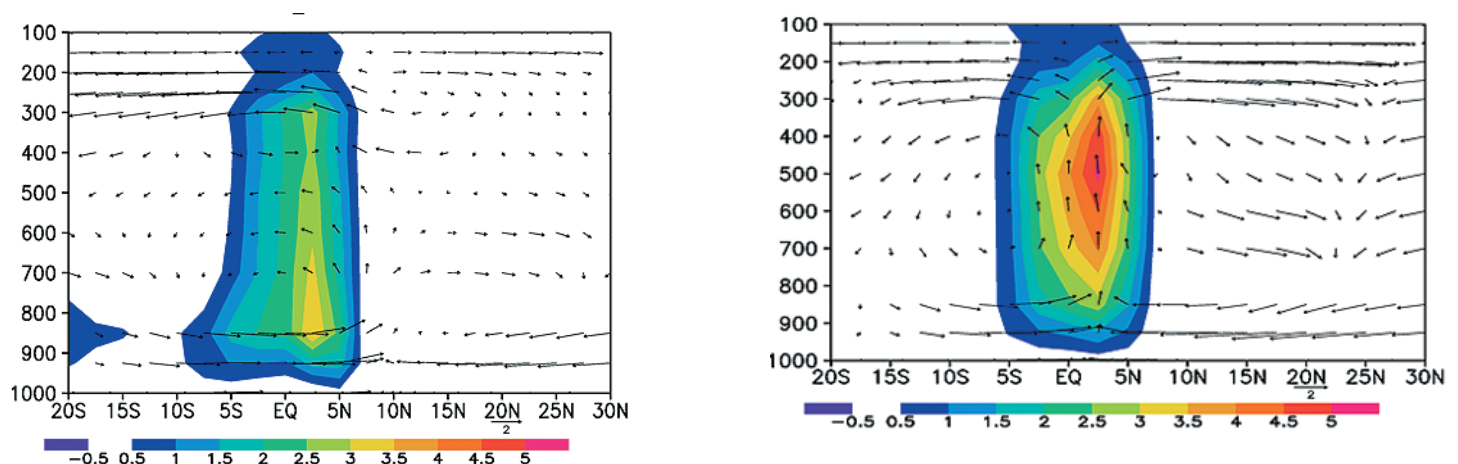
Figure 1: Meridional circulations and latent heating profiles over West Africa during the monsoon season. This figure shows that low-level moisture convergence due to deep heating is collocated with convective heating itself and thereby enhances convection (lower panel). In contrast, low-level moisture convergence due to shallow heating is north of the convective region (upper panel) and thereby help monsoon convection to advance inland during its seasonal migration.

Improving the Prediction of Tropical Cyclone Intensity and Rainfall by Evaluating and Comparing Microphysics Fields Measured from High-Resolution Numerical Models and Airborne and Space-Borne Platforms

K. Valde and P. Willis (UM/CIMAS); S. Chen (UM./RSMAS);
R. Rogers, F. Marks, M. Black and R. Black (NOAA/AOML);
A. Heymsfield (NCAR); G. Heymsfield (NASA/GSFC)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To improve the understanding and prediction of tropical cyclone genesis, intensity change and rainfall, as well as, the microphysical parameterization schemes in tropical cyclone simulations at all stages of their lifecycle.
Strategy: To evaluate and compare the microphysical fields from high-resolution MM5 model simulations, *in situ* and remotely-sensed data retrieved by the NOAA-WP-3D's and NASA ER-2 aircraft, and data from the TRMM Precipitation Radar and Microwave Imager.

CIMAS Research Theme:
Theme 5: Air-sea Interactions and Exchanges

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

NOAA Funding Unit: OAR/AOML   **NOAA Technical Contact:** Robert Rogers

Research Summary
Latent heat is a major source of energy needed to fuel a tropical cyclone (TC). It is hypothesized that knowing the distribution and amount of latent heat released within a TC will help improve genesis, intensity and rainfall forecasting. However, the microphysical processes that produce latent heat can differ throughout the lifecycle of a TC and can span a large range of spatial and temporal scales, thus making it difficult to determine the magnitude and distribution of latent heat released. By studying the microphysical fields (e.g. vertical velocity, hydrometeor mixing ratio, radar reflectivity), we are attempting to note any differences in the structural evolution and determine if these changes play a role in the genesis and intensity of a tropical cyclone and evaluate the ability of the models to correctly replicate theses changes and the formation of clouds and microphysical processes. To answer these questions, we are conducting comparisons of statistics of the distributions and concentrations of TC microphysical fields from airborne (Doppler Radar) and space-borne (TRMM satellite) observations and from a high-resolution numerical model (MM5). We will also use *in situ* microphysical observations to guide the model microphysical parameterizations, which will help find any model biases. In the end, these studies will help in the advancement of our knowledge of the morphology of the microphysical structures, which in turn will help in the improvement of predicting tropical cyclone genesis, intensity, and rainfall.

We have completed our TRMM TMI and PR database, which includes all global storms from 1998-2006. We have divided the database into three subsets: basins, intensity, and latitude locations. We have expanded our research and are in the process of applying our eyewall, rainband, stratiform (ERS) sorting algorithm to each subset, in order to compare any differences in the reflectivity structure for each region between the different intensity, basins, and location. We are currently studying the statistics of the reflectivity distribution of each region for the different tropical cyclone intensity levels (Figs. 1 and 2).

Along with the above comparisons, we are continuing the development of our dataset of past storms, which went through rapid intensification after experiencing a convective burst as well as those that did not go through rapid intensification after experiencing a convective burst. With this dataset, we are studying the difference of the morphology of precipitation during these episodes of deep convection and try to explain how these differences affect the genesis and intensity of a system.

In addition, we are planning to examine the precipitation structures of storms experiencing intensity change during a given time period. We will classify each storm or observation based on the magnitude of the intensity change in knots during a certain period and apply our sorting algorithms in order to study the statistics of the reflectivity distributions. This study will help in better understanding the relationship of the precipitation structures during different magnitudes of intensity change and allows us to document the differences and characteristics of these structures.

Research Performance Measure:
Objectives are being met on schedule.
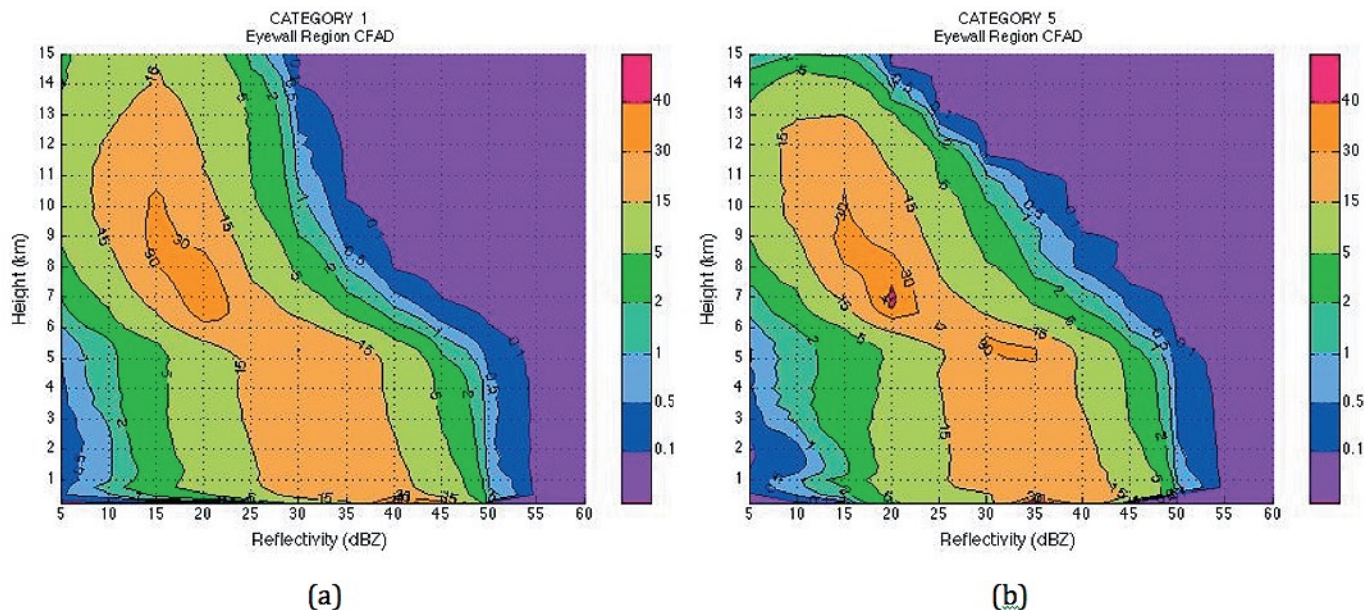
Figure 1: Contour Frequency by Altitude Diagrams (CFADs) of TRMM PR reflectivity of the eyewall region for (a) Category 1 and (b) Category 5 storms.
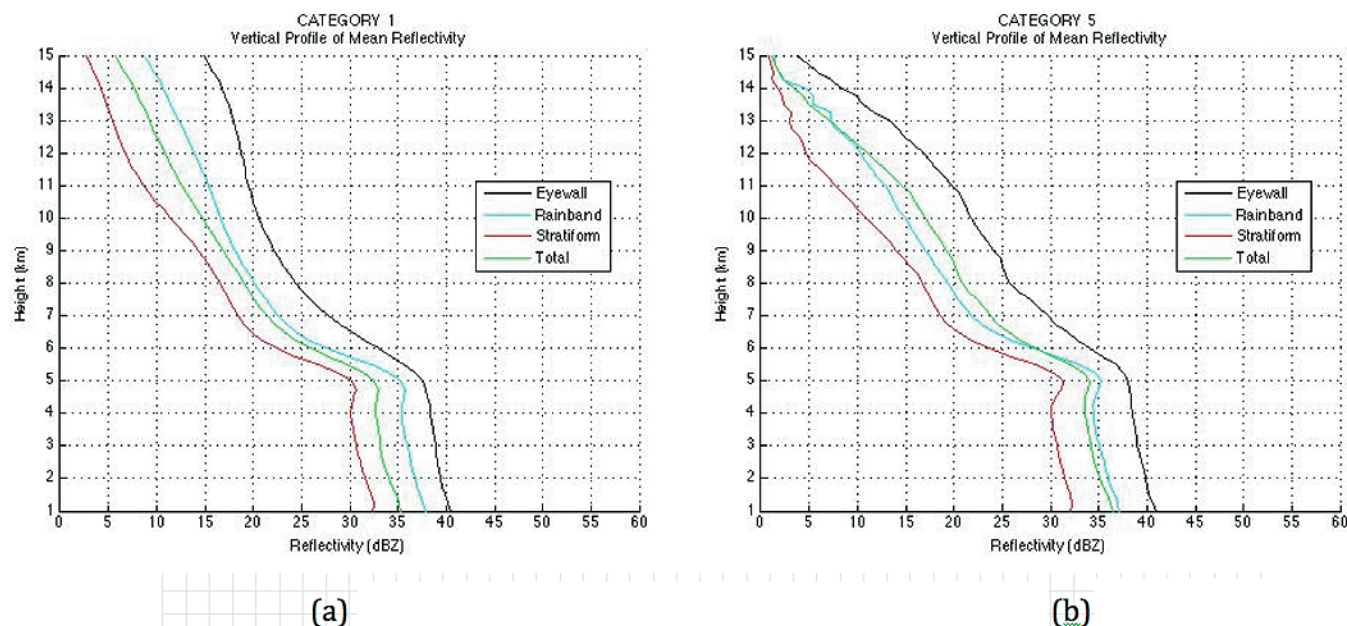
Figure 2: Vertical Mean Profiles of TRMM PR reflectivity of the eyewall region for (a) Category 1 and (b) Category 5 storms.

System Support for the Development & Simulation of Tropical Cyclone Numerical Models in a Cluster System

M.-L. Shyu (UM/ENG); F. Marks, S. Gopalakrishnan and R. Rogers (NOAA/AOML)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To investigate and develop innovative methodologies to provide systems support for the development and simulation of tropical cyclone (TC) numerical models in a cluster system; to develop a supporting visualization tool to analyze performance of all hurricane forecasting models including the one under development.

Strategy: To continue model development at higher resolution and to carry out at least 50 high resolution tests aimed at quantifying the impact of increased horizontal resolution in numerical models on hurricane intensity forecasts.

CIMAS Research Theme:

Theme 5: Air-sea Interactions and Exchanges

**Link to NOAA Strategic Goals:**

Goal 3: Serve Society's Needs for Weather and Water Information

NOAA Funding Unit: AOML
NOAA Technical Contact: Frank Marks, Sundaraman Gopalkrishnan and Robert Rogers

Research Summary:

The hurricane forecast improvement project (HFIP) is a unified NOAA approach to guide and accelerate improvements in hurricane intensity forecasts with emphasis on rapid intensity (RI) change and the reduction of false alarms. In addition to the development of visualization tools, we established an automatic forecast system on AOML HPCS that will automatically acquire storm information for running WRF-HFS (Weather Research Forecasting model - Hurricane Forecast System). The WRF-HFS can be run in a semi-operational mode either as a GUI system or an automated process. The automated system performs daily WRF-HFS runs from GFDL/GFS initial conditions for the 00Z cycle. The system will run continuously throughout the 2008 hurricane season on AOML/HRD HPCS. GFDL/GFS initial condition data are available on a daily basis through the daily acquisition system. The execution of these daily runs will enable the investigation of the similarity between WRF-HFS and the HWRF system; they will also provide valuable insights on how to improve larger-scale forecasts with WRF-HFS.
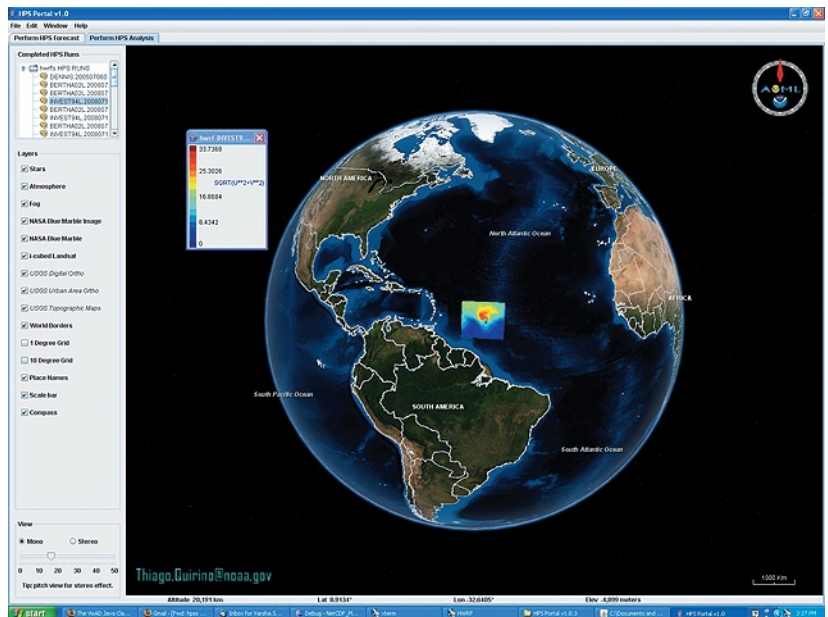
Figure 1: A snapshot of the Visualization Tool

As a part of this model improvement process, the Developmental Test bed Center (DTC) and the Hurricane Forecast Improvement Project (HFIP) Team hosted a workshop at the National Hurricane Center in Miami, FL, on 11-12 March 2008. Hurricane experts and numerical modelers met for two days to discuss strategy and to devise a plan to test models. Recent research suggested that prediction models with grid spacing ≤1 km in the inner core of the hurricane may provide a substantial improvement in intensity forecasts. Consequently, as an initial step to understand the RI changes, the numerical modelers from various groups agreed upon staging of at least 50 high resolution tests aimed at quantifying the impact

of increased horizontal resolution in numerical models on hurricane intensity forecasts.

Research Performance Measure:

One objective - the visualization tool - is being already used by NOAA personnel as new diagnostics are simultaneously being added to it. Also, the automated runs are all programmed and the model is automatically run every day. The results of the runs are readily available to scientists when they come to their desks next morning. Also a Wikipedia article and a new AOML website are under construction and will soon be released.
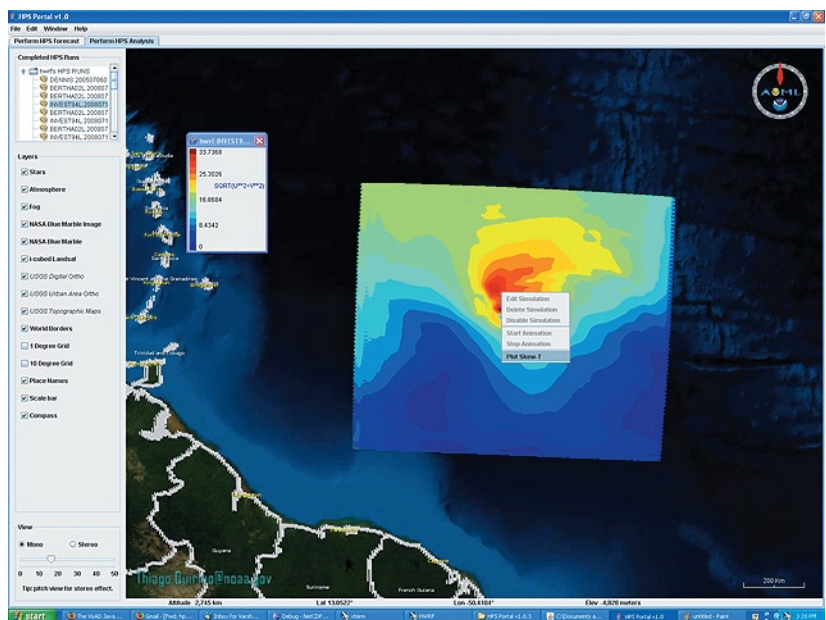

Figure 2: A snapshot of the Moving Domain for Hurricane
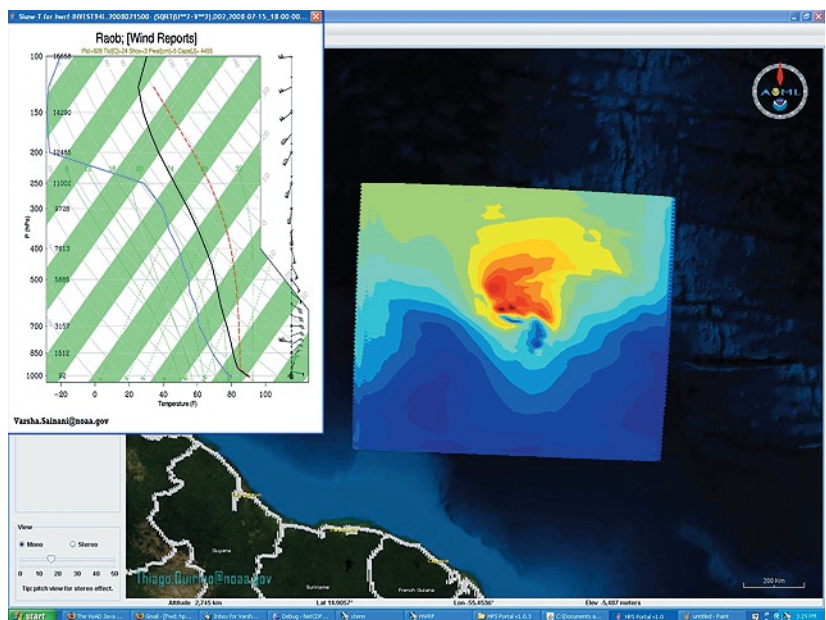

Figure 3: A snapshot of the Diagnostic Functionalities skewt

Real-Time Hurricane Wind Analysis

N. Carrasco, B. Annane, S. Otero and R. St. Fleur (UM/CIMAS);
M. Powell (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: To improve our understanding of the wind distribution in tropical cyclones.
Strategy: To apply advanced computing methodologies to integrate cyclone data and to make the data more readily available to scientists in real-time.

CIMAS Research Theme:
Theme 5: Air-Sea Interactions and Exchanges

Link to NOAA Strategic 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 and subsequently adjusts them to a common framework, 10m marine exposure. These observations are stored in a 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, database, quality control interface, analysis package, and product generation package.

Data collection is accomplished through a suite of Unix scripts and C programs. Current platforms being ingested include Air Force and NOAA reconnaissance, Dropwindsondes, GOES, SSM/I, TM/I, QSCAT, ASCAT, WINDSAT satellites and the AMSU satellite product, METAR, C_MAN, Buoys, Ships, mobile Towers, MESONET data from FSL MADIS Group and WeatherFlow. Currently based on research performed, the packages developed to bring data into the H*Wind database are being ported to Python, a platform-independent language similar to Java. The effort will lead to a wider use with in other systems and tools and will further promote the software paradigm of code reuse endorsed by the H*Wind project.

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
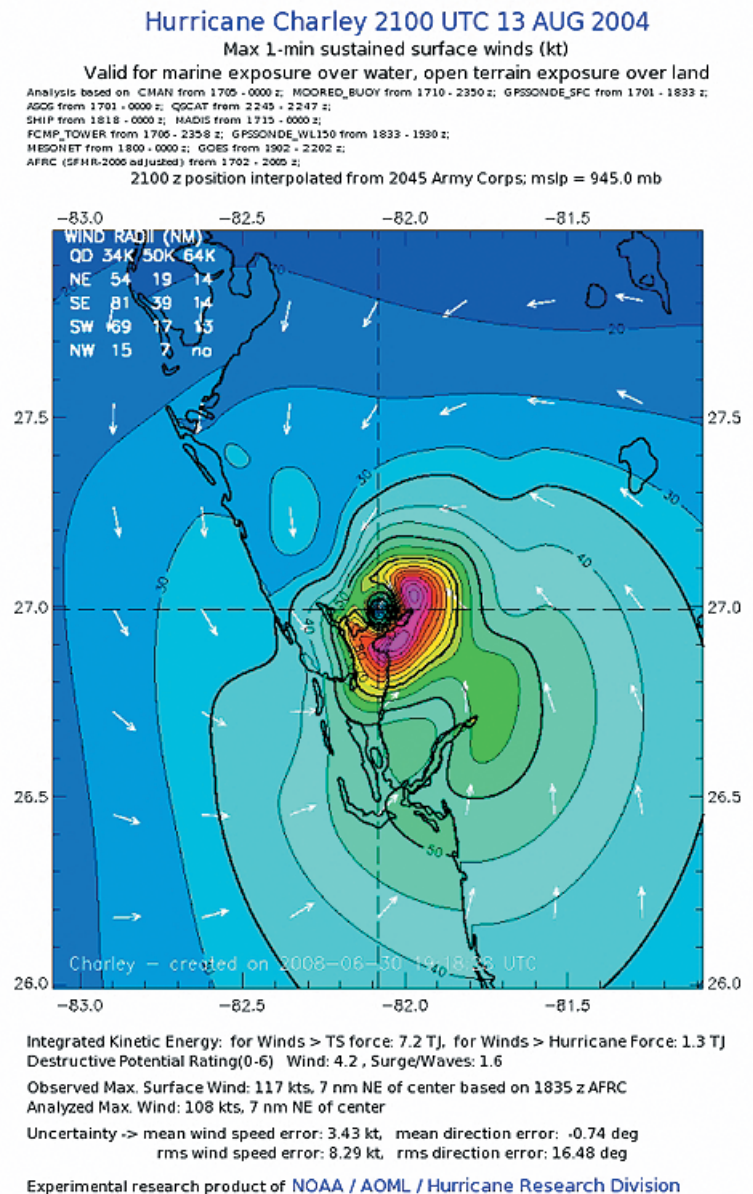
Figure 1: Hurricane Charley, August 13, 2004, 2100 UTC. Note the new annotation for integrated kinetic energy, surge and wind destructive potential ratings, and uncertainty errors for wind speed and direction.

inspection, editing or removal of data from the analysis, and customization of analysis parameters. 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, temperature and relative humidity. The product of this analysis is a colored and annotated wind contour plot, as seen in Figure 1. This year, the annotation was enhanced with the calculation of uncertainty errors for mean wind speed and wind direction errors, and rms wind speed and direction errors.

Proceeding with our open-source philosophy, we placed increased effort on the conversion of HRD's valuable dropsonde 0.5 Hz raw and processed data from a proprietary database to PostgreSQL which is already heavily and reliably used in the H*Wind system. Batch scripts, designed to avoid human intervention as much as possible, use pre-stored flight track splines and bathymetry in the database as well as logic to calculate derived fields and update inventory. As the program progresses we will continue to provide scientists with increased web access to the several years of accumulated dropsonde data.

With regard to the H*Wind and pre-H*Wind's analysis output web repository, it was completely converted from an *ad hoc* compilation of images in different formats and naming conventions to a homogeneous archive of PNG format and degree-scale detail provided to contour and data coverage file names of every analyzed event. Output standardization led to the formalization of an HTML page-generator script, which can also detect the exceptional presence of extra products (multi-analysis wind swaths). As a result of the detective and verification work, the currently available public archive slightly exceeds the range of the previous one.

Finally, the team also closely collaborates with a new CIMAS project, led by Dr. Mei-Ling Shyu, "Data Integration and Data Mining Support for Tropical Cyclone Integrated Observing Systems".

Research Performance Measure:
All objectives are being met on schedule.

Data Integration and Data Mining Support for Tropical Cyclone Integrated Observing Systems

M.-L. Shyu (UM/ENG); F. Marks and M. Powell (NOAA/AOML)

Long Term Research Objectives & Strategy to Achieve Them:

***Objectives*:** To improve the visualization capabilities of H*WIND by including more geographical information in the visualization of the analyzed wind data.

***Strategy*:** To integrate Google Earth and Google Maps platforms into one system in order to present them together with the wind observation data collected by the H*Wind platform.

CIMAS Research Theme:

***Theme 5*:** Air-sea Interactions and Exchanges (*Primary*)
***Theme 6*:** Integrated Ocean Observations (*Secondary*)

**Link to NOAA Strategic Goals:**

***Goal 3*:** Serve Society's Needs for Weather and Water Information

NOAA Funding Unit: AOML
**NOAA Technical Contact:** Frank Marks and Mark Powell

Research Summary:

The H*Wind platform developed in AOML HRD utilizes information content from a diverse set of atmospheric and oceanographic measurement systems so that we can more readily follow changes in the structure, intensity, and physical processes in tropical cyclones. The goal of this project is to improve the visualization capabilities of H*WIND by including more geographical information in the visualization of the analyzed wind data. This project calls for an integration of the data generated by H*WIND with data such as GIS satellite imagery, or radar imagery. By providing more information regarding the geographical characteristics of the area where the wind analysis is being visualized, the system could provide the user with a better understanding of wind behavior under different geographic conditions (over different surfaces for example).
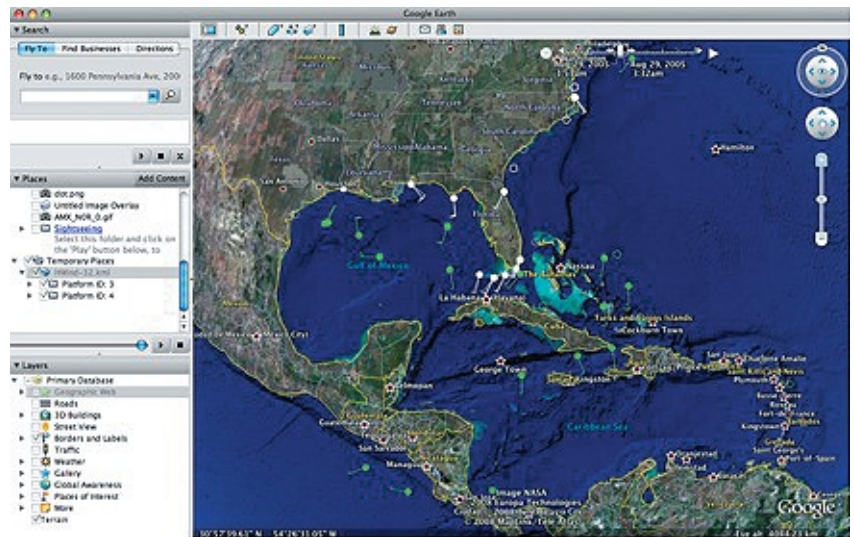
Figure 1: A snapshot of H*Wind Data Visulization in Google Earth.

GIS satellite and radar imagery are widely available from different sources. The main challenge is to integrate them all into one system in order to present them together with the wind observation data collected by the H*Wind platform. To achieve this goal, the freely available highly popular Google Earth and Google Maps platforms were selected. These platforms allow us to incorporate data that originate from different sources and to display them under one environment. In addition, these platforms provide additional geographical information to the H*Wind users which could aid them in improving their analysis. The main challenge has been to be able to display the H*Wind observations in the Google Earth/Maps environment. In order to achieve this, a program is to be designed to communicate with the H*Wind database, extract the necessary observations information, and formulate it in a format that can be read and displayed by the Google Earth/Maps platforms.

We have created a Java servlet which communicates with the H*wind database and extracts the observations of a desired QCSet. After extracting the data from the database, the servelet organizes the observations by the different platforms they were collected by. Next, the servelet formulates each observation as a placemark for Google Earth using KML (Keyhole Markup Language). Information such as wind speed, direction, date observed, etc. is made available in the KML file to be displayed to the user in Google Earth. Finally, the KML file is sent over to Google Earth where all the observations are displayed, represented by wind barbs which represent the wind speed and direction observed at each observation location.
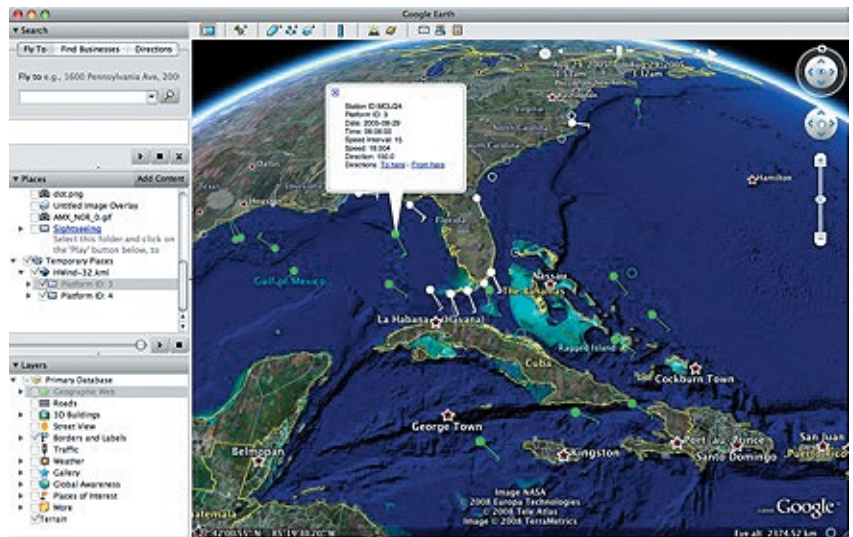
Figure 2: A snapshot of the information displayed once the user has clicked an observation.

Research Performance Measure:

Our program is achieving its objectives on schedule. The visualization of drop sonde wind speed measurements in Google Earth has been used by HRD scientists for research purposes. Currently, we are in the process of integrating the aforementioned servelet into the H*Wind platform so that it can use some of the H*Wind queries and can be easily accessible through the H*Wind environment.

An Eleven-Year Tropical Cyclone Global Positioning System Dropwindsonde Dataset
K. Sellwood (UM/CIMAS); S. Aberson (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To gather, organize, quality control, and make available to the broader community all GPS dropwindsonde data in and around tropical cyclones, and to provide support for other scientists who wish to use the data for research.
Strategy: To systematically organize data from past years and incorporate new data as it arrives.

CIMAS Research Theme:
Theme 5: Air-sea Interactions and Exchanges

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

**NOAA Funding Unit:** OAR/AOML   **NOAA Technical Contact:** Sim Aberson

Research Summary:
Since 1996, NOAA, the United States Air Force, and other international agencies have been releasing dropwindsondes in and around tropical cyclones to obtain wind velocity, temperature, humidity, and mass observations from flight level to the ocean surface. These observations are used operationally by meteorological centers to diagnose current conditions and to improve initial conditions of numerical weather prediction models. After the fact, these data are invaluable to researchers in studies of tropical cyclone dynamics and thermodynamics, and in studies of targeted observations and predictability, as well as in climate research. Hundreds of these profiles are obtained annually in the Atlantic and northern Pacific Oceans, and may soon become available in the Indian Ocean. In this program, we gather, organize, and quality control, all GPS dropwindsonde data in and around tropical cyclones. We subsequently make these data available to the broader community and we provide support for other scientists who wish to use the data for research. These data are organized and made freely available on an ftp site.

Research Performance Measure:
All objectives are being met on schedule.
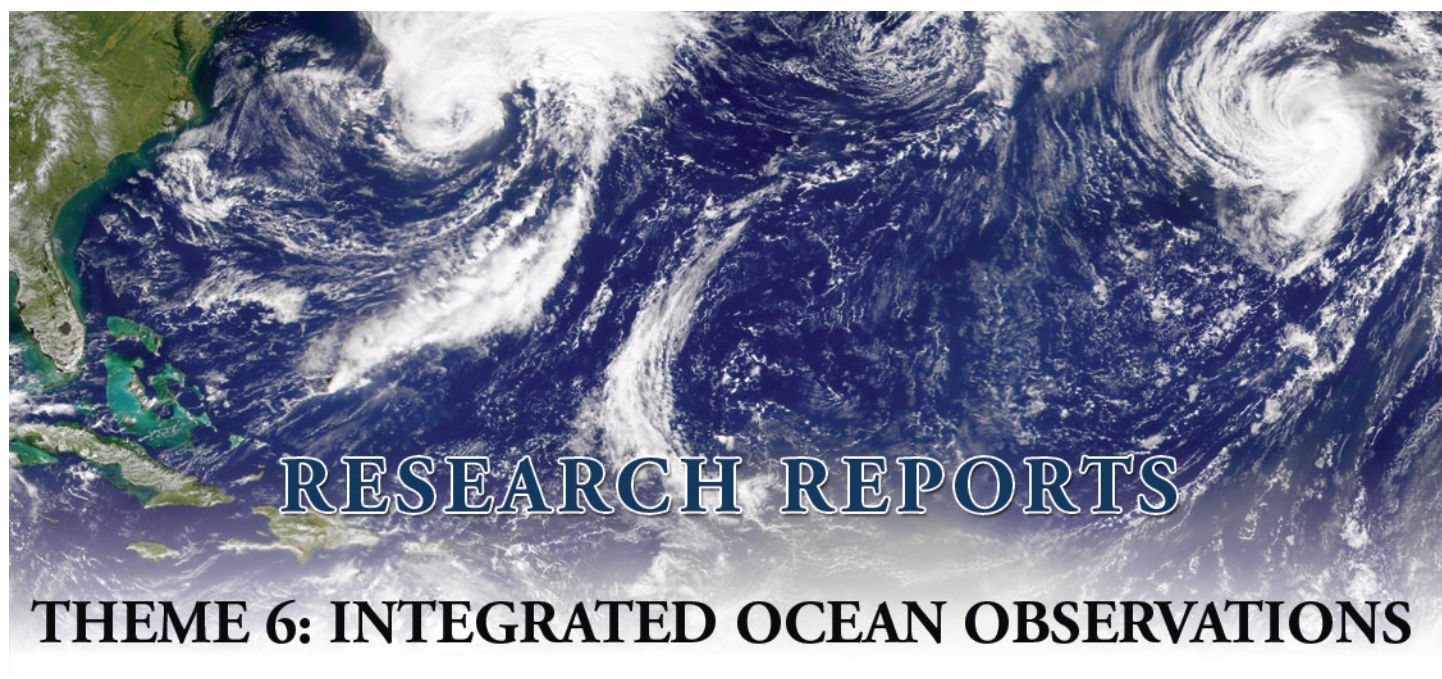
THEME 6: INTEGRATED OCEAN OBSERVATIONS

Ocean Biogeochemical Measurements

C. Langdon (UM/RSMAS); G. Berberian and C. Featherstone (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

***Objectives*:**   To assess changes in the ocean's biogeochemical cycle in response to natural and/or man-induced activity.

***Strategy*:**   To make accurate and precise measurements of the dissolved oxygen concentration in the water column along sections through the major ocean basins as part of the Repeat Hydrography CO_2/tracer Program. To compare these measurements with similar measurements made during earlier programs (e.g., World Ocean Circulation Experiment (WOCE)/Joint Global Ocean Flux Survey (JGOFS)) in the 1990s. To use the measured changes in dissolved oxygen to obtain the change in dissolved inorganic carbon (DIC) that is due to natural processes and, based on the difference between the observed change in DIC and that due to natural processes, to assess the net change due to man-induced activity.

CIMAS Research Theme:

***Theme 6*:** Integrated Ocean Observations

Link to NOAA Strategic Goals:

***Goal 1*:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: OCO   **NOAA Technical Contact:** Mike Johnson

Research Summary:

Global warming and ocean acidification have the potential to alter the way the oceans function physically, chemically and biologically. These changes will have a great impact a number of critical environmental processes. This program seeks to document the changes in the ocean oxygen and carbon chemistry that have take place since the surveys carried out in the 1990s and thereby to assess the impact of natural variability and human activities.

The funding provided by this grant allowed participation in both the P18 cruise along 110 W from 20N to 69S and the East Coast CO_2 survey cruise from Houston, TX to Gulf of Maine. The P18 oxygen data show a decline in oxygen and an increase in apparent oxygen utilization (AOU) in the main thermocline across the entire section. This is similar to change that was observed in the North Pacific along the P16N line. The current consensus is that these changes reflect physical

changes in the circulation of the ocean. Less ventilation of the thermocline as outcrop waters become warmer and fresher is likely part of the story however changes in isopycnal depth, water mass variability and changes in the biological pump are other possible contributors.

Research Performance Measure:
This program is attaining all its goals on schedule. High quality data has been collected and archived with CDIAC. Our results have been presented at national meetings and two papers have been published in peer reviewed journals.
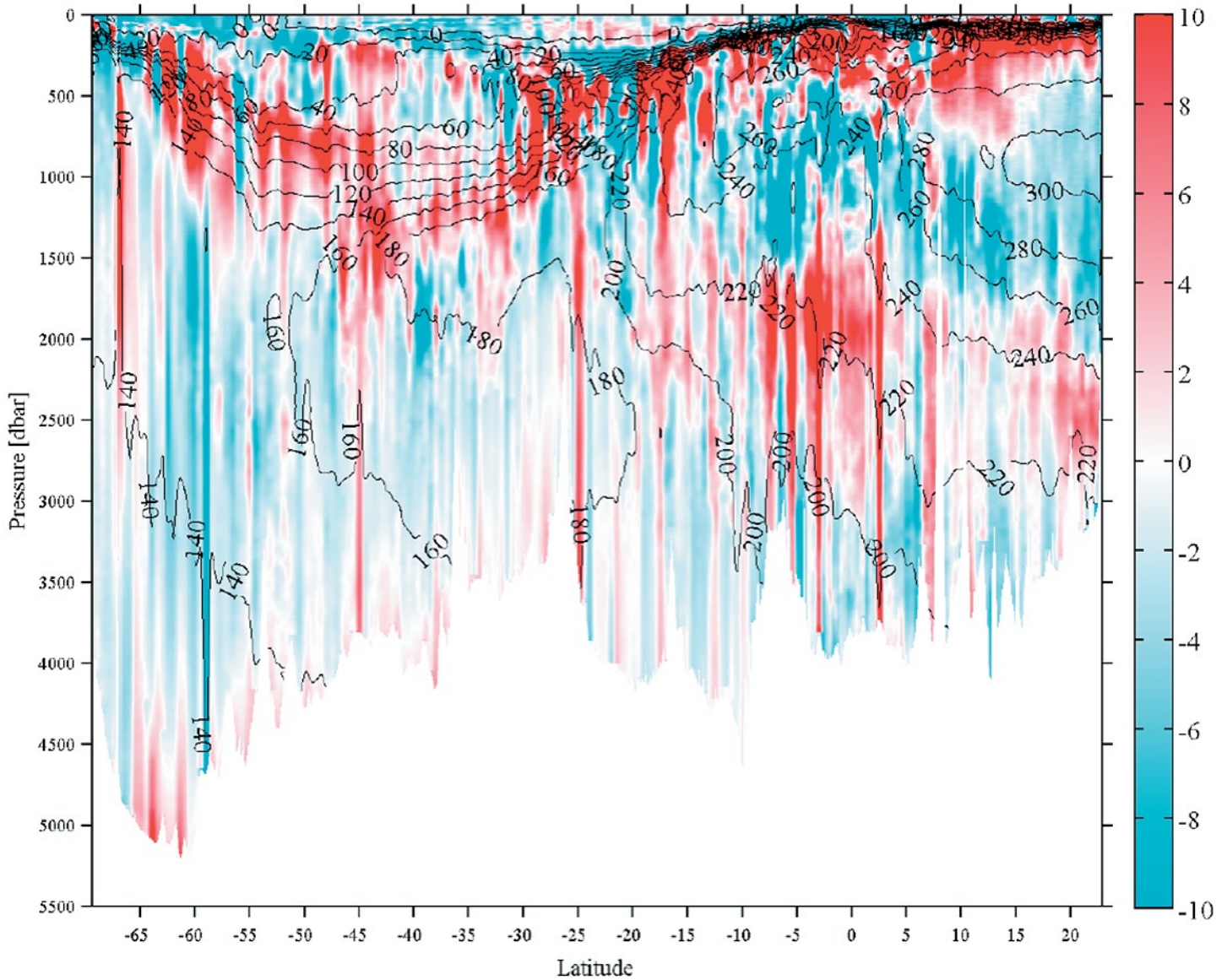
Figures 1: Section of the apparent oxygen utilization change along the P18 line between 1994 and 2008 (14 year difference).

Integrated Coral Observing Network (ICON) Project

L. Gramer, M. Jankulak and D. Manzello (UM/CIMAS); C. Langdon (UM/RSMAS);
J. Hendee, M. Shoemaker and J. Craynock (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

*Objectives***:** To facilitate *in situ* observations at coral reef areas; to integrate *in situ*, remote-sensing, and other environmental data so as to better understand the physical processes that affect the health and life cycles of organisms in the reef system; to compile ecological forecasts for coral reef ecosystems to help to understand them, and to aid in decision support for Marine Protected Area management.

*Strategy***:** To construct meteorological and oceanographic monitoring platforms near key coral reef areas; to provide data archiving and artificial intelligence tools to facilitate the acquisition and integration of high-quality data from these and other reef areas worldwide and enable rapid assessment of the physical and biogeochemical status of these reefs.

CIMAS Research Themes:

*Theme 6***:** Integrated Ocean Observations (*Primary*)
*Theme 3***:** Regional Coastal Ecosystem Processes (*Secondary*)

Link to NOAA Strategic Goals:

*Goal 1***:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: Coral Reef Conservation Program
NOAA Technical Contact: James Hendee

Research Summary:

Through continuous data collection and real-time monitoring, ICON provides scientists and managers with data critical to understanding the complex physical, chemical, and biological processes influencing coral reef ecosystems. ICON stations are currently installed at Salt River, St. Croix in the U.S. Virgin Islands; at La Parguera, Puerto Rico; and at Discovery Bay, Jamaica, with plans for additional stations in the Caribbean, Pacific and Indo-Pacific regions. For the 2007-2008 year, the project continued to focus its efforts in two primary areas: (1) development and field verification of real-time inference models about ecological and physical events on the basis of integrated *in situ*, satellite, and radar data; and (2) continued deployment of new, and maintenance of existing, stations and *in situ* sensors, with emphasis on field testing and integration of innovative new sensor and communications technologies. Biological monitoring of the coral reefs at each ICON and SEAKEYS site has become an integral part of the ICON mission, with frequent visits by field biologists and ecologists as part of or in collaboration with the ICON team throughout the past year (see Figure 1).
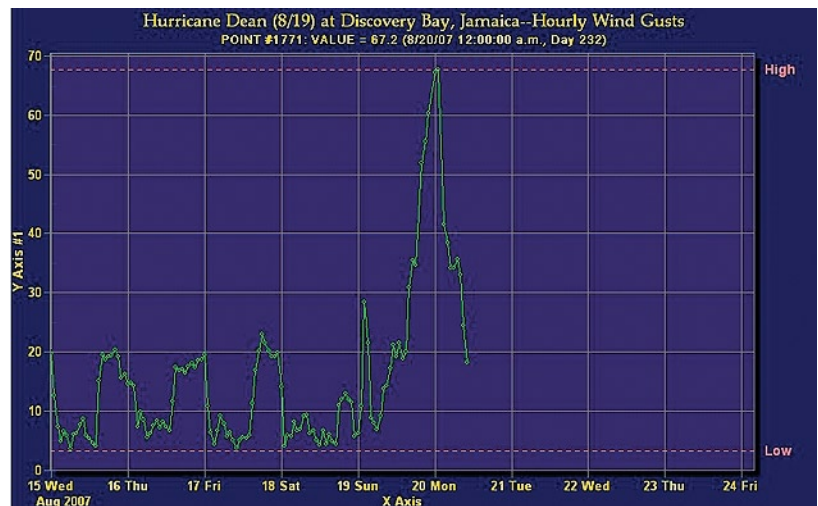

Figure 1: A photograph showing the progression of yellow-band disease on a coral head, from the ongoing program of biological monitoring at ICON station "SRVI2", near Salt River, St. Croix, U.S. Virgin Islands.

ICON station maintenance and instrument up-time for the 2007-2008 year have been exemplary, with stations reporting data in near real-time on average more than 95% of the time. This is particularly notable as ICON stations were subjected to four direct hits or very near misses by tropical cyclones during this past year (see Figure 2). Development has also continued on the ICON/G2 expert system, a research platform that combines station observations from instruments such as pCO_2 sensors, multi-spectral light instruments, temperature loggers, meteorological and hydrographic instruments and others,

together with data from satellite sensors including NOAA GOES, MODIS, AVHRR, AMSR-E, TRMM and QuickSCAT, and data from other remote sensing systems such as the ocean surface currents derived from the WERA High-Frequency radar operated by UM RSMAS. The resulting high-resolution, near real-time integrated data streams are used to predict conditions conducive to coral bleaching events, upwelling and other hydrodynamic events affecting ecosystem productivity, as well as reproductive activities of corals and other reef organisms (see Figure 3). These ecological forecasts are then distributed via email to researchers and protected resource managers, and via the web to the public at the ICON/G2 Ecoforecast website http://ecoforecast.coral.noaa.gov.

Continuous baseline data collection, combined with real-time monitoring tools allow scientists, modelers and managers to understand the processes that drive coral reef ecosystems and provide the necessary information to properly manage and protect these unique and valuable natural resources. A key information infrastructure project for the coming year is the development and integration of a relational database system, for complete historical and near real-time data storage and retrieval. The new database system will allow rapid access to all raw historical sensor data from ICON and SEAKEYS in situ monitoring stations, and a coordinated approach to management of quality controlled versions of those data. Further, it will facilitate access – for researchers and resource management decision makers – to ecological forecast models and output products, allowing the ICON/G2 expert system to become the basis for a true decision support system for coral reef ecosystem management. Integration of the new database system with ICON/G2 is also expected to significantly increase the performance and scalability of the expert systems platform – to handle new data from existing sites, and to continuously monitor data from many

Figure 2: A plot of hourly wind gusts measured by ICON station "DBJM1", in Discovery Bay, Jamaica, during and after passage of hrricane Dean off the southern coast of Jamaica in August, 2007.
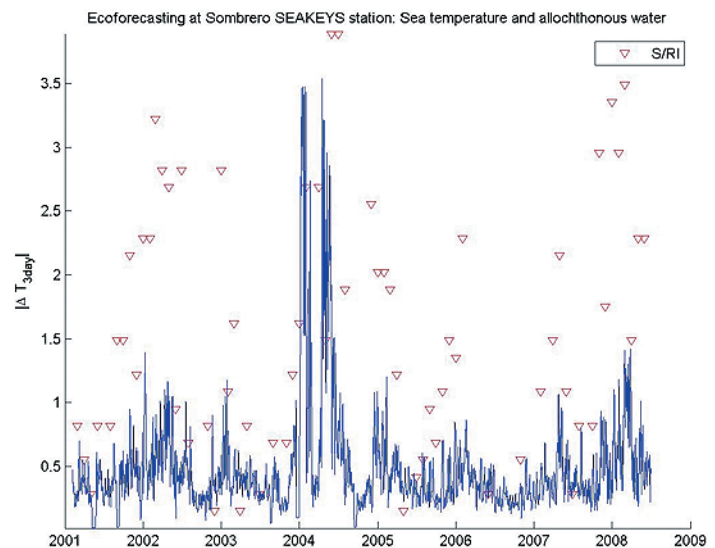
Figure 3: A plot showing the relationship between *in situ* sea temperature variability and an environmental index (Stimulus / Response Index or "S/RI") for nutrient flux: derived from 2001-2008 data at the SEAKEYS station "SMKF1" on Sombrero Reef, U. S. Florida Keys National Marine Sanctuary.

new reef sites around the world in 2009 and beyond. Finally, ICON continues to expand international partnerships for coral reef conservation and science. Notably, this past year saw the site survey and infrastructure installation for a new ICON monitoring station in Little Cayman, the Cayman Islands; as well as transition to local-country maintenance, management and ownership of the ICON station ("DBJM1") at Discovery Bay in Jamaica; and the initiation of a collaboration with the government of Taiwan P.R.C., to build, install and maintain ICON stations on coral reefs of the South China Sea and western Pacific islands.

Ship of Opportunity Program

Q. Yao, F. Bringas, P. DiNezio, A. Stefanick, S. Pochan, J. Delgado, G. Rawson, N. Melo and
R. Garcia (UM/CIMAS): M. Baringer, G. Goni and S. Garzoli (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them
***Objectives*:** To characterize the upper ocean thermal structure and to investigate the large-scale, low-frequency modes of climate variability. To characterize the upper ocean thermal structure in the center of the subtropical gyre in the North Atlantic and South Atlantic Ocean.
***Strategy*:** To make routine low-density (LD, broadly spaced) XBT observations along major shipping routes throughout the global ocean. To carry out high-density (HD) XBT observations to study the upper ocean thermal structure and associated ocean dynamics resolving mesoscale variability.   To combine these observations with those from other platforms, such as satellites, floats, drifters and moorings, to enhance the global ocean observing system.

CIMAS Research Theme:
***Theme 6*:** Integrated Ocean Observations (*Primary*)
***Theme 1*:** Climate Variability (*Secondary*)

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

**NOAA Funding Unit:** OAR   **NOAA Technical Contact:** Robert Roddy

Research Summary:
This program is designed to measure the upper ocean thermal structure along major shipping lines globally with low resolution and in key regions of the Atlantic Ocean with high resolution. Approximately 8000 XBTs (Figure 1) are deployed annually in all three modes (low density, frequently repeated and high density) Approximately 14000 XBT data, from NOAA and non-NOAA operations, are quality controlled every year. The seasonal to interannual variability in upper ocean heat content and transport is monitored (Figure 2) to understand how the ocean responds to changes in atmospheric and oceanic conditions and how the ocean response may feedback to the important climate fluctuations such as the NAO. This increased understanding is crucial to improving climate prediction models.

Within this context, five XBT lines have been chosen to monitor properties in the upper layers of the Atlantic Ocean. The global atmospheric and oceanic data from Ships of Opportunity (SOOP) serve as the foundation for understanding long-term changes in marine climate. This program is a component of the NOAA's Program Plan for building a sustained Ocean Observing System for Climate and directly addresses one of its milestone*: Occupy transects of the Ship Of Opportunity Program (SOOP) for high accuracy upper ocean observations.*

High-density XBT lines provide real time high resolution temperature profiles spaced approximately 30-50 km apart along five important lines in the Atlantic Ocean. These XBT transects are critical to investigate the upper ocean circulation since they are the only means to measure subsurface temperature fields on spatial and temporal scales designed to map the mean and fluctuating components of the ocean thermal structure. Data obtained from these lines, identified as AX25, AX18, AX08, AX10 and AX07,
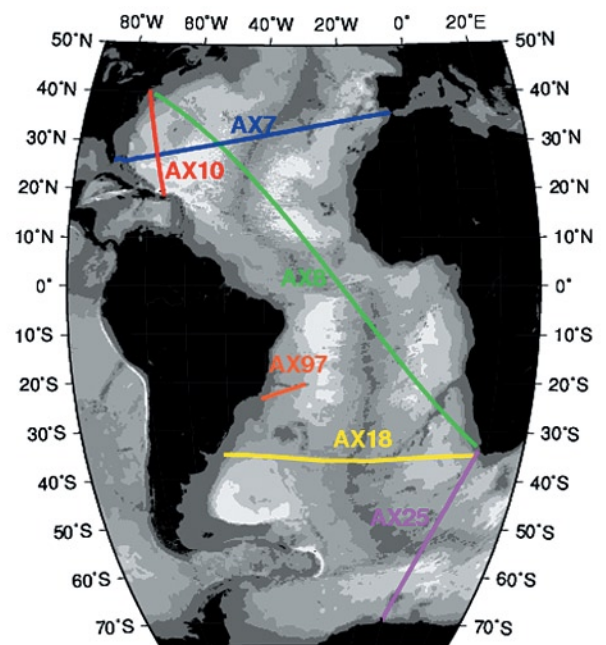
Figure 1: Map of station locations for the five high density lines maintained by NOAA/AOML.

are used to investigate the inter-basin mass exchange between the Indian and Atlantic Ocean (AX25), the meridional heat transport at 30°S (AX18) and 30°N (AX07), the variability of the Gulf Stream (AX10) and the zonal current system in the tropical Atlantic (AX08). Moreover, in the South Atlantic, line AX18 provides information on major boundary currents, such as the Brazil, Malvinas, Benguela and Agulhas, and their associated eddies. These are all important components of the Meridional Overturning Circulation in the Atlantic Ocean which is driven by temperature, salinity and wind variations.

This project includes extensive operations that collect, organize and distribute the data which are gathered from as many as eighteen cruises conducted each year, including in excess of 225 days at sea and more than 8000 XBTs deployed in all modes. Data obtained from these transects are provided to the scientific community to investigate the thermal structure of the subtropical gyres, equatorial system and the Antarctic Circumpolar Current and to study 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 (see http://www.aoml.noaa.gov/phod/hdenxbt/ for additional details). In addition, satellite altimetry data are being used to complement the observations provided by the XBT transects.

Research Performance Measure:
All operational research goals were met during this year with respect to the percentage recovery of good data based upon rigorous internal quality control. All scientific goals met with respect to timely assimilation of the data generated into operational NOAA modeling efforts.
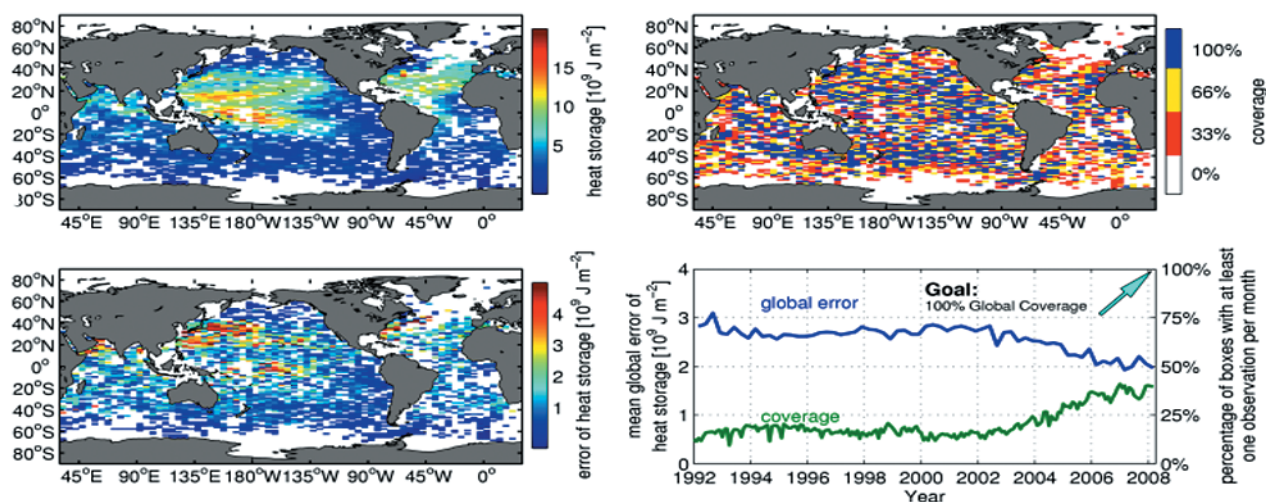
Figure 2: (a) Heat storage of the mixed layer estimated for Jan-Feb-Mar 2008 using XBT temperature profiles combined with ARGO observations. (b) Number of months during quarter JFM 2008 with observations on 5°x1.5° boxes. (c) Sampling uncertainty associated with estimates in (a). Time series of global heat storage and sampling error for the period 1992-2008. Available online at at www.aoml.noaa.gov/phod/soto/ghs/reports. (Schmid, Goni and DiNezio)

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

E. Forteza and S. Dong (UM/CIMAS); V. Halliwell (UM/RSMAS);
C. Schmid, R. Sabina and Y.-H. Chong Daneshzadeh (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
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.

CIMAS Research Theme:
Theme 6: Integrated Ocean Observations

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

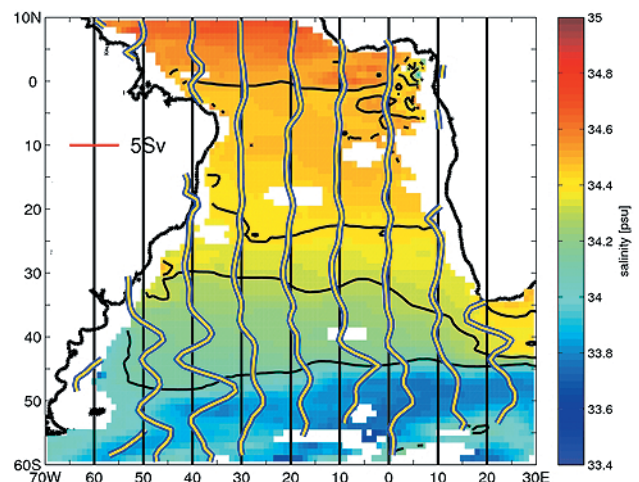**NOAA Funding Unit:** OAR/AOML   **NOAA Technical Contact:** Claudia Schmid

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 and salinity to depths of 1000-2000 meters, and of currents at the drift depth of the floats. Researchers in many scientific disciplines, including meteorology, climatology and oceanography, use data collected from the floats. The Argo array achieved its goal of a total of 3000 floats in November 2007; in the future the array will be maintained at this number of floats.

The US Argo Data Assembly Center (US DAC) at AOML is responsible for deploying floats, and for acquiring and processing the data. The US DAC has developed and maintained an automatic system for decoding, quality control, and distribution of data obtained from the US Argo floats in real-time. The system runs in a 24/7 mode. The data are open to the public, and are used by scientists working on climate models and oceanographic data analysis. Some of the accomplishments in this year are:

Figure 1: Zonal transport in the layer 800 to 1100 dbar superimposed on the salinity minimum of the Antarctic Intermediate Water (AAIW). Additional isolines are 34.1, 34.3, 34.4 and 34.5 psu. The pressure level corresponds to the depth of the AAIW throughout the subtropics and a large part of the tropics.

- 441 floats were deployed by the USA
- 79 of these floats were deployed by AOML
- 742 US floats are actively reporting.
- 67300 profiles have been sent to Global Data Centres
- 52110 profiles were sent to GTS by the US DAC
- US DAC is processing 120 Argo-equivalent floats (i.e. not funded by Argo) from different institutions and organizations (Florida State University, NAVOCEANO, University of Hawaii); 17 floats were donated to Brazil and Argentina.

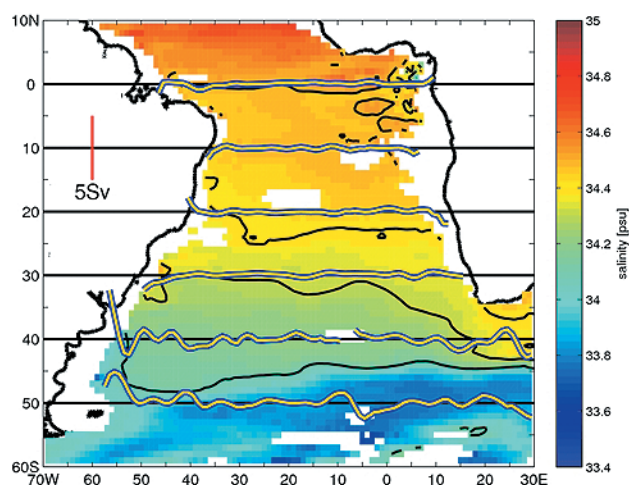The US DAC is maintaining a website that provides documentation and information about the operations at the US Argo DAC.   http://www.aoml.noaa.gov/phod/argo/index.php
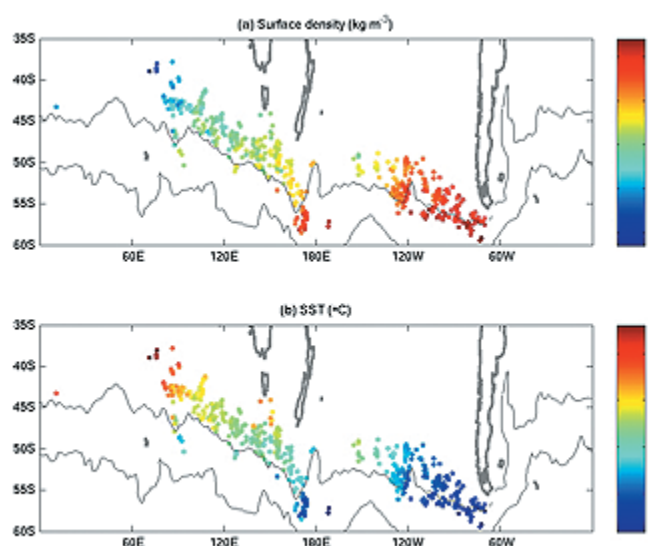
Data from Argo floats and other instruments are used in conjunction with sea surface height anomalies from satellite altimetry to derive heat storage of the upper part of the water column in the world ocean. We also continue to derive the properties of the mixed layer (temperature, salinity and pressure) from the combined hydrographic data sets on a monthly basis and generate products showing the quarterly heat storage of the mixed layer (see Figure 2, p.117, SOOP Report).

The same hydrographic data set is used in conjunction with trajectories from subsurface floats (including Argo floats) to analyze the spreading of the Antarctic Intermediate Water (AAIW) in the Atlantic Ocean. Figures 1 and 2 show the annual mean of the zonal and meridional transport in the 800-1100 dbar layer superimposed on the salinity at the salinity minimum of the AAIW. Lower (higher) salinities near the western (eastern) boundary are found in regions with northward flow. The much higher data density available now allows a more detailed study of this water mass, which is part of the upper branch of the Meridional Overturning Circulation, than before.

Figure 2: Meridional transport in the layer 800 to 1100 dbar superimposed on the salinity minimum of the Antarctic Intermediate Water (AAIW). Additional isolines are 34.1, 34.3, 34.4 and 34.5 psu. The pressure level corresponds to the depth of the AAIW throughout the subtropics and a large part of the tropics.

Temperature/salinity profiles from Argo were used to examine spatial and seasonal variations of the mixed-layer depth and the properties of the Sub-Antarctic Mode Water (SAMW) in the Southern Ocean. Deep mixed layers associated with SAMW are located just north of the Antarctic Circumpolar Current (ACC) where air-sea interaction is expected to be strongest. Consistent with past observations of SAMW properties, the surface density and temperature for those deep mixed layers (≥ 400 m) derived from the Argo profiles vary spatially (Figure 3). The potential density increases from 26.57 kg m^{-3} to 27.04 kg m^{-3}, and the temperature decreases from 13.3°C to 4.3°C as the ACC shifts southward from the Indian Ocean to the Drake Passage. As shown in Figure 3, these deeper mixed layers represent the thick SAMW found in the Indian and Pacific Oceans.

Figure 3: Spatial distribution of the near surface (a) density (kg m-3) and (b) sea surface temperature (°C) for mixed-layer depths that exceed 400 m. Black curves denote the Subantarctic Front (north) and Polar Front (south), respectively.

Research Performance Measure:
All operational research goals were met during this
year with respect to the percentage recovery of good data based upon rigorous internal quality control and all scientific goals met with respect to timely assimilation of the data generated into operational NOAA modeling efforts and improved physical understanding of the oceanographic features of special interest to UM and AOML physical oceanographers.

Data Analysis and Near-Real-Time Quality Control
in Support of the International ARGO Project (Phase I)

M.-L. Shyu (UM/ENG); C. Schmid and R. Sabina (NOAA/AOML)

Long Term Research Objectives & Strategy to Achieve Them:
Objectives: To investigate, develop, and implement innovative methodologies to perform a near-real-time quality control of ARGO profiling float data using a diverse set of oceanographic measurement systems.
Strategy: To analyze differences between recently collected data from Argo floats with analyzed fields in the form of publicly available long-term climatologies as well as newly derived climatologies.

CIMAS Research Theme:
Theme 6: Integrated Ocean Observations (*Primary*)
Theme 1: Climate Variability (*Secondary*)

Link to NOAA Strategic 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

NOAA Funding Unit: AOML
NOAA Technical Contact: Claudia Schmid and Reyna Sabina

Research Summary:
The focus of this project is to support an international ARGO program which involves the deployment of more than 3,000 drifting profiling floats distributed over the global oceans. These allow the continuous monitoring of real-time ocean temperature and salinity. In this program we develop, and implement innovative methodologies to perform a near-real-time quality control of ARGO profiling float data using a diverse set of oceanographic measurement systems.   We subsequently use these data sets to develop new climatologies in research applications in such a way that they can be readily updated on a regular basis. These are made available to the public.

To this end we worked on development and implementation of float processing software and programs of decoders. There are over 50 types of the floats and each type of the float requires a decoder to extract the needed information. There are five types of formats, i.e., PRV, HEX, CNT, PHY, QC data. ARGOS process software includes Unix shell scripts and C programs. We analyze existing data sets compared the data to help on data integration and updating, e.g., salinity adjustment from new metadata, to track the pressure at surface and various depths. The analyzing software includes
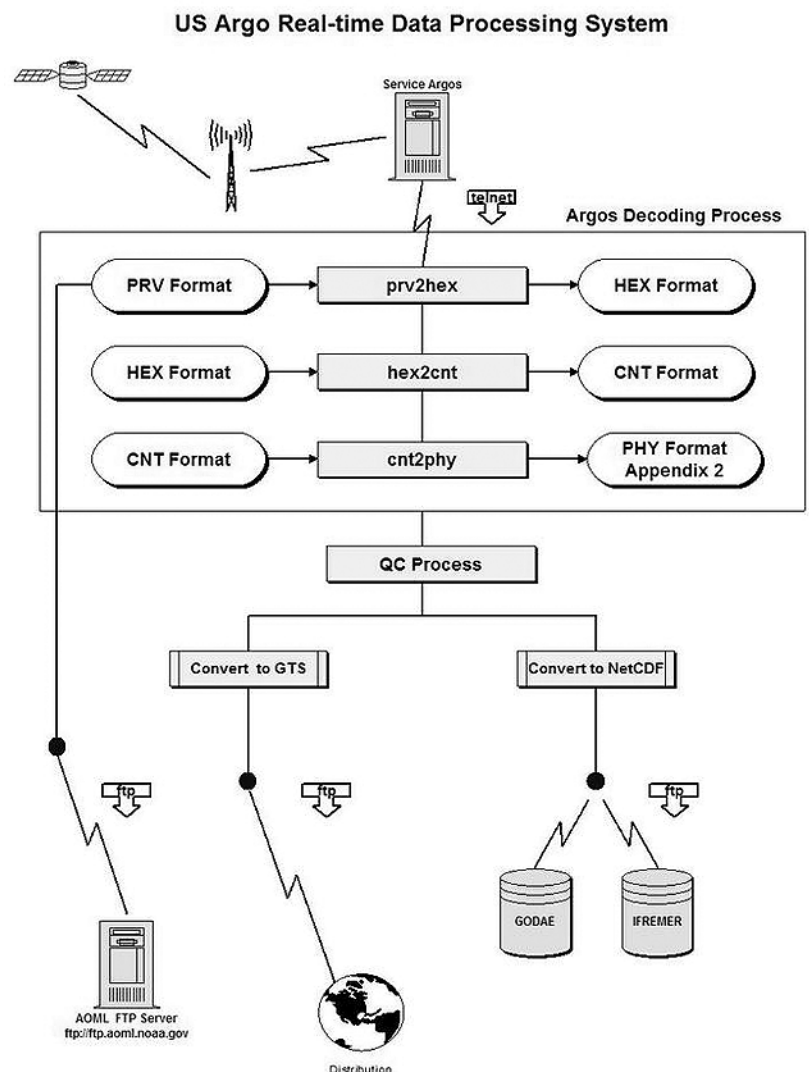
Figure 1: US ARGO Data Processing System

MATLAB and JAVA programs.

A flow chart of the US ARGO data processing system is shown in Figure 1. Figure 2 shows the real-time processing system.

Research Performance Measure:
We accomplished our primary objectives in support of the Argo project. We developed and implemented float processing software and decoder programs, and we integrated the newly acquired data into existing data sets and interpreted and compared the new data in the context of the integrated data sets.
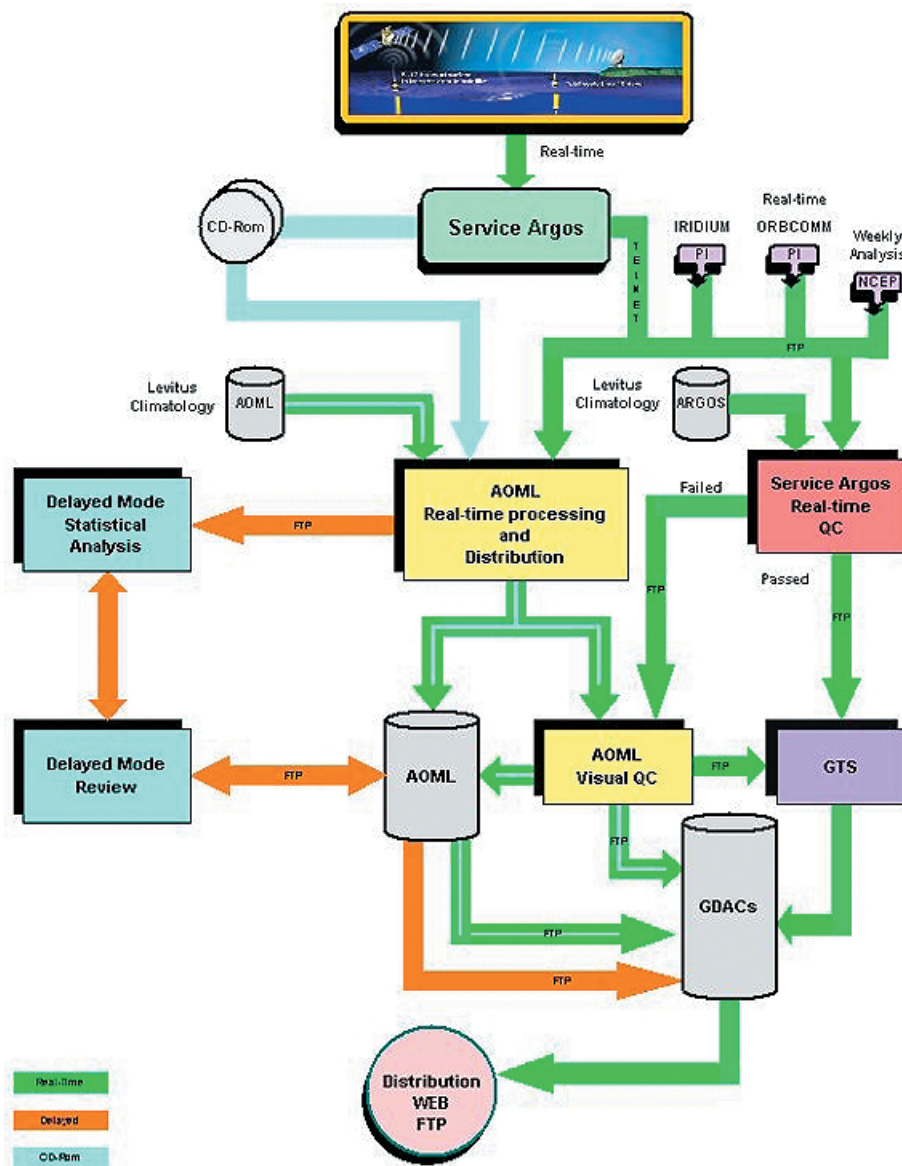

Figure 2: Real-time Processing System

Simulation of Circulation and Nutrients Transport Around Florida Bay and The Florida Keys With The South Florida Regional
SoFLA-HYCOM Model

V. Kourafalou (UM/RSMAS); G. Goni (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:

***Objectives*:** To improve our understanding of the processes that influence circulation and nutrient transport in the South Florida coastal seas, with an emphasis around enabling predictive simulation of the fields encompassing the ecologically important areas of Florida Bay and the Florida Keys

***Strategy*:** To complete the development of the NOAA/UMiami regional hydrodynamic model of the Southwest Florida shelf, Florida Straits and Gulf Stream (SoFLA-HYCOM) that encompasses Florida Bay and the Florida Keys. To perform simulations that include all relevant coastal processes that affect circulation and nutrient transport in the South Florida coastal ecosystem.

CIMAS Research Theme:

***Theme 6*:** Integrated Ocean Observations (*Primary*)
***Theme 3*:** Regional Coastal Ecosystem Processes (*Secondary*)

Link to NOAA Strategic Goals:

***Goal 1*:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management (*Primary*)
***Goal 3*:** Serve Society's Needs for Weather and Water Information (*Secondary*)

NOAA Funding Unit: COP
NOAA Technical Contact: Larry Pugh

Research Summary:

The South Florida Hybrid Coordinate Ocean Model (SoFLA-HYCOM) encompasses a variety of coastal regions (the broad Southwest Florida shelf, the narrow Atlantic Keys shelf, the shallow Florida Bay and Biscayne Bay) and deep regions (the Straits of Florida), including Marine Protected Areas (the Florida Keys Marine Sanctuary and the Dry Tortugas Ecological Reserve). The strong Loop Current/Florida Current system and associated eddies serve to link the local circulation systems with basin-wide dynamics. We developed a multi-nested approach to ensure resolution of coastal scale processes and proper interaction with the large scale flows. This strategy ensures that the model predicted circulation around Florida Bay and the Florida Keys includes all major circulation forcing mechanisms.

The SoFLA simulations are free-running (no data assimilation); however, effects of data assimilation are introduced through boundary conditions derived from larger scale models that include
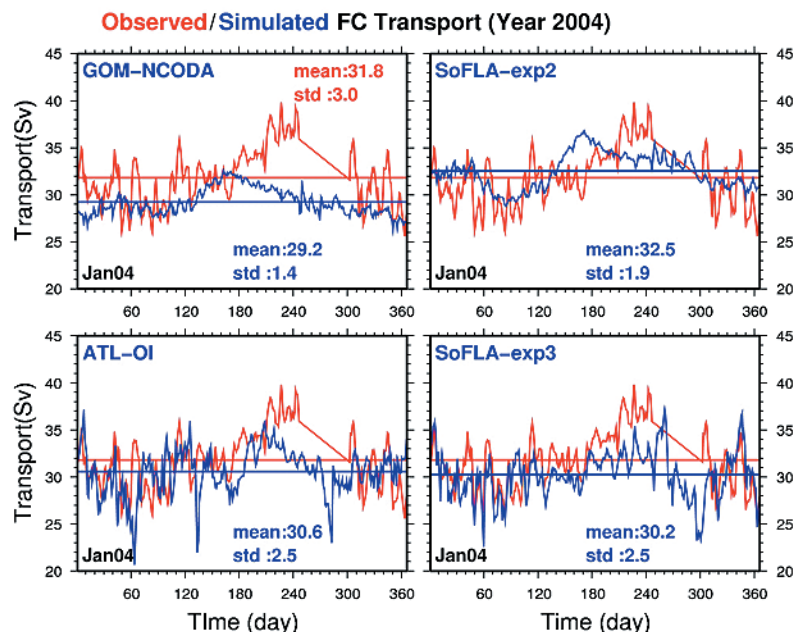
Figure 1: Observed and simulated hourly values of near-surface (at 5 m depth) along-shore velocity (in cm s^{-1}) at the mooring station C19 (on the Southwest Florida Shelf near the Dry Tortugas) for year 2004, computed from USF data (red lines) and SoFLA model simulations (blue lines): (a) *exp1*; (b) *exp2*; (c) *exp3*. The along-shore wind stress component (in N m^{-2}) from the 3-hourly COAMPS-27km forcing is given in (d). Time series mean and standard deviations (std) are also given.
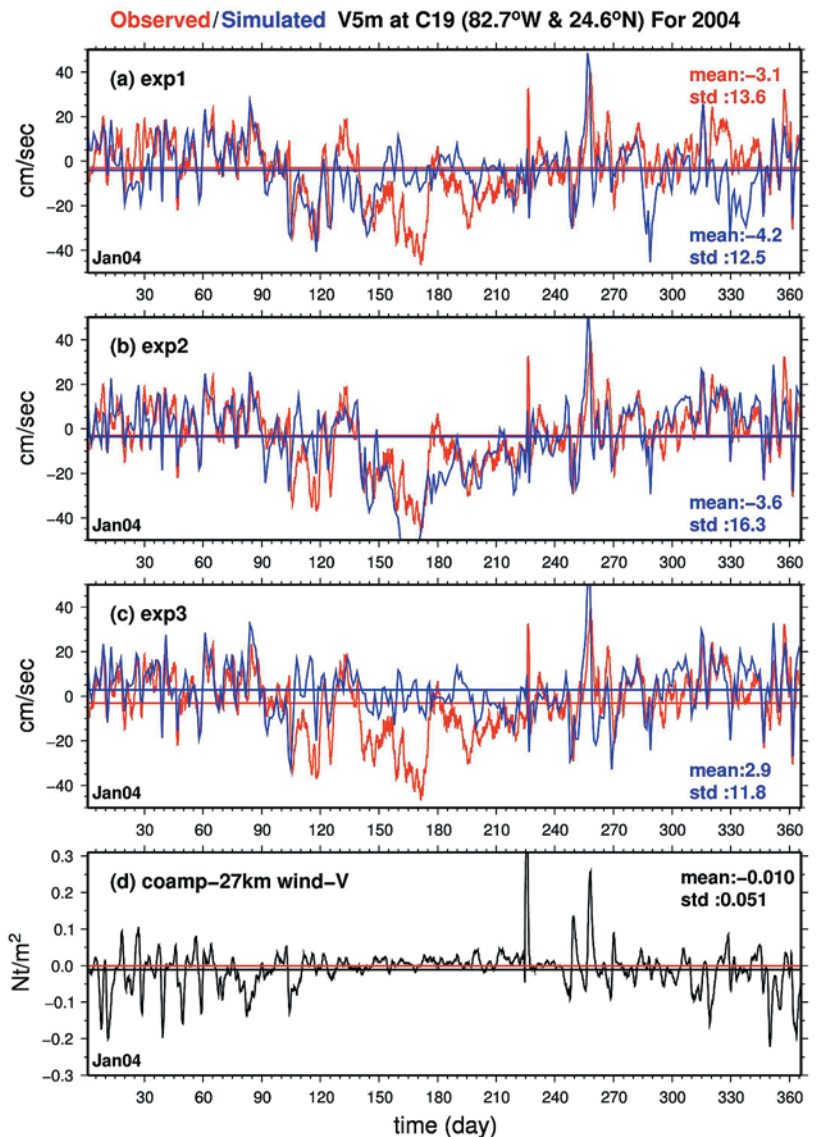
data assimilation, namely the Gulf of Mexico (GoM)-HYCOM and the North Atlantic (ATL)-HYCOM. In order to determine the optimal boundary conditions, model results are validated with observations. These include buoy data on the Southwest Florida shelf and Florida Current cable transport data in the upper limit of the Straits of Florida (~27⁰N). The results for a 2-year simulation period (2004-2005) reveal that wind-driven and buoyancy-driven (controlled by river input) flows dominate the inner- to mid- shelf flows, while basin-wide, large scale processes dominate the outer shelf and deep flows.

Several experiments have been performed to determine the optimal boundary conditions that yield SoFLA simulations that best fit to the observations. The atmospheric forcing has been improved over earlier simulations from the NOGAPS (Navy Operational Global Atmospheric Prediction System, 1 deg. resolution) to the COAMPS (Coupled Ocean / Atmosphere Mesoscale Prediction System, 27 km resolution). Three experiments are highlighted here that differ in boundary conditions: *exp1* employs the GoM-HYCOM free running simulation (no data assimilation) as the outer model; *exp2* employs the GoM-HYCOM simulation with the Navy Coupled Ocean Data Assimilation (NCODA) scheme (which is based on a Multivariate Optimal Interpolation technique); *exp3* bypasses the intermediate Gulf of Mexico model (1/25 deg. resolution) and is nested directly to the lower resolution (1/12 deg.) ATL-HYCOM model, which employs a simple Optimal Interpolation based data assimilation scheme.

Two examples are presented for the year 2004: Figure 1 is a comparison of the along-shore current velocity as measured at a buoy on the Southwest Florida Shelf near the Dry Tortugas (data provided by USF), with the model simulated velocity

Figure 2: Observed and simulated time series of daily Florida Current transport (in Sv) at a section across ~27°N for year 2004, based on: the GoM-NCODA simulation (upper left); the SoFLA *exp2* (upper right); the ATL-OI simulation (lower left); the SoFLA *exp3* (lower right). Time series mean and standard deviations (std) are also given. The data gap is marked by a straight red line.

superimposed and for each of the three experiments described above; the along-shore component of the wind at the same point is also shown, along with current mean and standard deviation values. Overall the model performs very well, capturing current reversals due to atmospheric frontal passages in the winter and extreme events associated with tropical storms in the fall season. Large currents during the summer are not wind-driven (as is obvious from the minimal values in the wind times series) but are controlled by eddy passages. The SoFLA *exp2*, which is nested in the Gulf of Mexico model with the NCODA data assimilation scheme performs best, as the data assimilative boundary conditions help improve the timing of the eddy passages.

Figure 2 is a comparison of the Florida Current transport time series at 27⁰N, as measured by a submerged cable (AOML data) and as computed by three model simulations: *exp2*, the GoM-HYCOM outer model (where *exp2* is nested), exp3 and the outer ATL-HYCOM model (where *exp3* is nested); the mean and standard deviation values are also given. As seen in

Fig. 2, although *exp2* (and also *exp1*, which is not shown, but is very close to *exp2*) has the closest mean, as compared to *exp3* and both outer models, it fails to capture the fluctuations and also has an earlier peak on summer 2004 than what is revealed by the data record. In contrast, *exp3* is very successful in capturing the timing and magnitude of the transport fluctuations, while also correcting the summer 2004 peak timing. The most striking result is that the nested *exp3* outperforms the ATL-OI outer model, in terms of capturing fluctuations, while *exp2* outperforms the GoM-NCODA in both years.

The results clearly suggest that (a) the Atlantic basin-wide circulation has a direct effect on the Florida Current fluctuations; (b) the resolution and topography in the nested SoFLA model contribute to improved representation of both shelf and deep sea flows.

Research Performance Measure:
Overall the research is progressing according to project planning. A series of model improvements have been made and data then employed to examine model skill. The successful inter-comparison of the models with observations is our most important performance measure.   These extensive comparisons have validated our model results.

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

C. Kelble, N. Melo, G. Rawson, A. Stefanick, X. Huang and P. Ortner (UM/CIMAS);
V. Kourafalou (UM/RSMAS); E. Johns, R. Smith, J.-Z. Zhang,
C. Fischer and S. Cummings (NOAA/AOML)

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 times scales; to quantify the variability in these parameters so as to provide a historical basis for distinguishing future changes that may occur as a result of the Comprehensive Everglades Restoration Plan (CERP).

Strategy: To carry out regular and supplemental event-focused monitoring cruises in conjunction with a moored instrument array and targeted drifter releases and to incorporate these results into the SoFLA-HYCOM model.

CIMAS Research Theme:

Theme 6: Integrated Ocean Observations (*Primary*)
Theme 3: Regional Coastal Ecosystem Processes (*Secondary*)
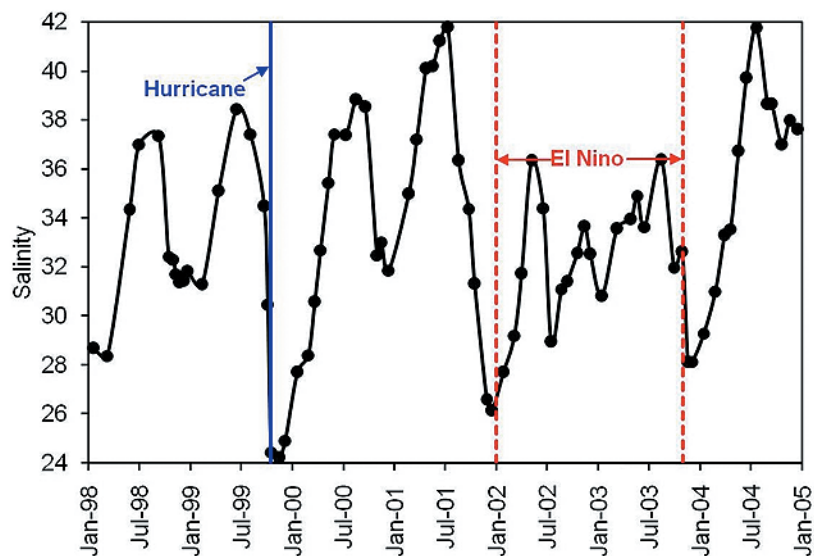
Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Funding Unit: IOOS   **NOAA Technical Contact:** Elizabeth Johns

Research Summary:

The Comprehensive Everglades Restoration Program (CERP) is the largest and most expensive ecosystem restoration ever attempted. The primary goal is to restore the quantity, quality, timing, and distribution of freshwater to as near historic levels as feasible in the greater Everglades Ecosystem. Restoration activities will have a significant effect on the downstream coastal ecosystem that supports a significant portion of south Florida's economy and includes the Florida Keys National Marine Sanctuary, as well as the Rookery Bay National Estuarine Reserve. The effect of restoration on the coastal ecosystem remains unclear and some have hypothesized that the end result could be eutrophication of specific areas within the coastal ecosystem. This concern along with others in the terrestrial system has resulted in the adoption of iterative adaptive restoration, whereby each project will be undertaken individually and management decisions will be altered if it is found they are likely to cause detrimental ecological effects. In

Figure 1: The time-series of mean salinity in Florida Bay indicates the bay-wide salinity is significantly affected by tropical cyclones and El Niño.

order to effectively implement Everglades Restoration with this capability it is necessary to quantifiably understand the distribution and variation of the relevant physical, chemical, and biological water column properties in the South Florida coastal ecosystem.

The underlying focus of this multi-disciplinary project is to understand the present-day variability in south Florida's coastal marine ecosystem and thereby to gain insights into how the Everglades' restoration might impact on this ecosystem. Recent research has included quantifying the relative contribution of chlorophyll *a*, CDOM, and tripton to the attenuation of photosynthetically available radiation (PAR) in Florida Bay along with investigating the potential for light availability to limit primary producers in this system. This understanding has enabled the development of a predictive, mechanistic model to estimate light attenuation. The long term variability in salinity was examined to determine the impact of meteorological phenomena on the physical environment of Florida Bay (Figure 1) and subsequently to partition the sources of salinity variation (precipitation, runoff, and evaporation) throughout the different sub-regions of Florida Bay.

Our research, combined with information on circulation in Florida Bay, suggests possible restoration approaches that might mitigate the magnitude, extent, and duration of hypersalinity in north-central Florida Bay. Current research includes an examination of the relationship between mesozooplankton dynamics and salinity. This allows for the formulation of hypotheses regarding the effect of an altered salinity regime (which is expected as a result of restoration) on the plankton community. Understanding the current variability of the system will result in the capability to develop sound working hypotheses regarding the effect of restoration projects on the water column of the downstream coastal ecosystem. The development of testable hypotheses will provide a rigorous way in which to assess the effect of Everglades Restoration on the coastal ecosystem and provide the feedback necessary to successfully implement iterative adaptive restoration.

Research Performance Measure:
Our research objectives are being met on schedule. The primary measure of performance is the degree to which the data and analysis are being incorporated into the scientific basis for CERP. With respect to this project year, the project data (and the Project Principal Investigator) provided critical contributions to the relevant components of the congressionally mandated 2007 System Status Report.

Western Boundary Time Series Project

R. Garcia, C. Fonseca, A. Stefanick, G. Berberian, Q. Yao, G, Rawson,
N. Melo, K. Seaton, S. Dolk, C. Alex and F. Bringas (UM/CIMAS);
M. Baringer, C. Meinen and S. Garzoli (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To monitor the meridional overturning circulation through sustained time series observations of the western boundary currents at 27°N.
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 Antilles Current systems.

CIMAS Research Theme:
Theme 6: Integrated Ocean Observations (*Primary*)
*Theme 1*: Climate Variability (*Secondary*)

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

NOAA Funding Unit: OAR/AOML   **NOAA Technical Contact:** Christopher Meinen

Research Summary:

Variations in the transport of the Meridional Overturning Cell (MOC) in the Atlantic Ocean have been shown in numerical climate models to have significant impacts on the climate at both the international and local levels. Near 27˚N in the Atlantic the warm upper-limb of the MOC is principally carried by the Florida Current between the eastern Florida coast and the Bahamas, although the Antilles Current east of the Bahamas also carries some of the warm northward flow. The southward deep flow of the MOC is contained primarily within the Deep Western Boundary Current east of Abaco Island in the Bahamas, although some fraction is also thought to transit near the Mid Atlantic Ridge. Long-term observations of the Florida Current, Antilles Current and Deep Western Boundary Current are required in order to quantify the natural time scales of variability for these currents.
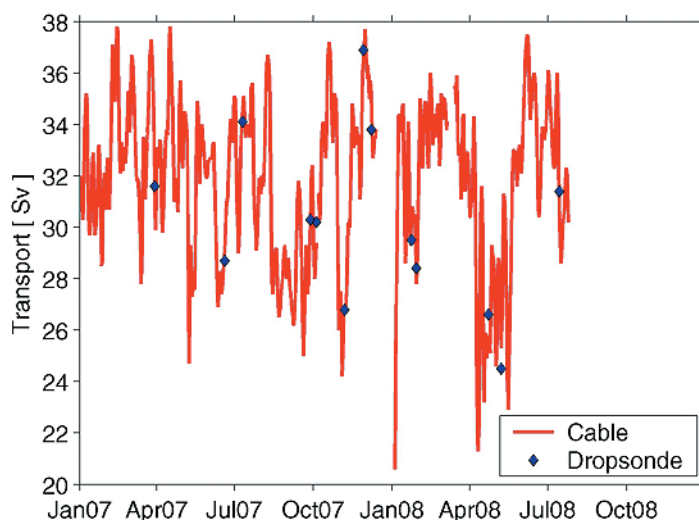
Figure 1: Time Series of Florida Current Transport

This project maintains NOAA's well-established and climatically significant Florida Current volume transport time series. Over 25 years of daily mean voltage-derived transports have been obtained for the Florida Current using out-of-use and in-use telephone cables spanning the Straits of Florida. The cable voltages are converted to physically meaningful volume transport estimates, i.e. intensity of the flow, using electromagnetic induction theory and data from calibration sections on research vessels. This project also maintains repeated hydrographic sampling east of Abaco Island that has established a high-temporal-resolution record of water mass properties in the Deep Western Boundary Current near 27ºN. Events such as the intense convection period in the Labrador Sea and the renewal of classical Labrador Sea Water in the 1980s are clearly reflected in the cooling and freshening of the Deep Western Boundary Current waters off Abaco, and the arrival of a strong pulse of Labrador Sea Water approximately 10 years later.

During the past year, the monitoring and data distribution systems for the Florida Current cable program have continued to see improvement, providing Florida Current transports in near real time via the web page www.aoml.noaa.gov/floridacurrent/ (See Figure 1). We completed two hydrographic cruises to monitor water mass changes along 26.5°N east of Abaco Island in the Bahamas during the past year, one on the NOAA Ship Ronald H. Brown and the other on the R/V Seward Johnson. These cruises also involved collaborations with scientists from RSMAS/University of Miami and from the National Oceanographic Centre, Southampton, United Kingdom through a program that is called the Meridional Overturning Circulation Heat-flux Array experiment by the US contributors and the RAPID Climate Change program by the UK participants. Calibration cruises for cable transport and water mass changes within the Florida Current were conducted on the University of Miami's R/V Walton Smith (2 cruises) and small sport fishing boats charter from Sailfish Marina in West Palm Beach (11 cruises).

Research Performance Measure:
All research goals were met during this last year. We continue to achieve our major long term objective – to maintain the continuity of this long term data set and to continually improve the calibration of the data obtained.

Enabling and Initiating Observing System Simulation Experiments of the Coastal High Resolution Oceanographic Model in the Northern Gulf of Mexico

V. Kourafalou, G. Halliwell and P. Ortner (UM/RSMAS);
Robert Atlas and Gustavo Goni (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:

Objectives: To quantify the contribution of new ocean observing systems to the quality of coastal now-casts; to assess the influence of downscaled information from basin scale ocean models on the capability of nested regional/coastal models to reproduce mean conditions and seasonal variability; to both hind-cast and forecast synoptic and mesoscale/submesoscale variability.

Strategy: To develop a nested system consisting of a high resolution coastal model in an area of strong coastal to offshore interactions and strong land-sea interactions (Northern Gulf of Mexico) nested within a regional (Gulf of Mexico) model; to perform numerical simulations that represent the coastal dynamics with sufficient accuracy (as validated through observations) to enable subsequent Ocean System Simulation Experiments (OSSEs).

CIMAS Research Theme:

Theme 6: Integrated Ocean Observations (*Primary*)
Theme 3: Regional Coastal Ecosystem Processes (*Secondary*)
Theme 5: Air-Sea Interactions and Exchanges (*Tertiary*)

Link to NOAA Strategic Goals:

Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management (*Primary*)
Goal 3: Serve Society's Needs for Weather and Water Information (*Secondary*)

**NOAA Funding Unit:** AOML   **NOAA Technical Contact:** Robert Atlas

Research Summary:

This project represents a unique collaboration between cooperative institutes (CIMAS and the NGI), and two federal agencies (NOAA and DOD/NRL). There is simply no other way to address this important problem. Although the coastal ocean is strongly influenced by surface atmospheric forcing and coastal freshwater runoff, offshore ocean variability can exert a significant influence in many regions due to a wide range of processes such as basin-scale climate variability, boundary current meanders, and mesoscale/submesoscale eddies. To accurately downscale this offshore variability to a coastal ocean model, models must be nested within fields that accurately represent the state of the ocean and its variability at the nested model boundaries. We are using a high resolution HYCOM (Hybrid Coordinate Ocean Model) assimilative model covering the Gulf of Mexico through the Florida Straits (GoM-HYCOM), itself nested within the larger-scale, publicly-available global HYCOM model, to obtain initial and boundary conditions for a higher resolution coastal model that covers the Northern Gulf of Mexico (NGoM-HYCOM).

The research completed during the past year is a necessary precursor of the Observing System Simulation Experiment (OSSE) system deemed essential to the development of a rigorous operational predictive capability in the Northern Gulf of Mexico. Specific activities and milestones are as follows:

- A comprehensive high resolution, three dimensional model that connects coastal to land and offshore hydrodynamics has been developed for the entire Northern Gulf of Mexico (NGoM) coastal region, based on the data assimilative HYCOM (Hybrid Coordinate Ocean Model). Development of the high resolution (~1.8 km horizontal grid) NGoM-HYCOM coastal model was completed. The NGoM-HYCOM is nested within the regional Gulf of Mexico HYCOM model (GoM-HYCOM), itself nested within the larger-scale, publicly-available HYCOM GODAE (Global Ocean Data Assimilation Experiment) product.

- The Navy Coupled Ocean Data Assimilation (NCODA) scheme was applied to the GoM-HYCOM (collaboration with the Naval Research Lab at the Stennis Space Center) and comparison of Free vs. Data Assimilative simulations were made, evaluating the representation of the Loop Current and its associated eddies, which have a substantial impact on the nested NGoM-HYCOM coastal model.
- Process studies on the Mississippi River plume were conducted to highlight the development and evolution of the river plume and the effects of topography and atmospheric forcing on the advection of low salinity plume waters.
- Satellite derived products were developed to investigate the variability in the upper layers in the Gulf of Mexico (GOM). These products are now produced in semi-operational mode and include time series and maps of Sea Surface Temperature (SST), Sea Surface Temperature Residuals (SSTR), Sea Height Anomaly (SHA) and Sea Height Residuals (SHR) and spectrum and wavelet analyses of the SSTR and SHR time series.
- A methodology of using satellite products for model validation has been developed.
- A preliminary methodology for an Observing System Simulation Experiment (OSSE) in the Gulf of Mexico using the HYCOM model has been developed.
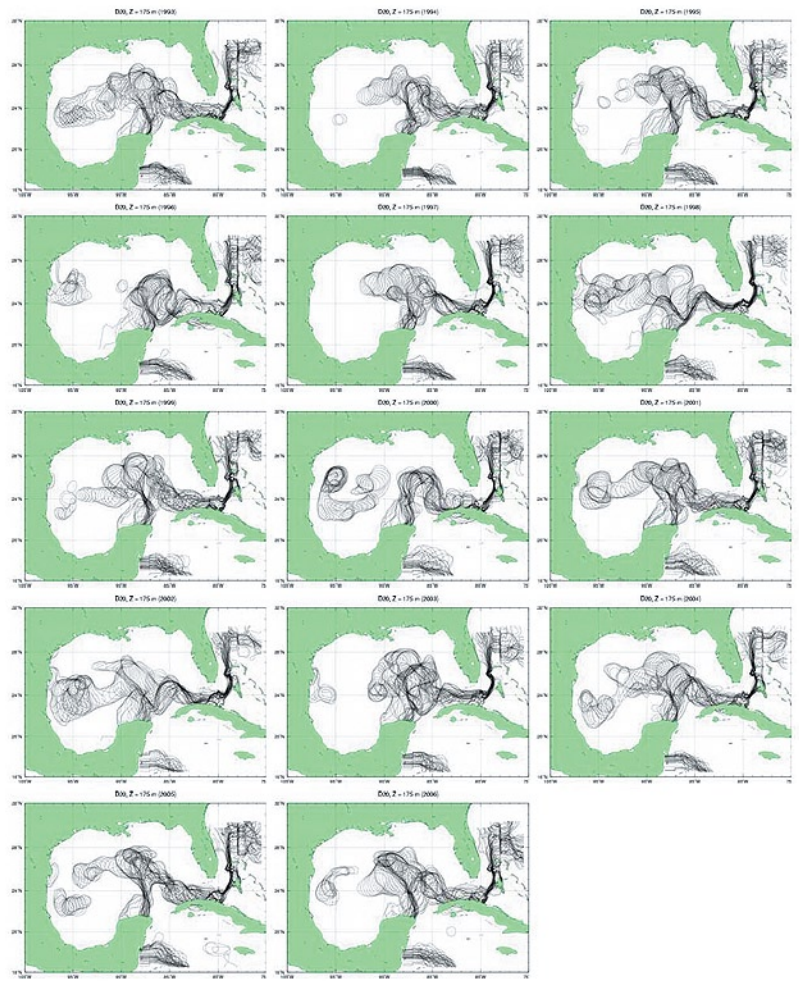
Figure 1: Variability of the frontal locations of the Loop current defined as the 175m deep contour of the 20°C isotherm from 1993 to 2006.

The GoM-HYCOM model has already successfully incorporated a state-of-the-art assimilation scheme (NCODA); coastal hindcasts and predictions nested within it will enable us to demonstrate the impact of high resolution initial and boundary conditions on coastal forecasts, to conduct Observing System Simulation Experiments (OSSEs) with available CODE drifter, SVP drifter and satellite data and, therefore, to help guide the design for the Gulf Coastal Oceanographic Observing System (GCOOS).

An example of employing project derived satellite products for the analysis of dominant circulation features is shown in Figure 1. The variability in the Loop Current is being studied implementing a methodology to determine the frontal location based on the depth of the 20°C isotherm, derived by synthetic temperature profiles obtained from satellite altimetry observations. These frontal locations for 1993-2007, using the contour when the 20°C isotherm is 175m deep, are presented in Figure 1, indicating large year-to-year variability. A similar analysis with model derived parameters is in progress and will serve as validation of model results.

Research Performance Measure:

The research is progressing according to the project planning. Model to observations intercomparison is our most important performance measure. A series of model improvements have been made and available data then employed to examine model skill. AOML satellite products have already been used for model validation.

The CLIVAR CO$_2$ Repeat Hydrography Program
K. Sullivan and G. Berberian (UM/CIMAS);
C. Langdon (UM/RSMAS); R. Wanninkhof (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objective: To constrain regional ocean CO$_2$ inventories to 2 Pg C/ decade.
Strategy: To reoccupy transects on a decadal timescale to quantify the uptake of anthropogenic CO$_2$ by the ocean.

CIMAS Research Theme:
Theme 6: Integrated Ocean Observations

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

NOAA Funding Unit: COD **NOAA Technical Contact:** Mike Johnson and Joel Levy

Research Summary:
The CLIVAR/CO$_2$ Repeat Hydrography Program is a global re-occupation of select hydrographic sections to quantify changes in storage and transport of heat, fresh water, carbon dioxide (CO$_2$), oxygen, nutrients, chlorofluorocarbon tracers and related parameters. The effort started in 2003 and to date sections have been completed in the Atlantic, Pacific and Indian Ocean (Figure 1).

Data from these cruises are compared to data from previous surveys (e.g., World Ocean Circulation Experiment (WOCE)/ Joint Global Ocean Flux Survey (JGOFS) during the 1990s) to measure changes in the physics and biogeochemistry of the oceans and to determine where/how much excess atmospheric CO$_2$ is entering the oceans on decadal timescales. The program is designed to assess changes in the ocean's biogeochemical cycle in response to natural and/or man-induced activity. Global warming-induced changes in the ocean's transport of heat and freshwater, which could affect the circulation by decreasing or shutting down the thermohaline overturning, can be followed through long-term measurements. The
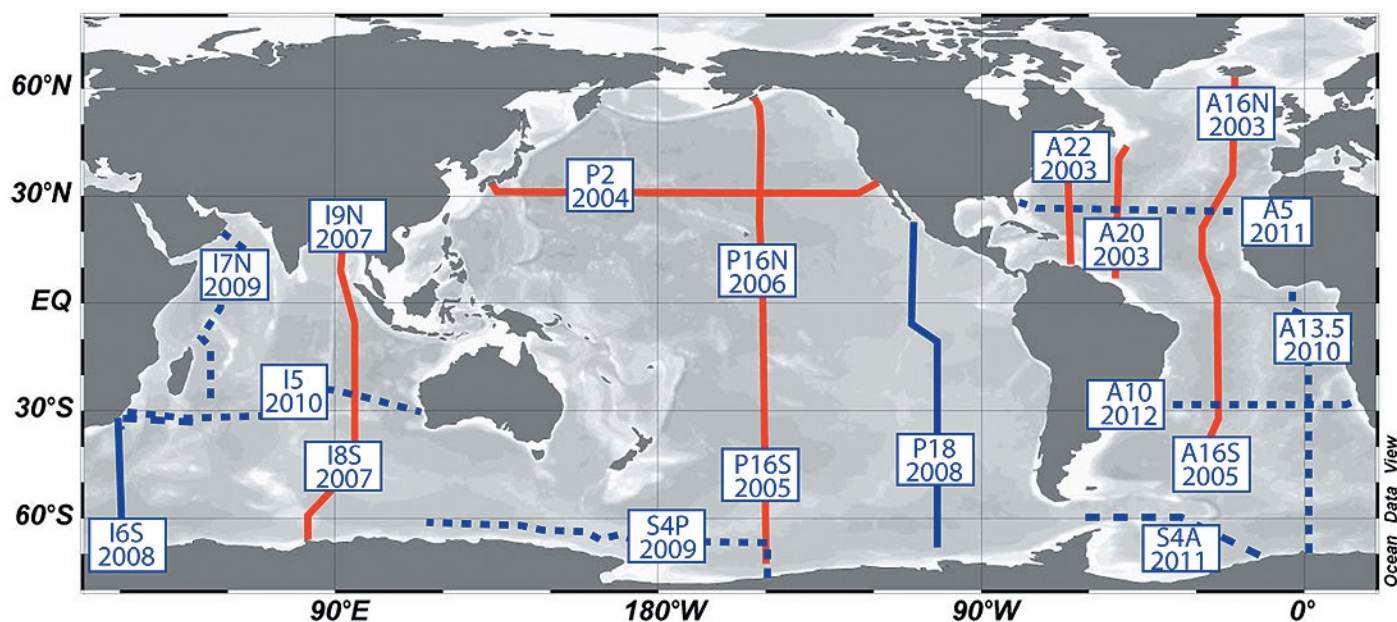
Figure 1: Cruise tracks of the CLIVAR/CO$_2$ repeat hydrography program. The red lines show completed cruise, blue solid lines are cruises completed in 2008 and the blue dashed lines show proposed cruises to complete the global survey.

program also provides data for continuing model development that will lead to improved forecasting skill for oceans and global climate. During FY-2008 a meridional line in the Pacific was occupied from 20° N to 65° S (P-18) with full physical and chemical characterization of 160 water column profiles.

In order to assess the impact of fossil fuel CO_2 on climate, we must be able to make an accurate inventory of the carbon stored in the atmosphere and the oceans. The most robust way to accomplish this goal is by measuring changes in atmospheric and ocean carbon inventories over time to quantitatively track the changes in these two reservoirs. While atmospheric changes have been accurately measured for many decades, this has not been possible for the oceans until now. In our program we have been able to accurately quantify the changes in the water column carbon in the Atlantic, Pacific, and Indian oceans by comparing data from recent cruises with those from WOCE cruises that occupied the same transect lines in the late 80's and early 90's. Besides clearly showing the anthropogenic CO_2 input our data also shows large changes in the biogeochemical properties of the upper water column. The estimates changes in anthropogenic carbon inventory are shown in Table 1. The largest uptake is in the North Atlantic and corresponds with the downwelling component of the Meridional Overturning Circulation (MOC) that enhances transport of carbon into the deep waters.

Table 1: Estimates of ocean column inventory changes in anthropogenic carbon (mol C m^{-2} yr^{-1}) over the last decade.

	Atlantic Ocean (along 25°W)	Pacific Ocean (along 152°W)	Indian Ocean (along 90°E)
Northern Hemisphere	0.75	0.25	0.3*
Southern Hemisphere	0.63	0.41	0.5*

*Preliminary: Indian Ocean changes are still being evaluated. From Sabine et al. (2008).

Research Performance Measure:
The program is progressing according to plan. Our most performance measure is that we have further constrained and verified global carbon flux models by quantifying the inter-decadal increase of CO_2 in the world's oceans to +2 Pg C.

Surface Water pCO$_2$ Measurements from Ships

K. Sullivan, D. Pierrot, J. Trinanes, G. Castelao, F. Bringas and S. Pochan (UM/CIMAS);
F.J. Millero and J. Waters (UM/RSMAS); G. Goni and R. Wanninkhof (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:
Objectives: Constrain regional air-sea CO$_2$ fluxes.
Strategy: Sustained observations using automated pCO$_2$ systems on ships of opportunity.

CIMAS Research Theme:
Theme 6: Integrated Ocean Observations (*Primary*)

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

NOAA Funding Unit: COD   **NOAA Technical Contact:** Mike Johnson and Joel Levy

Research Summary:

The ship-based surface pCO$_2$ program is designed to document regional oceanic carbon sources and sinks on seasonal timescale by measuring surface water and marine boundary pCO$_2$ on ships of opportunity. It is a collaboration of investigators at the NOAA laboratories AOML, and PMEL; and the following academic institutions: Columbia University, the University of Miami, and the Bermuda Institute of Ocean Sciences. The program contributes to the goal of creating regional flux maps on seasonal timescales to quantify uptake of anthropogenic CO$_2$ in the ocean and short-term changes thereof. The near-term focus is on development of the Northern Hemisphere ocean carbon observing system, which is closely linked to an assessment of the carbon dioxide sources and sinks over the coterminous United States through the North American Carbon Program (NACP). In FY-08 the NOAA funded participants maintained instrumentation and reduced data from seven ships and posted the data. Flux maps, based on extrapolation routines using remotely sensed wind and sea surface temperature (SST) have been created for the Equatorial Pacific, and Caribbean Sea. A prototype product of global seasonal air-sea fluxes has been produced as part of this effort (Figures 1 and 2).

Figure 1: Research Vessel *F. G. Walton Smith* is outfitted with a pCO$_2$ system that provides data for quantifying carbon dioxide sources and sinks in Florida coastal waters, along the eastern seaboard from Miami to New York and the Caribbean.

An increasing emphasis is put on coastal observations as the fluxes in the region are very poorly constrained. To address this, a new generation pCO$_2$ system was installed on the on the Miami research vessel *F. G. Walton Smith* (Figure 1). It is currently making measurements on coastal waters from Miami to New York. The autonomous system will provide coastal pCO$_2$ data in Florida Bay and Caribbean waters in the future.

An appreciable focus continues to be global coordination of like efforts. We have taken the lead in providing uniform autonomous instrumentation for installation on ships of opportunity (SOOP). Through a successful technology transfer and continued guidance, General Oceanics in Miami is now producing units for the community at large. We also are leading an effort for uniform data quality control procedures and data reduction that now is used as a standard for the International Carbon Coordination project (IOCCP) of UNESCO/IOC.

As part of the effort improvements in auxiliary data such as sea surface temperature (SST) and sea surface salinity (SSS) from thermosalinographs (TSG) have been made. Currently there are two ships transmitting TSG data as part of this project: M/V Oleander and M/V Explorer.

Recently, maintenance of the TSG system in the M/V Oleander was performed. Several aspects of the system were updated, involving the antenna installation and computer setup to ensure data transmission, even with low levels of satellite signal. Maintenance of the TSG system in the M/V Explorer was also necessary and several parts of the system were replaced. Both ships are now transmitting their data in real-time, the Oleander for a continuous track between New Jersey and Bermuda, the M/V Explorer for its transects around the world. Additionally, some tests are being facilitated at AOML to improve equipment performance.

Research Performance Measure:

All goals are being met on schedule. We have achieved some of our major goals: created flux maps for the Caribbean Seas, Equatorial Pacific and North Atlantic; assessed seasonal variability of air-sea CO_2 fluxes; further constrained and verified global carbon flux models by quantifying the annual increase of CO_2 in the world's oceans to +- 0.2 Pg C.
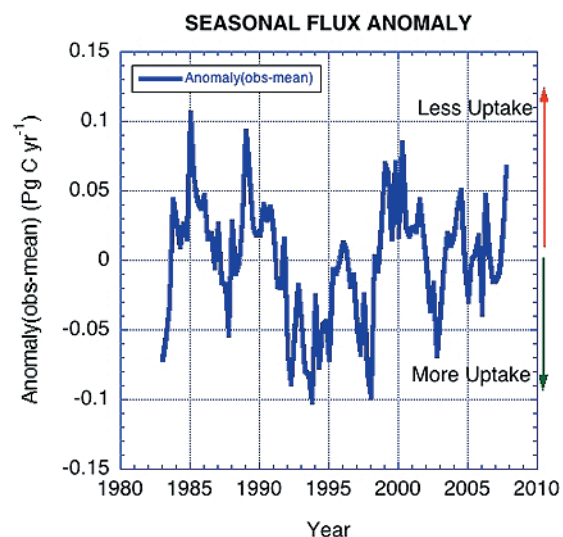
Figure 2: Seasonal anomalies in air-sea CO_2 fluxes over the past two decades determined from satellite observations of winds and sea surface temperature utilizing the climatological surface water CO_2 data of Takahashi et al. (2008).

Development, Maintenance, and Migration of the Pathfinder Sea Surface Temperature Algorithm and Associated Data Systems
R. Evans and K. Kilpatrick (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Theme:
*Objectives***:** To ensure the long term availability of the NOAA/NASA AVHRR Pathfinder SST time-series by transferring the algorithms, code and expertise to NODC.
*Strategy***:** To transfer the AVHRR Pathfinder SST processing code and SST retrieval equation coefficient generation to NODC by incorporating the Pathfinder code into the community accepted SeaDAS satellite processing framework.

CIMAS Research Theme:
*Theme 6***:** Integrated Ocean Observations

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

NOAA Funding Unit: NODC   **NOAA Technical Contact:** Ken Casey

Research Summary:
The widely accepted AVHRR Pathfinder SST time-series has from inception been developed and processed at RSMAS. This activity ensures the long term stability of the time-series by providing NODC with the ability to continue production and

Figure 1: Number of users of the Pathfinder data set per month, January 2004 - June 2006.
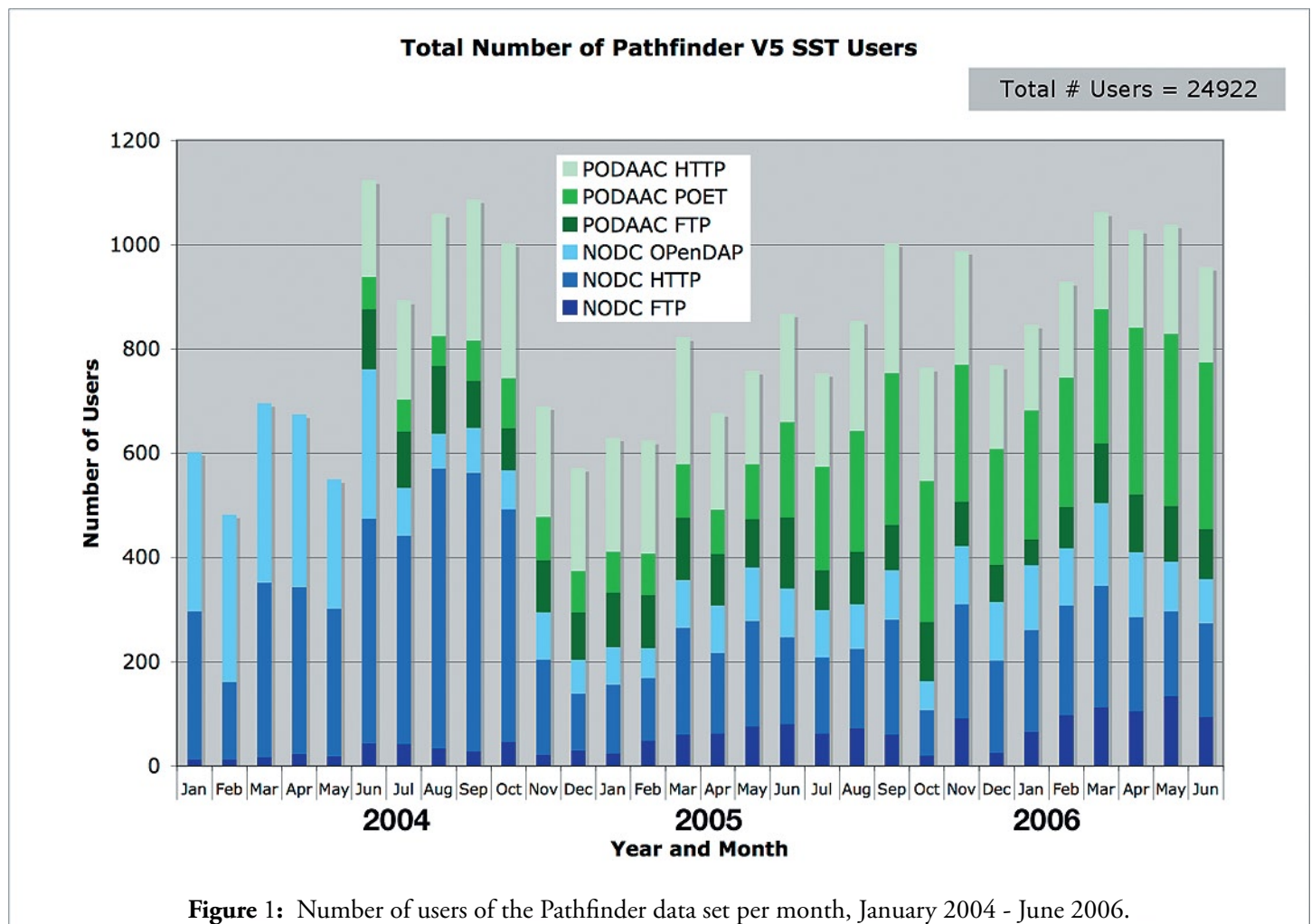
thus continuity of this widely used data set. To date RSMAS and NODC have decided on a sustainable code framework and production environment. An initial implementation of the Pathfinder code, together with an ingest program for NOAA CLASS AVHRR L1b files, has been delivered to NODC.

Research Performance Measure:
We accomplished our primary objective: the delivery of the initial code base was on schedule.

NPOESS/VIIRS Sea Surface Temperature (SST) Pre-Launch Performance Analysis and Option Improvement Development
P. Minnett and R. Evans (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Theme:
***Objectives*:** To determine the effectiveness of the algorithm proposed for computation of Sea Surface Temperature by the VIIRS sensor to be flown on the NPOESS satellites; to determine if alternate SST algorithms provide better constrained error budgets.
***Strategy*:** To use available satellite and *in-situ* data sets to explore the behavior and error characteristics of the SST field produced by the VIIRS SST algorithm; to use MODIS brightness temperature fields and point MODIS/*in-situ* matchups as the test data set.

CIMAS Research Theme:
***Theme 6*:** Integrated Ocean Observations

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

NOAA Funding Unit: IPO   **NOAA Technical Contact:** Heather Kilcoyne

Research Summary:
The algorithm proposed for computing Sea Surface Temperature (SST) for the NPOESS/VIIRS sensor was analyzed using equivalent spectral bands from the MODIS sensor and an associated Match Up database of co-located, contemporaneous in-situ observations. We found a number of deficiencies that gave rise to unacceptable discontinuities in SST retrieved using MODIS data as proxy VIIRS observations. An alternative algorithm was proposed. The IPO has now adopted the proposed alternate algorithm as the standard VIIRS SST retrieval algorithm.

Research Performance Measure:
Adoption of the proposed algorithm by the IPO. This objective has been accomplished.
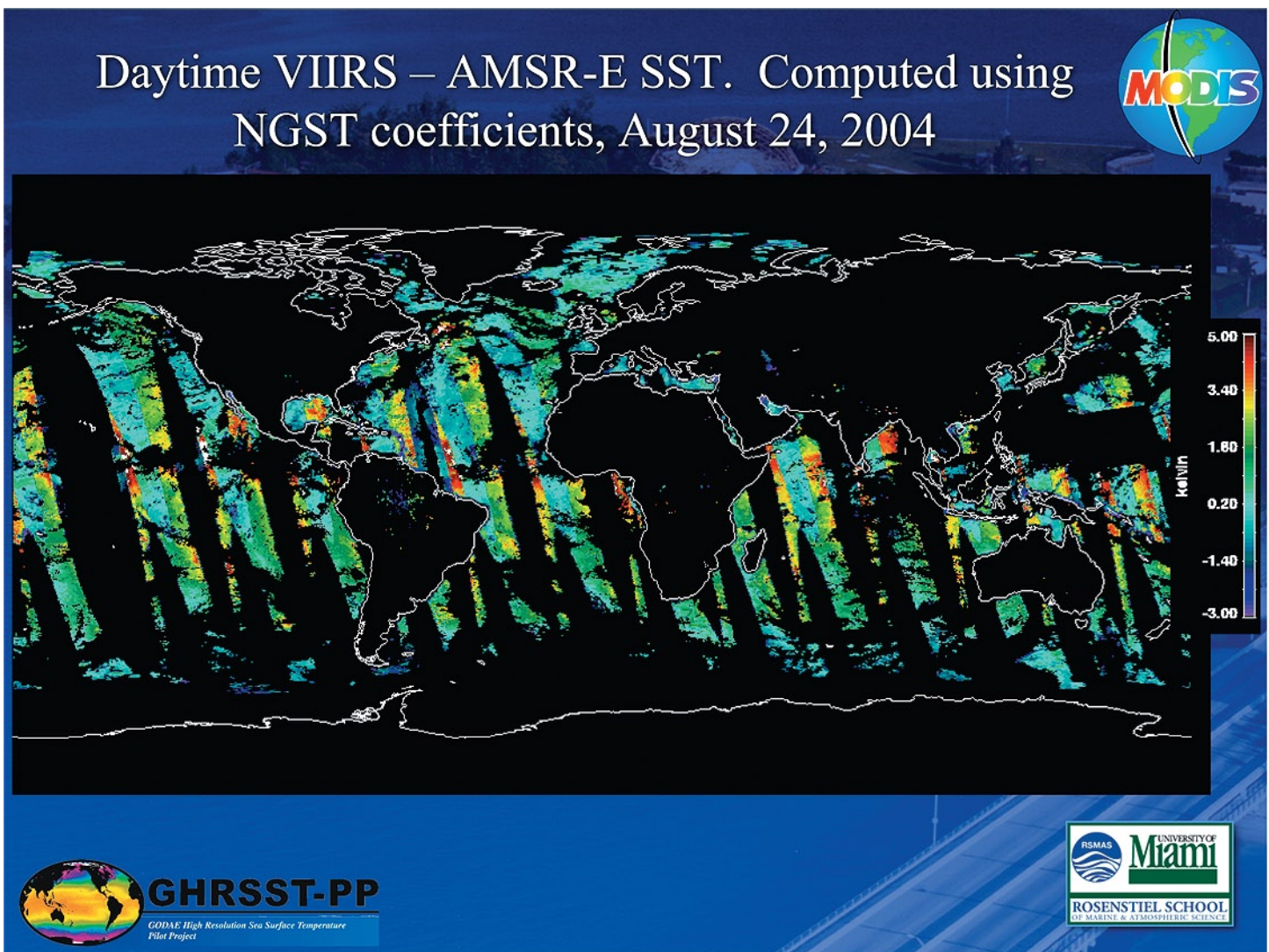
Figure 1: VIIRS SST computed using NGST coefficients (Nov 2006) - EOS AMSR microwave SST computed for August 24, 2004.   The 'non-sun glint' portion of the scan is computed using algorithms that incorporate the mid-IR wavebands.   This part of the swath shows elevated SST, order 2-4K higher that the adjacent regions computed using equations that incorporate only the long wave IR bands.

Global Drifter Program

S. Dolk, E. Valdes and S. Elipot (UM/CIMAS);
R. Lumpkin and M. Pazos (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

***Objectives*:** To maintain a global 5x5 degree array of 1250 ARGOS-tracked surface drifting buoys to meet the need for an accurate and globally dense set of in-situ observations of mixed layer currents, sea surface temperature (SST), atmospheric pressure, winds and salinity. To provide archive and disseminate a uniform quality-controlled data from the historical data sets of SST and surface velocity, web access, archival and distribution.

***Strategy*:** To produce an annual plan for the global distribution and deployment of 1000-1050 drifters through interaction with international partners. To coordinate drifter objectives with NOAA field personnel, contractors, shipping companies and various ship personnel. To verify deployment status and update the Drifter Database and tomonitor on a daily basis systems status.

CIMAS Research Theme:

***Theme 6*:** Integrated Ocean Observations

Link to NOAA Strategic Goals:

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

NOAA Funding Unit: OAR/AOML

NOAA Technical Contact: Rick Lumpkin and Mayra Pazos

Research Summary:

The Global Drifter Program (GDP) is a principal component of the Global Surface Drifting Buoy Array, a branch of NOAA's Global Ocean Observing System (GOOS) and a scientific project of the Data Buoy Cooperation Panel (DBCP). There are two major activities in this program.

- *Drifter Operations Center (DOC)* whose task is to maintain a global 5x5 degree array of 1250 ARGOS-tracked surface drifting buoys to meet the need for an accurate and globally dense set of in-situ observations of mixed layer currents, sea surface temperature (SST), atmospheric pressure, winds and salinity.

- *Drifter Data Assembly Center (DAC)* whose tasks are: to arrange data dissemination to the Global Telecommunications System (GTS); to provide uniform quality-controlled data from the historical data sets of SST and surface velocity, web access, archival and distribution. These data support short-term (seasonal to interannual) climate predictions as well as climate research and monitoring.

The design of the Global Drifter Program drifter has continued to evolve - as demonstrated by the recent introduction of the mini drifter - while its qualitative characteristics and water-following properties have remained relatively stable since the earliest deployments. Incremental improvements in design and manufacturing continue to increase drifter lifetime, and alternative methods for detecting drogue presence (such as tether strain) are being considered. We continue to develop new methodologies for drifter data analysis, aided by increasing information from the ever-growing drifter array and from other sources of complimentary observations. Dense deployments in eddy-rich, frontal regions will help us improve our understanding of eddy fluxes and their role in modifying air-sea heat fluxes and water mass formation.

The major challenge facing AOML's DOC, which coordinates drifter deployments, is to arrange deployments in regions of surface divergence and areas infrequently visited by research or voluntary observation vessels. This logistical challenge is being addressed by increased international cooperation, and the development of tools to predict global drifter array coverage based on its present distribution and historical advection/dispersion. As the array grows, it provides invaluable observations of ocean dynamics, meteorological conditions and climate variations, and offers a platform to test experimental sensors measuring surface conductivity, rain rates, biochemical concentrations, and air-sea fluxes throughout the world's oceans.

The AOML's DAC is responsible for processing data from the global surface drifter project. This specific program focuses on

the maintenance and support of a population of 1250 active drifters (see Fig. 1). The DAC works closely with researchers to provide high-quality drifter data in a rapid an accessible manner. The DAC drifter program has four primary objectives: Global Telecommunications System (GTS) data distribution, quality control, web access, and performance evaluation. The DAC inserts and deletes drifters onto the GTS. The accuracy of data is monitored and data are removed once sensors fail. The DAC also notes drifters that have lost their drogue so that this information can be relayed in the GTS message.

A major activity as an added task under this program is: Evaluating the Observing System for Surface Currents: a Global Drifter Program (Pedro DiNezio, CIMAS; Rick Lumpkin and Gustavo Goni, NOAA/AOML). In this study, the status of the observing system for surface currents obtained from quality-controlled, drogued Lagrangian drifter observations is derived. Sea height anomaly data are used to match with those from the drifters to evaluate the correlation between along-track sea height anomaly gradients and across-track drifter-derived geostrophic velocity anomalies. Global fields of correlations and eddy kinetic energy are computed and differences between estimates from both observations are evaluated. High correlations indicate where altimetry observations can be calibrated by the in-situ measurements to provide a good proxy for surface currents. On the other hand, low correlations may be indicate where errors in the winds or Ekman model are problematic, where ageostrophic ocean dynamics are contributing significantly to the surface momentum budget, where the signal-to-noise ratio is low, or where there are depth-compensating effects in the upper layer causing the sea height to have low variability.

Research Performance Measure:
All goals were met in that the array was both maintained and markedly enhanced and timely quality-controlled data made available to the research and operational communities. The first global analysis of hourly-resolution drifter data was published in Elipot and Lumpkin, *Geophys. Res. Letts., 35,* 2008. This study documented the tidal, inertial and superinertial motion measured by drifters in the Atlantic, Pacific and Indian Ocean basins.
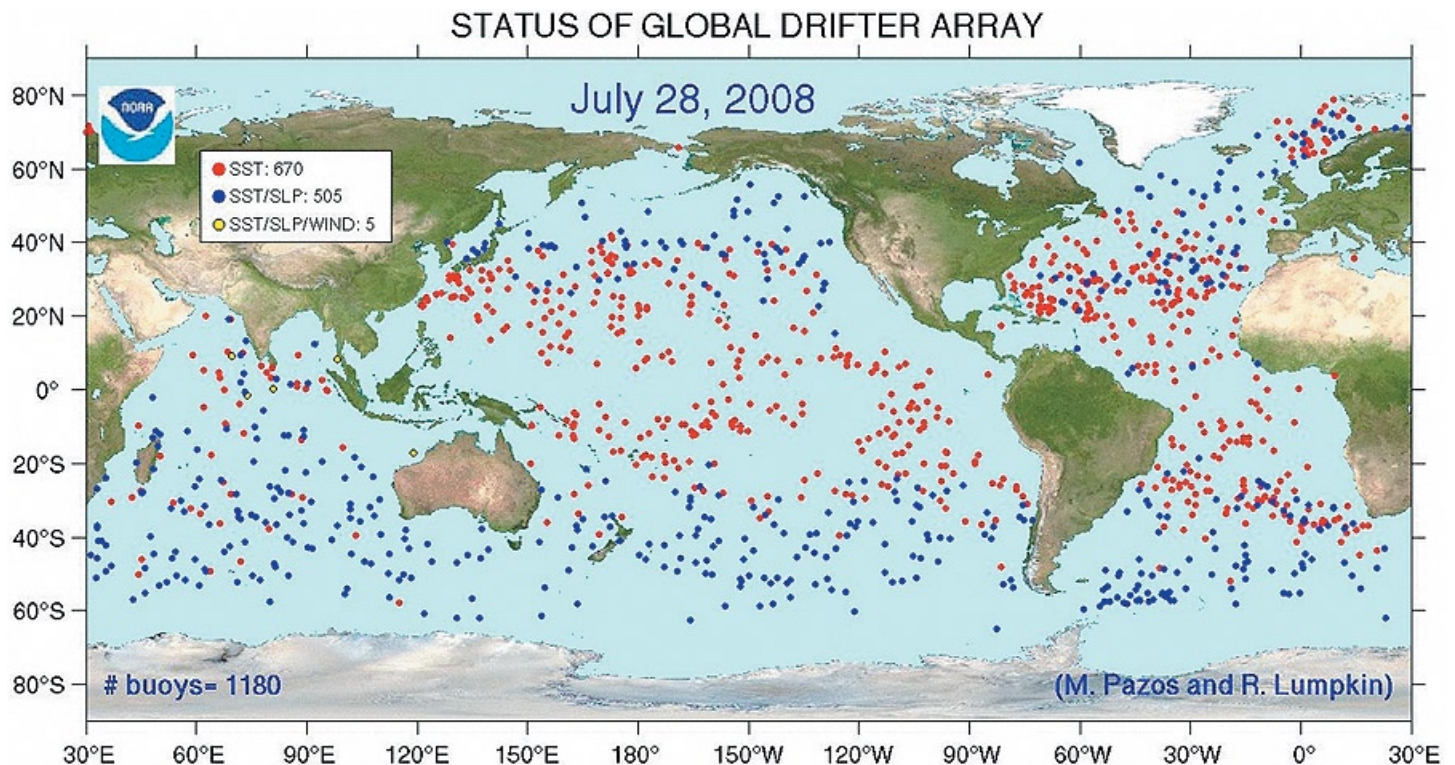
Figure 1: Status of the Global Drifter Array (updated weekly)

Determining Information Content in Repeat XBT Drops
R.L. Molinari, C. Alex and P. DiNezio (UM/CIMAS), G. Goni (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Theme:
Objectives: To determine information content (e.g., dominant periods, propagation of signals, etc.) in individual eXpendable BathytThermograph lines occupied since the late 1960's. To compare model results and observational data to determine model's ability to simulate recent ocean climate. To develop new techniques for more efficient ocean observing systems.
Strategy: To select XBT lines in the Pacific and Atlantic Oceans that have been occupied for greater than 35 years and perform statistical analyses on resulting time-series of upper layer temperature.   To compare with models to determine if the simulations are capable of replicating current oceanic characteristics. To develop a model to estimate surface drifter trajectories in order to determine regions requiring future deployments.

CIMAS Research Theme:
Theme 6: Integrated Ocean Observations (*Primary*)
Theme 1: Climate Variability (*Secondary*)

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

NOAA Funding Units: OAR/CCP, OAR/AOML
**NOAA Technical Contact:** Dr. Joel Levy

Research Summary:
We have determined the mean and time-dependent properties of upper layer temperature using the low density network lines in the Atlantic and Pacific Oceans. Many of these lines reveal decadal signals. However, these results have to be revisited because of recently discovered uncertainties in the depths recorded in the data base as discussed below.

We began this study by selecting XBT lines in the Pacific and Atlantic Oceans that have been occupied for greater than 35 years and we performed statistical analyses on the resulting time-series of upper layer temperature. We analyzed the time series of each line to determine if we could detect the dominant signals (annual, decadal) and if they could be related to oceanic features such as El Niño, North Atlantic Oscillation induced anomalies, Pacific Decadal Oscillation. The lines examined are components of the World Ocean Circulation Experiment and are scheduled to be discontinued once it has been demonstrated that the Argo array and satellite altimetry can provide equivalent information. Using GFDL and University of Miami coupled and uncoupled Global Circulation Models, we compared the model results to observations to determine if the simulations are capable of replicating current oceanic characteristics. To date we have compared NOAA and SST data.

In a comparison of the most recent Geophysical Fluid Dynamics Laboratory coupled model with the SST characteristics of the North Atlantic, we find that the model can simulate the large-scale SST patterns of the basin. However, the model fails to capture the properties of several intense surface currents (e.g., the Gulf Stream, North Atlantic Current, Azores Current), which creates temperature discrepancies compared to observations of the order several degrees.

Unfortunately this research is placed in doubt by the conclusions of a paper, published in the past few months, which reports a time-dependent variability in the fall-rate equation used to compute depths for XBT drops. This variability can result in errors that mimic (and possibly cause) decadal signals in the observations. This finding will require the recalibration of the historical XBT database. The absence of suitable metadata particularly for older profiles complicates this process.

Finally a new effort is underway that focuses on the development of a model to estimate surface drifter trajectories in order to determine which ocean regions will require deployments in the future.
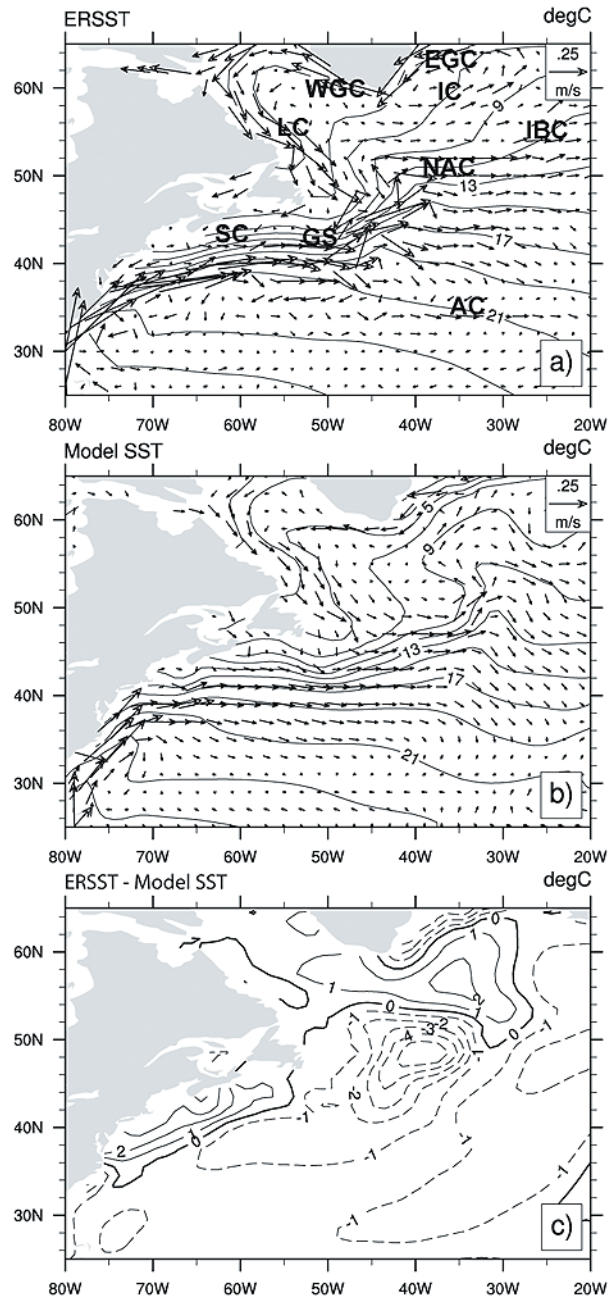
Figure 1: Upper panel: Observed mean surface currents (1992-2005), derived from surface drifters drogued at 15m, and SST, °C distributions. Currents are truncated from a 1° latitude-longitude grid to a 2° to increase clarity. Current initials include: SC=Slope Current; GS = Gulf Stream; AC=Azores Current; NAC=North Atlantic Current; E(W)GC=East(West) Greenland Current; LC=Labrador Current. Middle panel: Simulated mean surface current, from the model depth at 15 m, and SST, °C. Bottom panel: Simulated minus observed SST distribution, °C

Research Performance Measure:

All other major objectives have been met although the conclusions of some of this work are in doubt because of the aforementioned discovery of XBT drop errors.
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Interdisciplinary Surveys of Western Florida Bay and Connecting Waters Including Gulf Stream Transects

P. Ortner and C. Kelble, (UM/CIMAS); Gary Hitchcock (UM/RSMAS);
L. Johns, M. Barringer and R. Smith (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

*Objectives***:** To support the ability of CIMAS to determine the circulation and water property patterns in south Florida's coastal waters on "event" to inter-annual time scales and quantify variability of the Florida Current, the Antilles Current, and the Deep Western Boundary Current.

*Strategy***:** To provide ship-time aboard the R/V Walton Smith to allow for collection of the necessary datasets to achieve the above objectives.

CIMAS Research Theme:

*Theme 6***:** Integrated Ocean Observations (*Primary*)

Link to NOAA Strategic Goals:

*Goal 1***:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management (*Primary*)

Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond (*Secondary*)

NOAA Funding Unit: OGP, GFDL, NOS/IOOS

NOAA Technical Contact: Mike Johnson (OGP) and Carl Gouldman (NOAA/IOOS)

Research Summary:

The continuation of the Western Boundary Time series measurements involves long term monitoring of the Florida Current, the Antilles Current and the Deep Western Boundary Current as part of the overall effort to monitoring the Meridional Overturning Circulation in the North Atlantic. The 20+ year record of Florida Strait's cable transport is especially critical and is used as a benchmark validation by all the global coupled ocean-atmosphere climate models. This specific objective of our project is to provide the hydrographic data required to verify the cable transports and, as such, it is critical to maintaining the continuity and inter-comparability of the long term record (see *Western Boundary Time Series* project) (Figure 2).

The Florida Bay and Adjacent Waters monitoring cruises are part of the Comprehensive Everglades Restoration Plan Monitoring and Assessment effort and contribute data central to the congressionally mandated biannual assessments of system status and restoration progress (see *Long-Term Measurement of Physical, Chemical, and Biological Water Column Properties in the South Florida Coastal Ecosystem* project). At the same time the cruises provide the infrastructure to be moving forward on the development of the South Florida Regional Observing System as part of NOAA's regional integrated ocean observing system network (see Figure 1). While well reviewed, due to funding constraints SF-ROS development has been deferred to FY09 pending funding made available to the NOAA IOOS office.
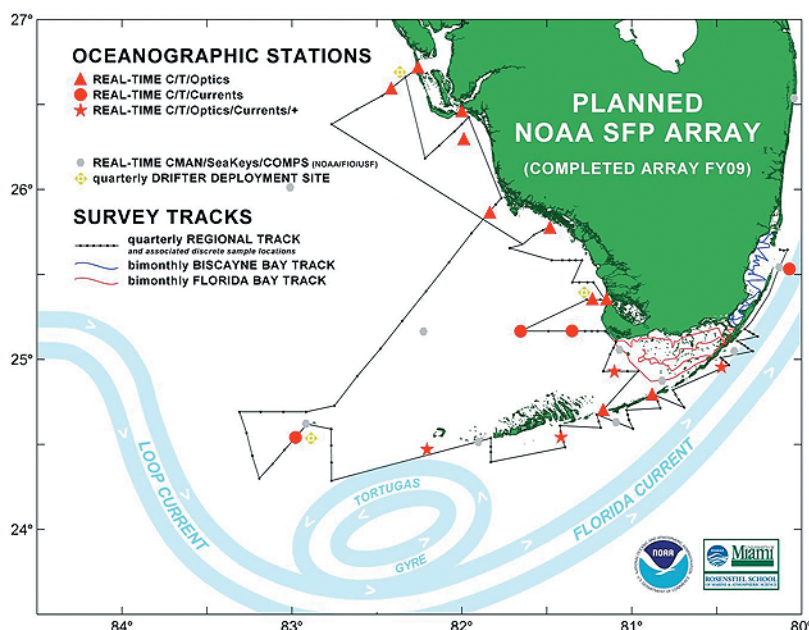
Figure 1: Evolutionary Development of South Florida Regional Observing System (SF-ROS).
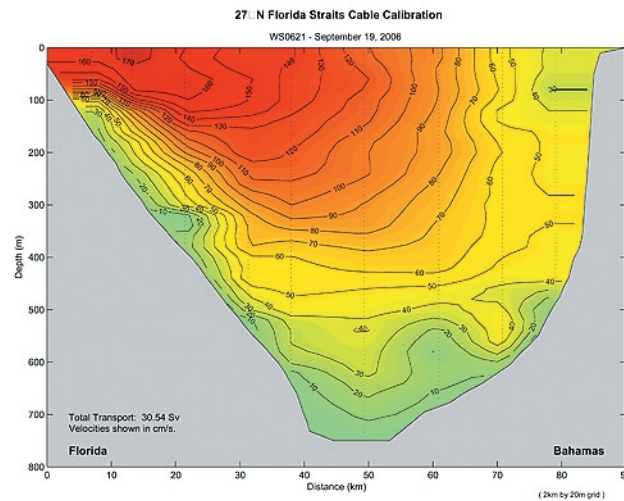
Figure 2: Florida Straits Transport for Cable Calibration calculated from Hydrographic Section taken by W.G. Smith.

Research Performance Measure:

All objectives were met in that all cruises were successfully made and all mandated data collected. Only one ship day was lost due to weather or equipment malfunction and this had no impact on attaining overall project objectives. We were able to successfully accomplish all objectives despite a substantial reduction (33%) in the number of ship days funded. However should this funding shortfall continue this next fiscal year, a further reduction in the number and duration of cruises will be necessary which may compromise the mission objectives.

VII. OUTREACH

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., fishermen), conducting tours, preparing articles for various media, etc. We do not list those here. Also many CIMAS personnel are active in setting up and maintaining web sites at AOML and SEFSC. These sites are often designed to serve as an outreach function. We only list those that have a specific broadly-based educational component.

The MAST Academy and High School Student Outreach

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 in grades 9-12. 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. In past years, the school has received an "A" rating from the Florida Department of Education.

RSMAS participates in education-related activities at MAST by providing faculty and graduate students, including CIMAS-linked personnel, to deliver lectures and to teach courses. Every summer, 12-18 students are selected to participate in summer research programs 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.

MAST is one of three schools involved with the South Florida Student Shark Program (SFSSP). The SFSSP is a collaborative, multi-disciplinary research and education program that exposes students to marine science field research. They focus on the study and conservation of coastal Florida shark species, mangrove fish habitats, and the Florida watershed through in-service learning, education and research (see below). MAST students have also participated in other field programs, for example in a comprehensive habitat study of Biscayne Bay. In this way, the School and CIMAS scientists have developed a solid working and teaching relationship with the MAST Academy.

In addition to MAST students, we have students from other high schools participating in CIMAS - NOAA activities. Here we cite a few examples:

Assisted in the NMFS-SEFSC fish tagging program. Prepared tagging kits for distribution to fishery constituents, coding incoming tagging data, data entry of both tag release and tag recapture, and interacting with constituents about tag requests and tag recovery reports.

Assisted in sorting and identifying postlarval pink shrimp from the Florida Bay program and working with bird by-catch data.

Assisted in downloading sea-surface temperature (SST) data from the NOAA Coast Watch web site and using it in analyses of fisheries and environmental data.

Assisted in a study modeling connections between life stages and habitats of pink shrimp in South Florida.

Assisted in using bioinformatics software in a study to identify, detect, and quantify microbial contaminants in coastal

waters. Students worked on the development of a microbial contaminant database using FileMaker Pro Software.

Undergraduate Student Education

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. Students also participate in various projects as part of their program of study or as volunteers. Some examples:

During the past year, students actively participated in the SEFSC-CIMAS program: *Monitoring Coral Reef Fish Populations in the Florida Key* in a program led by Dr. J. Ault, RSMAS, and funded through CIMAS (see below). The program drew students from UM, from Florida International University (FIU) and from Miami-Dade College. Students have used this work for their senior research topics. Past students have gone on to graduate school in the sciences.

UM undergraduate students from the Marine Science Program participate in the bi-monthly cruises that take place as a part of the program: *Interdisciplinary Surveys of Western Florida Bay and Connecting Waters Including Gulf Stream Transects*, a project involving P. Ortner, C. Kelble (UM/CIMAS), G. Hitchcock (UM/RSMAS) and L. Johns, M. Barringer, and R. Smith (NOAA/AOML).

University of Miami (UM), 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. UM participates under the leadership of Dr. D. Letson, a CIMAS Fellow. This program is lead by Florida A & M University (FAMU) through the Environmental Cooperative Science Center (ECSC). The Center is funded through a cooperative agreement between NOAA and FAMU. Other partners are Morgan State University, Delaware State University, South Carolina State University and Jackson State University. Located on the campus of FAMU, the science center was established to study and address ecological and coastal management issues.

The goals of the science center are to increase the number of under-represented minority scientists in NOAA-related sciences, develop ways to monitor coastal ecosystems and assess impacts of human and natural actions, improve the scientific knowledge base used in coastal resource management, and facilitate community education and outreach relating to coastal ecosystems. 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.

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 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.

Many of the RSMAS activities associated with this program are carried in the context of CIMAS-related programs.

Monitoring Coral Reef Fish Populations in the Florida Keys

Reef fish populations are monitored in an annual census as a part of this CIMAS program, led by Dr. Jerald Ault and Steven Smith, RSMAS faculty members and James Bohnsack, SEFSC. The program involves the coordination, cooperation, and

participation by different government agencies, universities, and private organizations to achieve a common goal. The annual census receives a great deal of attention in the media. Among others, it has received coverage from National Geographic, Los Angeles Times, BBC, NBC, Discovery Channel, Animal Planet, Chicago Tribune, Miami Herald, Associated Press, Christian Science Monitor, and similar publications.

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 carried out in conjunction with the project: *Investigation of the Movement of Adult Billfish in Potential Spawning Areas*. The program is led by Dr. R. Cowen, RSMAS, with NOAA funding through CIMAS. Other participants include scientists from SEFSC, and the UM Medical School. Thus far this cooperative program has been responsible for the tagging of about half of the 300 PSAT deployments made in the entire billfish study.

The program initially focused on RSMAS billfish pop-up satellite tagging (PSAT) efforts along the Pacific coast of Central America. The Billfish Research Initiative provides University of Miami's Rosenstiel School and CIMAS scientists and collaborating federal scientists of the National Marine Fisheries Service with the opportunity for an interdisciplinary, multi-faceted program to study the biology, environment and management of billfish within an ecosystem context. Main partners include individuals affiliated with the Presidential Challenge Central America (a group promoting catch-and-release fishing tournaments and other billfish conservation efforts), the NMFS' SEFSC and SWFSC, and the Bermuda Department of Environmental Protection. To date, the program has successful tagged over 50 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. The costs of the program, estimated to be about $4000 per tagged fish, are supported to a large extent by donations from anglers.

South Florida Shark Student Program

The South Florida Student Shark Program (SFSSP) is a collaborative, multi-disciplinary research and education program. It is funded from various sources including CIMAS funds and lead by the CIMAS-CUFER coordinator, and a CIMAS Fellow, Dr. David Die (RSMAS). Graduate and undergraduate students, high school teachers, and RSMAS scientists train high school students in marine science field sampling techniques, research protocols, data synthesis and scientific reporting. The SFSSP supports student career development in a variety of natural science disciplines, focusing on the study and conservation of coastal Florida shark species, mangrove fish habitat, and the Florida watershed through service learning, education and research.

The SPSSP provides interactions among high school, undergraduate and graduate students, teachers, and scientists within a research and mentoring setting. Every year, more than 100 high school students from three South Florida high schools (MAST Academy, South Broward High School and Palmer Trinity), several undergraduate students from the University of Miami Marine Science Program, and few graduate students from RSMAS participate in the program. The SPSSP aims to foster environmental stewardship and student and public awareness of the marine sciences. Information from the program is disseminated to both the scientific community and the general public through peer reviewed journals and scientific conferences as well as to the public *via* presentations to schools, civic organizations, the media and websites: <http://cufer.rsmas.miami.edu>http://cufer.rsmas.miami.edu

Juvenile Snapper Acoustic Tagging & Tracking Project and Adopt-a-Fish

In the fall of 2006, through a successful mini-grant application to the NMFS Education Spending Plan, the Juvenile Snapper Acoustic Tagging and Tracking (J-SATT) project acquired additional funds to include an education-outreach component to the project entitled *"The Connectivity Project: Love Your Reefs? -- Know Your Mangroves"* and partnered with local schools,

natural resources managers, and community groups. This program, led by S. Whitcraft (RSMAS) and W. Richards and J. Lamkin (NMFS-SEFSC) integrates results from our tagging and tracking study of juvenile snappers in mangroves with an education and conservation message about coastal habitats geared to grade-school students and the general public. In the past year, the project involved three Miami-Dade grade-schools, two community groups, two water-front condo-owners' associations in Naples, community attendees at the Loxahatchee *RiverFest* 2007 (Fig. 1) and the NOAA.

We actively partner with C. Layman (FIU) who leads the web-based *Adopt-a-Fish/Adopt-a-School Program* (*www.adoptafish.net*). The program focuses on describing the structure and function of species-rich tropical and sub-tropical food webs, especially as to how these complex food webs are impacted by human activities. We use the site to post current data from our fish tracking study along with our education program and materials on this publicly available, interactive webpage. Through our interactive presentations in the community and on the website itself, students and community groups can "name a fish" and "track a fish" by watching its movements over time on a map of the Loxahatchee Estuary. To date, 44 juvenile snappers have been named and "adopted" by local school children and they are currently posted and active at: *www.adoptafish.net*.

Figure 1: Local students "adopt" and name a tagged fish in the Loxahatchee Estuary and take home fish ID card to track its movements on www.adoptafish.net.

Assessment of Candidate Corals

D. Williams, L. Kramer, and A. Valdivia (RSMAS) and M. W. Miller (SEFSC) lead a research program whose overall objectives are to document the status and distribution of the remaining Elkhorn populations in the upper Florida Keys and other locations, and to determine the relative importance of the various 'threats' (disease, predation, etc.) to those populations. This project consists of two complementary components: demographic monitoring and regional-scale mapping. As an adjunct to the program the scientists have formed a partnership with the *Semester at Sea* program (http://www.semesteratsea.com/) and incorporated their coral reef survey protocol into *Semester at Sea* undergraduate curriculum. The students make observations during cruises. The data are reported back to the scientists for incorporation into their data base. This program exposes the students to real-world scientific field research experiences which produce scientifically useful data.

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

The SECC is a consortium of five university groups (U. Miami, U. Florida, Florida State U., U. Georgia, U. Alabama) that develop climate forecasts that are relevant to specific agriculture crops. The U. Miami effort involves G.P. Podestá,

D. Letson, N. Breuer, D. Solis and K. Broad (UM/RSMAS). These outlooks were disseminated in various media forms and outlets to stakeholders including county agents and growers. A significant outcome was the increased visibility of the climate extension program as a result of extension specialists and county agents developing their recommendations (e.g. peanut, cotton, turfgrass management) based on the impacts of climate forecasts. Various climate products and the forecasts are made available on a web site, AgroClimate: http://agroclimate.org/.

The SECC also presented a series of four training workshops in 2007 on *AgClimate* decision support tools for extension agents and growers in GA and AL. In 2007 workshops were developed in response to the extreme drought in N. Georgia during 2007. Workshops on drought and livestock management were presented to extension agents, cattlemen, and ranchers across the state. Agricultural commodity outlooks were developed in close collaboration with different SECC members and UGA Research and Extension Faculty.

Integrated Coral Observing Network (ICON) Project: Coral Literature, Education and Outreach (CLEO) Program
L. Gramer, M. Jankulak, D. Manzello (UM/CIMAS) and C. Langdon (UM/RSMAS) along with J. Hendee, M. Shoemaker and J, Craynock (NOAA/AOML) participate in the ICON project which places sophisticated environmental instrumentation on threatened reef complexes. As a part of ICON, they supply data to the *Coral Literature, Education and Outreach (CLEO) Program*. CLEO was designed to provide expertise in oceanographic instrumentation and coral reef processes to the classroom environment. These data are presented in the form of educational modules developed for middle-school-level students on the CLEO website: http://www.coral.noaa.gov/cleo

Surface Water pCO_2 Measurements from Ships: Hollings Scholar Training

K. Sullivan, D. Pierrot, J. Trinanes, G. Castelao, F. Bringas, S. Pochan (UM/CIMAS); F.J. Millero, J. Waters (UM/RSMAS); and G. Goni, R. Wanninkhof (NOAA/AOML). As a part of the pCO_2 program, the group hosted Hollings Scholar students during the summer of 2008.

Assay and Sensor Development to Identify, Detect, and Quantify Microbial Contaminants
D. Wanless, C. Sinigalliano (UM/CIMAS) and Kelly Goodwin (NOAA/AOML) are developing in situ sensors for microbial contaminants. This project cooperated closely with the educational outreach program of the Oceans and Human Health Center at University of Miami on topics regarding beach health, water quality and ocean-human health interactions. This included planning and organizing sessions with the UM OHH outreach personnel, participating in public demonstrations and sampling by the OHH center, and presentations to the general public at special educational seminars on topics of Oceans and Human Health at both University of Miami and at Woods Hole Oceanographic Institute. They have also been providing workshops on molecular microbial water quality for water resource managers, as well as hands-on workshops for undergraduate students at University of Miami. They have hosted a NOAA Hollings Scholar, and an EPA student intern who have participated on this project. They are hosting on-site visits and workshops of high school and middle-school students during the summer in topics of microbial water quality and its impact of public health and ecosystem health.

VIII. CIMAS FELLOWS

The Fellows provide guidance to the Director on matters concerning the ongoing activities and future direction of CIMAS. There are currently 22 Fellows, 13 from RSMAS, 7 from the local NOAA laboratories, 1 from the National Hurricane Center and 1 from Florida International University. Normally membership is approximately balanced between RSMAS and NOAA. Because of several personnel changes during the past year, NOAA is currently underrepresented. In addition to the regular members, The Dean of RSMAS and the Directors of the NOAA laboratories are invited to attend on an *ex officio* basis. With regard to Ex Officio members, Dr. Bonnie Ponwith, Acting Director of SEFSC, replaces Dr. Alex Chester who has departed Miami.

The Fellows are typically scheduled to meet on a nominal quarterly basis although scheduling is usually difficult because of the extensive travel schedules. During Year 7 there were two formal meetings: 15 November 2007 and 28 May 2008. In addition there are frequent meetings of focus groups. In particular during the past year there have been many meetings between CIMAS Fellows, RSMAS Faculty and scientists from AOML, and the National Hurricane Center to discuss the planning and implementation of a proposed Science and Technology Center: "Center for Hurricane Impacts and Prediction Research (CHIPR)". The Center would closely link research activities in RSMAS, including NOAA-supported hurricane research, with that carried out in NOAA.

Also many Fellows-related matters are addressed and implemented by means of email exchanges. Finally, because of the close proximity of the three Institutions and the frequent social activities, there are many ad hoc meetings and discussions.

FELLOWS	AFFILIATION
Dr. Bruce Albrecht	UM/RSMAS Meteorology and Physical Oceanography
Dr. Molly Baringer	NOAA/Physical Oceanography
Dr. James Bohnsack	NOAA/Southeast Fisheries Science Center
Dr. David J. Die	UM/RSMAS Marine Biology and Fisheries
Dr. Nelson Ehrhardt	UM/RSMAS Marine Biology and Fisheries
Dr. David Enfield	NOAA/AOML/Physical Oceanography
Dr. Rana A. Fine	UM/RSMAS Marine and Atmospheric Chemistry
Dr. Silvia Garzoli	NOAA/AOML/ Physical Oceanography
Dr. William E. Johns	UM/RSMAS Meteorology and Physical Oceanography
Dr. Kevin D. Leaman	UM/RSMAS Meteorology and Physical Oceanography
Dr. David Letson	UM/RSMAS Marine Affairs
Dr. Frank Marks	NOAA/AOML/Hurricane Research Division
Dr. Christopher N.K. Mooers	UM/RSMAS Applied Marine Physics
Dr. Donald B. Olson	UM/RSMAS Meteorology and Physical Oceanography
Dr. Peter B. Ortner	UM/RSMAS Marine Biology and Fisheries
Dr. Edward N. Rappaport	NOAA/National Weather Service
Dr. Victor Restrepo	NOAA/Southeast Fisheries Science Center
Dr. Nick Shay	UM/RSMAS Meteorology and Physical Oceanography
Dr. Sharon S. Smith	UM/RSMAS Marine Biology and Fisheries
Dr. Rik Wanninkhof	NOAA/AOML/Ocean Chemistry Division
Dr. Hugh E. Willoughby	Florida International University, Dept. of Earth Sciences
Dr. Rod Zika	UM/RSMAS Marine and Atmospheric Chemistry

Ex Officio

Dr. Robert M. Atlas	NOAA/AOML, Office of the Director
Dr. Otis B. Brown	UM/RSMAS Dean
Dr. Bonnie.Ponwith	NOAA/Southeast Fisheries Science Center

IX. AWARDS AND HONORS

Western Boundary Time Series Project
Rigoberto Garcia, Carlos Fonseca, Andrew Stefanick, George Berberian, Qi Yao, Grant Rawson, Nelson Melo, Kyle Seaton, Shaun Dolk, Carmen Alex, Francis Bringas (UM/CIMAS); Molly Baringer, Christopher Meinen, Silvia Garzoli (NOAA/AOML).
· U.S. Department of Commerce Bronze Medal: Western Boundary Time Series – Meridional Overturning Circulation team

Monitoring Coral Reef Fish Populations in the Florida Keys
Jerald S. Ault, Steven G. Smith (UM/RSMAS); James A. Bohnsack (NOAA/NMFS)
• *Winner, National Planning Award.* Category: '*Outstanding Collaborative Planning Project or Program: Tortugas National Park General Management Plan*'. Federal Planning Division. American Planning Association. University of Illinois at Chicago. Recipients: National Park Service, Southeast Region; National Park Service, Denver Service Center; Dry Tortugas National Park; University of Miami, Rosenstiel School of Marine and Atmospheric Science; Florida Keys National Marine Sanctuary.
• Certificate of Recognition, for valuable contributions as Technical Review Committee Member to development of South Dade Watershed Plan, by Mayor Carlos Alvarez.

Coastal Fisheries Logbook Program
Jose Diaz (UM/CIMAS); Steve Turner, M. Judge, N. Baertlein, J. Hall (NOAA/SEFSC)
• Jose Diaz - NOAA Contractor- Team Member of the Year

Investigation of the Movement of Adult Billfish in Potential Spawning Areas
Robert K. Cowen, J.P. Hoolihan and J. Luo (UM/RSMAS); E.D. Prince, D. Snodgrass and Eric Orbesen (NOAA/SEFSC); Joseph E. Serafy (NOAA/SEFSC and UM/RSMAS); Dr. Phil Goodyear (Contractor, Niceville, FL); D. Schultz (UM/Medical School)
• *N. American Journal of Fisheries Management* Featured paper entitled ; Predicting Hook Depths Using Catenary Geometry for Shallow Experimental Pelagic Longline Fishing in the Windward Passage in 2003, authored by Patrick H. Rice, C.P. Goodyear, E. D. Prince, J. E. Serafy, and D. Snodgrass.
• Patrick Rice received the honor of student recognition at University of Miami commencement, May 2008.

Real-Time Hurricane Wind Analysis
Nicholas Carrasco, Bachir Annane, Sonia Otero, Russell St. Fleur (UM/CIMAS); Mark Powell (NOAA/AOML/HRD)
• In August 2007, each member of the H*Wind team (scientists and developers) received a Certificate of Appreciation from the U.S. Army Corps of Engineers for our contribution provided to the Interagency Performance Evaluation Taskforce (IPET) in reference to the performance assessment of the Southeast Louisiana Hurricane Protection Project, documenting the surge and wave environments created by Hurricane Katrina, 2005.
•

Integrated Coral Observing Network (ICON) Project
Lewis Gramer, Mike Jankulak, Derek Manzello (UM/CIMAS); Dr. Chris Langdon (UM/RSMAS); Dr. James Hendee, Michael Shoemaker, Jules Craynock (NOAA/AOML)
• Derek Manzello received a 2008 National Research Council post-doctoral fellowship.

Past and Future North American Drought
Robert Burgman, Amy Clement (UM/RSMAS); Richard Seager (Lamont Dougherty (Earth Observatory, Columbia University)
• Robert Burgman received the 2008 Outstanding Alumni Award from George Mason University, College of Science.

Climate Noise and Climate Predictability
Ben Kirtman (UM/RSMAS)
• 2008 University of Maryland Department of Atmospheric and Oceanic Sciences Distinguished Alumni Award.

X. POSTDOCTORAL FELLOWS AND GRADUATE STUDENTS

CIMAS-Supported Postdoctoral Fellows and Graduate Students

CIMAS Postdoctoral Fellows

Amornthammarong, Natchanon
Casal, Tania
Elipot, Shane
Jones, David L.
Kerstetter, David W.
Lorsolo, Sylvie
Muñoz, Ernesto

CIMAS-Supported Graduate Students

Buck, Eric
Castellano, G.
Chen Chao
Farmer, Nicholas
Forretal, Francesca
Gleason, Arthur
Kapur, Atul
Karras, Constantina
Kleisner, Kristin
Larkin, Mike
Lerner, Justin
Lin, Lin
McCrea, Ashley
McNeal, Jena
Pina, Diana
Quinino, Thiago
Rice, Patrick
Saul, Steven
Serrano, Xaymara
Tomoleoni, Joe
Tust, Michael
Zhang, Jun

Other Postdoctoral Fellows and Graduate Students Associated with CIMAS Programs

Other Postdoctoral Fellows

Baigorria, G.
Bannayan, M.
Crane, T.
Garcia y Garcia, A.
Gerard-Marchant , P.
Hoolihan, J.P.
Huang, Jingfeng
Lueger, Heike
Mulhing, Barbara
Solis, Daniel

Other Graduate Students

Basquez-Yeomans, Lourdes
Berg, Robert
Bolson, Jessica
Cázarez, Dalia
Cascella, Guy
Chanson, Mareva
Ditrolio, Benjamin
Forsee, William
Keener, V.
Kelly, Patrick
Koch, Veronique
McCrea, Ashley
Machemer, Ethan
Mason, Benjamin
Parra Flores, Ana Maria
Pathak, T.
Piela, Christina
Quintal, Carolina
Ravitz, Guy
Schiller, Rafael
Sainani, Varsha
Smith, Ryan
Swanson, Dione
Trapp, Michael J.
Uhlhorn, Eric
Vaughn, Nathan
Waters, Jason
Woli, P.
Woosley, Ryan

XI. RESEARCH STAFF

Alex, Carmen	Research Associate II
Amornthammarong, Natchanon	Post Doctoral Associate
Annane, Bachir	Senior Research Associate III
Bringas Gutierrez, Francis	Research Associate II
Cardenas, Hernando	Research Associate II
Carrasco, Hector N.	Senior Research Associate I
Casal, Tania	Post Doctoral Associate
Delgado, Juan	Research Associate I
Di Nezio, Pedro N.	Research Associate II
Diaz, Jose E.	Research Associate II
Dolk, Shaun	Research Associate I
Dong, Shenfu	Assistant Scientist
Elipot, Shane	Post Doctoral Associate
Erickson, Kristin L.	Research Associate II
Fonseca, Carlos A.	Research Associate III
Forteza, Elizabeth	Research Associate II
Garcia, Rigoberto F.	Research Associate II
Gramer, Lewis J.	Research Associate II
Huang, Xiaolan	Assistant Scientist
Jankulak, Michael L.	Research Associate III
Johnson, Darlene R.	Scientist
Jones, David L.	Post Doctoral Associate
Kelble, Christopher R.	Senior Research Associate II
Kerstetter, David	Post Doctoral Associate
Kramer, Katherine	Research Associate II
Lara, Monica	Associate Scientist
Lee, Sang-Ki	Associate Scientist
Lorsolo, Sylvie	Post Doctoral Associate
Malca, Estrella	Research Associate II
Melo, Nelson	Senior Research Associate I
Munoz, Ernesto	Post Doctoral Associate
Otero, Sonia	Research Associate III
Pierrot, Denis P.	Assistant Scientist
Pochan, Sommyr D.	Research Associate I
Rawson, Grant T.	Research Associate II
Reedman, Jessica	Research Associate II
Seaton, Kyle	Research Associate I
Sellwood, Kathryn J	Research Associate II
Shiroza, Akihiro	Research Associate I

Sinigalliano, Christopher	Assistant Scientist
Stefanick, Andrew J	Research Associate II
Sullivan, Kevin F.	Senior Research Associate III
Valde, Krystal M.	Research Associate I
Valdes, Erik	Research Associate I
Valdivia, Abel	Senior Research Associate I
Wanless, David R.	Research Associate II
Whitcraft, Samantha R.	Senior Research Associate I
Wicker, Jesse A.	Research Associate II
Williams, Dana E.	Assistant Scientist
Xia, Xiangdong	Research Associate II
Yang, Huiqin	Research Associate II
Yao, Qi	Senior Research Associate II
Yeh, Kao-San	Scientist
Zhang, Xuejin	Assistant Scientist

XII. VISITING SCIENTISTS PROGRAM

Prof. Friedrich A. Schott
Ifm-Geomar Leibniz-Institut für Meereswissenschaften
Düsternbrooker Weg 20, D-24105 Kiel, Germany

7 – 28 December, 2007

Dr. Maureen H. Conte
Bermuda Institute of Ocean Sciences
17 Biological Lane
St. Georges Place
Bermuda
11 – 12 March, 2008

12 March, 2007: *"Weather in the Ocean Abyss: Particle Rain, Storms, and Hurricanes"*

Dr. David A. Farrell
Director, Caribbean Institute for Meteorology and Hydrology
Husbands, St. James BB23006
Barbados
18 – 20 March, 2008

Dr. Daniel J. Vimont
Department of Atmospheric & Oceanic Sciences
University of Wisconsin-Madison
1225 West Dayton Street
Madison, WI 53706
8 – 13 June, 2008

10 June, 2008: *"Meridional Modes in the Climate System: Dynamics, Impacts and Predictability in the Pacific and Atlantic"*

XIII. PUBLICATIONS

We list all publications for the years 2007-2008, presented in categories. The category "Conference Proceedings" lists only publications that derive from presentations at meetings, it does not include oral presentations.

I Table 1 we summarize the record of publications over the period 2001 – 2008, listed as "peer reviewed" and "non-peer reviewed". The table also shows the distribution of lead author affiliation (CIMAS, NOAA scientist, or other institutions).

TABLE 1: PUBLICATION RECORD 2001-2008

	Institute Lead Author				NOAA Lead Author				Other Lead Author			
	2001 2002	2002 2003	2003 2004	2004 2005	2001 2002	2002 2003	2003 2004	2004 2005	2001 2002	2002 2003	2003 2004	2004 2005
Peer Reviewed	54	60	36	33	0	7	14	14	--	--	30	28
Non Peer Reviewed	7	8	34	10	0	3	17	11	--	--	28	6

	Institute Lead Author				NOAA Lead Author				Other Lead Author			
	2005 2006	2006 2007	2007 2008	2008 2009	2005 2006	2006 2007	2007 2008	2008 2009	2005 2006	2006 2007	2007 2008	2008 2009
Peer Reviewed	37	37	39		17	32	38		37	47	29	
Non Peer Reviewed	9	18	21		7	3	5		15	13	3	

Refereed Journal Articles

Albright, R., B. Mason and C. Langdon (2008), Effect of aragonite saturation state on the settlement and post-settlement growth of Porites astreoides larvae, *Coral Reefs*, doi:10.1007/s00338-008-0392-5.

Baigorria, G.A., J.W. Jones and J.J. O'Brien (2007), Understanding rainfall spatial variability in the southeast USA, *Intl. J. Climatol., 27*(6), 749-760, doi:10.1002/joc.1435.

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Baigorria, G.A., J.W. Hansen, N. Ward, J.W. Jones, J.J. O'Brien (2008), Assessing predictability of cotton yields in the Southeastern USA based on regional atmospheric circulations and surface temperatures, *J. Appl. Meteorol. Climatol., 47*(1), 76-91, doi:10.1175/KAM2592.1.

Baigorria, G., J. Jones and J. O'Brien (2008), Potential predictability of crop yield using an ensemble climate forecast by a regional circulation model, *Agric. Forest Meteorol., 148*(9), 1353-1361, doi:10.1016/j.agrformet.2008.04.002.

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Breuer N, V. Cabrera, K. Ingram K. Broad, P. Hildebrand (2008), AgClimate: A case study in participatory decision support system development, *Clim. Change, 87*, 385-403.

Burgman, R.J., A.C. Clement, C.M. Mitas, J. Chen, and K. Esslinger (2008), Evidence for atmospheric variability over the Pacific on decadal timescales, *Geophys. Res. Lett., 35*, L01704, doi:10.1029/2007GL031830.

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Caldeira, K., D. Archer, J.P. Barry, R.G.J. Bellerby, P.G. Brewer, L. Cao, A.G. Dickson, S.C. Doney, H. Elderfield, V.J. Fabry, R.A. Feely, J.P. Gattuso, P.M. Haugan, O. Hoegh-Guldberg, A.K. Jain, J.A. Kleypas, C. Langdon, J.C. Orr, A. Ridgwell, C.L. Sabine, B.A. Seibel, Y. Shirayama, C. Turley, A.J. Watson and R.E. Zeebe (2007), Comment on "Modern-age buildup of CO_2 and its effects on seawater acidity and salinity" by Hugo A. Loaiciga, *Geophys. Res. Lett., 34*(18), L18608.

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Deng, X., B. Barnett, G. Hoogenboom, Y. Yu and A Garcia y Garcia (2008), Alternative crop insurance indices, *J. Agric. Appl. Econ.* (accepted).

Dong, S., J. Sprintall, S.T. Gille and L. Talley (2008), Southern Ocean mixed-layer depth from Argo float profiles, *J. Geophys. Res.-Oceans*, *113* (C6).

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Gambacorta, A., C. Barnett, B.J. Soden, and L. Strow, 2008: An assessment of the tropical humidity-temperature covariance using AIRS, *Geophys. Res. Lett., 35,* L10814, doi:10.1029/2008GL033805.

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Gleason, A.C.R., D. Lirman, D.E. Williams, N.R. Gracias, B.E. Gintert, H. Madjidi, R.P. Reid, G.C. Boynton, S. Negahdaripour, M. Miller, and P. Kramer (2007), Documenting hurricane impacts on coral reefs using two dimensional video-mosaic technology, *Mar. Ecol.*, *28*, 1-5.

Goodyear, C.P., J. Luo, E.D. Prince, J.P. Hoolihan, D. Snodgrass, E.S. Orbesen and J. E. Serafy (2008), Vertical habitat use of Atlantic blue marlin (*Makaira nigricans*): Interaction with Pelagic Longline Gear, *Mar. Ecol. Prog. Ser., 365*, 233-245.

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