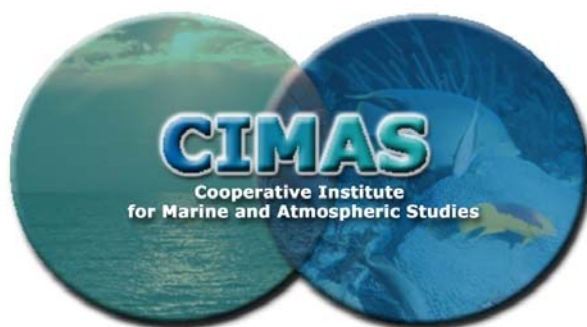


Cooperative Institute for Marine and Atmospheric Studies

CIMAS



Sixth Year Annual Report

NOAA Cooperative Agreement NA17RJ1226

2006 – 2007

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**UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL OF MARINE AND ATMOSPHERIC SCIENCE**

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I. EXECUTIVE 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 closely with two local 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 Fiscal Year 2006 - 2007, Year 6 under the Cooperative Agreement, showed substantial growth. Total expenditures were \$10.6M, an increase of \$3.6M (51%) over FY 5. Task 1, which provides support for administrative activities, totaled \$2.3M, an increase of \$1.1M over Yr 5. Task 2, which supports CIMAS employees who work closely with AOML and SEFSC, totaled \$4.3M, an increase of \$1.8M (70%) over FY 5. Task 2 has experienced strong growth under the Agreement, essentially tripling from FY 1 to FY 6. In FY 6.

Research funding (Task 3 and Task 4) in FY 6 was \$3.9M, an increase of \$0.6M (17%) over FY 5. But, in contrast to Task 2 funding, research funding has remained relatively unchanged over the past four years of the Cooperative Agreement with an annual average of \$3.8M. Nonetheless, the rate over the past four years is substantially greater than that in the first two years which averaged \$2.5M. About half the research funds are expended under Theme 1: Climate Variability (44%) and allied themes (e.g., Theme 5: Air-Sea Interactions and Exchanges). This activity reflects in part an increased effort on hurricane research. The second most active area of research is under Theme 3: Regional Coastal Ecosystem Processes, largely a reflection of activities in the South-Florida Everglades Restoration. The third major area of research is under Theme 2: Fisheries Dynamics, some aspects of which are closely linked to Theme 3. Together these two themes account for 39% of the research funding in CIMAS.

During FY 2006-2007 a total of 99 persons were involved with CIMAS in various capacities. Of these, 78 received over 50% of their support from NOAA sources. A total of 94 personnel work in NOAA facilities: 57 with AOML and 37 with SEFSC. The employees in the Research Associate and Research Scientist ranks have a rather diverse demographic profile. The population is 41% female. Foreign-born individuals make up 47% of the personnel; of these Hispanics make up 24% of the ranks; Asian and Pacific Islander, 14%.

The research program in CIMAS continues to yield 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 results can be found in the body of the Report under the Themes.

Research Highlights

Climate Impacts of the Western Hemisphere Warm Pool on the Americas

The Atlantic Warm Pool (AWP) variability has substantial effects on the summer climate and Atlantic hurricane activity. A large AWP: increases the summer rainfall in the western tropical North Atlantic and in the eastern North Pacific; decreases the summer rainfall over the central United States; and reduces the tropospheric vertical wind shear in the main hurricane development region and increases the moist static instability of the troposphere, both of which favor the intensification of tropical storms into hurricanes.

Understanding and Improving Medium-Range Forecasts

It is generally assumed that medium-range forecasts of high-impact weather can be improved by making judiciously ‘targeted’ supplementary atmospheric observations. In our research we focused on evaluating the ability of the Ensemble Transform Kalman Filter to predict the influence of dropwindsonde observations deployed over the central North Pacific Ocean. For 3-6 day global model forecasts of winter weather, we found that the strategy was most effective for synoptic-scale forecasts when the storms were over the ocean and when the flow was predominantly zonal.

Improving the Prediction of Tropical Cyclone Intensity and Rainfall

Using NOAA P-3 and NASA ER-2 aircraft, we were able to successfully sample the entire five-day lifecycle of Hurricane Dennis, from tropical storm until landfall. These datasets give us a better understanding of the microphysical processes that occur within a tropical cyclone at different stages of its lifecycle and give us the opportunity to improve model predictions of hurricane intensity change.

Western Boundary Current Time Series and Climate Variability

The Meridional Overturning Circulation plays a major role in climate on global scales. Recent publications have suggested that the circulation is slowing. In contrast our ongoing Florida Current monitoring program and a new monitoring system for the Deep Western Boundary Current show that there has been little change in the system over the past 20 years.

Biogeochemical Measurements and the Ocean Carbon Cycle

We have detected changes in the apparent oxygen utilization (AOU) in the tongue of water in the North Pacific. These changes reflect either a change in the rate of oxygen consumption induced by changes in the export of organic matter (that is, changes in the biological pump) or a change in the large scale circulation. These AOU changes not only affect the dissolved oxygen budget of the North Pacific, but also the carbon distributions; they must be considered in any assessment of Pacific carbon decadal changes.

Meridional Circulation, the Saharan Heat Low and Tropical Atlantic Variability

Understanding and predicting the West African Monsoon is vital to the economic development and societal stability of the region. Our study of the West African Monsoon reveals a new feature, a shallow meridional circulation which plays an important role in Monsoon development. This research provides new insights to diagnose global climate models in this region and to assess the regional impact of global climate change.

Coupled Biophysical Approach to Fisheries Habitat in Southeastern North Atlantic

We examined the relationship between the Gulf of Mexico Loop Current and the abundance of dolphinfish. The goal is to provide a new method for understanding the fluctuations of a highly migratory pelagic species in terms of environmental variation. We find a strong link between the inter-annual variations in catch and the structure of the Loop Current. Also, changes in the Loop Current lead to warming events on the reef track which can lead to increased stress on corals.

Transport and Exchange of Florida Bay Interior Waters

In Florida Bay, interior basin water exchanges are weak and controlled by local wind forcing. Seasonal water balance estimates made for the northern region of the Bay indicate that groundwater inflows are negligible and probably not a factor in water quality considerations. Thus hyper-salinity conditions within this region of the bay can only be alleviated by diverting a portion of the Everglades surface flow away from the northeast basin and into Whipray Basin during the dry season.

Seeding Marine Boundary Layer Clouds over the Eastern Pacific

Our field research has documented boundary layer and stratocumulus cloud variability and the role of air-sea exchange in the initiation of drizzle over the southeast Pacific. We demonstrated for the first time the feasibility of combining *in situ* observations made in the context of seeding experiments with sophisticated remote sensing systems for the systematic studies of this climatically important cloud regime. This approach shows the merit of using the seeding approach for controlled observational studies of aerosol-cloud interactions in marine stratocumulus and opens a new area of research.

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

We have adapted and developed a variety of molecular assays to allow assessment of coastal water quality. The assays detect genetic signatures of microbial contaminants and help identify the source of contamination (for example, human versus animal). We have transitioned a series of technologies into a regional monitoring effort, the Florida Area Coastal Environment (FACE) program. Through active collaboration with researchers at Oceans and Human Health Centers of Excellence, genetic technologies were used to sample the post-Katrina New Orleans environment in support of public health safety.

Air-Sea Flux Estimation in High Wind Boundary Layers

Tropical storms gain their energy primarily from the condensation of water vapor evaporated from the warm ocean waters. However, the ocean also removes energy from storms through wind drag at the surface. During the CBLAST campaign, we carried out the first direct measurements of air-sea fluxes in hurricane conditions. We developed new parameterizations based on these data. These are already being used by the modeling community. We have also gained new insights into the structure of hurricane boundary layers.

Investigating the Boundary Layer in Hurricanes using Unmanned Aircraft Systems

We studied the feasibility of using an unmanned aircraft, the Aerosonde, to document in real time the dynamic and thermodynamic structure in the lower levels of hurricanes. With the Aerosonde measurements obtained in Tropical Storm Ophelia we examined how they might best be used to improve the parameterization of the boundary layer in hurricanes and, thus, to improve hurricane forecasts.

Surface Water pCO₂ Measurements from Ships

We perform routine measurements of CO₂ during oceanographic cruises in the effort to develop a new pCO₂ climatology that will serve as a critical observational constraint on the estimates of the uptake of CO₂ by the oceans. Using the sea-air CO₂ transfer rates and the sea-air pCO₂ differences measured on recent cruises, we find that the uptake is substantially less than previous estimates. This suggests that the oceans are less of a CO₂ sink than previously thought.

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

The SECC has developed and adopted some common methodologies in our approach to identify climate variability patterns in temperature and precipitation associated with ENSO events and the assessment of related agricultural impacts. Research has shown the different phases of ENSO to have unique, quantifiable impacts on the Southeast United States and the rest of the world. We apply this research, using historical climate data, to understand these impacts and identify areas where they can be expected.

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 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 serves as a mechanism to promote synergisms between University scientists and those in NOAA. Most of our research is related to programs in OAR and in the National Marine Fisheries Service (NMFS). Most activities in CIMAS are associated with research programs at the local NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML) and the Southeast Fisheries Science Center (SEFSC) both of which are located on Virginia Key in close proximity to the CIMAS/RSMAS campus.

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

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

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

The Link between CIMAS Research and NOAA Goals

CIMAS research and its scientific objectives are guided by the general objectives of NOAA's *Strategic Plan for FY 2005-2010*. NOAA identifies four mission goals:

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

NOAA's Mission Goals are consistent with the broader mission of CIMAS in the Earth System Sciences. Each research project in CIMAS is associated with a specific NOAA mission goal.

The Administration and Governance of CIMAS

The organization of CIMAS is designed to reflect 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 staff members of NOAA. The Fellows play an important role by providing guidance to the Director of CIMAS in matters regarding the promulgation of research programs. One of the Fellows' most important tasks is to work on the development of CIMAS activities that benefit both University and NOAA research objectives.

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. Most research activities are carried out under Task II wherein CIMAS provides highly specialized research scientists who work on research projects carried out in NOAA's Miami laboratories. The expertise of these CIMAS employees complements that present in NOAA and the University. CIMAS employees provide support that is essential to the success of specific activities or projects under the collaborative research themes of the Institute.

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

III. PERSONNEL

Distribution of Personnel

CIMAS personnel participate in a wide range of NOAA-related activities. During FY 2006-2007 a total of 99 persons were involved with CIMAS in various capacities. Of these, 75 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 75 who receive over 50% NOAA support, 50 are associated with AOML and 25 with SEFSC.

Table 1: CIMAS Personnel 2006 – 2007

Personnel				
Category	Number	BS	MS	Ph.D
Research Associate/Scientist	45	17	18	10
Part Time Research Associate/Scientist	2	1	1	
Postdoctoral Fellow	6			6
Research Support Staff	22	6	2	4
Total (> 50% NOAA support)	75	24	21	20
Administrative (<50% NOAA Support)	5			2
Undergraduates Students	8			
Graduate Students	11	6	5	
Visiting Scientist	4			4
Personnel located at AOML	50			
Personnel located at SEFSC	25			
Obtained NOAA employment within the last year	5			

Research Associates and Research Scientists are those employees under Task 2 who work closely with the local NOAA laboratories. A total of 45 persons were employed under Task 2 in FY 6. 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 FY 4 the number increased sharply to 44 and in FY 5, 43. Thus 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 who are 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 parallel those of the research faculty at the University (i.e., Assistant Research Professor, Associate Research Professor, Research Professor).

There are a total of six Postdoctoral Fellows. Postdocs have become an important part of the CIMAS employee pool during the current Cooperative Agreement with numbers usually in the range of six to nine.

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

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 are not counted in the listing of persons associated with CIMAS except for those who serve as Fellows. Similarly, graduate students who work on CIMAS programs have their primary affiliation with an academic division which has the ultimate responsibility for overseeing the students' academic performance and the granting of degrees.

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 local NOAA laboratories (R. Atlas, AOML; A. Chester, SEFSC). A list of the CIMAS Fellows membership is shown in the *Fellows* section of this report along with their affiliation. At present 12 Fellows are from RSMAS, nine from the local NOAA laboratories, and one from the National Hurricane Center.

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 but it functions as an independent office within CIMAS.

Transition to Federal Positions

During the past year five CIMAS employee assumed positions as a Federal Employee in the local NOAA laboratories. Since the start of the current Cooperative Agreement a total of 13 have assumed Federal positions in the local laboratories.

Demographics of CIMAS Employees

The employees in the Research Associate and Research Scientist ranks have a rather diverse demographic profile. The population is 41% female. Foreign-born individuals make up 47% of the personnel; of these Hispanics make up 24% of the ranks; Asian and Pacific Islander, 14%. Only 2 African-American has been recruited, despite our efforts to expand this demographic. The population of CIMAS is relatively young with an average age of 37. The largest age group is the 30s decade, a total of 25.

IV. FUNDING

General Funding Trends

Expenditures during Fiscal Year 2006 - 2007 showed substantial growth. In FY 6, funds from all NOAA sources totaled \$10.6M, an increase of \$3.6M (51%) over FY 5 and \$4.6M (77%) over FY 1. A summary of CIMAS funding under the four Tasks in FY 6 is shown in Table 1 along with funding under the first five years of the Cooperative Agreement (CA).

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

	Task I	Task II	Task III	Task IV	Total
Year 1	1,620	1,434	2,604	320	5,979
Year 2	1,381	2,059	1,444	625	5,509
Year 3	700	2,435	3,548	413	7,096
Year 4	1,847	2,701	2,853	945	8,345
Year 5	1,133	2,527	2,683	675	7,018
Year 6	2,343	4,301	3,360	580	10,584

The history of NOAA funding through CIMAS is shown graphically in Figure 1. Total funding in FY 6 was markedly greater than FY 5 (\$7.0M), Although CIMAS has shown a steady growth trend, the increase of 51% over FY 5 is the greatest in the recent history of CIMAS. This sharp increase relative to FY 5 is due in part to the fact that in FY 5 expenditures were substantially below the trend line in CIMAS budgets over the past decade and markedly below the FY 4 budget, \$8.4M.

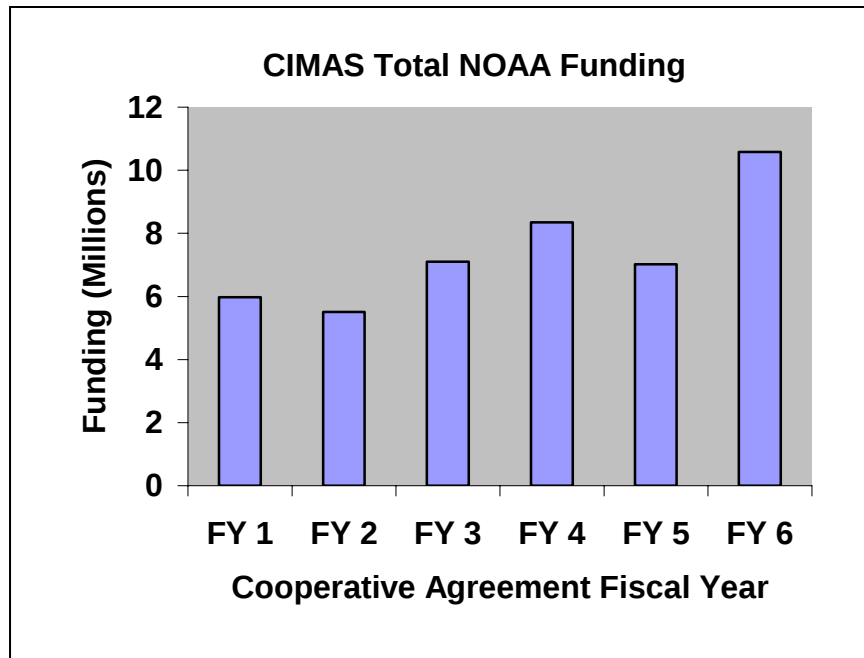


Figure 1: CIMAS funding from NOAA sources

The NOAA line-office sources of funding in CIMAS are shown in Table 2. The major source of funding is OAR which provides 68% of the total. Over the course of the CA about 85% of CIMAS funds has come from two NOAA sources: OAR and NMFS. Of the total OAR funding, \$1.4M (20%) comes from the Climate Program Office (CPO), the competitive grants program in OAR.

Table 2: NOAA Funding by Source		
Line Office	Funding FY 6	% Total
OAR	7,160,926	68%
NMFS	1,754,298	17%
NOS	661,938	6%
NWS	482,876	5%
NESDIS	374,405	3%
Other	150,000	1%
Grand Total	10,584,443	

The trends in CIMAS funding sources over the lifetime of the current CA are shown in Figure 2. Clearly, funding through OAR has grown dramatically for reasons to be discussed below. The other sources of funding have been relatively stable. Funding through the competitive grants programs under CPO (and previously through OGP) has been relatively flat with a downward tendency. This trend reflects in part the decreasing funding made available through CPO and the increased competition for these funds.

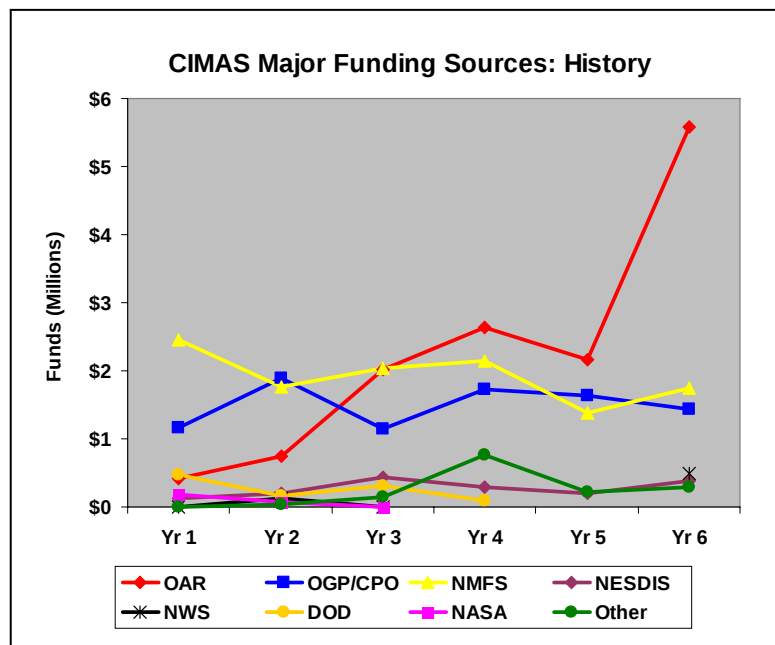


Figure 2: Trends in funding from the major sources under the current Cooperative Agreement. Note that CPO, formerly the Office of Global Programs (OGP), is now merged with OAR; OGP/CPO are plotted separately from OAR to provide a sense of the trends independent of other OAR sources.

Funding Trends by Task

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

- **Task 1** provides the administrative structure for the Institute and includes support graduate students and limited-term collaborating research scientists from outside Miami. The University contributes to the administrative support of CIMAS in its role as a Division in the School. Task 1 also provides travel expenses and honoraria for short-term visits by scientists. CIMAS has an active Visiting Scientist program.
- **Task 2** provides support for highly specialized research scientists who are employed by CIMAS to complement existing expertise at NOAA and the University in the collaborative research themes of the Institute. Support for limited-term postdoctoral research associates is also included in this Task.
- **Task 3** and **Task 4** encompass the directed research programs of CIMAS. These provide support for research in CIMAS themes by University faculty, scientists and students. Task 3 encompasses activities of CIMAS scientists that are carried out in cooperation with the personnel at the local NOAA laboratories in Miami. Under Task 4 are projects that support or complement activities at NOAA laboratories other than those located in Miami. The indirect cost rates for these two tasks differs in recognition to the direct funding support that CIMAS receives under Task 1 from the local NOAA laboratories.

The history of Task 1 funding under the CA is presented in Figure 3. Year 6 funding is the clearly the highest of the six years in the CA. Although there are substantial year-to-year variations in Task 1 funding, there is a general increasing trend which is consistent with the longer-term funding history in CIMAS. In comparing the total for Yr 5 and Yr 6 with previous years under the CA, it should be noted that beginning in Yr 5 there was a policy change with regard to Postdoctoral Fellows; these were previously funded under Task 1 but they are now being employed under Task 2.

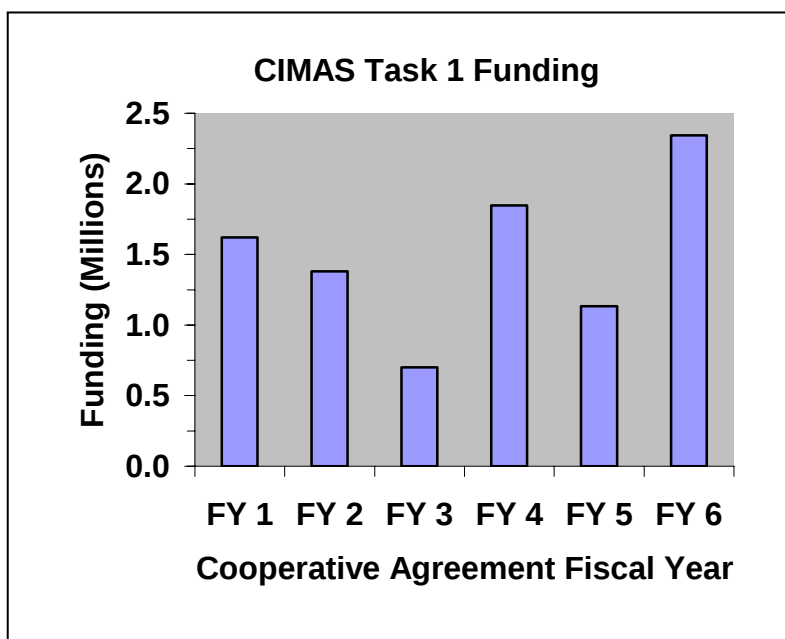


Figure 3: History of Task 1 Funding

The distribution of NOAA Task 1 funding is shown in Figure 4. The total NOAA-supported Task 1 budget is \$2.34M. In addition the University of Miami contributed \$0.227M to Task 1. These funds are used to support a portion of the salaries of staff. Under Task 1, the category "Other Research Support" includes: travel for Postdoctoral Fellows, students, visiting scientists, and salary for temporary staff in support of research activities; relocation expenses for newly hired research personnel supported on Task II; new hire expenses (drug tests, background searches); advertisements for new positions; visa costs; consulting agreements, and other supplies (computer equipment, peripherals, etc.). This accounts for the largest expenditure under Task I of 33%. Temporary staff (persons hired on a temporary basis to support research) accounts for 24% of the budget. Task 1 still shows some support for Postdoctoral Fellows who were "grandfathered". New Postdoctorals are now funded through Task 2.

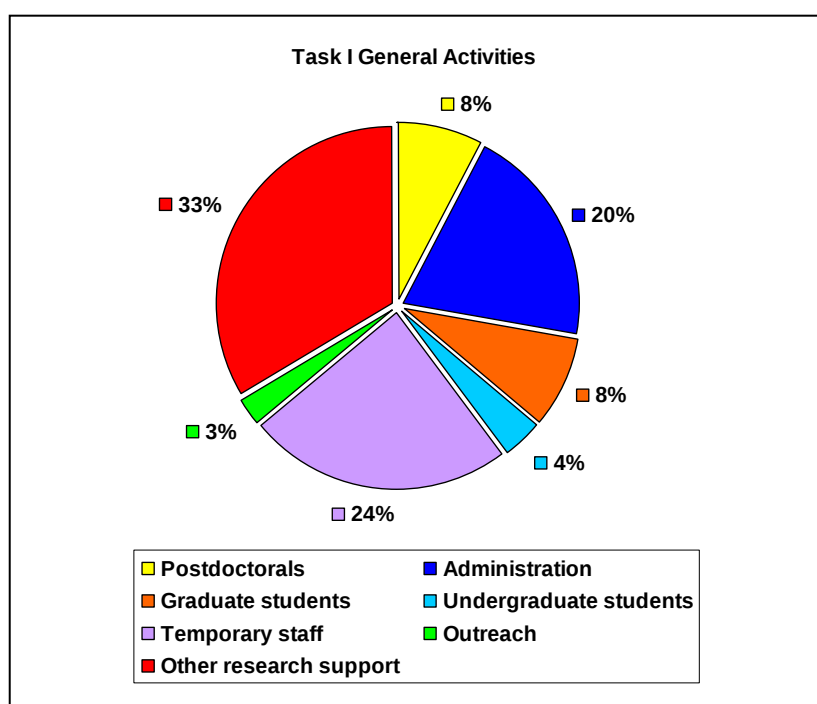


Figure 4: Distribution of Task 1 Funding

The history of funding under Task 2, which supports CIMAS employees who work closely with AOML and SEFSC (i.e., the Research Associate and Research Scientist program) is shown in Figure 5. In FY 6, Task 2 totaled \$4.3M, \$1.8M (70%) greater than FY 5.

The growth in Task 2 accounts for much of the sharp growth in the overall budget of CIMAS. There was strong and steady growth in funding for Task 2 over the CA, essentially tripling from FY 1 to FY 6. In contrast, as we show below, the research budget has been stable for much of the CA.

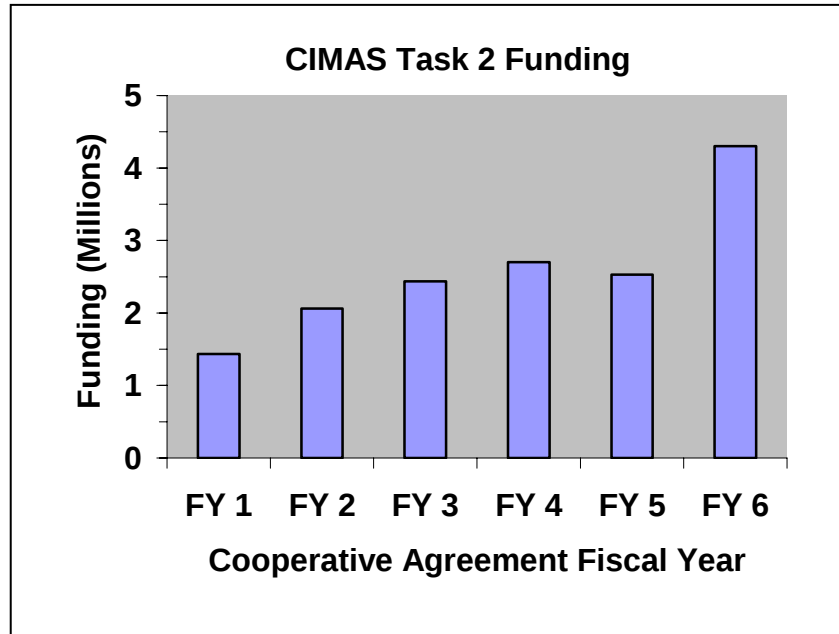


Figure 5: History of Task 2 Funding over the Cooperative Agreement

The history of NOAA-supported research funding (Task 3 and Task 4 combined) is shown in Figure 6. Research funding has remained relatively unchanged over the past four years of the CA with an annual average of \$3.8M. Nonetheless, this rate is substantially greater than that in the first two years which averaged \$2.5M. But there is no evidence of any increasing trend. This contrasts sharply with the strong increases in Task 2 budgets over the CA.

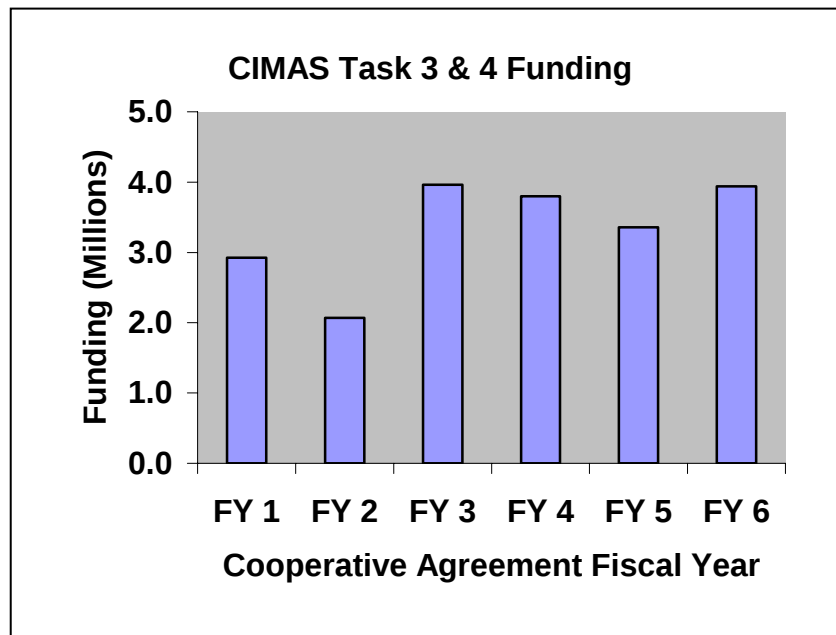


Figure 6: CIMAS Research Funding (Task 3 and Task 4)

Funding By Theme

Figure 7 shows the percentage of Task 3 and Task 4 funding that is expended in the CIMAS Themes. Of total CIMAS research funds. Almost half, 44%, is expended under Theme 1: Climate Variability. Second is Theme 3: Regional Coastal Ocean Ecosystem Processes (30%), reflecting activities in the large effort associated with the South-Florida Everglades Restoration. Theme 2: Fisheries Dynamics is third (9%).

The distribution of research 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. The allocation used here based on their assessment of the Theme of primary relevance.

Note that this figure only shows the distribution of funding under Theme 3 and Theme 4; it does not show the funding that supports Task 2 personnel, many of whom carry out research in the local NOAA laboratories in programs that fall under the CIMAS Themes.

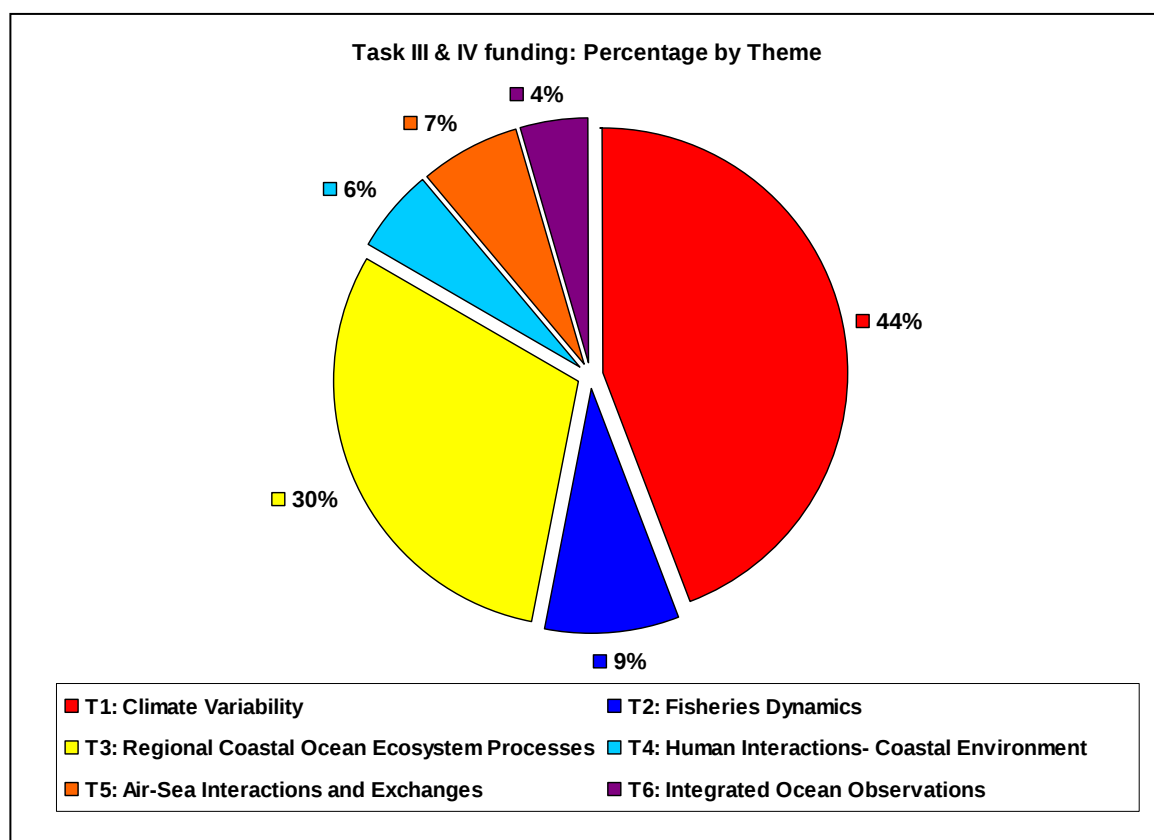


Figure 7: Percentage of Task 3 and Task 4 (Research) funding in the CIMAS Themes

Conclusion

In this report we have detailed research expenditures made through CIMAS. We emphasize once again that there are a substantial number of research programs carried out by RSMAS faculty that are complimentary to the NOAA-supported CIMAS-linked programs but that are supported by other agencies. The grants obtained by these faculty are credited to the academic division in which they reside. Consequently there is considerable leveraging of NOAA funds across the campus which does not show up 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 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. 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. Since 2002, the CIE has expended \$3,309,871. These expenditures do not appear in any CIMAS budget data. Although CIE remains housed in CIMAS.

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

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

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

carry out reviews of ongoing and completed assessments and who serve as independent experts on advisory panels and working groups.

Theme 2 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.

Research in this theme is consistent with three Mission Strategies as related to fisheries research:

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

Theme 3: Regional Coastal Ecosystem Processes

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

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

A major part of the research in Theme 3 is carried out in the context of the South Florida Ecosystem Restoration initiative, a program that seeks to reverse the damage caused by the rapid growth in this region. Legislation passed by Congress several years ago 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., CO₂, 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.*

VI. RESEARCH REPORTS

Theme 1: Climate Variability

Western Boundary Current Time Series Project

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

Long Term Research Objectives & Strategy to Achieve Them:

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 1: Climate Variability (*Primary*)

Theme 6: Integrated Ocean Observations (*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: Ulises Rivero

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 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. 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. 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.

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.

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 27°N. 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. In 2006 we published a paper in the journal *Geophysical Research Letters* describing the first year of time series observations of the Deep Western Boundary Current using data from the line of bottom pressure gauges and inverted echo sounders that were deployed as part of the expanded NOAA monitoring system in September 2004.

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/. 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 on the NOAA R/V Ronald H. Brown. 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 (3 cruises) and small sport fishing boats charter from Sailfish Marina in West Palm Beach (7 cruises).

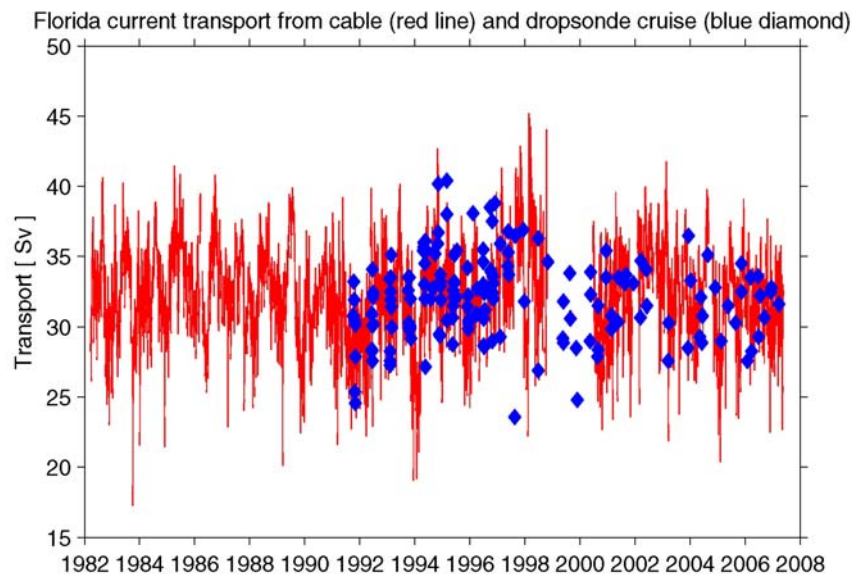


Figure 1: Time Series of Florida Current Transport

Research Performance Measure: All research goals were met during this year.

Biogeochemical Measurements

G. Berberian (UM/CIMAS); C. Langdon (UM/RSMAS)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To assess changes in the ocean's biogeochemical cycle in response to natural and/or man-induced activity (e.g., global warming).

Strategy: To make long term measurements of changes in the ocean's transport of heat and fresh water which could affect the circulation by decreasing or shutting down the thermohaline overturning.

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: OCO

NOAA Technical Contact: Mike Johnson

Research Summary:

The Repeat Hydrography CO₂/Tracer Program is a systematic and global re-occupation of select hydrographic sections. It builds upon earlier programs (e.g., World Ocean Circulation Experiment (WOCE)/Joint Global Ocean Flux Survey (JGOFS) during the 1990s) that have provided full depth data sets against which to measure changes in the ocean carbon sink. The effect of changing circulation on the total DIC change based on decadal changes in the apparent oxygen utilization rate is estimated to be greater than 10 $\mu\text{mol kg}^{-1}$ in the North Pacific along 152 W, accounting for as much as 80% of the total DIC change in that region between 1991/1992 and 2006.

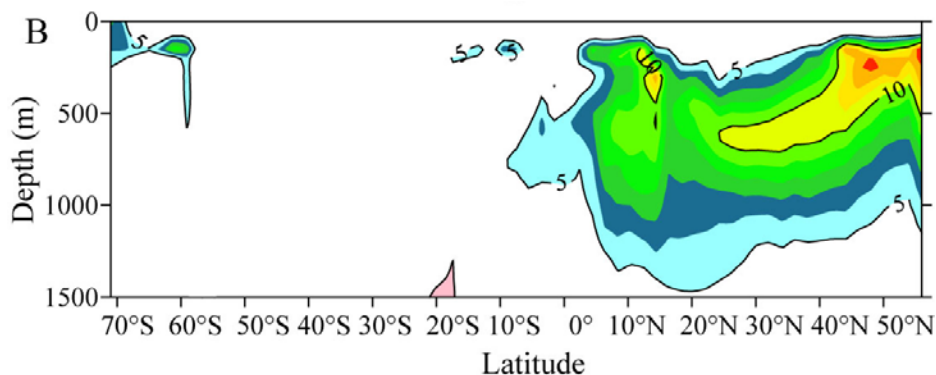


Figure 1: Section of the carbon change due to a change in circulation estimated from the change in apparent oxygen utilization along the P16 line (14/15 year difference).

A total of 2842 oxygen samples were collected on the P16N cruise. The total number of samples flagged after quality control: Questionable (QC=3) 25: Bad (QC=4) 120: Not reported (QC=5) 7. This means that 95% of the analyses were of the highest quality, which is excellent.

Research Performance Measure: All goals are being met.

Data Assimilation with a Hybrid Coordinate Ocean Model (HYCOM)

H. Kang (UM/CIMAS); Z. Garraffo (UM/RSMAS); W. C. Thacker (NOAA/AOML)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To improve simulations of HYbrid Coordinate Ocean Model (HYCOM).

Strategy: To assimilate *in-situ* and satellite observations such as altimetry, multi-channel sea surface temperature (MCSST), and profile data from ARGO floats. To implement the NRL Coupled Ocean Data Assimilation (NCODA) System which uses a multi-variate optimal interpolation (MVOI) to assimilate in-situ and satellite observations.

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: NOPP

NOAA Technical Contact: William C. Thacker

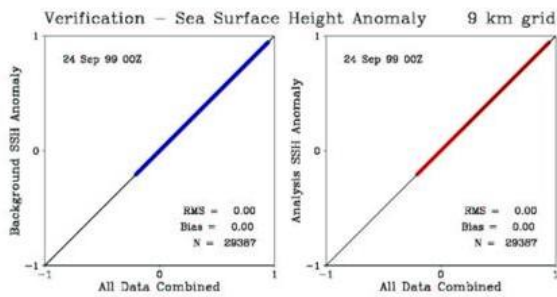
Research Summary :

Until she left CIMAS on 31 October 2006, HeeSook Kang was working on a project funded by NOPP with the objective of assimilating data into HYCOM, the hybrid-coordinate ocean model that was developed largely at UM/RSMAS. Her role in this project was to adapt NCODA, the Navy's general purpose data-assimilation software, to function with HYCOM. The principal complication was related to the different treatment of the vertical coordinate by HYCOM and NCODA --- HYCOM used layers while NCODA used fixed pressure levels. A first attempt to convert from layers to levels to assimilate and then interpolate back to layers was found to smooth out details of the vertical structure in the model state, so it was necessary to alter NCODA internally to accommodate HYCOM's layers. An identical twin experiment has been designed to make sure layered data information passing through the NCODA structures. In this way, we can check the increment to be zero. It was done for September 2, 1999 and was reported with satisfactory results in last year's report. After then, another test case was conducted for September 24, 1999. In Figure 1, we show the verification of assimilated data in twin experiment; SSH, SST, Profiles. From the results of twin experiment, it is very clear that now NCODA can handle layered profile data.

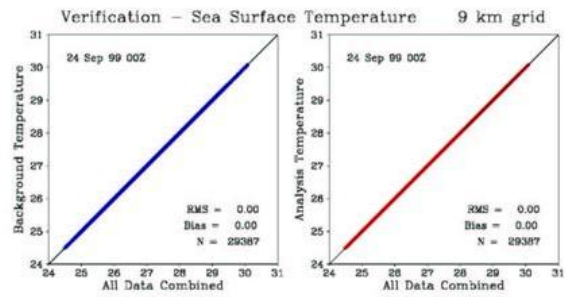
The next step would be working on velocity fields to make sure the geostrophic balance of assimilated data. We are going to introduce HYCOM method to NCODA to correct velocity fields. In the middle of this task, HeeSook Kang left the project and now this project is continued by Zulema Garraffo. After making sure that NCODA is working properly with HYCOM aspects, real observation will be applied.

The twin experiment has been designed and prepared to make sure that NCODA can handle the layered data. So far, pseudo altimeter data, pseudo MCSST, and T & S from pseudo profiles were able to go through the NCODA package.

SSH verification



SST verification



Profile verification: Temperature & Salinity

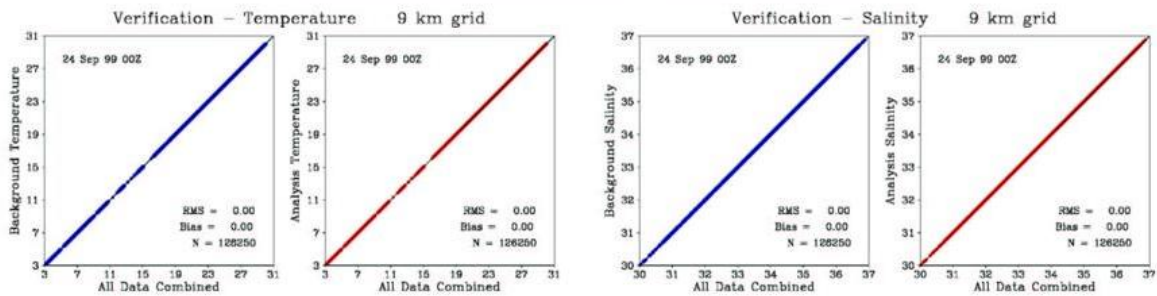


Figure 1: Verification of assimilated data with twin experiment; SSH, SST, and Temperature & Salinity from profiles on September 24, 1999.

Research Performance Measure: The program is on schedule and meeting its goals.

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 & Strategy to Achieve Them:

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

Strategy: To use both data and the NCAR Community Atmospheric Model, CAM3, to understand these relationships.

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

NOAA Technical Contact: Chunzai Wang

Research Summary:

Climate Response to Anomalous Large and Small Atlantic Warm Pools during the Summer:

The NCAR community atmospheric model is used to show the influence of the Atlantic Warm Pool (AWP) variability on the summer climate and Atlantic hurricane activity. The model runs show that climate response to the AWP's heating extends beyond the AWP region to the eastern North Pacific. Both the sea level pressure and precipitation display a large response (low pressure and increased rainfall) with two centers located in the western tropical North Atlantic and in the eastern North Pacific. In response to the pressure changes, the easterly Caribbean low-level jet is weakened, so is its moisture transport. The model runs also show that the anomalous AWP weakens the southerly Great Plains low-level jet that in turn reduces the northward moisture transport from the Gulf of Mexico to the United States east of the Rocky Mountains and thus decreases the summer rainfall over the central United States, in agreement with observations. Since the climate response to the North Atlantic SST anomalies is primarily forced by the tropical SST anomalies, this study implies that mechanism of North Atlantic SST-related (or Atlantic multidecadal oscillation-related) rainfall over North America may be operated through the AWP-induced change of the northward moisture transport. The model experiments show that the AWP reduces the tropospheric vertical wind shear in the main hurricane development region and increases the moist static instability of the troposphere, both of which favor the intensification of tropical storms into major hurricanes.

Research Performance Measure: The main object is to investigate the impact of the AWP on the summer climate of the Western Hemisphere using the NCAR community atmospheric model and observational data. This objective is accomplished.

Large – Small Atlantic Warm Pool

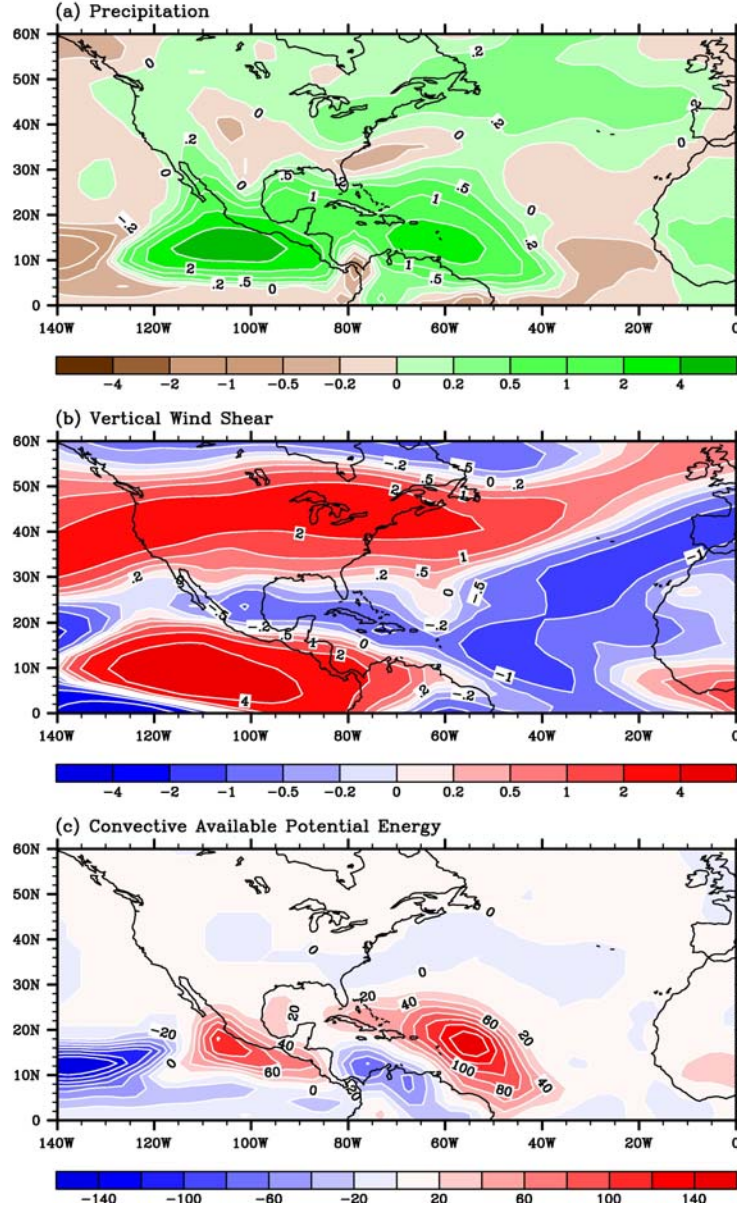


Figure 1: The difference between the Large and Small AWP runs during June-July-August-September-October-November (JJASON): (a) precipitation rate (mm day⁻¹), (b) tropospheric vertical wind shear ($[(U_{200} - U_{850})^2 + (V_{200} - V_{850})^2]^{1/2}$; m s⁻¹) and (c) convective available potential energy (CAPE; J kg⁻¹).

Understanding and Improving the Ensemble Transform Kalman Filter Targeting Strategy

S. J. Majumdar and K. J. Sellwood (UM/RSMAS); S. D. Aberson (NOAA/AOML);
C. H. Bishop (NRL, Monterey)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To assess whether upstream observations are useful for 3-6 day forecasts and whether their effects can be predicted in advance on a daily basis.

Strategy: To test in various flow regimes whether the Ensemble Transform Kalman Filter (ETKF) can predict the influence of upstream observations on winter weather forecasts.

CIMAS Research Theme:

Theme 1: Climate Variability

Link to NOAA Strategic Goals:

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

NOAA Funding Unit: USWRP

NOAA Technical Contact: John Gaynor

Research Summary:

A core objective of NOAA is to improve 3-6 day forecasts of high-impact winter weather over North America. One method of making such improvements is by augmenting the present routine observational network with extra observations upstream. The primary goal of this NOAA/CIMAS/THORPEX research has been to evaluate and further develop the Ensemble Transform Kalman Filter (ETKF) adaptive observing strategy, which has been used to date in operational NOAA/NWS Winter Storm Reconnaissance (WSR) to improve forecasts of shorter range (1-3 days).

In order to assess the performance of the ETKF, the influence of observations on numerical forecasts was first computed and analyzed via 'data denial' experiments, in which selected observational data were withheld from the data assimilation. Surprisingly, the downstream influence of observations on forecasts was often found to be contaminated by rapid local growth of initially tiny errors around the globe. A paper documenting this issue has been accepted for publication (Hodyss and Majumdar, 2007).

In the past year, the ability of the ETKF to predict the influence of assimilating dropwindsonde data on 3-6 day NCEP global model forecasts of winter weather has been evaluated. The study involved 19 cases from the 2006 WSR program, and two evaluation metrics were devised. The ETKF would only be deemed successful at predicting the influence of data (via the "signal variance") if it performed better than a climatology of (quasi) random predictions. The main result was that the ETKF was found to be successful in predicting signal variance of 200 hPa winds for 1-2 day forecasts over the eastern Pacific and western North America. Encouragingly, the ETKF also performed very well for forecasts of 200 hPa wind between 4-6 days, when the forecast corresponded to a winter storm system over the Atlantic Ocean (and sometimes Europe). In contrast, the ETKF performed most poorly for weather systems over North America east of the Rockies, perhaps because the influence of observations often decayed significantly in these regions. The ETKF signal variance prediction and the associated

influence of observations (or ‘signal’) on the NCEP global model forecast is shown for a typical case in Figure 1.

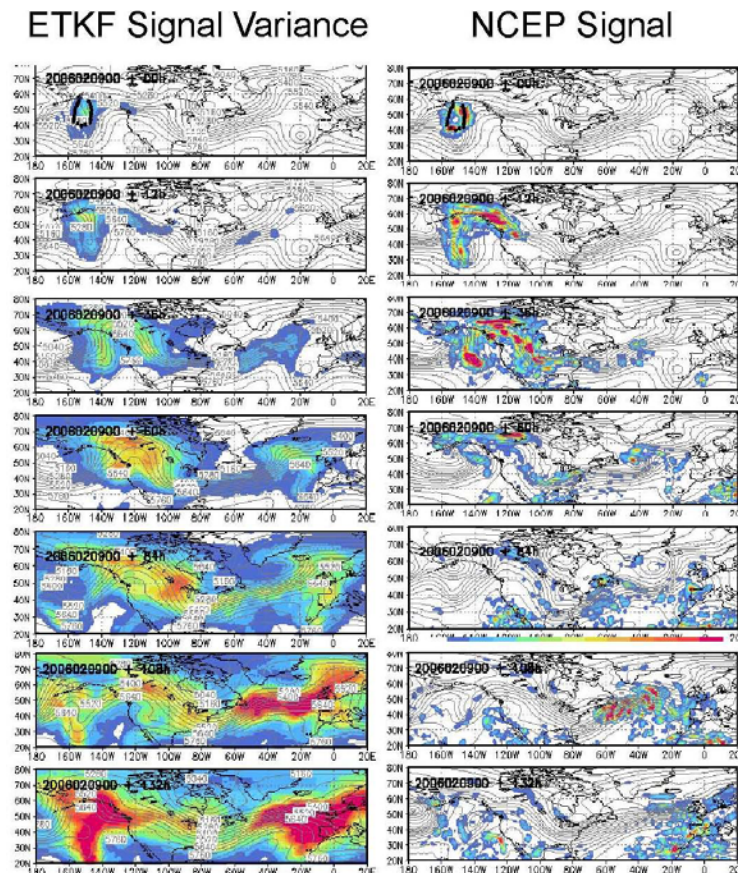


Figure 1: (Left) Evolution of predicted ETKF Signal Variance of 200 hPa winds between +00h and +132h, using a 50-member ECMWF ensemble initialized 36h prior to 00 UTC, 09 Feb 2006. (Right) Evolution of unfiltered NCEP Global Forecast System signal, initialized at 00 UTC, 09 Feb 2006. Dropwindsondes from a round-trip flight from Alaska were removed from the NCEP assimilation in the data-denial run.

In general, the ETKF performed best on synoptic scales (5-10° resolution), and not so well on small scales (1° resolution). The optimal size of the downstream ‘verification region’ that was objectively selected for evaluation was typically 40° in longitudinal extent. The effect of the flow regime on the skill of the ETKF was also investigated. It was found that the ETKF was most capable when the upper-tropospheric flow was mostly zonal, while it fared most poorly when the flow was either blocked or strongly meridional.

The results from this project will enable NOAA to consider the ETKF as a strategy for adaptive sampling to improve medium-range forecasts of winter weather, with an understanding of when the method is likely to be particularly effective or ineffective. A candidate field campaign is the winter phase of the THORPEX Pacific Asian Regional Campaign, which is being planned for winter 2008/9.

Research Performance Measure: The program is on schedule.

Fine Structure in North American Summer Climate

B. Mapes (UM/CIMAS)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To understand the seasonal cycle of North American climate.

Strategy: To examine and compare observational analyses with climate model outputs.

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: Ken Mooney

Research Summary:

The seasonal cycle of North American climate was examined at high resolution (in daily data), to better resolve such features as sudden monsoon onset and the mid-summer drought of the Mesoamerican region, including the Caribbean and South Florida. The most promising area turned out to be this midsummer drought, which corresponds to poorly understood circulation changes in the Atlantic subtropical high.

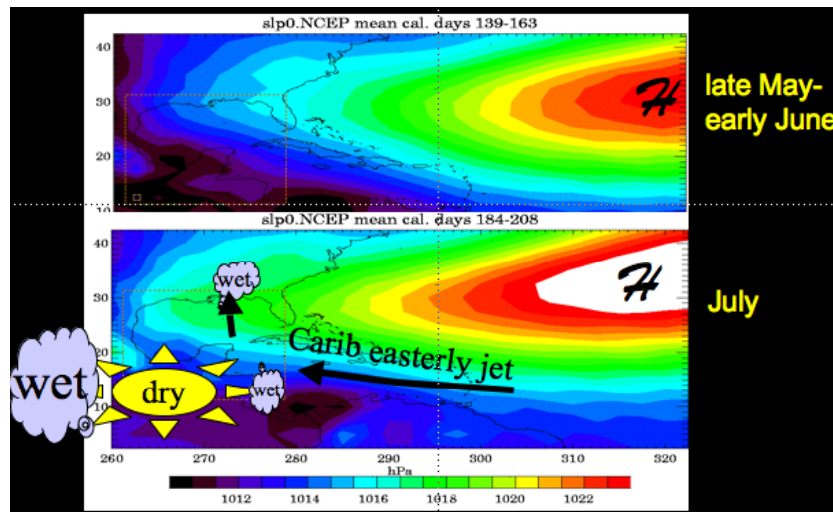


Figure 1: This figure shows the mean configuration of sea level pressure (SLP) contours in early and middle summer, with cloud and sun icons illustrating the implications for rainfall anomalies in mid-summer. Although the Mesoamerican regional average is less rain in mid-summer, some areas are wetter like upwind slopes of mountains and the offshore area of the eastern Pacific.

This exploratory research led to one publication; another is in process. On the basis of this research, a substantial NSF grant to study the system in greater detail has been proposed and funded.

Research Performance Measure: The program is on schedule. All goals are being met.

Improving the MJO Simulation of the NCEP GFS Model

B. Mapes (UM/CIMAS); J. Lin (NOAA/CIRES)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To improve the MJO Simulation of the NCEP GFS Model.

Strategy: To adjust cumulus parameterization to increase its sensitivity to moisture.

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: COP

NOAA Technical Contact: Ken Mooney

Research Summary:

In this newly initiated study, we are obtaining the NCEP Global Forecast System (GFS) model code in order to experiment with its cumulus parameterization scheme. We intend to increase the entrainment rate, which will make the scheme more sensitive to humidity, while at the same time adjusting other aspects in order to offset the undesirable side effects of entrainment.

The measure of MJO fidelity will follow Lin et al., 2006 (*J. Climate* 19, 2665-2690), which intercompared many models and found clear and similar shortcomings in many global models.

Research Performance Measure: The program is on schedule.

**NAME (North American Monsoon Experiment
Climate Process and Modeling Team**
B. Mapes (UM/CIMAS); J. Schemm (NOAA/CPC)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To improve the simulation and prediction of the North American Monsoon.

Strategy: To compare models among themselves and with meteorological observations to identify processes which appear deficient in the models. To facilitate improvements in model used in model centers, including NOAA-NCEP.

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: Ken Mooney

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. My work with student Patrick Kelly is to study land-atmosphere interactions in columnar datasets from field sites and column output from models.

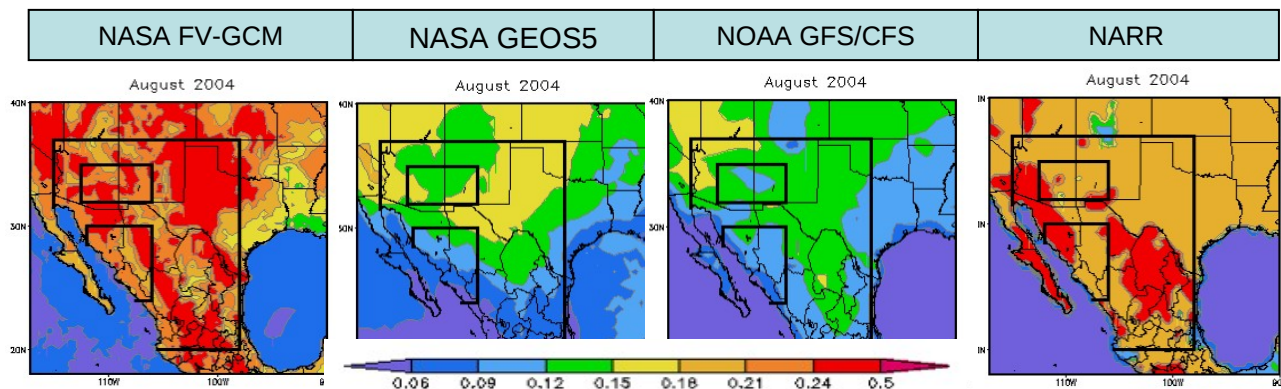


Figure 1: Shown is surface albedo from 3 models and a reanalysis (NARR). Even before complex processes like clouds are incorporated, the different continental solar heatings implied by this figure are expected to generate differences in the monsoon. Observations help us choose among them and combine strengths of different models to improve predictions.

Research Performance Measure: The program is progressing on schedule.

CO₂/CLIVAR Repeat Hydrography Program CO₂ Synthesis Science Team

F. J. Millero (UM/RSMAS); R. Wanninkhof and T.-H. Peng (NOAA/AOML);

R. Feely and C.L. Sabine (NOAA/PMEL); R. Key (Princeton);

A. Dickson (Scripps, San Diego); A. Kozyr (CDIAC)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To observe and quantify changes in the ocean carbon system.

Strategy: To provide a core set of carbon and tracer measurements in the NOAA/NSF Repeat Hydrography CO₂/tracer Program.

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 (*Primary*)

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

NOAA Funding Unit: COSP

NOAA Technical Contact: Joel Levy

Research Summary:

The NOAA/NSF Repeat Hydrography CO₂/Tracer Program is a component of the Carbon Cycle Science Program (CCSP) and is a collaborative effort between NOAA and NSF to conduct a global, decadal time-scale, sampling of ocean transports and inventories of climatically significant parameters. It is part of NOAA's strategic climate goal of climate forcing. It provides a core set of carbon and tracer measurements and anticipates that additional carbon/CLIVAR measurements will be added to the cruises on an "as required" basis. During the 1990s ocean sampling expeditions were carried out as part of the World Ocean Circulation Experiment (WOCE), the Joint Global Ocean Flux Study (JGOFS) and the Ocean Atmosphere Carbon Exchange Study (OACES). Most of the cruises included various inorganic carbon species among the suite of routinely measured parameters. Both during and after the field work, a group of U.S. scientists collaborated to synthesize the data into easily usable and readily available products. This collaboration is known as the Global Ocean Data Analysis Project (GLODAP).

Both measured results and calculated quantities were merged into common format data sets, segregated by ocean. The carbon data were subjected to rigorous secondary quality control procedures, beyond those typically performed on individual cruise data, to eliminate systematic biases in the basin-scale compilations. For comparison purposes, each ocean data set included results from a small number of high quality historical cruises. The calibrated 1990s data were used to estimate anthropogenic CO₂, potential alkalinity, CFC watermass ages, CFC partial pressure, bomb-produced radiocarbon and natural radiocarbon. The calibrated-merged data were used to produce objectively gridded global property maps designed to match existing climatologies for temperature, salinity, oxygen and nutrients. Both the data sets and the gridded products are available from the Carbon Dioxide Information Analysis Center (CDIAC).

The synthesis was carried out one ocean at a time progressing from the Indian to Pacific and ending with the Atlantic.

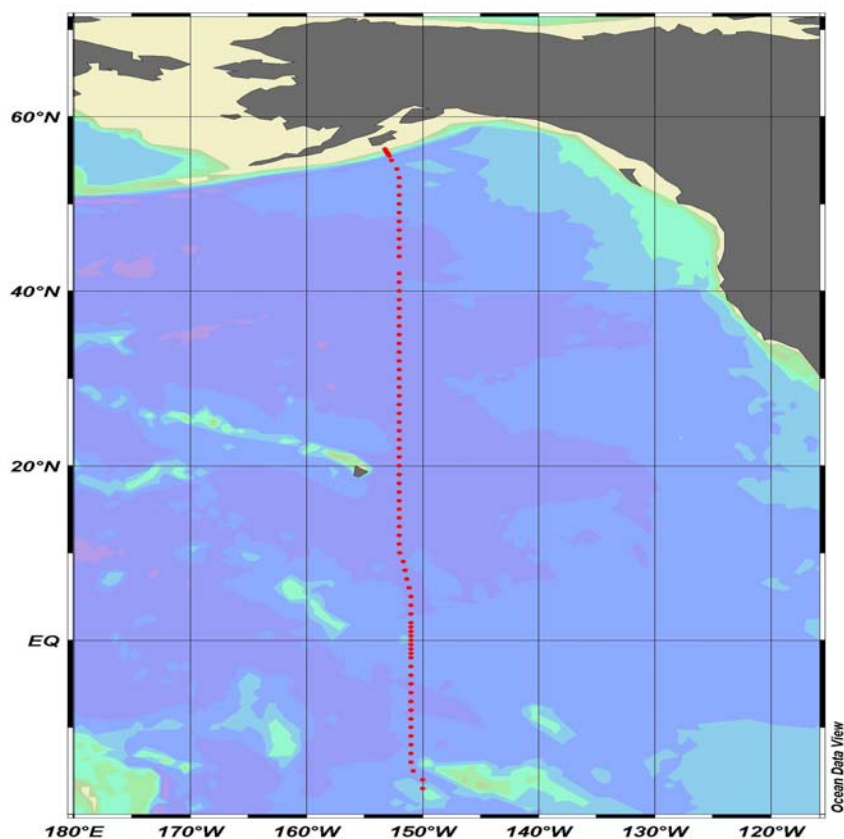


Figure 1: Cruise track beginning in Tahitian waters on 14 February, 2006 and ending in Alaska on March 30, 2006. Millero's group measured pH and total alkalinity (TA) as part of the CLIVAR/CO₂ repeat hydrography Program. (P16N from Papeete, Tahiti with a stop in Honolulu, HA and on to Kodiak, Alaska).

The GLODAP data set described here (Gv1.1) is available free of charge as a numeric data package (NDP-83) from the Carbon Dioxide Information Analysis Center (CDIAC). The data, and any subsequent updates, are also available through the GLODAP web site (http://cdiac.ornl.gov/oceans/glodap/Glodap_home.htm). The GLODAP bottle data files are available in flat ASCII file data format, in Ocean Data View (ODV) format, and through the CDIAC live access server (LAS); the gridded data files are available in flat ASCII and netCDF data file formats and through CDIAC LAS.

All of the carbonate and DOM data collected on these cruises will be disseminated as core measurements to the oceanographic community. These will be useful in examining the uptake of the fossil fuel CO₂ by the oceans and for testing ocean models that examine biogeochemical models of ocean processes.

Research Performance Measure: All program goals are being met on schedule.

Studies of Climate Feedbacks and Sensitivity Using GFDL Models

B. J. Soden (UM/RSMAS)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To provide a quantitative assessment of the strengths of climate feedbacks in current coupled ocean-atmosphere climate models.

Strategy: To use the results from the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment model archive to compute climate feedback parameters from radiative adjoint calculations.

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: GFDL

NOAA Technical Contact: Brian Gross

Research Summary:

The extent to which the climate will change due to an external forcing depends largely on radiative feedbacks, which act to amplify or damp the surface temperature response. Differences in the representation of these feedbacks are directly responsible for the uncertainty in current model estimates of climate sensitivity. There are a variety of issues that complicate the analysis of radiative feedbacks in global climate models (GCMs), resulting in some confusion regarding their strength and distribution. In our research we developed a method for quantifying climate feedbacks based on “radiative kernels” which describe the differential response of the top-of-atmosphere radiative fluxes to incremental changes in the feedback variables. The use of radiative kernels enables one to decompose the feedback into one part that depends on the radiative transfer algorithm and the unperturbed climate state, and a second part that arises from the climate response of the feedback variables. Such decomposition facilitates an understanding of the spatial characteristics of the feedbacks and the causes of intermodel differences. This technique has the advantage of requiring fewer computations and being easier to implement than “partial radiative perturbation” methods. More importantly, it provides a simple and accurate way to compare feedbacks across different models using a consistent methodology. Cloud feedbacks cannot be evaluated directly from a cloud radiative kernel because of strong nonlinearities, but they can be estimated from the change in cloud forcing and the difference between the full-sky and clear-sky kernels. Our results using this method confirm that models typically generate globally-averaged cloud feedbacks that are substantially positive or near neutral, unlike the change in cloud forcing itself which is as often negative as positive.

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

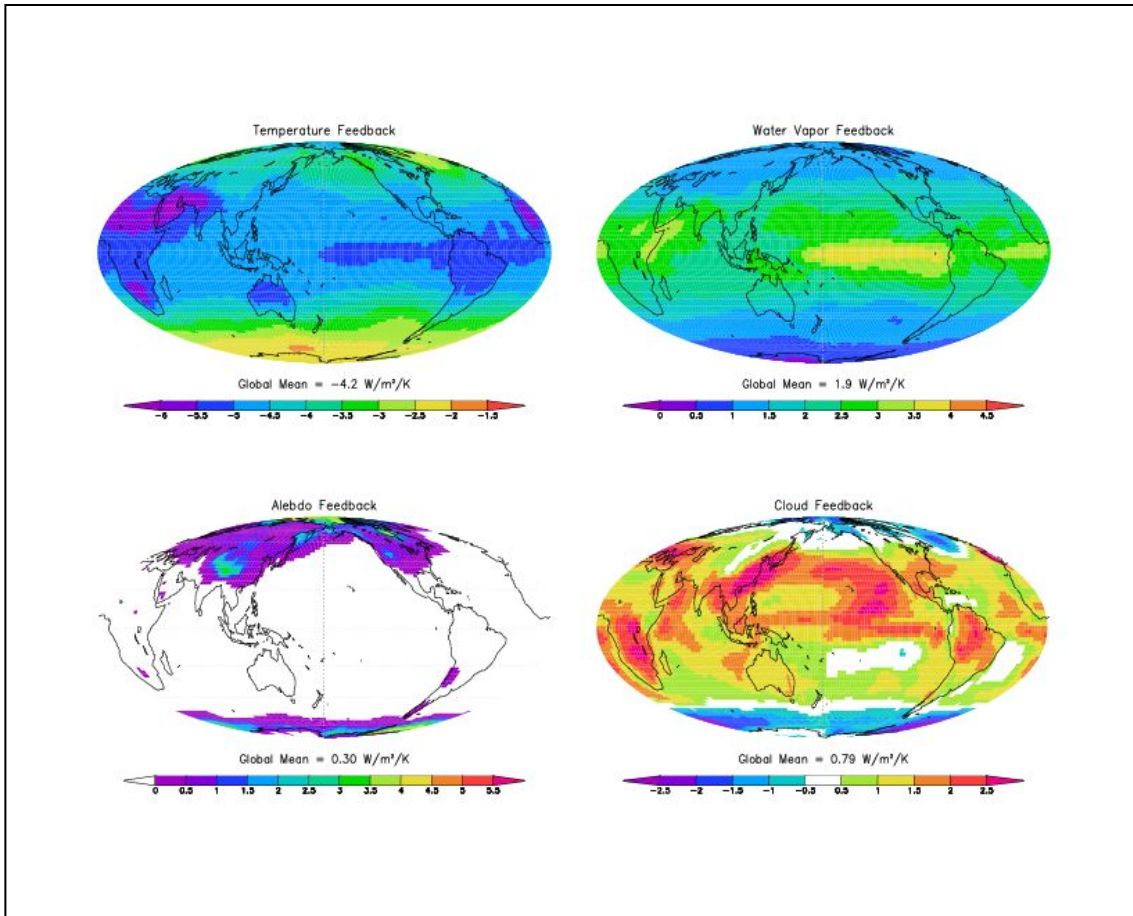


Figure 1: Multi-model ensemble-mean of the temperature, water vapor, surface albedo and cloud feedback computed from the IPCC AR4 models.

Assessment of Decadal Variability in the Tropical Radiation Budget

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

Long Term Research Objectives & Strategy to Achieve Them:

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: OGP

NOAA Technical Contact: James Todd

Research Summary:

Currently there exists 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. No GCM can currently reproduce this shift (Wielicki et al., 2002). Existing 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 simply have not been analyzed in a disciplined enough manner to enable the scientific community to assess their consistency with model projections or ERBE measurements.

This 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 will then be exactly matched in the model. This enables us to emulate the drift in the satellite observation times on the operational radiance record. This will, for the first time, provide a direct and consistent comparison between a GCM and TOVS satellite observations free of retrieval uncertainties and sampling biases. As demonstrated here, such attention to detail is required in order to accurately assess the decadal variability in spectral radiances. If the decadal variations are substantiated, the analyses 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.

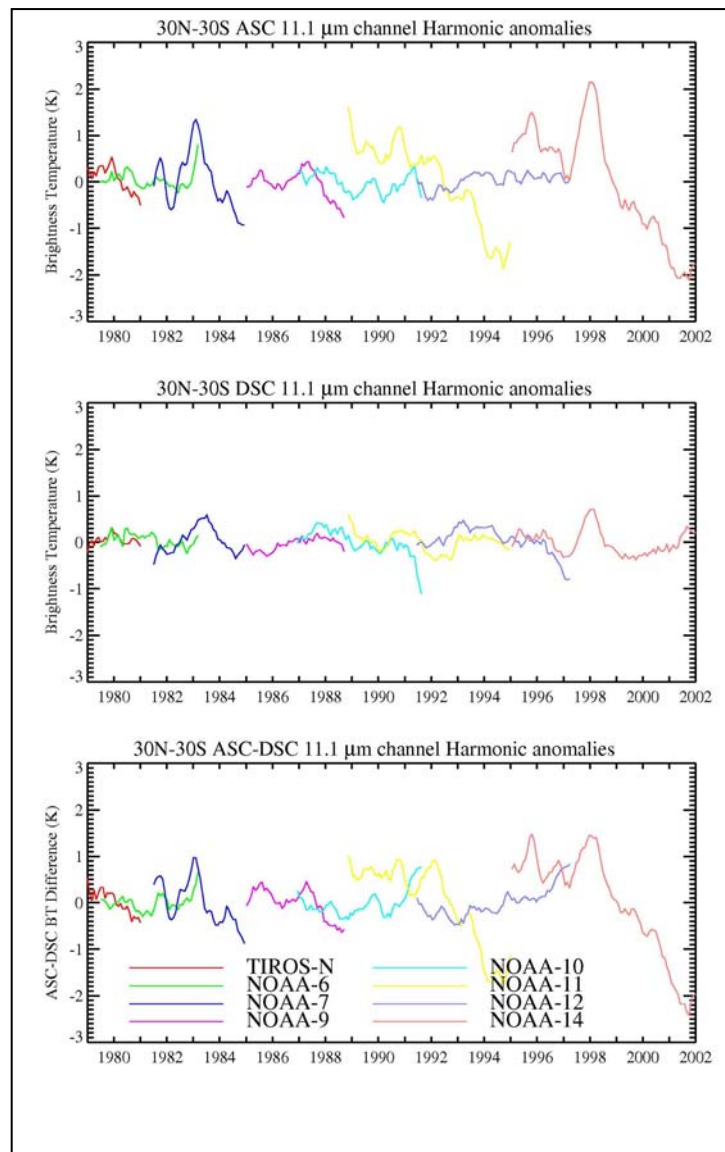


Figure 1: Time series of ascending (a), descending (b) and total (c) total 11.1 micron Tb anomaly data for eight NOAA polar-orbiting satellites.

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 SS and coupled ocean atmosphere GCMs under natural and anthropogenic forcing scenarios. 3) Identified anthropogenic signatures in HIRS spectral radiance trends.

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);
M. Black, R. Black, R. F. Marks and R. Rogers (NOAA/AOML);
A. Heymsfield (NCAR); G. Heymsfield (NASA/GSFC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To improve the understanding and prediction of tropical cyclone genesis, intensity change, and rainfall; to improve microphysical parameterization schemes in tropical cyclone simulations at all stages of their lifecycle.

Strategy: To evaluate and compare the microphysical fields from both high-resolution MM5 model simulations and *in situ* and remotely-sensed data collected by the NOAA-WP-3D's and NASA ER-2 aircraft, as well as data from the TRMM Precipitation radar and Microwave imager.

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: OAR/AOML

NOAA Technical Contact: Michael Black

Research Summary:

Previous research has shown that diabatic heating plays an important role in determining tropical cyclone intensity, rainfall, and genesis. The impact of this heating on the vortex is dependent on its magnitude and distribution in the horizontal and vertical, which is in turn dependent on the structure of the precipitation. These structural changes can vary throughout the tropical cyclone lifecycle and span a large range of spatial and temporal scales. As a result, these variations make it difficult for numerical models to correctly forecast genesis, intensity, and rainfall as well as correctly reproduce cloud and precipitation formation processes. Knowing and understanding these variations could be a vital aid for model forecast predictions. Thus our goal is to determine: 1) how the changes of the precipitation structure vary throughout a tropical cyclone's lifecycle; 2). whether models can capture these changes, if they exist; 3). how these changes may or may not affect the genesis and intensity of a tropical cyclone; and 4) how well the models are able to replicate the formation of clouds and precipitation processes. Our strategy for achieving our goals is to conduct a comparison of the statistics of the distribution and concentrations of different microphysical fields from airborne radar, space-borne radar, and a high-resolution numerical model. These studies will advance the understanding of the morphology of precipitation. We will also use *in situ* microphysical observations to guide the model microphysical parameterizations and compare key components of the water budget in the ice and liquid regions of a tropical cyclone, which will help determine any model biases. In the end, these studies will help in the improvement of intensity and rainfall predictions.

We began comparisons of statistics of reflectivity and vertical air motion data from both NOAA-P3 and NASA ER-2 aircraft airborne Doppler radar (collected during the NASA TCSP and NOAA IFEX field program on July 2005) with high-resolution MM5 model data for Hurricane Dennis. We compared data from the time period from 12 UTC July 5 to 12 UTC July 7, when Dennis experienced a period of enhanced precipitation while it intensified from a weak tropical storm to a hurricane. This includes a period of rapid intensification from 12 UTC July 6 to 12 UTC July 7. Using our previous algorithm, the precipitating areas of each dataset were partitioned into convective and stratiform regions. Based on a Contour Cumulative Frequency by Altitude Diagram (CCFAD), the peak vertical motion in the model shows a change from a broader peak at higher altitude to a sharper peak at lower altitudes in the convective regions as Dennis intensified. This supports previous studies of the relationship between peak diabatic heating and storm intensity. In contrast, the observations from both aircrafts do not show this change in the peak vertical motion over time, which could be caused by sampling different areas between the two days. The CCFAD of reflectivity for each datasets (Fig. 1) shows the model having higher reflectivity at higher altitudes during the earlier times, which supports the vertical motion evolution, compared to the observations, in which the higher reflectivity at higher altitude occur on the second day when Dennis was a weak hurricane. As an overall result, we do see a change in the precipitation structure during the different stages of Dennis, although the changes are different between the model and the observations.

Currently, a collaborative effort with A. Heymsfield and associates at NCAR is underway to apply analyses of microphysical measurements (Fig. 2) collected during the TCSP and NAMMA field experiments as well as past particle image data from the NASA DC-8 and NOAA P-3. Using software developed at NCAR, we will begin the comparison of observations and model microphysics.

Along with the above comparisons, we are expanding our database to include observations and simulations of systems during their pre-genesis stages as well as cases that experience convective bursts and rapid intensification. Using a best-rack pre-genesis file, which is based on the ERA40 analysis, supplied by Brandon Kerns of the University of Utah, we are mining for TRMM observations of systems from the time of pre-genesis to development as well as systems that did not develop into storms. With this dataset, we will be able to see the evolution of the precipitation changes throughout a systems lifecycle, as well as see any differences between systems that formed into storms compared to those that did not.

Additionally, we are compiling a 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 will be able to study the difference of morphology of precipitation during these episodes of deep convection and try to explain how these differences affect the genesis and intensity of a system.

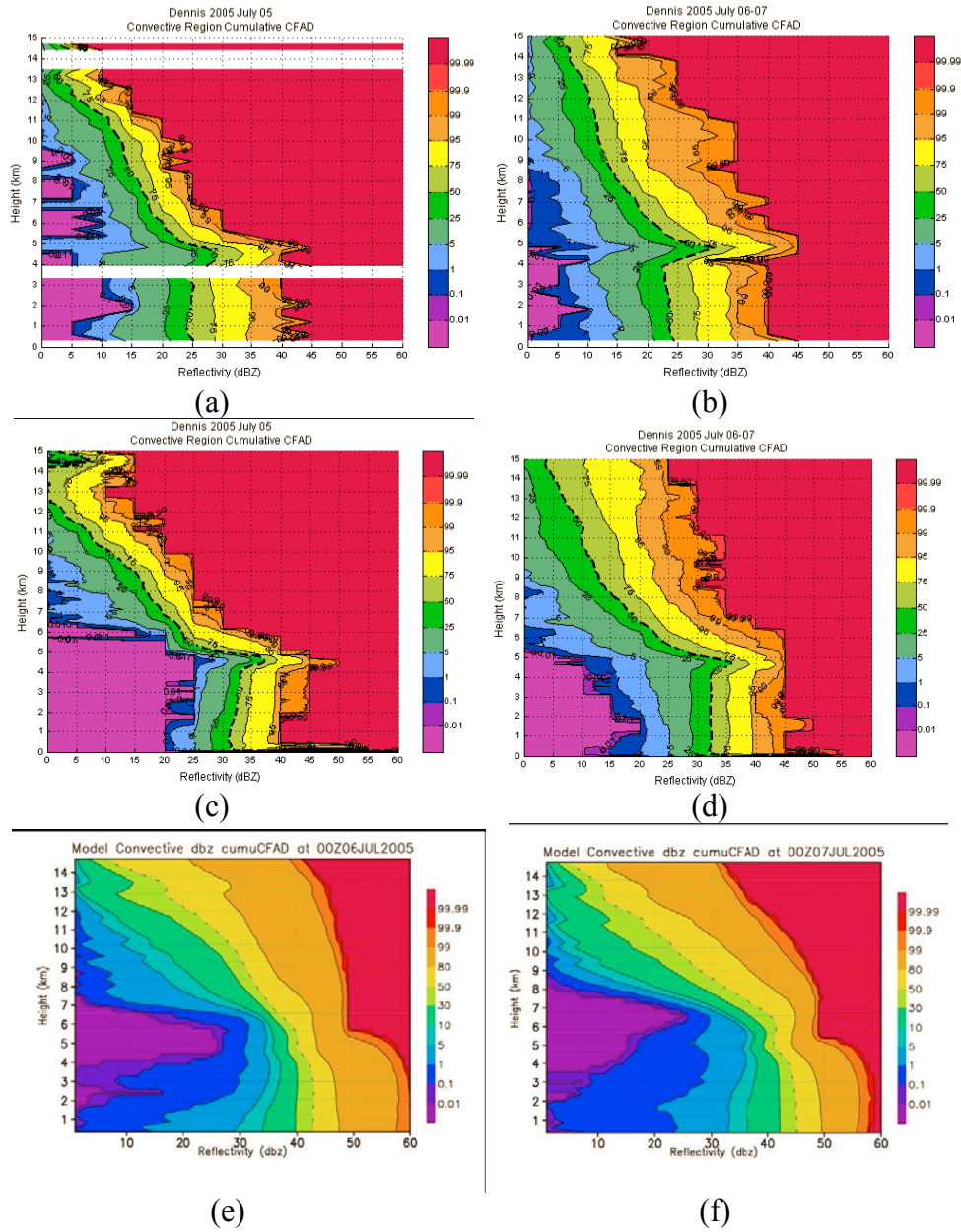


Figure 1: Contour Cumulative Frequency by Altitude Diagrams (CCFAD) of reflectivity for Hurricane Dennis. (a) NOAA P-3 on July 5; (b) NOAA P-3 on July 6-7; (c) NASA ER-2 on July 5; (d) NASA ER-2 on July 6-7; (e) MM5 on 00 UTC July 06; (f) MM5 of 00 UTC July 07;

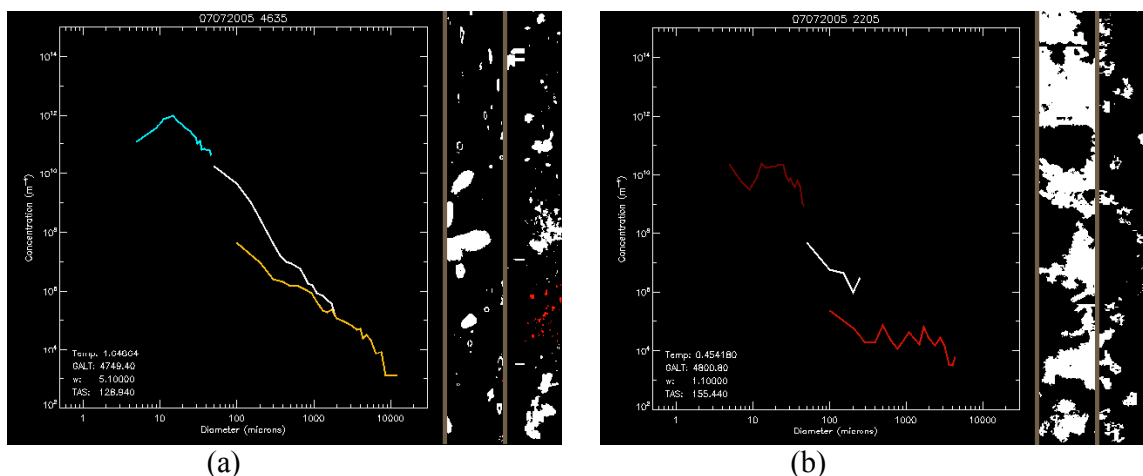


Figure 2: (a) Composite 3 instrument spectra, and a small sample images for cloud probe (width 1.6 mm) and precipitation probe (width 6.4mm) at 0036/45UTC showing very large complex ice aggregates at a temp. of .5C in the melting layer; (b) same as 2a, but at 0117/15 at a temp of 1.6C in an updraft at 5.1 m/s.

Research Performance Measure: Objectives are being met on schedule.

* * * * *

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

C. Zhang, J. Prospero and J. Huang (UM/RSMAS)

Long Term Research Objectives & Strategy to Achieve Them:

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 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

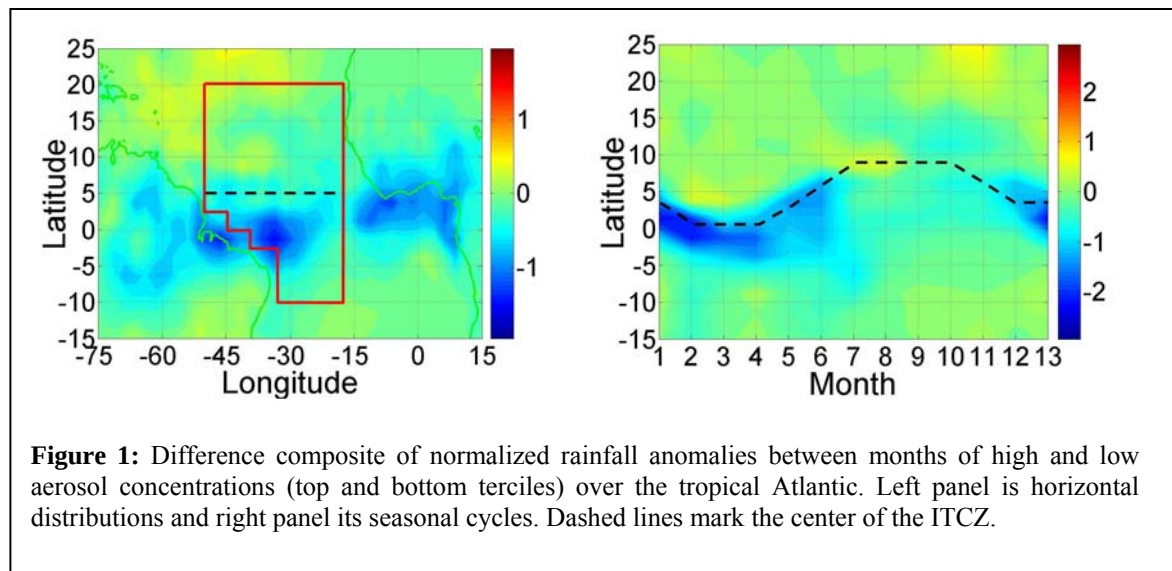
Research Summary:

Aerosols are known to play a critical role in cloud-nucleation and precipitation processes. However the effects of aerosol on rainfall are complex and poorly understood. Observational and modeling studies, although not always consistent with each other, suggest that these effects

sensitively depend on the types of cloud, the types of aerosols, and the physical processes involved. In our study we used multiyear satellite observations over the tropical Atlantic to investigate the relationship between the large-scale variability of rainfall and that of aerosol concentrations (dust and smoke) traced to African sources. We find that there are coherent signals between African aerosol and precipitation over the tropical Atlantic Ocean. During winter and spring, when aerosol concentrations are typically high, there is a significant reduction in rainfall south of the intertropical convergence zone. This reduction cannot be attributed to known climate factors such as El Niño-Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), and tropical Atlantic sea surface temperature (SST) zonal and meridional modes. The fractional variance in rainfall related to aerosol is as much as 15% of the interannual variance and it is comparable in magnitude to that related to those known climate factors. Our result suggests a connection between aerosol emissions and climate variability in the Pan-Atlantic region. The transport of African aerosol, primarily attributed to dust and smoke, has varied considerably over the past several decades in part attributable to human activities that affect soil mobilization and biomass burning. Thus the aerosol-related rainfall reductions that we observe may be in part attributable to anthropogenic impacts.

In addition, we have examined the relationship between aerosols and visual range (VR) using data from various islands in the Caribbean. We compare the variations of VR with changes in the concentration of African dust measured in the trade winds on Barbados. We find that dust plays a major role in modulating VR over a large area of the Caribbean on a seasonal basis. Long-term trends are also apparent linked to increased dust transport associated with drought in Africa.

Finally, we are investigating long term trends in aerosol concentrations over the oceans as retrieved from different satellite remote sensing platforms and retrieval algorithms. It is clear that there are major problems in using such products to detect long-term trends.



Research Performance Measure: The research program is accomplishing its objectives on schedule.

A Study of the MJO-ENSO Problem: Phase II

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

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To improve ENSO prediction through quantifying the contribution to ENSO from the MJO as a source of stochastic forcing and 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:

We have identified interdecadal variability in the MJO and ENSO in a 160-year simulation by a coupled global climate model (CGCM). This opens a door to investigate possible connections between the MJO and ENSO on this timescale which is impossible to do using available observations. We have used the stochastic forcing derived from both global re-analyses and this CGCM to force a commonly-used ENSO prediction model (the C-Z model) and shown that the statistics of stochastically-forced ENSO are much more realistic than ENSO due to chaotic instability.

Research Performance Measure: We had not originally proposed to use the C-Z model but this opportunity has provided additional valuable physical insights to the problem at hand. Meanwhile, the proposed diagnoses of CGCM have been made as planned.

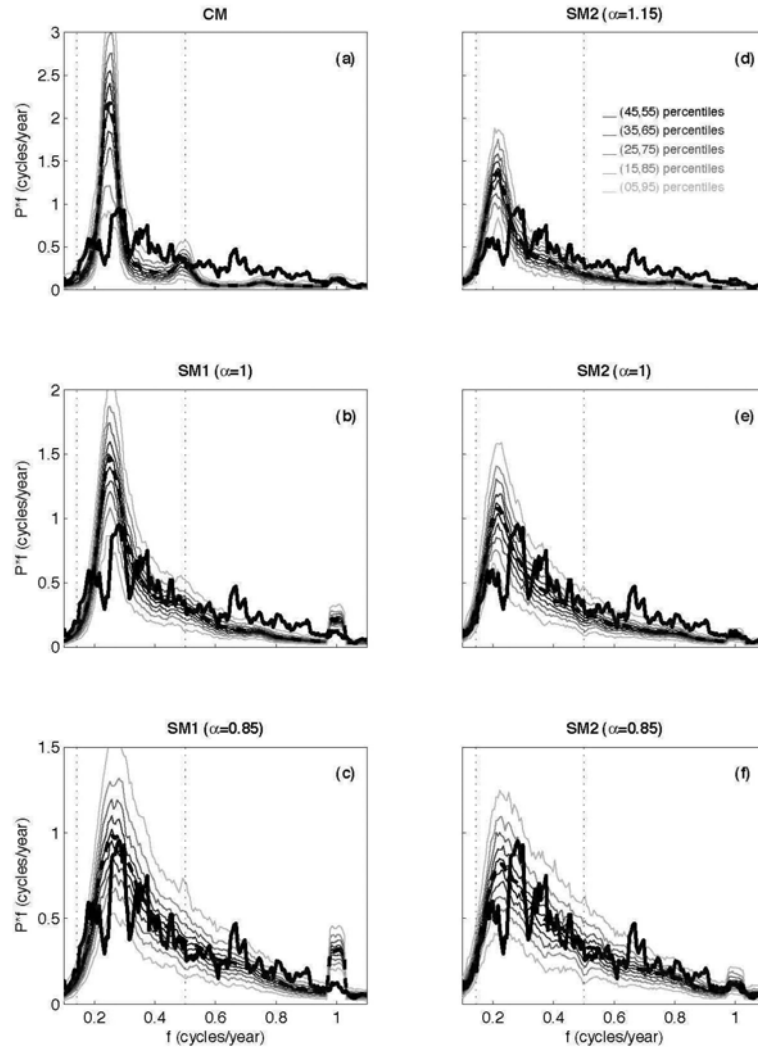


Figure 1: Ensemble estimate of variance preserving spectra of Ts for CM (a), SM1 in its neutral (b) and stable (c) regimes, and SM2 in its unstable (d), neutral (e) and stable (f) regimes. In all panels the dashed black line shows the mean and the gray lines show selected percentiles (shown in d) of the associated probabilities, and the multitaper spectral estimate from observations is superimposed (note that the vertical scale is different for the unstable, neutral and stable cases).

***Shallow Meridional Circulation and Saharan Heat Low:
Their roles in the Tropical Atlantic Variability***

C. Zhang (UM/RSMAS)

Long Term Research Objectives & Strategy to Achieve Them:

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 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:

The comparison of three global reanalyses in the context of the shallow meridional circulation has been finalized. The results summarized in a manuscript submitted to the Journal of Climate. In collaboration with State University of New York at Albany, we have started a new analysis to emphasize on the moisture transport by the shallow meridional circulation and its role in the West African monsoon. We have found that moisture transport and convergence by the shallow meridional circulation is instrumental to the monsoon.

Research Performance Measure: The research has made progress as planned.

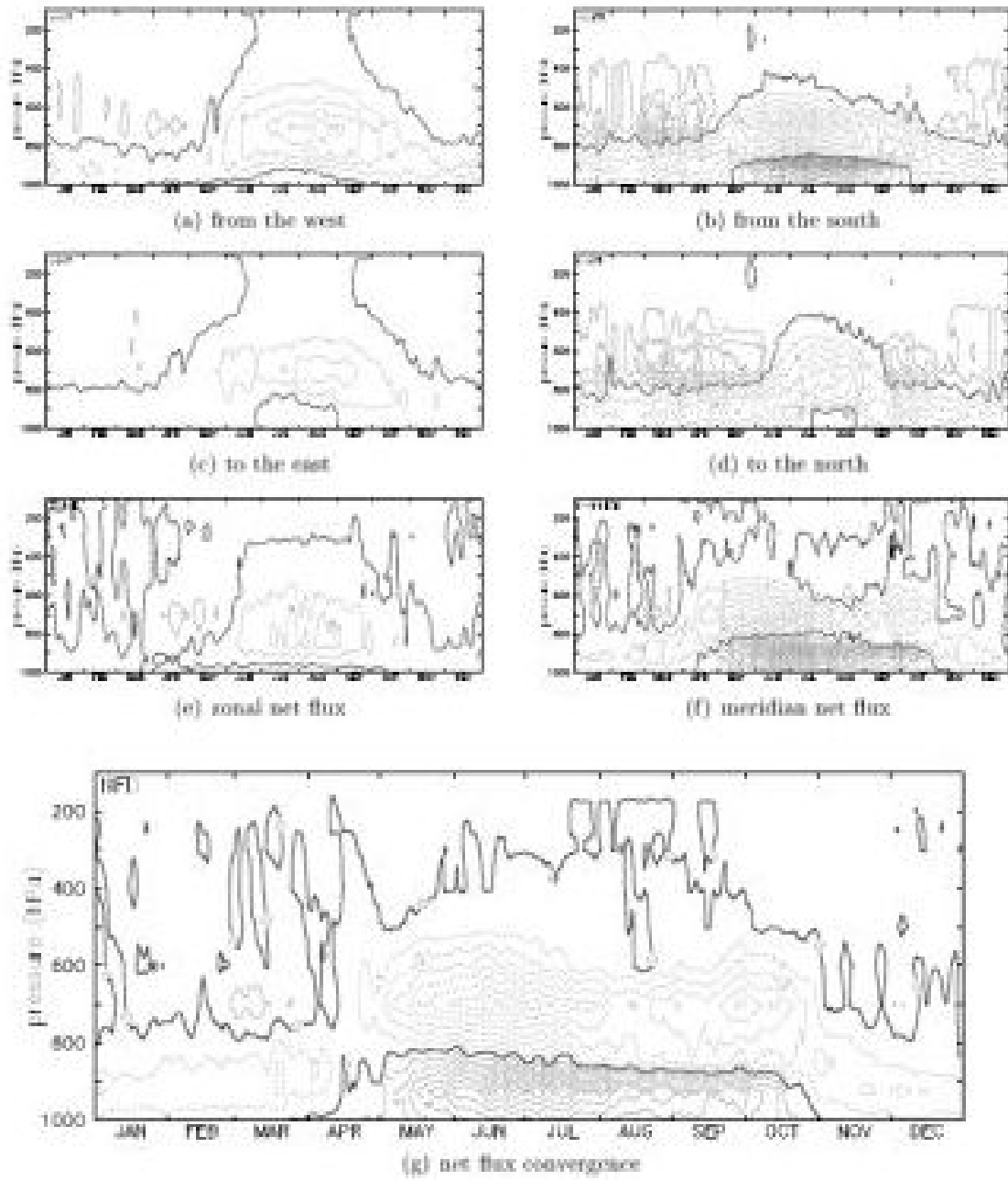


Figure 1: Seasonal cycle of ERA40 moisture flux(contour interval $1 \cdot 10^7 \text{ kg s}^{-1}$) incoming from the (a) west and (b) south and outgoing to the (c) east and (d) north through the Saharo-Sahelian region SAH (17.5°W - 15°E , $15^\circ\text{-}20^\circ\text{N}$). (e) Zonal, (f) meridional, and (g) total net flux convergence in the region.

Theme 2: Fisheries Dynamics

Coral Reef Assessment, Mapping and Monitoring Efforts in Florida, US Caribbean, and Pacific Islands

J. S. Ault, S. G. Smith and J. Luo (UM/RSMAS); M. Monaco (NOAA/NOS)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To provide collaborative and cooperative field and quantitative analytical research support for coral reef assessment, mapping and resource monitoring efforts by NOAA Biogeography Division so as to facilitate the development and refinement of protocols necessary to monitor and quantify coral reef fish community and benthic habitat changes in the coral reef ecosystems of Florida, US Caribbean and Pacific Islands.

Strategy: To employ the fisheries systems science approach we have developed and applied in the Florida Keys.

CIMAS Research Themes:

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: NOS

NOAA Technical Contact: Mark Monaco

Research Summary:

For the past decade U. Miami scientists have cooperated with various research groups in conducting large-scale synoptic assessments of coral reef fisheries and benthic habitats to explore and characterize these unique marine environments and to support management decision making. The University of Miami is an integral partner with NCCOS in research projects related to coral reef mapping and monitoring in Florida and the US Caribbean. The fisheries systems science approach that we have developed and applied in the Florida Keys has advanced the understanding of the ecological and fishery risks associated with human impacts on the sustainability of fisheries resources and habitats in coral reef ecosystems. This collaborative research effort provides the NOAA Biogeography Division with quantitative analytical support to facilitate development and refinement of protocols necessary to monitor and quantify coral reef fish community and benthic habitat changes in Florida, US Caribbean and Pacific Islands. Quantifying changes in reef fish communities and benthic habitats on a spatially explicit basis is critical for assessing future impacts of the natural and anthropogenic changes to provide a scientific basis for management strategies to build sustainable reef fish populations, coral reef habitats, and the reef fish community in Florida, US Caribbean and Pacific Island coral reef ecosystems.

New benthic habitat and topographic maps have been completed for the Florida Keys and Puerto Rico which have greatly improved sampling survey design performance and reef fishery assessments. Specifically, this collaborative research program achieved the following

goals: (1) assisted in development of benthic habitat schemes for coral reef mapping; (2) assisted in determining the accuracy of benthic habitat map products; (3) provided analytical support and develop new database products in support of coral reef fish assessment and monitoring protocols; (4) conducted quantitative analyses of the long-term Caribbean and NOAA Biogeography Division's US Virgin Islands visual census databases; (5) conducted analyses on the biogeography of reef fishes throughout Florida and the US Caribbean; and (6) coordinated the Florida scientific community in development of integrated coral reef ecosystem mapping and monitoring studies in support of NOAA's National Monitoring Program.

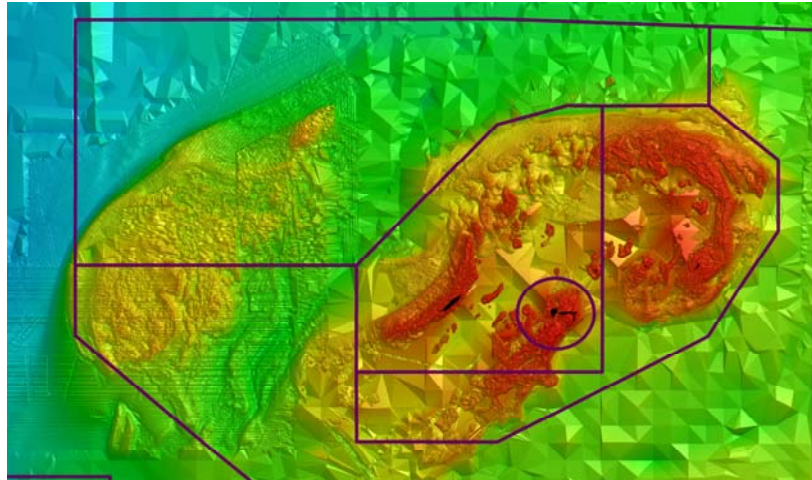


Figure 1: Integrated high-resolution bathymetric map of the Dry Tortugas

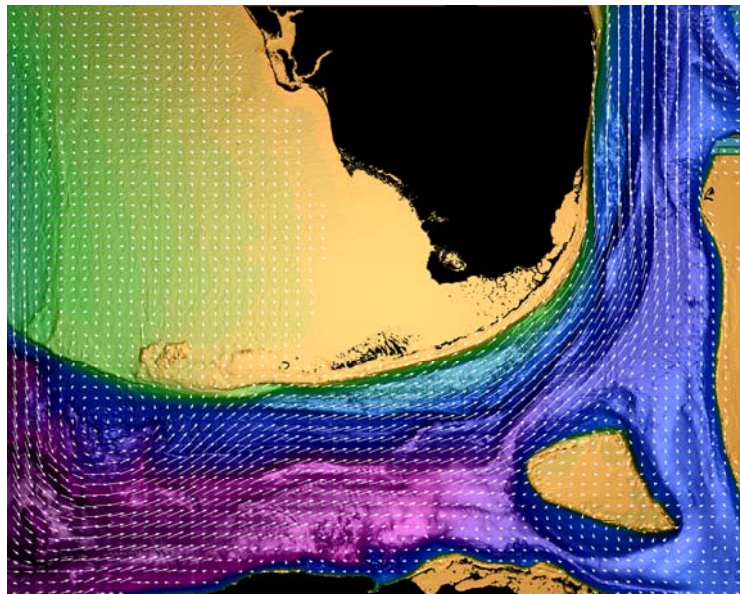


Figure 2: South Florida bathymetry overlain with ocean surface currents

Research Performance Measure: The objectives of this program are being met on schedule.

***CRES: Integrating Science & Management in the Caribbean:
Ecological and Socioeconomic Coupling***

J. S. Ault, J. Luo (UM/RSMAS); M. Monaco (NOAA/NOS)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To create a flexible decision support system for the Puerto Rican coral reef ecosystem that allows resource managers to bring together a suite of biological, physical, ecological and socioeconomic data and models relevant for spatial multi-objective management decision making.

Strategy: To use modern statistical data mining, decision theoretic, and simulation methods to facilitate synthesis and integration of biological and physical empirical research to improve spatial management for sustainability of the Puerto Rico coral reef ecosystem.

CIMAS Research Themes:

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: NOS

NOAA Technical Contact: Mike Dowgiallo

Research Summary

Work during this year's project period continued to concentrate on developing robust statistical and mathematical assessment methods for interpreting the status of exploited reef fish populations relative to federal fishery management benchmarks for sustainability and stock productivity. The work was based on interpreting length-frequency distributions of both fishery-dependent and fishery-independent data against theoretical size-frequency distributions in the absence of fishing, in a model-based approach that incorporated a suite of life-history parameters. An important aspect of this year's research was a large-scale synthesis of the scientific literature covering the past decade in conjunction with a meta-analysis of the demographic data available for the Puerto Rican snapper-grouper complex. By and large, we found that maximum age (life-time survivorship) had been increased in the literature (usually by otolith measurements) by more than 50% for most of the species re-analyzed in the complex. These increased estimates life-span have significant implications for the sustainability of reef fish resources in the region.

For the multi-species stock assessment analyses, three data sources were employed and results were cross-validated for robustness. The data sets were from the Puerto Rico TIP commercial and MRFSS recreational fisheries (representing on-going fishery dependent data sets), and the random stratified scientific sampling surveys of reef fish from the CRES (CCMA) project (representing fishery-independent data). These data were used to compute sustainability benchmarks for the exploited reef fish community in Puerto Rico.

Results (Fig. 1), although still preliminary, show that most species are over exploited or at full exploitation. This represents the first assessment of reef fish in Puerto Rico in over 10 years, and the most comprehensive to date. The model still requires some fine tuning, but when

refined will offer management a reliable new method to assess Caribbean reef fish stocks in a routine and timely manner.

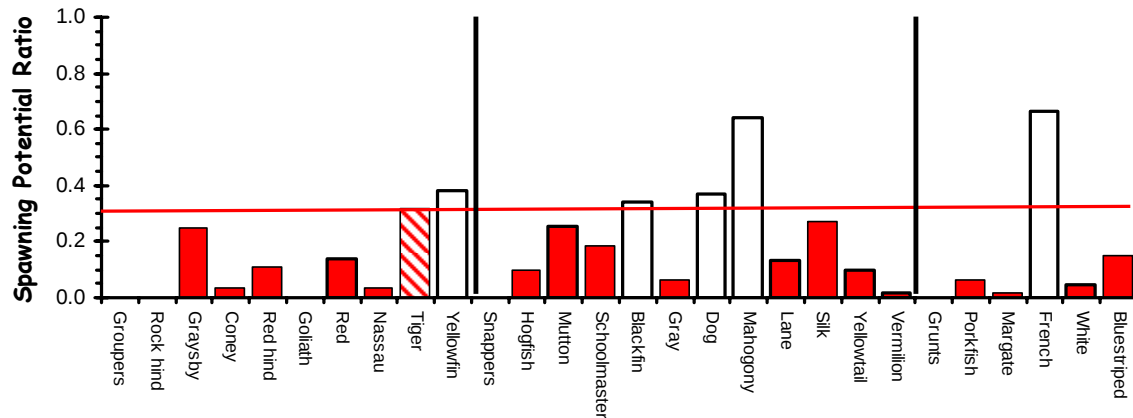


Figure 1: Assessment of the spawning potential ratio (SPR) for groupers (left), snappers (center) and grunts (right) in Puerto Rico for the period 2000-2002 from Ault et al. (2007a). A SPR lower than 30% (red horizontal line) indicates overfishing. Dark red bars indicate overfished stocks, open bars indicate stocks that are above the 30% SPR standard, and hatched red bars indicate that stocks are within $\pm 3\%$ of the SPR standard. Reliable data for red hind and goliath grouper were not available.



Figure 2: Juvenile hogfish (*Lachnolaimus maximus*) in gorgonian tendrils

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

Statistical Analysis of Existing Data towards the Application of Ecosystem-based Management in the Northwest Hawaiian Islands

J. S. Ault, S. G. Smith (UM/RSMAS); M. Chow (NOAA/NOS)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To develop a cooperative program that is focused on strategic support for the Northwest Hawaiian Island Monument and the Pacific Island Fishery Science Center for coral reef fish stock assessment and resource monitoring efforts; and, to provide critical analyses for coral reef resource data inventory, assimilation and mapping, and development of statistical sampling designs for monitoring, ultimately supporting stock assessment efforts by NOAA in the US Pacific Islands.

Strategy: To use modern methods in data mining, spatial statistics, geographical information systems and sampling design were used to analyze and assess an existing 6-year monitoring database on reef fishes, coral reefs, algae, and the physical environment collected by the NOAA Coral Reef Ecosystem Division from the northwestern Hawaiian Islands leading to development of a new robust ecosystem sampling design.

CIMAS Research Themes:

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: NMFS/SEFSC

NOAA Technical Contact: Malia Chow

Research Summary:

The NOAA Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve has recently undergone a process to designate the Northwestern Hawaiian Islands (NWHI) as a National Marine Monument (hereafter referred to as NWHI Monument). This new designation, combined with NOAA's goal to manage the use of coastal and ocean resources through ecosystem approaches to management, requires advancements to existing observing systems and analytical approach methodologies. To achieve this goal, the NWHI Monument is collaborating with NOAA Fisheries Pacific Islands Fishery Science (PIFSC) Center to undertake investigations that promote the application of ecosystem approaches to fisheries management (EAF) in the NWHI.

The PIFSC is responsible for assessing the status of deepwater snapper (hereafter referred to as bottomfish), crustacean, coastal pelagics, coral reef fish, and precious coral populations using the application of EAF in the NWHI. The fisheries management plans (FMP) for these resources require that annual stock assessments are generally conducted and published. However, no assessments have been done for any species listed in the Western Pacific Regional Fishery Management Council's Coral Reef Ecosystem FMP. Those stock assessments that have been conducted rely heavily on biased fishery-dependent data sets that lack information on important segments of the populations, which leads to uncertainty in stock assessments.

A recent surge in research activity in the NWHI has resulted in the collection of fishery-independent data to improve stock assessments; however, the quality of these data is unknown as most of the data sets have not been analyzed or subjected to formal quantitative evaluation for consistency, completeness, accuracy, precision, etc. The Fisheries Ecosystem Modeling and Assessment Research (FEMAR) group at the University of Miami, RSMAS has developed an unprecedented capability utilizing a systems science approach that stresses an applied scientific research strategy to support policy made by federal, state, and local agencies. For the past decade, FEMAR, in collaboration with state and federal partners, has been conducting large-scale synoptic assessments of coral reef fisheries and benthic habitats in the Florida coral reef ecosystem to explore and characterize these unique marine environments and to support management decision making. In this relatively new program, the NWHI Monument, working jointly with PIFSC, is working with to FEMAR to conduct the following three tasks: (1) Data Inventory. - Conduct an inventory of the existing NWHI biological and physical data resources for consistency, completeness, accuracy, and precision, including spatial and temporal resolution. (2) Data Assimilation and Mapping. - Conduct a statistical standardization of the existing data by spatial and temporal references and, if feasible, adjustment for collection biases (such as those arising from use of different sampling gears or methods) to maximize the capacity to link data sets to each other and have confidence in inferences drawn from them. (3) Statistical Sampling Design. - Evaluate statistical properties (*e.g.*, bias, accuracy, and precision) of current sampling and monitoring program designs and conduct a formal evaluation to identify cost-effective ways to improve the accuracy and precision for future sampling and monitoring designs such that those sampling regimes are responsive to the needs of decision makers (*e.g.*, track changes in abundance). The NOAA/PIFSC is supporting University of Miami RSMAS scientists in implementing interdisciplinary research on multispecies fisheries dynamics in the Hawaiian Archipelago.

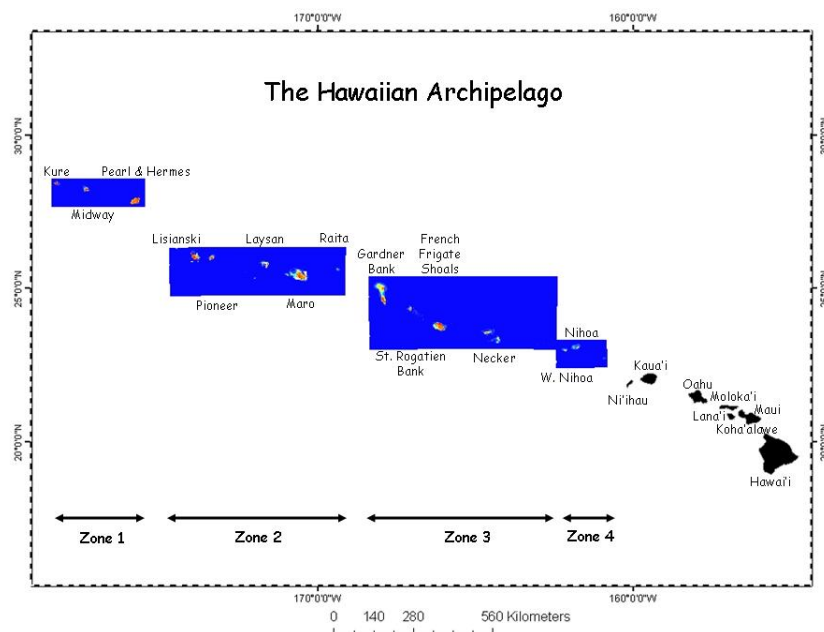


Figure 1: The Hawaiian archipelago showing the relationship of the GIS data zones for the northwestern Hawaiian Islands relative to the main 8 islands.

Research Performance Measure: The objectives of this program are being met on schedule.

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 Them:

Objectives: To augment the South Florida Ecosystem Restoration Program research by providing a comprehensive quantitative evaluation of trends in the Florida Keys National Marine Sanctuary (FKNMS) and Dry Tortugas National Park (DTNP) ‘no-take’ zones: Sanctuary Preservation Areas (SPAs), Ecological Reserves (ERs), and Research Natural Area (RNA).

Strategy: To carry out state-of-the-art multispecies assessments in the region, mapping coral reef habitats, and spatially-based monitoring of coral reef fish composition, occurrence, abundance, and size structure in the Florida reef tract to assess population changes, ontogenetic habitat associations, and ecosystem responses to fishing, recreational use, pollution, MPA zoning, and Everglades restoration.

CIMAS Research Themes:

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: SEFSC

NOAA Technical Contact: James Bohnsack

Research Summary:

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 km² that protect the high-relief coral reef; (2) one large (30 km²) ecological reserve (ER) that includes several different habitats; and, (3) 4 special-use SPAs designed for research purposes. Two large Ecological Reserves, 206 and 312 km², were added in 2001 west of the Tortugas, Florida. The NPS Service has scheduled a 100 km² Research Natural Area (RNA) for implementation in the western half of Dry Tortugas National Park in late 2006.

The main objective was to design and conduct comprehensive surveys of coral reefs and reef fish stocks along the Florida coral reef tract. Simultaneous assessment surveys were conducted of fishes, corals, conch, spiny lobster, other reef species and coral reef habitats using newly developed state-of-the-art sampling strategies. Results have been used to define current baseline conditions and to monitor future changes that result from management actions in Biscayne National Park, the Florida Keys National Marine Sanctuary, and Dry Tortugas National Park. Regionally-synoptic monitoring and assessment expeditions, led by Drs. Ault and Bohnsack, have included participation by scientists from many state and federal agencies, several universities, and a volunteer non-profit organization. Although still early in the recovery process, our results are encouraging and suggest that NTMRs in conjunction with

traditional management, can potentially help build sustainable fisheries while protecting the Florida Keys coral reef ecosystem.

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

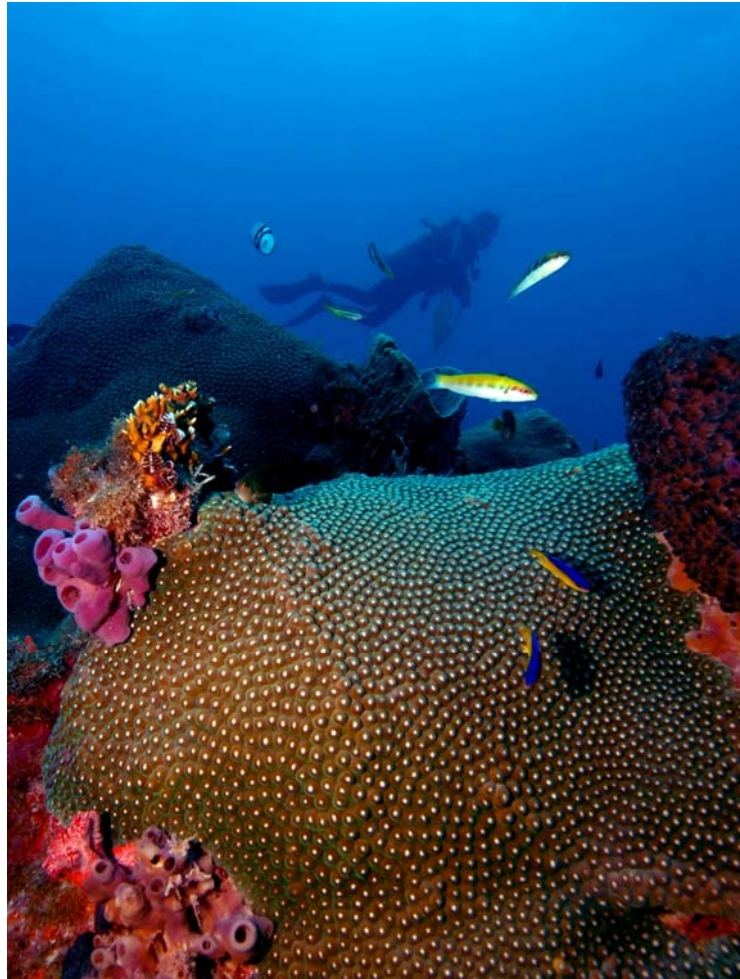


Figure 1: Reef fish visual census diver in the coral reefs of the Dry Tortugas.



Figure 2: Bar jacks swim among stony coeals in the Florida Keys



Figure 3: Creole wrasse over a reef terrace in the Dry Tortugas

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

Investigation of the Movement of Adult Billfish in Potential Spawning Areas

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

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To characterize the horizontal and vertical movement of Istiophorid billfish and other tropical pelagic fishes in potential spawning areas in the context of large marine ecosystems.

Strategy: To use electronic tags, plankton nets, and biological samples to describe habitat utilization and spawning state of subject teleosts; to describe depth of pelagic longline gear using electronic monitors and available oceanography of the study areas from the World Ocean Atlantic web site.

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

NOAA Technical Contact: Eric Prince

Research Summary:

To date approximately 252 publications have been collected in the literature review. Topics cover a wide variety of issues associated with pelagic animals and fishing but were grouped into several categories including: (1) pelagic long-line gear behavior; (2) pelagic fish habitat and (3) terminal gear experiments (circle vs J hooks). Pelagic longline gear and pelagic fish habitat parameters from previous publications will be used to report fish and gear distributions associated with the current state of knowledge.

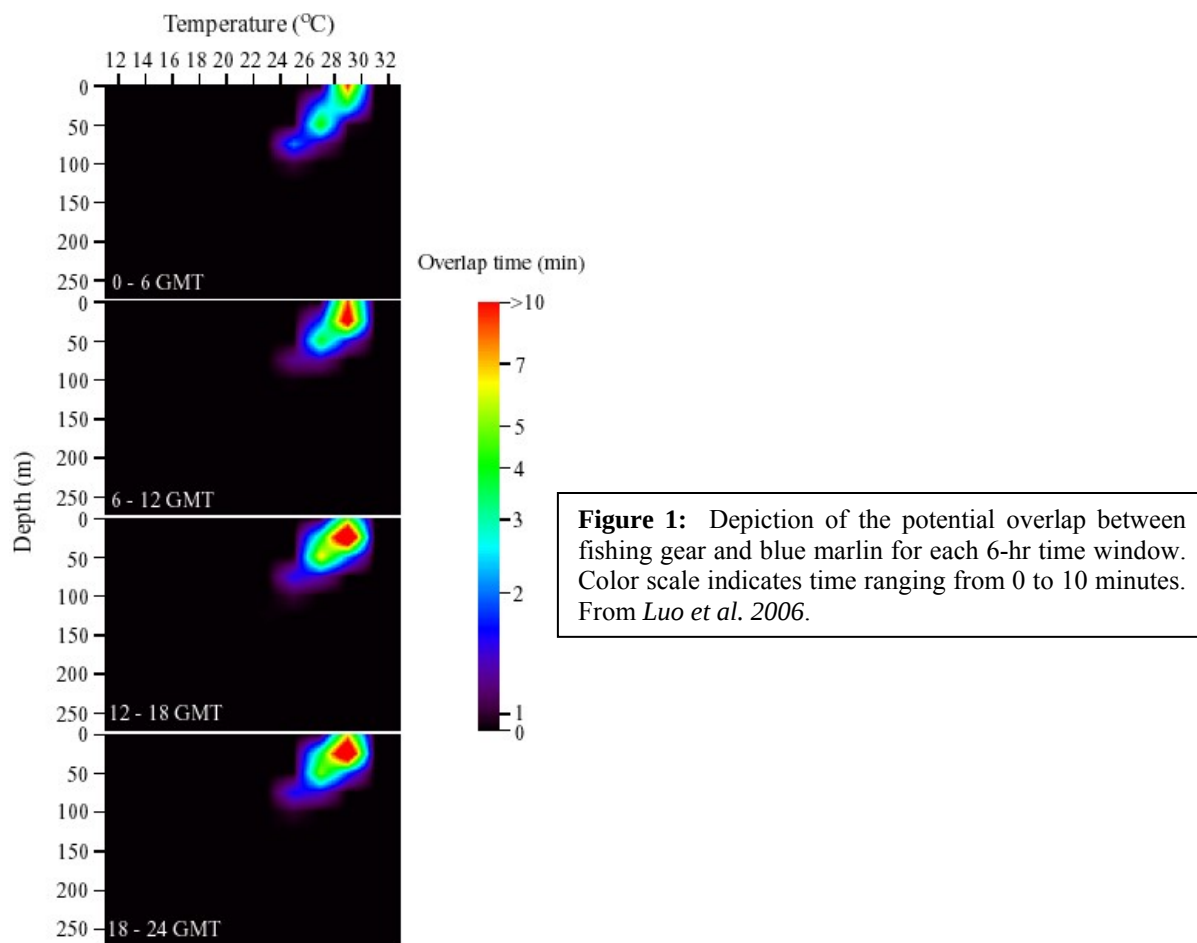
We used a combination of recreational and commercial fishing vessels to (1) catch pelagic fish known to interact with pelagic long-line fishing gear, (2) attach pop-up satellite archival technology (PSATs) to them and (3) release them back into pelagic waters to record their (horizontal and vertical) movements for periods up to 120 days. A total of over 300 fish were implanted with PSATs by the NOAA-SEFSC Migratory Fisheries Biology Branch and about 78% of the deployed PSATs reported summarized data on fish behavior via the Argos satellite system and is currently undergoing data quality control and analysis. In addition, we have recovered 18 PSAT tags that had previously transmitted a summary of data through the Argos Satellite System. As PSATs have non-volatile memory, these tags produce large volumes of biological information of extremely high resolution data when recovered and this information are currently augmenting our PSAT data base.

During April 2005, a pelagic longline research cruise was conducted in the Gulf of Mexico. Forty-three longline sets were deployed from a NOAA research vessel (Oregon II) with 100% electronic coverage (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 collected.

Ongoing research is being conducted under the auspices of the Cooperative Research Program (CRP) in the N. Atlantic and Gulf of Mexico onboard commercial fishing vessels using fishing gear monitoring electronics (i.e. TDRs and hook strike timers) and experimental terminal fishing gear (i.e. hooks) to assess impacts on catch composition, catch rates and/or fish condition. Longline cruise data are being analyzed to characterize gear movement and hook distribution in the water column and, ultimately, to determine degree of overlap with pelagic animal habitat (see Figure 1). Preliminary results indicate that hooks on longline gear generally fish shallower than predicted by presently-used depth equations.

Ongoing analysis of marlin and sailfish vertical habitat use in the Western and Eastern Atlantic sectors is ongoing relative to development of the Atlantic Habitat Compression paper. This is will result in the second of a series of papers on hypoxia based habitat compression and will form a mechanistic basis for using habitat standardization techniques of Atlantic longline catch rates.



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

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

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

Long Term Research Objectives & Strategy To Achieve Them:

Objectives: To develop a pink shrimp (*Farfantepenaeus duorarum*) simulation model and performance measures to evaluate the impact on Florida Bay of upstream water-management changes resulting from efforts to restore the Greater Everglades ecosystem.

Strategy: To carry out coordinated field experiments on the different life history stages of pink shrimp to model the population changes in the context of water quality, transport, settlement and recruitment for a better understanding of the ecology of this important fishery species.

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: Joan Browder

Research Summary:

The population dynamics of pink shrimp are strongly influenced by biological and physical processes that affect the different life history stages. Without an understanding of these processes it would not be possible to fully identify variability of the population, hampering attempts for an effective management of this fishery species and for the ecosystems of south Florida.

We have conducted a series of studies to develop an understanding of the movements of pink shrimp post-larvae into Florida Bay. Initially we sampled at channels on the eastern and western boundaries of the bay as in previous years. After observing that the flux across the western boundary was much higher and more regularly timed than that on the eastern boundary, we established a series of stations along a distance gradient from the western edge of the Bay to the center to determine the movement of post-larvae into the bay's interior. We explored the hypothesis that recruitment of pink shrimp post-larvae into Florida Bay is related to distance from the western margin of the Bay or the prevailing amplitude of the tide. By exploring this hypothesis, we addressed the question of whether the abundance of pink shrimp juveniles in the bay's interior is limited by the availability of favorable habitat, food, or the supply of post-larvae reaching the area. Contrary to our working hypothesis, we found that the concentration of post-larvae was not highest at the westernmost stations, where the tidal amplitude is highest. Rather it is highest to the east (east of Flamingo) in an area of relatively low tidal amplitude (Figure 1). However, concentrations further east in the most interior stations were extremely low. Clearly, the relationship of larval supply to tidal amplitude or distance from the edge of the bay is not linear.

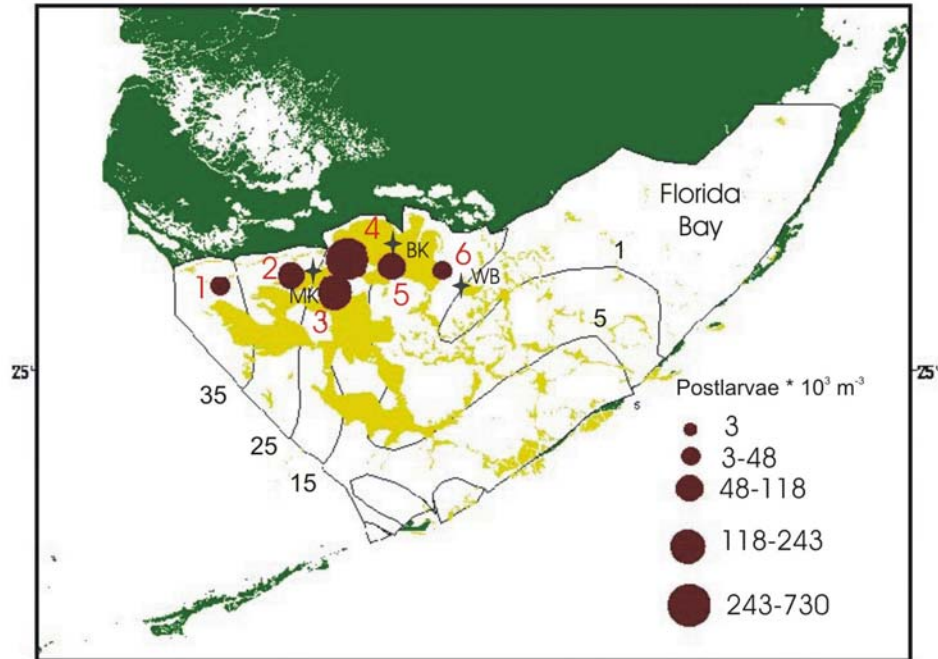


Figure 1: Tidal amplitude isopleths (cm) of the M_2 tidal constituent in Florida Bay (Smith 1997) with superimposed average concentrations of pink shrimp post-larvae collected July through November 2004 and June through October 2005 at six stations in Florida Bay. The circles sizes are proportional to the post-larvae concentrations and centered at each sampling station. The stars are Everglades National Park stations: MK=Murray Key, BK=Buoy Key, and WB=Whipray Basin.

A relevant result of our research was that the post-larval transport into Florida Bay occurs almost exclusively during the dark flood period (DFP) or “window of opportunity”. Post-larvae are active in the water column during the flood tide at night and rest near the bottom at the ebb tide. In summer 2006 we examined the post-larval transport into the bay’s interior as a function of lunar tidal stage. At the western stations, a semidiurnal tidal pattern was clearly observed, while at the interior stations the tides experienced a diurnal periodicity. Results indicated that the DFP decreases in duration moving eastward into the bay’s interior; a DFP is not evident at the interior stations during any of the four moon phases (Figure 2). These results suggested that the extremely low concentrations of pink shrimp post-larvae in the interior stations (central Bay) may be related to the damping of the semidiurnal tides with movement eastward across the bay (from MK to BK and then to WB) and the lack of a defined DFP in the Bay’s interior (BK and WB).

Another result from our research is related to the reversal in direction of migration at different life stages of pink shrimp. By means of hourly experiments during the full and new moon it was determined that pink shrimp post-larvae use flood-tide transport by positioning themselves in the water column during the dark-flood for movement up the estuary; in contrast juveniles use the dark-ebb by positioning themselves in the near surface layer to move out of the estuary (Figure 3). The number of juveniles was significantly higher during the full moon than new moon, while post-larvae were about eight times higher during the new moon than during the full moon. Thus the emigration pattern of juveniles is opposite to that of influx of the post-larvae.

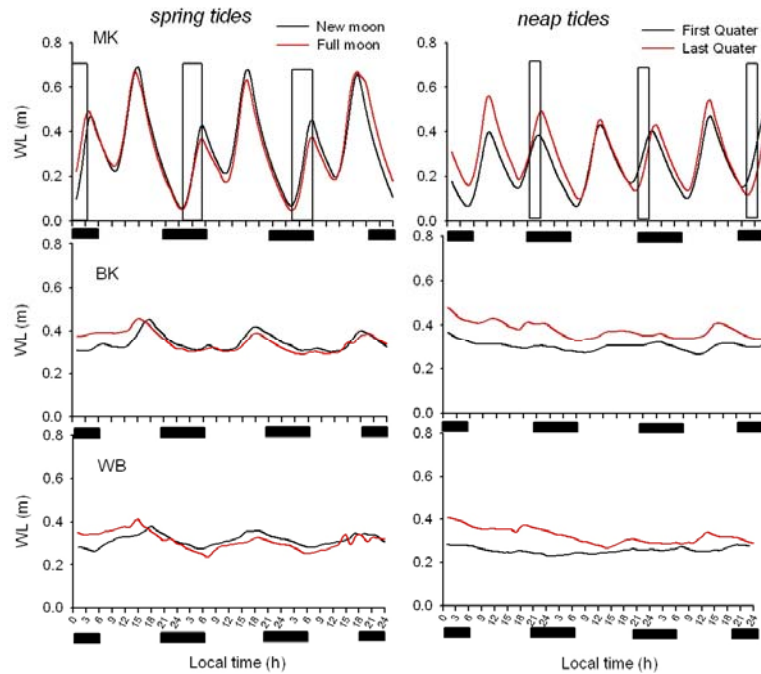


Figure 2: Hourly water levels from Murray Key (MK), Buoy Key (BK) and Whipray Basin (WB) stations on June 2005, shown separately by station and by spring and neap tides. The dark horizontal bars represent hours of darkness (from sun light) and empty vertical rectangles represent the dark flood period (DFP).

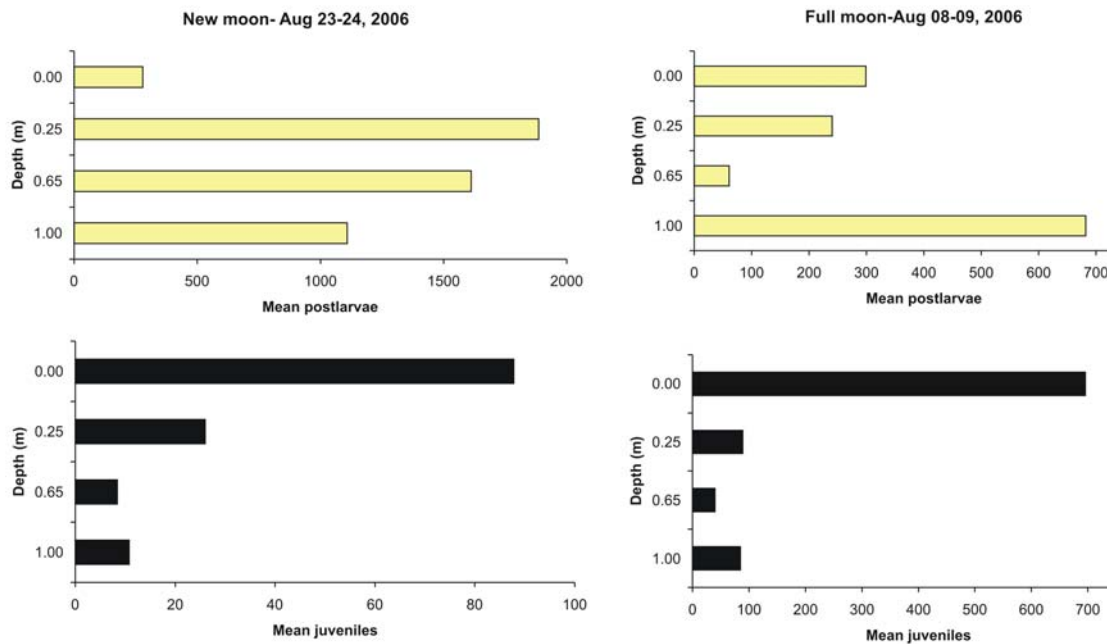


Figure 3: Mean number of pink shrimp post-larvae and juveniles collected at four depths during hourly sampling at Conchie channel during new moon (left) and full moon (right).

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

Characterization of Essential Fish Habitat and Spawning Behavior of Black Grouper (*Mycteroperca bonaci*) in the Florida Keys

D. Die (UM/RSMAS); T. Kellison (NOAA/NMFS)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To describe and quantify black grouper habitat in the Florida Keys.

Strategy: To: 1) conduct a literature review of grouper biology and habitat requirements, with particular emphasis on groupers in the Florida Keys; 2) conduct acoustic monitoring of groupers in the Florida Keys; 3) manage the database of quarterly acoustic detections; 4) analyze the acoustic data to determine home range and habitat use; 5) conduct stakeholder interviews to ascertain local knowledge.

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: NOS

NOAA Technical Contact: Todd Kellison

Research Summary:

We initiated habitat mapping efforts of Fowey and Carysfort reefs in 2004. In 2005, we purchased acoustic tags and acoustic receivers (VR2s), and upgraded our VRAP radio acoustic positioning buoys (which required training). We conducted a pilot study to assess the reliability of using the VRAP buoys in Biscayne National Park that same year. Shortly after we conducted at the Benwood wreck in Key Largo, Florida, a study to observe the distribution and spawning behavior of a suspected black grouper aggregation. Outreach to the fisher and diver communities helped us gather information about other aggregations, as well. We were then able to compare the results of our work in the Florida Keys with a related project characterizing known spawning aggregations in Providencia, Colombia. In November of 2005 we started the main acoustic telemetry study in Conch Reef, Florida Keys, and ended it in February of 2007 (making the study over a year to include two spawning seasons). We downloaded the first set of acoustic data in March of 2006 and are currently analyzing it.

In the spring of 2007 we conducted a pilot political ecology study of stakeholders to test the feasibility of the interviewing methods. During this study we interviewed dive shop employees, a charter boat captain, a fish house manager, a fish house owner and a scientist. We initiated a much larger scale interview project in June 2007, interviewing stakeholders from Islamorada to Key Largo. So far, we have interviewed more than forty people but we still require additional trips for interviews.

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

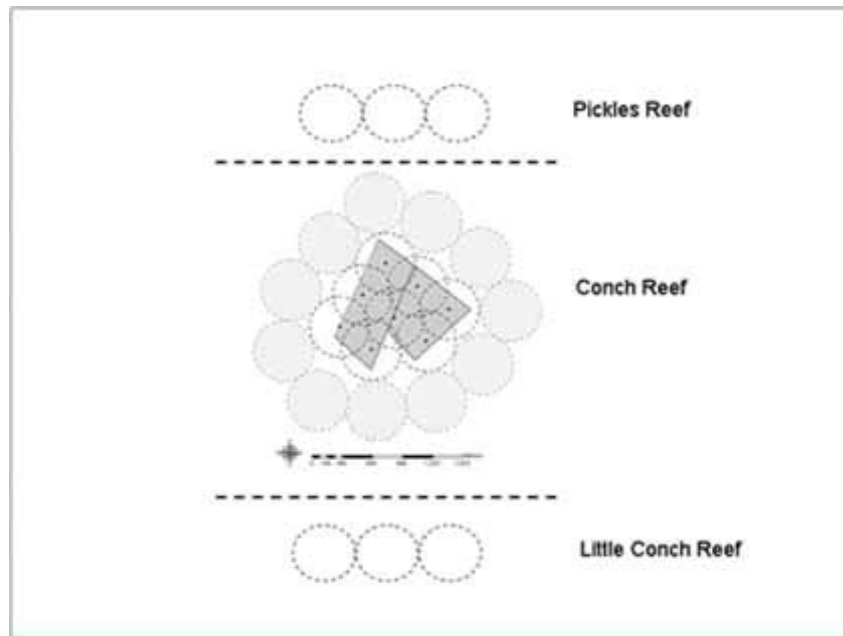


Figure 1: A schematic of the array of acoustic receivers on Conch Reef, Key Largo; each circle representing a detection zone with a receiver in the middle. The central receivers have overlapping detection areas, increasing the resolution of detection. (Drawing Courtesy of Dr. James Lindholm, PIER).

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Simulation of Management Strategies

D. Die (UM/RSMAS); M. Valle and J. Walter (UM/CIMAS);
M. Lutcavage (Univ. of New Hampshire)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To develop assessment methods for the evaluation of management strategies.

Strategy: To: 1) develop and test a simulation framework which will help determine factors that are critical in affecting the success of management strategies; 2) incorporate state-of-the-art operating and assessment models into the framework so that can be applied to the study of management strategies for highly migratory species; and 3) make the framework available to fishery scientists with different levels of modeling capabilities.

CIMAS Research Theme:

Theme 2: Fisheries Dynamics (*Primary*)

Theme 4: Human Interactions with the Environment (*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: SEFSC

NOAA Technical Contact: Gerry Scott

Research Summary:

This project has contributed to an analysis framework part of an international project co-funded by the European Union and involving fishery institutions in France (IFREMER), United Kingdom (CEFAS), Spain (Instituto Espanol de Oceanografia), Portugal (Universidade dos Açores), USA (University of Miami, University of New Hampshire) and two international fishery commissions, the International Council for the Exploration of the Sea (ICES) and the International Commission for the Conservation of Atlantic Tunas (ICCAT). Information on migration rates for bluefin tuna have been inferred from a finite-state continuous-time approach using conventional tagging data. These rates will now be incorporated into simulations to evaluate the performance of current management under different scenarios of migration rates.

A second line of work has directed its efforts towards understanding the spatial correlation of catch rates of pelagic fish and how these catch rates relate to oceanographic features such as fronts. This work has been done using observations of dolphinfish catch rates from long-line fleets in the North Atlantic and Caribbean. Additional basic fishery research has been conducted in support of the framework applications including the reconstruction of historic catch series for heavily exploited species such as Gulf of Mexico red grouper.

The framework has already been used to evaluate both theoretical and real fisheries which target highly migratory species such as the Atlantic Bluefin tuna, Atlantic bigeye tuna and Atlantic marlins.

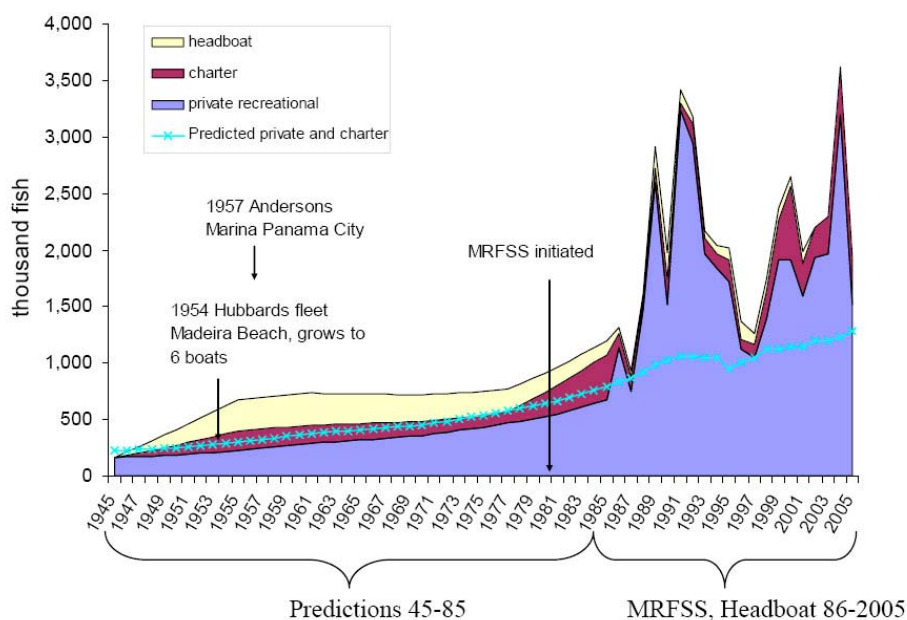


Figure 1: Total catch (A, B1 and B2) of red grouper in all recreational fisheries (thousands of fish). For years 1945-1985 catches are based upon regressions and literature estimates. For 1986 to 2005 catches are from MRFSS and the Beaufort Headboat survey. The blue line is the predicted private recreational and charter catches based upon the total number of nationally owned boats.

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

***Characterization of Escolar *Lepidocybium flavobrunneum* Catches
in the U.S. Atlantic Pelagic Longline Fishery***

D.W. Kerstetter (UM/CIMAS); E.D. Prince (NOAA/SEFSC)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To characterize the domestic escolar fishery in the United States.

Strategy: To use published literature and NOAA Fisheries logbook and Pelagic Observer Program data to describe the landings and catch characteristics for this fishery.

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:

Escolar, *Lepidocybium flavobrunneum*, is a mesopelagic teleost that occurs as bycatch in the pelagic longline fishery for tunas and swordfish. Analyses of U.S. pelagic observer program and pelagic logbook reporting data indicate that the majority of domestic catches occur in the Gulf of Mexico and the Caribbean Sea/Florida East Coast statistical areas. Catch-rates per unit effort (CPUE) were standardized with a Generalized Linear Mixed Model using a delta lognormal model approach. CPUEs and mean lengths appear relatively stable over time, although the short time-series (1996-2004) precludes conclusions prior to the peak effort in the domestic fishery. An overall increase in landings over time suggests that the fishery is retaining a greater percentage of this previously-discarded species. An additional dataset consisting of the record from one pop-up satellite archival tag attached to an escolar was also analyzed and written into a manuscript in preparation for submission.

Research Performance Measure: The program is on schedule.

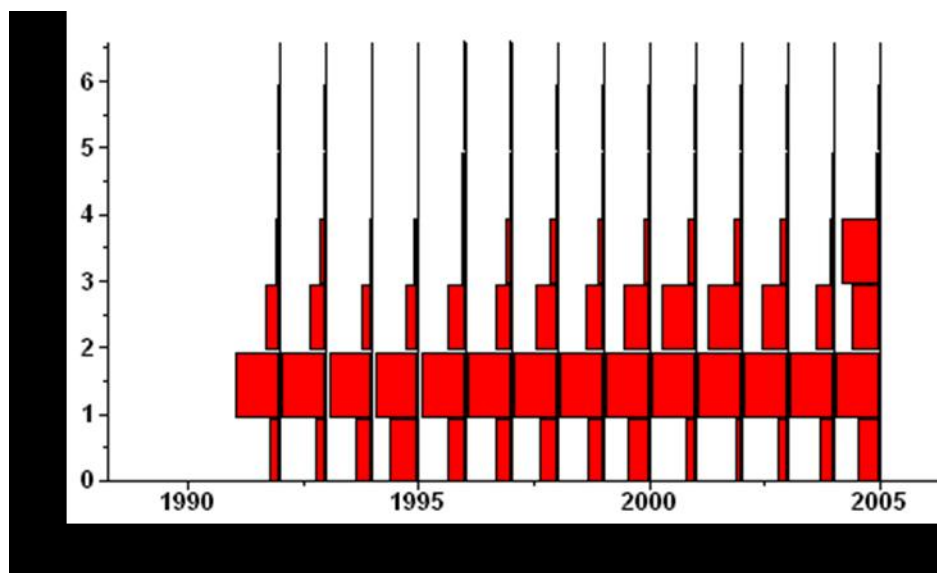


Figure 1: Results of age-slicing analyses of length-frequency data, indicating age-classes of escolar caught by the U.S. pelagic longline fishery.



Figure 2: David Kerstetter on the deck of pelagic longline vessel F/V Ark Angel with an escolar.

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

M. R. Lara and D. L. Jones (UM/RSMAS); J. T. Lamkin (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To investigate aspects of transport and settlement of fish larvae and measure physical oceanographic phenomena in order to better understand the variables involved in the transport of these organisms to the coral reef ecosystem.

Strategy: To carry out the sampling of plankton using light traps and moored channel nets and simultaneous measurement of physical oceanographic variables at reefs of the Yucatan coast.

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: Isabel Holder

Research Summary:

The aim of the study is to investigate aspects of transport and settlement of fish larvae arriving at coral reefs and to measure physical oceanographic phenomena that may be involved in this transport. We are interested in the connectivity among different regions as sources and sinks of fish larvae and the large and small scale oceanographic processes that may be acting to determine the scale of this connectivity. Specifically, we attempt to address the questions: (1) what physical oceanographic mechanisms are important in the transport of fish larvae; (2) at what scale these mechanisms come into play; and (3) what patterns of larval fish distribution do they produce? The long term goal of this research is to better understand the mechanisms of transport of fish larvae to coral reefs and their distribution, abundance and diversity. We are also using the larval specimens collected to further our understanding of the early life history of many important species. The larval and early-juvenile stages of fishes are the least known in the life cycle of most fishes and is a great source of uncertainty in the design of management plans. For the proper management of fish stocks, the design and maintenance of marine protected areas, and the establishment of essential fish habitats, we require information about 1) the identification of larvae, 2) their distribution, mechanisms of transport, supply to nursery areas, and 3) their habitat requirements.. The basis of the current study is the collection of fish larvae using moored plankton nets, settlement traps and a new design of light trap. These studies are carried out concurrently with the collection of small-scale oceanographic and meteorological data over several years at various sites near Yucatan, Mexico. This region was chosen as a model of reef fish recruitment because of the large abundance and diversity of reef fishes recruiting to the sites and the relatively pristine condition of these habitats.

Sampling of larval fish and zooplankton began in 2004 at mainly two locations, Xcalak on the southernmost coast of the Yucatan peninsula and Banco Chinchorro, an atoll and biosphere reserve off the coast. Sampling was subsequently conducted each month of the year at Xcalak resulting in an extensive collection of fish larvae. In March 2005 we conducted the first

extended sampling and monitoring study at Xcalak that involved the capture of fish larvae and simultaneous measurement of physical oceanographic properties. We obtained over 100 plankton samples using 3 different types of gear. A new light trap design was developed over the course of this study. Moored physical oceanographic instruments at our collection site have continued to collect data on current speed and direction through the present time. We returned to Xcalak for a second extended effort in August 2005. Sampling at this site has been continued by our collaborators in Mexico. Field excursions have been conducted in the summer months to sample fish larvae. We now have an extensive collection of fish larvae and zooplankton currently being sorted and various groups of both fish larvae and zooplankton have received closer study.



Figure 1: One of numerous larval seabass collected on Banco Chinchorro atoll in January 2007. This individual was grown out in the laboratory until identification to species level was possible. Harlequin Bass (*Serranus tigrinus*)

In 2006 and 2007 we extended our experiments to conduct sampling on the Banco Chinchorro atoll. As a result of a limited time series experiment using light traps in March 2006 we collected an astounding diversity of fishes and have data from a drifter showing a coincident current reversal which may have delivered these larvae. We collected late-stage larvae of several commercially important species, notably three species of groupers, and identified several other species of fishes not previously recorded for the area.. This year we conducted an extended sampling and monitoring study on Banco Chinchorro. Daily samples were collected from various points on the reef and lagoon. Oceanographic and meteorological instrumentation obtained data during the sampling period.



Figure 2: NOAA science diver samples larval fish light traps in 20 m of water off the Mesoamerican barrier reef system.

Research Performance Measure: The research program is achieving its objectives on schedule.

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

M. R. Lara and D. L. Jones (UM/CIMAS); J. T. Lamkin (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To monitor coral reef fish recruitment processes in the Florida Keys reef system and adjacent juvenile habitat.

Strategy: To use trace element analysis of the otoliths (ear bones) of fishes as a basis of estimating the contribution of various nursery habitats as sources of recruits.

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: Isabel Holder

Research Summary:

Juveniles of commercially, recreationally, and ecologically important snapper species are found in great numbers in Florida Bay. The extensive sea grass and mangrove habitats there are believed to serve as nursery areas for many fishes that later migrate to populate the reefs off the Florida coast as adults. Little is known about the nature of these nursery areas or their contribution to the reef population. Our research has focused on developing techniques that could be used to identify these areas for important reef fish species in South Florida and to subsequently identify the nursery areas used by adults collected on the reef tract.

Using inductively coupled plasma-mass spectrometry (ICP-MS) the elemental chemistry of the otoliths of juveniles from five nursery regions was resolved by establishing elemental “signatures” for each region. In this study we simultaneously analyzed 32 elements, including a suite of rare earth elements. Eight of these elements (including 2 rare earths) were found to contribute substantially to separating fishes. This is one of the first studies in which rare earth elements in otoliths have contributed to separation of fish stocks. The classification success rate in assigning fishes to the correct region of origin was 82%. Resolution of sites less than 10 km apart suggested high site fidelity in juvenile gray snapper and little mixing of water masses between sites. Five elements were important in distinguishing fish from Florida Bay. In this case, 81% correct classification to Florida Bay was found.

These otolith signatures will be used to determine the relative contribution of different nurseries to the adult population on the adjacent reef tract. A protocol was developed using a computer-controlled micromill to remove the juvenile “core” from adult otoliths. Snapper age and growth curves generated for juvenile gray snapper (separate study) were used in to determine the portion of an adult otolith formed during the fish’s juvenile stage. Work is underway extracting juvenile cores from adult snapper for microchemical analysis. These data will be used, along with the results of our previous juvenile work, to determine from which south Florida nursery area each adult originated.

In 2006 we expanded our analyses to include two additional species that co-occur with gray snapper in southern Florida: schoolmaster (*L. apodus*) and yellowtail snapper (*L. chrysurus*). This was initially done to determine whether these species could serve as proxies for gray snapper if sample sizes, for example, were too small for statistical analyses. However, highly significant differences in otolith microchemistry were found among these three snappers, indicating the existence of species-specific otolith elemental signatures. Our analyses also found both schoolmaster and yellowtail exhibited spatial distribution patterns similar to that of gray snapper. The ecological significance and management implications of finding populations of three species of juvenile snapper in southern Florida with limited migration patterns (< 10 km) and species-specific elemental signatures is the topic of our second manuscript.

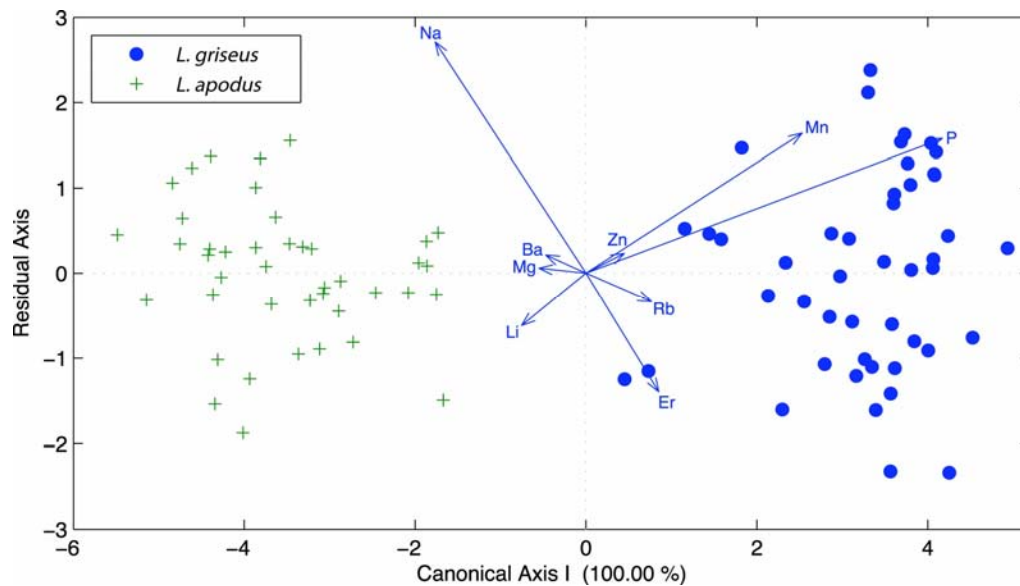


Figure 1: CDA plot comparing elemental ratio signatures in otoliths of two species of juvenile snappers collected in southern Florida. Each symbol represents an individual otolith ($n = 46$ for *L. griseus*; $n = 42$ for *L. apodus*). Biplot vectors are provided for 9 of the 27 elements screened that were found to contribute substantially to the separation of species. Canonical axis I shows the separation among species, while the residual axis displays the variability within each species. The magnitude of each vector is proportional to the standardized discriminant function coefficient of each corresponding elemental ratio, which provides a measure of its discrimination power. The heading of each vector indicates the direction of the underlying gradient of each elemental ratio.

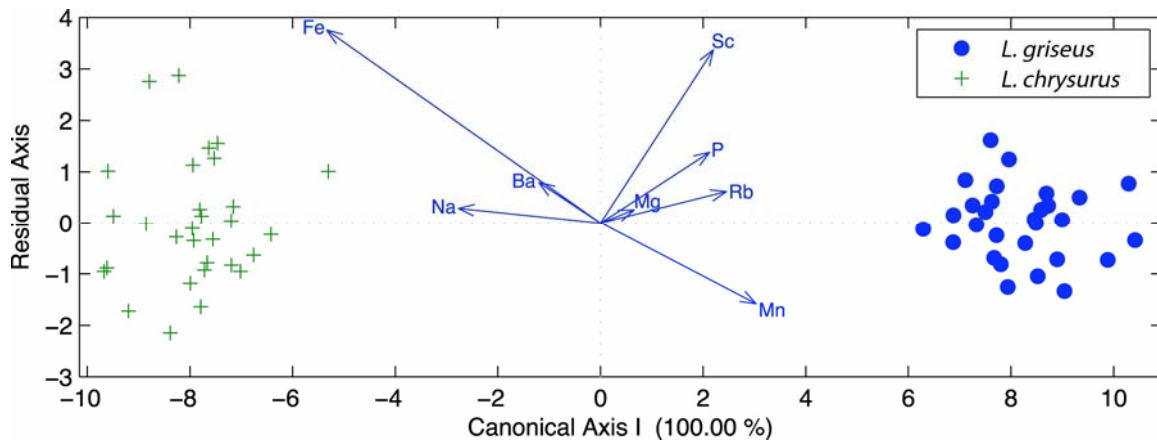


Figure 2: Canonical discriminant analysis plot comparing elemental ratio signatures in otoliths of two species of juvenile snappers collected in southern Florida. Each symbol represents an individual otolith ($n = 29$ for *L. griseus*; $n = 30$ for *L. chrysurus*). Biplot vectors are provided for 8 of the 27 elements screened that were found to contribute substantially to the separation of species. Canonical axis I shows the separation among species, while the residual axis displays the variability within each species. Interpretation of biplot vectors is explained in Figure 1.

Information on key nursery areas can help guide decisions such as where to establish Marine Protected Areas (MPAs). The long-term monitoring and effective management of these areas requires research on the links between habitats, specifically their function as sources and destinations of recruits. This is of particular importance given the recent efforts to restore Florida Bay and the establishment of the Tortugas Ecological Reserve.

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

***Settlement, growth, and migration of snappers in
Florida Bay and adjacent marine ecosystems***

M. R. Lara and D. L. Jones (UM/CIMAS); T. L. Gerard (NOAA/SEFSC)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To investigate population replenishment, habitat use, migration, and growth of juvenile stages of snapper (Lutjanidae) in southern Florida.

Strategy: To: 1) monitor the influx of larval and early juveniles using a variety of gears so as to determine spatial and temporal patterns of recruitment; 2) use daily otolith increment ageing techniques to determine juvenile growth rates; and 3) analyze geochemical composition of otoliths to assess habitat use and migration patterns.

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: Isabel Holder

Research Summary:

We examined early stages of snappers (Lutjanidae: *Lutjanus* spp.) to investigate the range of natural variability in their recruitment, how this is influenced by natural environmental variability, and what impacts ecosystem change might have on their populations. The location and timing of settlement of these fishes to nursery habitats is being determined through collection efforts monitoring their influx using a variety of gears. In the Florida Keys larvae were sampled using light traps, while early juveniles were monitored using an otter trawl; seine collections were used to track their influx into Biscayne Bay. Preliminary results indicate settlement occurred mostly in the Lower and Middle Keys (> 97% of the catch). More work is underway determining the consistency of this trend and the underlying causative agents. Variability in settlement is being analyzed in relation to lunar, seasonal, oceanographic, and meteorological phenomena in order to determine how it is influenced by local and regional environmental characteristics and their changes. This will ultimately be used to develop a conceptual model of population replenishment in southern Florida incorporating larval origin and oceanographic transport scenarios.

Previous studies on the age and growth of tropical snappers have mostly been limited to work on their adult stages. Our goal is to compare the size-age structure and growth rates of juvenile snapper across nursery habitats in southern Florida. The extent to which habitat characteristics and environmental factors (i.e., temperature, salinity, dissolved organic carbon) influence growth rates are also being examined to assess the potential impact of changes in the ecosystem on these fishes—such as that resulting from the Comprehensive Everglades Restoration Plan. Juvenile gray snapper (*L. griseus*), ranging in size from 62–275 mm SL, were aged by counting daily rings in their otoliths. Age–length curves were generated using the von Bertalanffy growth function (Figure 1) to estimate growth rates and allow prediction of age of juvenile fish based only on length data. Length-at-age data from pre-settlement larval

and newly settled juvenile stages, obtained from our work on settlement, will be used to further refine the growth model of this species.

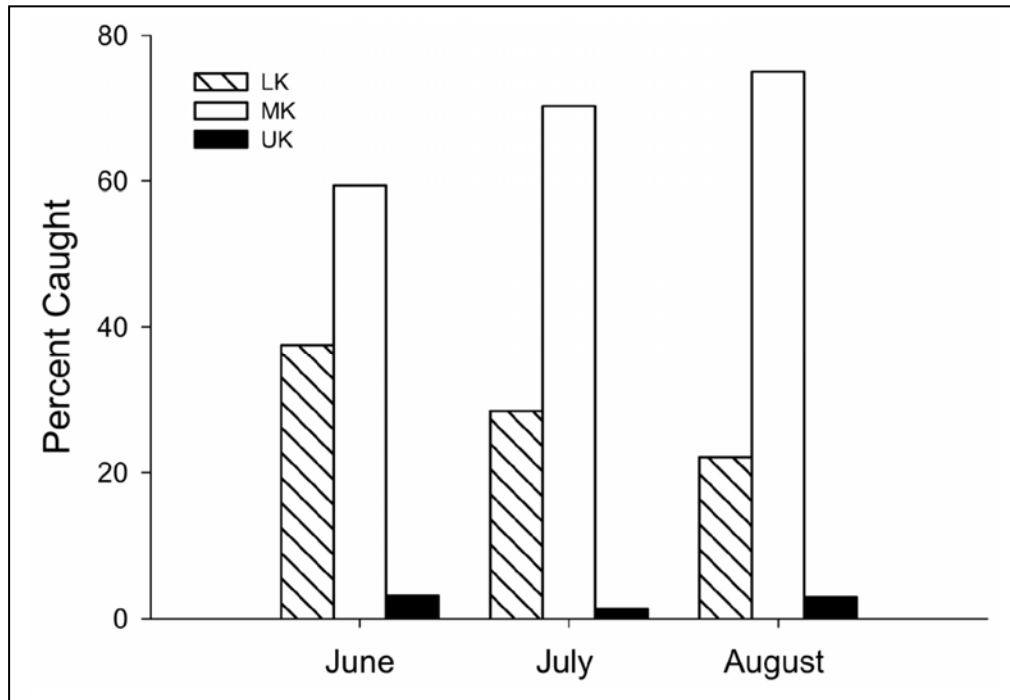


Figure 1: Percent relative abundance of recently settled juvenile snapper caught during trawl surveys of three regions of the Florida Keys; LK = Lower Keys, MK = Middle Keys, UK = Upper Keys.

The geochemical structure of otoliths record the environmental variability of the water masses fish are exposed to during growth. This allows their use as natural tags in studies of the life history, stock structure, and migration fishes. For example, otolith O_2 stable isotope ratios vary with environmental conditions (e.g., temperature, salinity), while C ratios vary with biological and ecological conditions (e.g., ontogeny, metabolic rate, available nutrient sources). The spatial and temporal variability of these ratios were examined in 330 juvenile gray snapper from southern Florida. Highly significant differences geochemistry were found among five nursery regions ($p < 0.0002$), indicating a significant spatial structure in populations here (Figure 2). Within regions, significant differences were also found among collection sites separated by as little as 10 km—indicating the spatial scale of site fidelity, the upper limit of diel migration patterns, and the level of mixing of adjacent water masses. When treated as an unknown, 80% of the fish could be accurately classified to region of origin based on otolith geochemistry. These data provide important insights towards elucidating the migration patterns and habitat use of juvenile snapper inhabiting southern Florida and hold great potential in affording managers with impacts of ecosystem change resulting from the Comprehensive Everglades Restoration Plan.

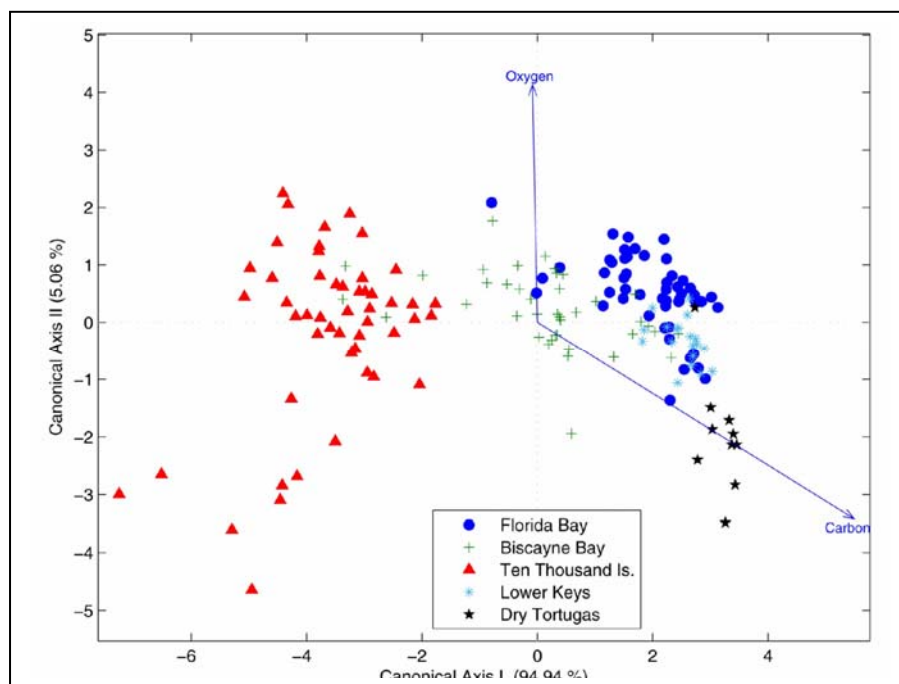


Figure 2: Canonical discriminant analysis plot depicting the spatial separation of juvenile gray snapper ($n = 169$; range = 50–210 mm SL) from 5 regions of nursery habitat in southern Florida based otolith carbon and oxygen stable isotope ratios. Biplot vectors indicate carbon, which is more correlated with canonical axis I than oxygen, is responsible for most (~ 95%) of the spatial separation.

Research Performance Measure: The program is on schedule.

Monitoring Shoreline Fish Assemblages of Biscayne and Florida Bays

J. Luo and B. Teare (UM/RSMAS); D. Johnson, M. Valle and S. Frias-Torres
(UM/CIMAS); J. E. Serafy (NOAA/SEFSC)

Long Term Research Objectives & Strategy to Achieve them:

Objectives: To continue to monitor shoreline fish assemblages as part of the Shoreline Fish Community Visual Assessment (SFCVA) effort, a component of the REstoration, COordination and VERification (RECOVER) program of the Comprehensive Everglades Restoration Plan (CERP).

Strategy: To: 1) continue the seasonally-resolved, >9-year visual fish monitoring effort; 2) expand this effort spatially to include sites in northern Biscayne Bay, Card Sound, Barnes Sound and northeastern Florida Bay; 3) perform data analyses that evaluate variability in these fish communities before, during, and (ultimately) after CERP-related changes to freshwater flow (and salinity) are implemented; and 4) correlate changes in salinity with changes in the shoreline ichthyofauna.

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 (*Primary*)

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

NOAA Funding Unit: NMFS/SEFSC

NOAA Technical Contact: Joe Serafy

Research Summary:

Sampling effort throughout the monitoring domain increased during the earliest years of fish monitoring from 33 transects surveyed in 1998, to 336 in 2002. Beyond 2002, effort was reduced to an average of 124 transects per year, with 145 during the dry season of the current year (2007). Sampling has been evenly distributed between seasons (dry, wet) over all the years sampled (1998-2007). A power analysis, based on wet and dry season fish survey data collected in 2004 was conducted to determine the minimum number of visual transects necessary to effectively monitor mean levels of taxonomic richness and dominance along four shoreline segments. These results guided the collection of new data during 2005. Specifically, we completed over 250 visual fish transects throughout the study domain during the wet and dry seasons of the current year. However, poor visibility, especially due to recent hurricane activity, had an impact on sampling distribution and intensity in northeastern Florida Bay.

In the baseline condition analyses, we took a generalized linear mixed model (GLMM) approach, to construct time series of nominal and standardized indices for taxonomic richness, taxonomic dominance, and the abundances of four fish taxa: gray snapper (*Lutjanus griseus*), great barracuda (*Sphyraena barracuda*) and two mojarras (*Geres cinereus* and *Eucinostomus* spp.). Delta-lognormal models were applied for data dominated by zero values. Standardization reduced the influence of extraneous sources of variation on each time series, yet also captured the contribution of concurrently measured habitat factors, such as salinity,

water temperature and depth, to overall variability. Mean seasonal levels, with 95% confidence intervals, of each fish metric have been generated from 1998 through 2007 and these have been plotted for the mainland shoreline and its component segments, as well as for shorelines on the leeward side of Sands and Elliot Keys.

For the (un-segmented) mainland shoreline, mean taxonomic richness, dominance and the mean densities of each fish taxon have been relatively stable from 1998 to 2007. Along the leeward key shorelines, mean taxonomic richness has remained consistently higher (and dominance lower) over the same 8-year period of record. New shoreline fish data (i.e., that for 2008 and beyond) continue to be collected and will be incorporated into our database, ultimately to serve to gauge future impacts of CERP-related modifications to freshwater flow can be assessed.

Finally, in this report, we present the properties and patterns of only six potential performance measures, which is a small fraction of the total number of potential shoreline fish community metrics in our dataset that could have utility. Evaluation of additional fish community variables is underway, thus the current suite of fish metrics is expected to grow and become increasingly important as CERP-related modifications to freshwater flow proceed.

Research Performance Measure: The objectives of this program are being met.

* * * * *

A Coupled Biophysical Approach to Fisheries Habitat in the Southeastern North Atlantic

D. B. Olson (UM/RSMAS); J. Sladek Nowlis and J. Lamkin (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To link dominate oceanographic patterns to fisheries data for a highly migratory species.

Strategy: To compare an index of the northern-most Loop Current extension into the Gulf of Mexico to catch rates of dolphinfish, *Coryphaena hippurus*, from the U.S. pelagic longline dataset.

CIMAS Research Theme:

Theme 2: Fisheries Dynamics (*Primary*)

Theme 1: Climate Variability (*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 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond (*Secondary*)

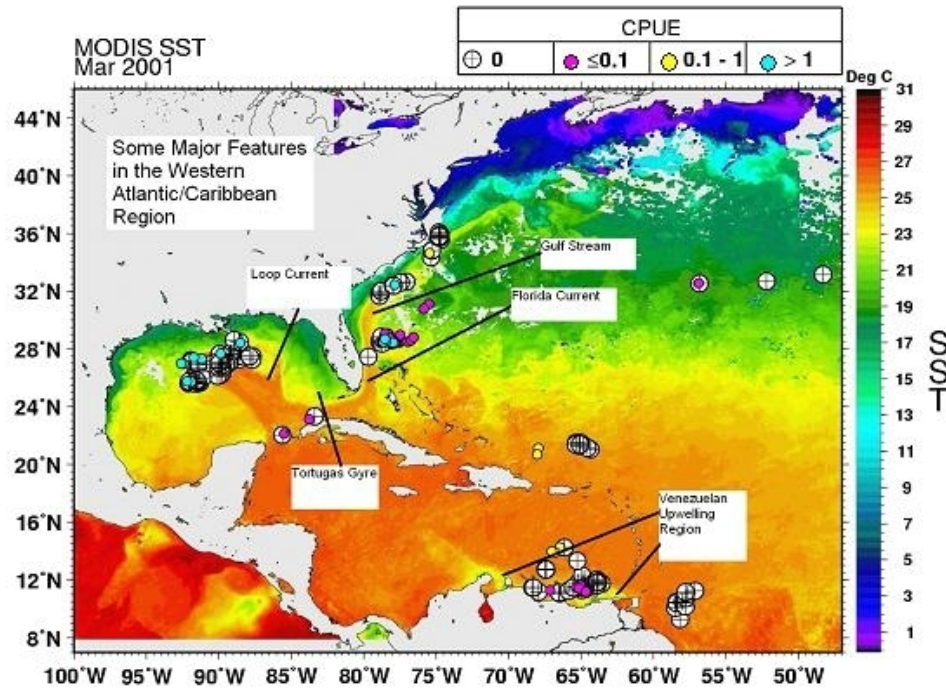
NOAA Funding Unit: NMF/Fisheries and the Environment (FATE)
NOAA Technical Contact: John Lamkin

Research Summary:

There are two dominant and semi-permanent features of circulation in the Gulf of Mexico basin: (1) the Loop Current system in the eastern Gulf with a predominately annual cycle and (2) the anticyclonic cell of circulation along the western boundary. Both are identifiable and quantifiable through the use of satellite imagery. Because these features have such a strong effect on the oceanography of this region, it is certain that fluctuations in these features have significant effects on marine population dynamics. The Gulf of Mexico supports some very diverse fisheries with fairly long time series of data. Given that the region has such a long record of both fisheries data and ocean physics makes it a potentially rich area to explore long term linkages between fisheries and climate. This work aims to identify interactions between species and the environment in terms of an index of variation, with a particular emphasis on highly migratory species, which are notoriously difficult to assess due to their inherent mobility and the fact that few fishery-independent surveys exist.

The basic temporal variations in the geometry of the surface fronts associated with the Loop Current in the Gulf of Mexico are documented using NASA MODIS sea surface temperature (SST) images from 2000 to early 2005. In the context of the fisheries data and its analysis with variables including SST described above, the following analysis is meant to provide a larger scale dynamical background in which to understand the actual physical processes that lead to observed changes in the fishery. The MODIS SST data used are eight day composite data available through the Jet Propulsion Lab (JPL). The data set consists of images starting in February 2000 when the satellite became operational to mid-April 2005 when the current work was started. The data was remapped to a Mercator grid covering the eastern Gulf at nine kilometer resolution. The fronts were then hand digitized off of the images by D. Olson. The analysis here involves a time series of northern-most Loop extension into the Gulf extracted from the digitized fronts and a description of the history of the Loop Current and its rings based on a joint comparison of the digitized fronts and the images themselves.

The northern most position of the Loop Current front is taken from the digitized fronts when the position could be discerned in the images. At times it is obscured by clouds or impossible to see the fronts due to low thermal contrast across the Gulf. The latter occurs in June and September-October when the contrast between waters coming out of the Caribbean through the Yucatan Straits and the waters in the Gulf are low due to the position of the sun. In the winter months the contrast is typically strong with Gulf waters being substantially colder than those coming into the Loop Current from the Caribbean. In summer the Caribbean is cooler than the Gulf of Mexico due to higher solar incident radiation and less Trade Wind cooling. The front during summer is also marked by the presence of strong upwelling along the coast of Yucatan and Campeche Bank. The position of the Loop Current intrusion into the Gulf is measured relative to Cabo Catoche which is a prominent cape on the northern end of Yucatan that is easily seen in the imagery. The northern most extent of the Loop is given in kilometers north of the cape. The east/west location of the northern-most intrusion is also measured in kilometers to the east (positive) or west (negative) of Cabo Catoche. Precision of the location of the points is good to within 7 kilometers based on resampling of the data. The overall accuracy of the data is limited to somewhat less than this by the 9 kilometer resolution of the data.



Map of the SST from the MODIS satellite in March 2001. Major frontal features of the western Atlantic are distinguishable from the temperature gradients. White circles containing crosses represent zero CPUE of dolphinfish. Pink, yellow, and blue circles represent increasing CPUE of dolphinfish respectively. Note the presence of fishing in the proximity of frontal features.

Initial analysis of the data in comparison with longline catch and down stream conditions in the Straits of Florida suggest significant influence of Loop Current frontal development with larger scale habitat modifications. A statistical analysis of dolphin fish catch in comparison with SST, frontal position, and bottom depth shows significant interrelationships. A working hypothesis that the inter-annual variations in fish catch is related to the changes in the configuration of the Loop Current is now being tested. The goal is to produce a fisheries/climate index based on the interrelationship. Preliminary inter-comparisons between changes in the Loop Current and warming events on the Florida Reef track are also promising. The latter has possible implications to bleaching events and recruitment in the reef system.

Research Performance Measure: The major objectives of this research are being met and research is on schedule.

Costs and Earnings Study of Commercial Stone Crab and Spiny Lobster Fishermen in Florida

M. Shivilani (UM/RSMAS)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To collect demographic, revenue, variable and fixed cost, capital investment and other auxiliary information about the commercial trap fisheries for stone crab and spiny lobster.

Strategy: To use a stratified random-sampling strategy to conduct a costs-and-earnings study with a set percentage of stone crab and spiny lobster fishermen.

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: NOS/SEFSC

NOAA Technical Contact: Jim Waters

Research Summary:

The objective of the proposed work is to collect demographic, revenue, variable and fixed cost, capital investment and other auxiliary information about the commercial trap fisheries for stone crab and spiny lobster. This project builds upon an existing University of Miami project to survey commercial fishermen in the Florida Keys. Using a stratified random sampling strategy, the project targets the completion of approximately 150 voluntary, in-person interviews from a total of 488 participants in Miami-Dade County and western Florida.

The research team, comprised of Shivilani, Waters, and a University of Miami graduate student, developed an eight-page questionnaire that consists of sections concerning general, socio-demographic information, economic information, fishery effort and landings information, and regulatory performance information. The research team submitted the questionnaire for approval for implementation to the Office of Management and Budget (OMB) in January 2007, and the agency approved the submission at the end of June 2007.

In July 2007, the research team finalized a sampling strategy that would lead to the completion of 150 voluntary, in-person interviews by targeting four, key counties that comprise a majority of the stone crab and spiny lobster landings outside of the Florida Keys; the counties are Miami-Dade, Collier, Pinellas, and Citrus Counties. The latter three counties are located along the western Florida coast, from the southwest up to the Florida panhandle (see Figure 1 below for the study region). As per the sampling strategy, additional surveys are to be conducted in adjacent counties in western Florida, which the research team will complete in conjunction with the key county surveys. The research team has determined a sampling period of three months (mid-July to mid-October) to coincide with the closed months of the stone crab season (mid-May to mid-October).

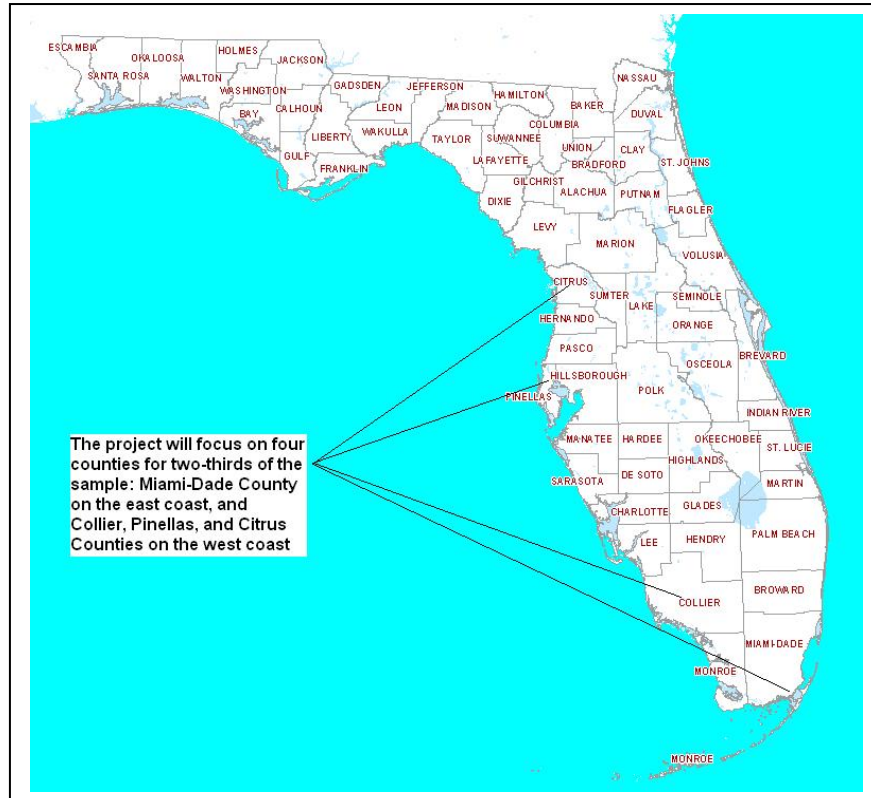


Figure 1: Map of Study Area.

The research team, under the direction of Waters, developed a stratified sample for the population of 488 participants, based on high (equal to or greater than 5,000 pounds in landings of stone crab claws) and low volume (less than 5,000 pounds in landings of stone crab claws). Under this sampling scenario, the research team will conduct a proportion of its in-person interviews in each of the aforementioned, four counties, based on total landings per county, as well as additional surveys in adjacent counties.

The research team had decided to employ a three-staged approach to conduct in-person interviews: the first stage consists of mailing an introductory letter to the entire population of stone crab and spiny lobster fishermen in the region informing the group of the study and its objectives; the second stage involves a telephone call to randomly selected fishermen from the population to request that the fishermen participate in an in-person interview; and the third stage includes travel to the site and the completion of the in-person interview.

Research Performance Measure: The implementation of the program was delayed due to delayed approval of the questionnaire by OMB. We expect to make rapid progress over the next three months of the field session (i.e., after the close of the season).

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/SEFSC)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: 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.

Strategy: To monitor the distribution of bottlenose dolphin populations in Biscayne Bay; to observe their role in the south Florida ecosystem and the impacts of human activities on them.

CIMAS Research Themes:

Theme 2: Fisheries Dynamics (*Primary*)

Theme 3: Regional Coastal Ecosystem Processes (*Secondary*)

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: 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 to detect any large-scale changes in bottlenose dolphin abundance and to establish 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 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. This involves a remote biopsy-sampling study 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 and ultimately, understanding the consequences of anthropogenic influences on the bottlenose dolphin population in Biscayne Bay.

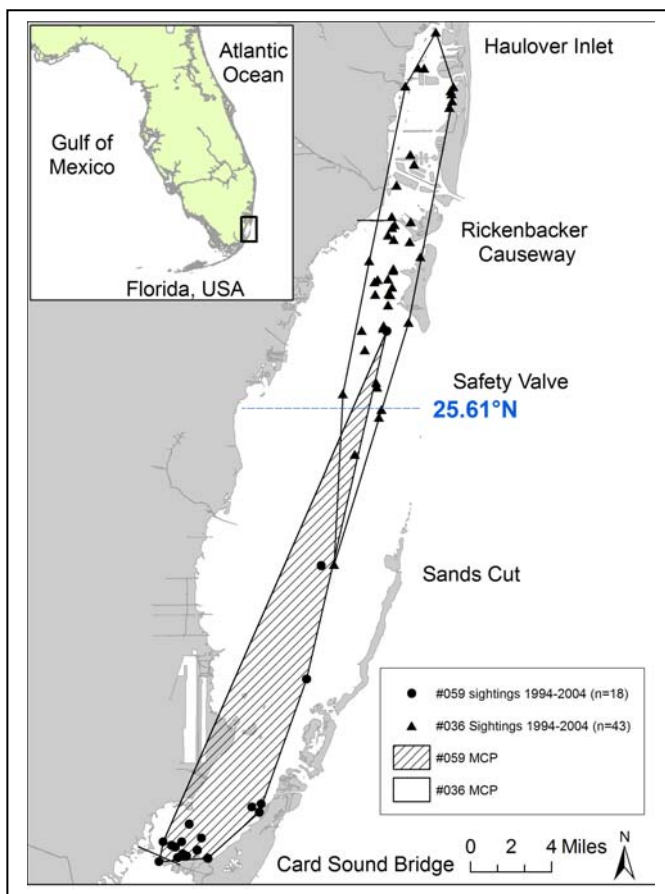


Figure 1: Sightings and minimum convex polygon home ranges of two different dolphins (059 and 036) for a ten year period

Research Performance Measure: All major objectives have been met with the Biscayne Bay Photo-Identification project.

Theme 3: Regional Coastal Ecosystem Processes

Quality Control and Interpretation of Environmental Data

P. Glynn and D. Manzello (UM/RSMAS)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To characterize trends in environmental data in the Florida Keys coral reef areas; to interpret the data in terms of the health of the corals in this region.

Strategy: To quality control and interpret environmental data gleaned from 1992 to present from seven monitoring stations in the Florida Keys (the SEAKEYS network); to extend these studies to data from current and planned stations at other coral reef areas throughout the world (the Integrated Coral Observing Network (ICON)).

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: NOAA/AOML

NOAA Technical Contact: James C. Hendee

Research Summary:

We seek to understand the factors that impact on the health of corals in the Florida reef tracts and in other regions of the world. To this end we are establishing long-term time series of environmental parameters in the Keys. This involves gathering the data and checking the data for quality.

Completeness reports are compiled for each station for each year and are archived in metadata reports. Completeness reports list the availability of each parameter (e.g., sea temperature, salinity etc.) for that year. Once the completeness report is finished, metadata files are then emailed to and stored by NOAA's Coral Reef Information System (CoRIS). Annual data files are then uploaded to the Integrated Coral Observing Network web site (<http://ecoforecast.coral.noaa.gov/>) where they can be accessed by the general public.

ICON and SEAKEYS data have been quality controlled and archived to the present time. Metadata for each site is now served by CoRIS through 2006. Two studies have been completed. One develops coral bleaching indices and thresholds for the Florida Reef Tract, Bahamas and US Virgin Islands. A second focuses on hurricane associated cooling and amelioration of coral bleaching.



Figure 1: Time-series of bleached coral (*Colpophyllia natans*) at Coral Gardens, Florida Reef Tract. (A) Pre-bleaching (11 August 2005). (B) Bleached (6 September 2005). (C) Nearly recovered (9 November 2005). (D) Recovered with normal pigmentation (2 March 2006). Note: Copyright of figure belongs to *PNAS* and may be used only if credited to *PNAS*. (From Manzello et al., 2007).

Research Performance Measure: This program is achieving its goals on schedule.

Epifauna along the Western Shoreline of South Biscayne Bay and the Potential Influence of Salinity on Distribution and Abundance

D. S. Hazra, J. Tomoleoni and H. Cardenas (UM/CIMAS); J.A. Browder and T. L. Jackson (NOAA/SESFC); M. B. Robblee (USGS/CWRS)

Long Term Research Objectives And Strategy To Achieve Them:

Objectives: To characterize the epifaunal community of nearshore Biscayne Bay and relate distribution, abundance, and community characteristics to salinity, bottom vegetation, and other potential influencing factors.

Strategy: To conduct a twice-yearly (dry season and wet season) spatially intensive sampling activity along the western shoreline of South Biscayne Bay and analyze the data to relate epifaunal attributes to salinity.

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&SF). Now a plan is underway to restore, through both structural and operational changes to the C&SF Project, some of the lost or diminished ecological function of the Greater Everglades, including South Biscayne Bay. 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 nearshore epifauna and 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. This report is part of the continuing baseline characterization study and covers the first year of epifaunal collections along the shoreline. The project study area is the shallow area immediately adjacent to the mainland along the southwestern shoreline of Biscayne Bay between Matheson Hammock and the south side of Turkey Point. Sampling was conducted with a 1-m² throw-trap. Salinity, temperature, and bottom vegetation data were collected at each site. Bottom vegetation cover (i.e., seagrasses, macroalgae) was estimated visually (Braun Blanquet).

Catches at the 47 sites consisted of 1,110 fish in February, 655 (59%) of which were rainwater killifish (*Lucania parva*), and 1,650 fish in August, 1,381 (84%) of which were rainwater killifish. The increase in total fish from dry season to wet season was due solely to the increase in rainwater killifish. The total number of individuals of other fish species was lower

in August, however more fish species were caught in August than in February. Fifteen fish species were represented in the February catch, whereas 19 fish species were represented in the August catch. Other than rainwater killifish, the most abundant fish species in February catches were code goby (*Gobiosoma robustum*) (158), Gulf pipefish (*Syngnathus scovelli*) (113), and clown goby (*Microgobius gulosus*) (70). Next to rainwater killifish, the most abundant species in August were Gulf toadfish (*Opsanus beta*) (136), followed by goldspotted killifish (*Floridichthys carpio*) (62). Four species were found only in the dry season, eight were found only in the wet season, and 11 were common to both seasons. More pink shrimp (*Farfantepenaeus duorarum*) were caught in the dry season than the wet season, 189 vs. 101. More hermit crabs were caught in the dry season, 159 vs. 70. More caridean shrimp were caught in the dry season, 3,653 vs. 640.

Some plots of occurrence (MeanFreq) and concentration (PosMean) of dominant species (Fig. 1) show a convex parabolic relationship of mean frequency and/or mean density to salinity, which suggests a salinity optimum within the salinity range plotted (e.g., both dry- and wet-season pink shrimp, rainwater killifish, and silver jenny, and dry-season Gulf pipefish and clown goby). Other plotted curves appear hyperbolic, flat, concave, or exponentially increasing or decreasing.

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 constancy of other variables such as water depth and cover made this approach feasible. Additional data from continuing sampling will strengthen the results.

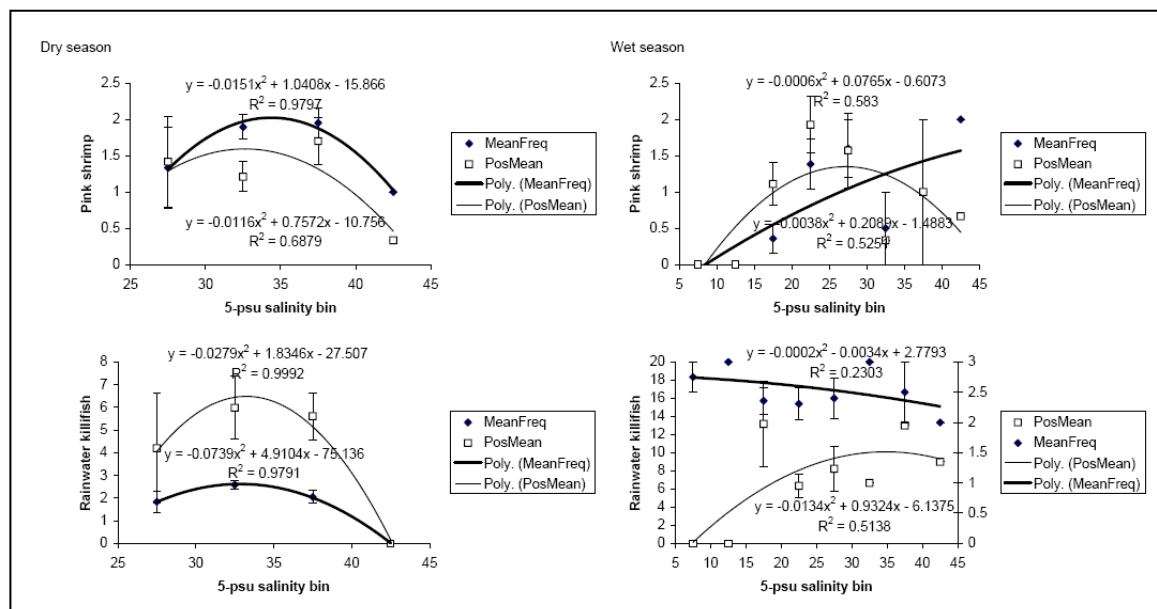


Figure 1: Mean frequency (MeanFreq) (max=3) and mean of the positive means (PosMean), by 5-psu salinity bin, for six common species, 2005 dry (Feb.) and wet season (Aug.) (mean freq. is upper equation).

Research Performance Measure: The collection of data is on schedule, but analysis of the data is behind schedule, partly because of a change in staff (the loss of Destiny Hazra).

Interdisciplinary Surveys of Western Florida Bay and Connecting Waters of the Gulf and Atlantic for FY2006

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

Long Term Research Objectives & 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 obtain hydrographic data in the study region during cruises on *R/V Walton Smith*..

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes (*Primary*)

Theme 1: Climate Variability (*Secondary*)

Theme 6: Integrated Ocean Observations (*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 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 (NOS/IOOS)

Research Summary:

Western Boundary Time series 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 Straits cable transport is especially critical and is used as a benchmark validation by all the global coupled ocean-atmosphere climate models. This project provides the hydrographic data required to verify the cable transports and as such is absolutely critical to maintaining the continuity and inter-comparability of the long term record (see Figure 1). 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 Figure 2). 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 2).

Research Performance Measure: All objectives were met.

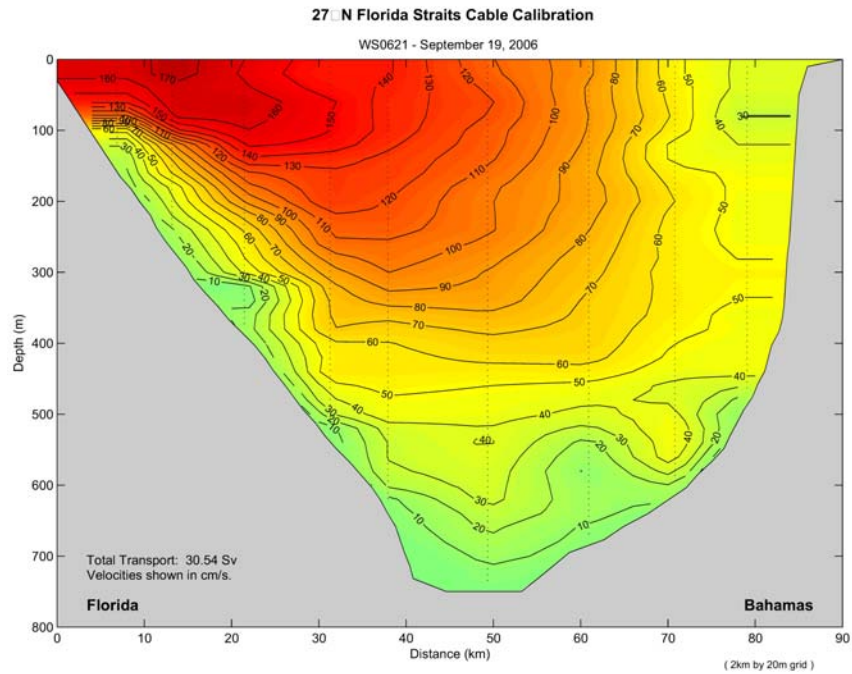


Figure 1: Florida Straits Transport for Cable Calibration calculated from Hydrographic Section taken by WG Smith.

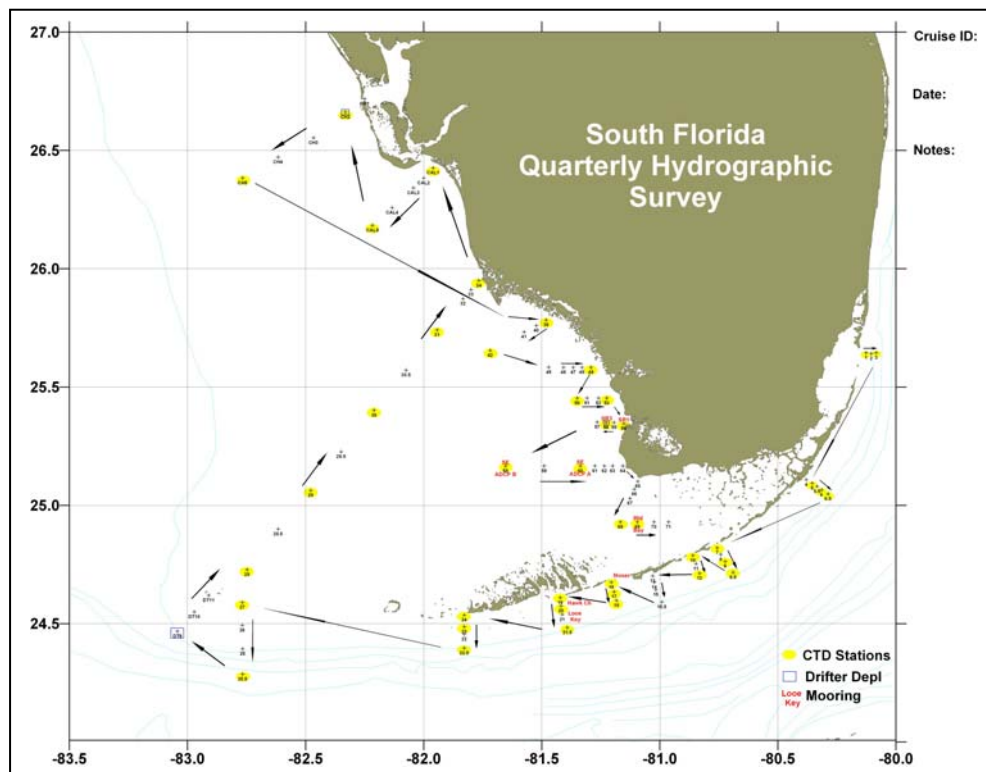


Figure 2: South Florida Quarterly Hydrography Survey Tract including mooring locations and drifter deployment sites.

Sediment-Water Exchange of Dissolved Organic Phosphorus in Florida Bay

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

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To quantify the partitioning of organic phosphate at the sediment/water interface in Florida Bay.

Strategy: To carry out systematic experiments to quantify sediment characteristics with respect to organic P exchange, including the distribution coefficient, and buffering capacity of sediment at ambient temperature and salinity.

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: NOS

NOAA Technical Contact: Jia-Zhong Zhang

Research Summary:

We have found exchangeable phosphate content in the sediment governs the overall sediment inorganic phosphate sorption behaviors, whereas amorphous iron oxides content in the sediments plays a secondary role, becoming important only in sediments that are poor in phosphorus. However, our multiyear monitoring of Florida Bay waters has demonstrated that bay water contains a very low concentration of dissolved inorganic phosphate (10-100 nM). The dissolved organic phosphorus (DOP) can be an order magnitude higher than dissolved phosphate, dominating dissolved phosphorus pool in the water column. On the other hand, our study on the fractionation of sedimentary P pools by a sequential extraction technique reveals that 60% of exchangeable sediment P is in the organic form, indicating that the dissolved organic P in bay water is reactive in adsorption/desorption processes at sediment/water interface. 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. This study is an ongoing process, currently focusing on different type organic phosphorus and sediments from different areas of the Bay.

In addition to sorption process at sediment/water interfaces, organic phosphorus also undergo hydrolysis to break down to phosphate that is bioavailable. We have found that the hydrolysis rate was related to the sediment composition. Further study is underway to reveal the factors influencing the rates of organic phosphorus hydrolysis.

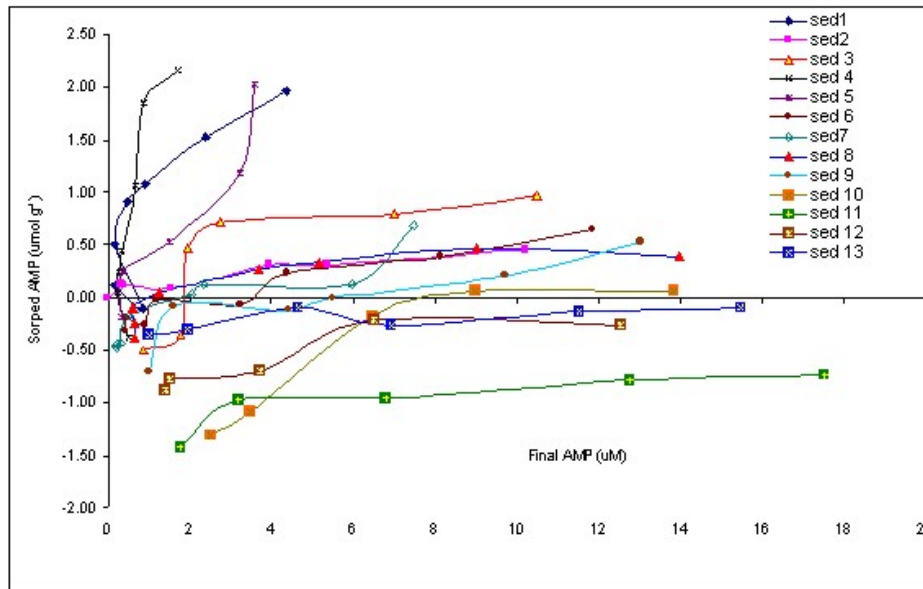


Figure 1: Typical AMP adsorption isotherms of sediments across sedimentary P gradient along the northern coast (station 1-13) in the Florida Bay. There are significant differences between the eastern bay and the western bay. Equilibrium AMP concentrations are given on the x-axis. The amount of organic P sorbed or desorbed from sediments during the sorption experiments are given on y-axis.

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

* * * * *

SFP 2004: Transport and Exchange of Florida Bay Interior Waters

T. N. Lee (UM/RSMAS); N. Melo (UM/CIMAS);
E. Johns and R. Smith (NOAA/AOML); N. Smith (HBOI)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To understand Florida Bay interior basin water renewal processes and salinity changes and to improve prediction of the effects of modifying fresh water supply to the Everglades as part of Everglades restoration plans.

Strategy: To analyze, describe, and understand the results of recent observations of salinity variability and water transports between major sub-regions of Florida Bay during wet and dry seasons.

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 (*Primary*)

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

Research Summary:

The objectives of this project are to identify the primary physical processes controlling water renewal and salinity variability within the inner basins of Florida Bay and their interactions with connecting regions of the southwest Florida shelf and Florida Keys. This information is needed to aid calibration and verification of hydrodynamic models for prediction of the impact of future changes in water deliveries to the Everglades and Florida Bay as part of Everglades restoration projects.

Our earlier studies showed a vigorous exchange between the western basins and the surrounding regions driven by tide and wind forced transports. The exchange of Rabbit Key basin waters with the southwest shelf caused considerable freshening of the western basins with Rabbit Key basin waters consistently fresher than waters of Twin Key basin. All channels displayed significant mean outflows in both basins. In Rabbit Key basin the interior circulations were a mixed response to tide and wind forcing, but in Twin Key basin they were primarily wind driven. This indicates strong frictional dampening of the semi-diurnal and diurnal tidal wave by the shallow Twin Key Bank separating the two basins as the water moved into the basins from the Gulf. These results clearly show that shelf and oceanic transport of Shark River discharge and riverine inputs from the west Florida coast southward to the western Florida Bay region can have a considerable effect in moderating the development of hypersalinity in Florida Bay.

In the current year we concentrated on analysis of data and publication of results from the northeast subregion of Florida Bay (Fig. 1). This region receives approximately 75% of the direct freshwater runoff to the bay, most of which is retained within the subregion (Fig. 2). Thus, in contrast to the results of the processes studied in our previous year's study, this input of fresh water has little impact on the dilution of hypersalinity development in adjacent subregions.

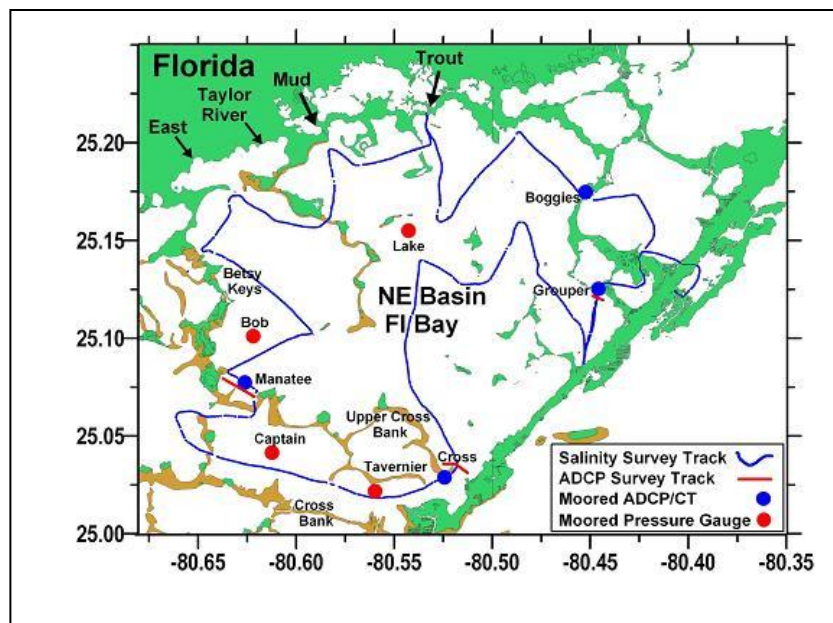


Figure 1: Location of northeast basin measurement stations for the wet season of 2002 and dry season of 2003: blue circles indicate current, temperature and salinity stations; red circles identify bottom pressure stations; ACP transport transects are shown with red lines and vessel salinity survey track with a blue line; estuarine creeks and small rivers discharging freshwater directly to the northeast basin are indicated by black arrows; shallow banks are light brown.

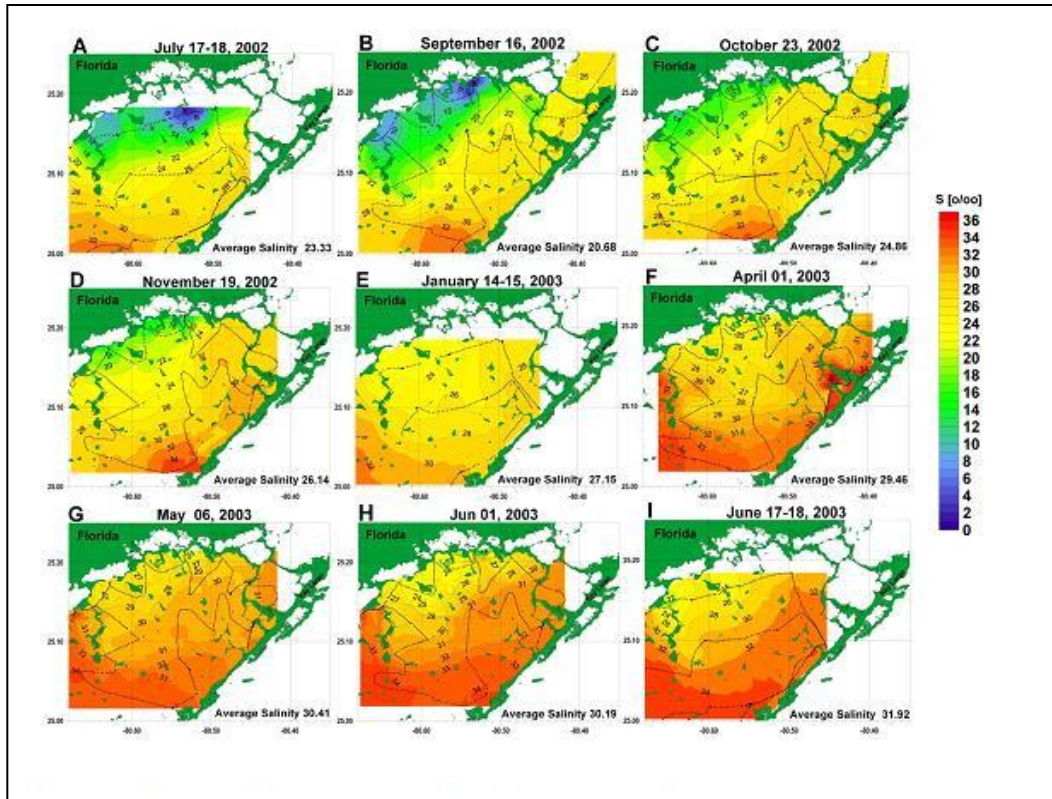


Figure 2: Northeast basin surface salinity from surveys of the *r/v Virginia k* using continuous underway measurement for (A) Jul 17-18, (B) Sept 17, (C) Oct 23, and (D) Nov 19 of the 2002 wet season: and (E) Jan 4-15, (F) Apr 1, (G) May 6, (H) Jun 1 and (I) Jun 1 of the 2003 dry season. Vessel track is shown with a dotted line. The basin spatially-averaged salinity is given at the lower right of each panel.

Research Performance Measure: All operational and scientific project objectives are being met.

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

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

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To determine the circulation and water property patterns within Florida Bay and surrounding coastal waters on “event” to inter-annual time scales and quantify the current natural variability in these parameters. This will result in a capability to quantify 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 incorporate these results into the SoFLA-HYCOM model.

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes (*Primary*)

Theme 6: Integrated Ocean Observations (*Secondary*)

Link to NOAA Strategic Goals:

Goal1: 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: Peter Ortner

Research Summary:

The Comprehensive Everglades Restoration Plan (CERP) is the largest and most expensive ecosystem restoration ever attempted. The primary goal of CERP is to restore the quantity, quality, timing, and distribution of freshwater to as close to historic levels as feasible in the greater Everglades Ecosystem. These activities are likely to have a significant effect on the downstream coastal ecosystem. The effect of CERP on the coastal ecosystem is an area of specific to concern to NOAA, because this ecosystem supports a large portion of south Florida’s economy and the affected region includes the Florida Keys National Marine Sanctuary and the Rookery Bay National Estuarine Reserve. The exact effect on the coastal ecosystem remains unclear and some have hypothesized that the end result could be eutrophication. This concern along with similar ones has resulted in CERP adopting an adaptive management plan, 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 order to effectively implement CERP with the capability to adaptively manage restoration in response to changes in the coastal ecosystem 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. This is essential to provide a baseline condition and thus the capability to accurately assess the effect of CERP on the south Florida coastal ecosystem.

This long-term research project has been multi-disciplinary and wide-ranging, although the underlying focus is to understand the coastal ecosystem's natural variability. 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 enabled the development of a predictive, mechanistic model to estimate light attenuation (Fig. 1). The long term variability in salinity was examined to determine the impact of meteorological phenomena on the physical environment of Florida Bay (Fig. 2) and partition the sources (precipitation, runoff, and evaporation) of salinity variation throughout the different sub-regions of Florida Bay (Fig. 3). When this knowledge was combined with information on circulation in Florida Bay it was possible to suggest a method to mitigate the magnitude, extent, and duration of hypersalinity in north-central Florida Bay. Understanding the natural variability of the system will result in the capability to develop sound working hypotheses regarding the effect of CERP projects on the water column of the adjacent coastal ecosystem. The development of testable hypotheses will provide a rigorous way in which to assess CERP's effect on the coastal ecosystem and provide the feedback necessary to successfully implement CERP's adaptive management component.

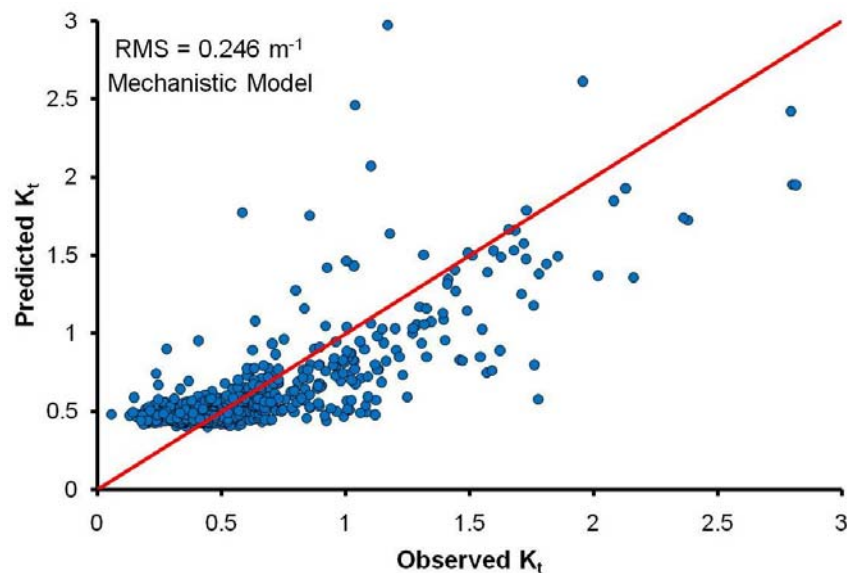


Figure 1: Scatter-plot of observed light attenuation (K_t) values versus the values predicted by the mechanistic model.

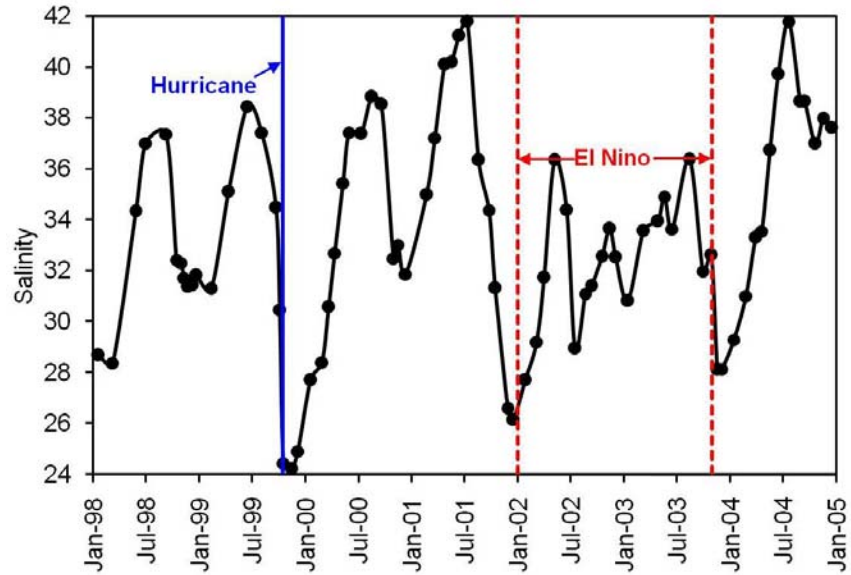


Figure 2: The time-series of mean salinity in Florida Bay indicates the bay-wide salinity is significantly affected by tropical cyclones and El Niño.

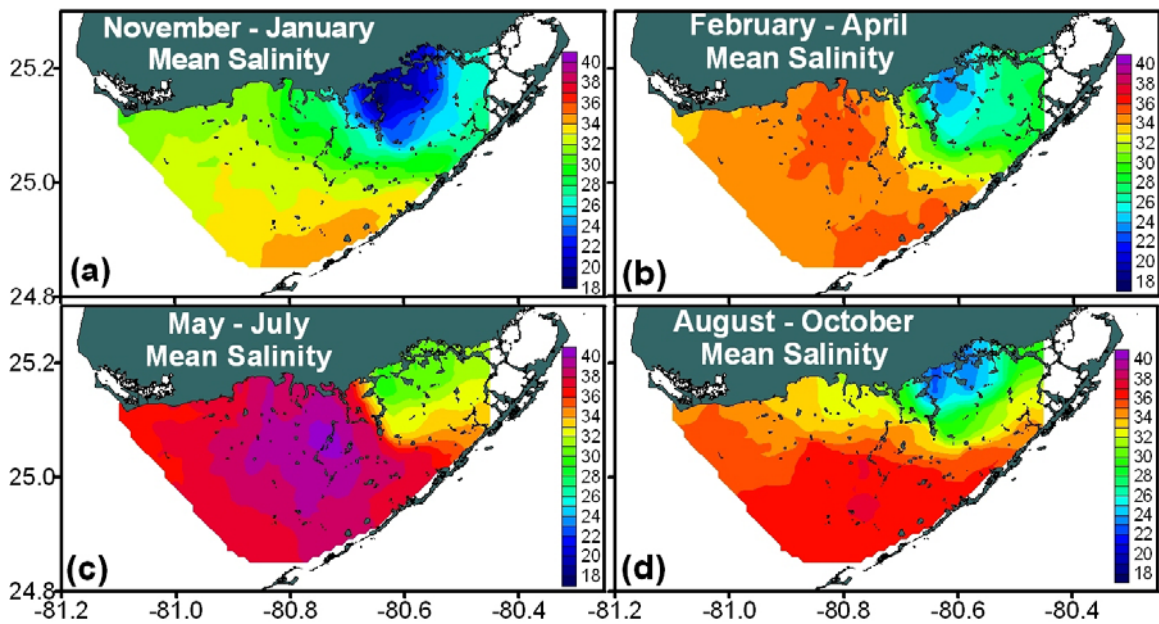


Figure 3: Contour maps of the mean spatial salinity distributions for each season in Florida Bay.

Research Performance Measure: All objectives are being met.

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); Gustavo Goni (NOAA/AOML)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To study the processes that influence circulation and nutrient transport in the South Florida coastal seas, with an emphasis around the ecologically important areas of Florida Bay and the Florida Keys.

Strategy: To further develop 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, in order to perform simulations that include all relevant coastal processes that affect circulation around the South Florida ecosystems with implications on nutrient transport.

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes (*Primary*)

Theme 6: Integrated Ocean Observations (*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: NOS

NOAA Technical Contact: Larry Pugh

Research Summary:

The regional South Florida Hybrid Coordinate Ocean Model (SoFLA-HYCOM) domain was first used for additional experiments and further analysis of an existing inter-annual simulation during 1999-2002 (performed in SFP2004). A set of moored and ship-board observations was available for this period and provided a good basis for comparison to modeled fields. The results show that the model currents compared well with observations on the Southwest Florida Shelf. The NOGAPS 1.0 deg. wind forcing was adequate for the simulation of wind driven currents, but considerably underestimated wind magnitude during tropical storms and hurricanes. In general, model and observed currents were highly correlated with no obvious phase shift. However, the HYCOM currents had persistently higher magnitude, despite tests with changes in vertical resolution and bottom friction. We presume that simulations with tides might reduce sub-tidal currents. High frequency riverine inputs from a hydrological model and the specification of a line source of river inputs along the SW Florida shelf greatly improved the modeled salinity fields. The model currents compared less favorably with the observations along the Florida Straits, as eddy passages and the proximity of the Florida current front were not represented accurately in the model. Therefore, we employed data assimilative boundary conditions to reduce such errors.

In order to improve the coastal to offshore interactions in the Straits of Florida, fields from larger scale Gulf of Mexico (GoM-HYCOM) simulations that include data assimilation were employed for the SoFLA-HYCOM boundary conditions. The Navy Coupled Ocean Data Assimilation (NCODA) system is a fully three-dimensional multivariate optimum interpolation system that uses a volume formulation that permits several thousand observations located in the same region to be processed simultaneously. Free-running and NCODA simulations with

the Gulf of Mexico GoM-HYCOM model have been performed for 2004-2005. Using independent ocean color satellite data, we have shown that the position of the Loop current and the associated frontal eddies are more accurate in the NCODA simulations (Fig. 1).

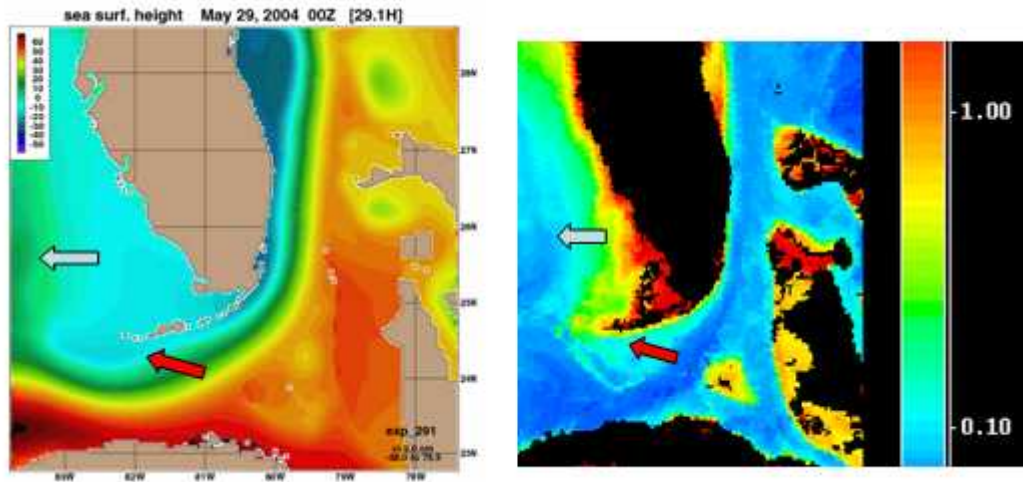


Figure 1: (Left) Model computed Sea Surface Height with NCODA boundary conditions depicting the Loop Current (blue arrow) impinging in the SoFLA-HYCOM model domain and an eddy (red arrow) in the Straits of Florida on May 29, 2004. (Right) Ocean color (Acquachla, provided by V. Benzon, UM/RSMAS) image composite for the week of May 24-31, 2004 depicting the same characteristics of Loop Current and eddy positions.

A series of SoFLA-HYCOM simulations have taken place with different atmospheric forcings (NOGAPS 1 degree resolution and COAMPS 27 km resolution) and with boundary conditions from the Gulf of Mexico GoM-HYCOM model and from the North Atlantic NA-HYCOM model. The NOAA-AOML cable data at 27°N have been employed as a validation tool and analysis of model and measured time series is under way.

The SoFLA-HYCOM simulations have helped explain observations within Florida Bay related to intrusions of low salinity waters of regional river origin from the Southwest Florida shelf. Such an intrusion was documented in the winter of 2005, when a long lasting freshening of Florida Bay waters was observed during the dry season. The model simulation demonstrated that this was due to a strong event of northerly winds in late fall of 2004, which initiated the transport of large amounts of low salinity waters from the Ten Thousand Island river influenced area to the western Florida Bay.

Research Performance Measure: The research is progressing according to the project planning.

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

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

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To quantify the contribution of new ocean observing systems to the quality of coastal nowcasts; 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 hindcast and forecast synoptic and mesoscale/submesoscale variability.

Strategy: To develop a nested system of: 1) a high resolution coastal model in an area of strong coastal to offshore interactions and strong land-sea interactions (Northern Gulf of Mexico) and 2) a regional (Gulf of Mexico) model and to perform numerical simulations that represent the coastal dynamics with enough accuracy (as validated through observations) to enable Ocean System Simulation Experiments (OSSEs).

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes (*Primary*)

Theme 6: Integrated Ocean Observations (*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: OAR

NOAA Technical Contact: John Cortinas

Research Summary:

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 during the first year period has focused on numerical simulations that study river plume dynamics, satellite data products and simulation of seasonal variability and extreme events in the GoM-HYCOM domain.

As a first step to understand and model the dynamics of the Mississippi River buoyant plume, idealized domain numerical experiments with the Hybrid Coordinate Ocean Model (HYCOM) have been performed. This is an important evaluation of model performance on the

representation of such a large buoyant discharge and the factors that influence the plume development and evolution.

Analysis of satellite data has focused on the monitoring of (a) the Yucatan Straits Current, a key component of the Meridional Overturning Circulation; (b) sea surface temperature and heat content, which are upper ocean variables critical for tropical cyclone genesis. A long time series of sea height anomaly (proportional to the heat content to a depth that usually goes from the mixed layer to the upper one or two hundred meters) has been produced. This time series indicates that this signal has a very long period (not seen in the sea surface temperature observations) that suggests a warming of the upper layers from 1998 to mid 2005. Preliminary results from a time series of sea height residues (sea height anomaly referenced to the monthly means) also reveals that the Gulf of Mexico has been experiencing a constant cooling of its upper layer waters since mid 2005.

Free-running and data assimilative simulations have been performed with the regional Gulf of Mexico (GoM-HYCOM) model for 2004-2005. An extreme event simulation (September 10-17, 2004) focused on Hurricane Ivan which impacted the entire GoM region and made landfall in the Northern Gulf, within the NGoM-HYCOM model region. This simulation employed the NOAA-AOML HWIND product that provided the necessary details in the atmospheric fields during the hurricane passage. The oceanographic features present during Ivan are illustrated in the simulated sea surface height (SSH) field at the time of maximum coastal storm surge (Figure 1). The Loop Current (LC) followed a medium-amplitude intrusion into the eastern GoM while the strong, previously-detached Warm Core Ring (WCR, indicated by high SSH) was located to the northwest. Two smaller cold-core rings (CCRs, indicated by low SSH) were also present, one located northeast and the other to the southeast of the WCR. The largest cooling during the simulation exceeded 5°C and occurred within the two CCRs. This result is confirmed by the SST cooling pattern observed in daily SST images derived from microwave satellite sensors, specifically the TMI/AMSR-E fusion product (Figure 1). The 17 September image was chosen to represent post-Ivan conditions because the largest cooling in the northern GOM was observed on this date. Overall, there is good agreement between the satellite measurements and the simulation in both structure and magnitude of the large-scale cooling pattern. The impacts within the coastal NGoM model domain will be studied in the next project period.

Research Performance Measure: The research is progressing according to the project planning.

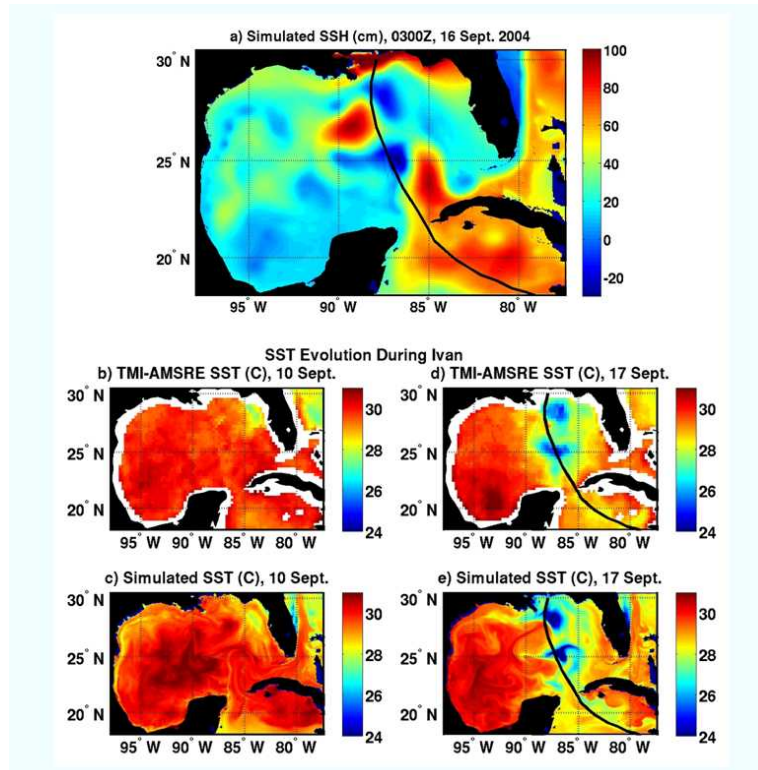


Figure 1: (a) Sea surface height from the free-running simulation of the ocean response to hurricane Ivan at the time of maximum simulated coastal storm surge (0300 UTC 16 Sept., 2005). SST maps prior to Ivan (10 Sept. 2004) (b) estimated from blended microwave satellite measurements from the TMI and AMSR-E instruments and (c) obtained from the initial fields used for the free-running Ivan simulation. SST maps following Ivan (17 Sept. 2004) (d) from the microwave satellite measurements and (e) obtained from the free-running Ivan simulation.

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Juvenile Snapper Acoustic Tagging & Tracking Project (J-SATT)

S. Whitcraft (UM/CIMAS); W. Richards and J. Lamkin (NOAA/SEFSC)

Long Term Research Objectives & 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 3: Regional Coastal Ecosystem Processes (*Primary*)

Theme 4: Human Interactions with the Environment (*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: NOAA Coral Reef Conservation Program and NOAA/SEFSC

NOAA Technical Contact: John Lamkin

Research Summary:

In January 2007, 21 VEMCO VR2 acoustic receivers were deployed in the Loxahatchee estuary covering approximately 5 miles (Fig. 1). Forty-four juvenile mangrove or gray snappers (*Lutjanus griseus*) were caught and successfully tagged and released (size range = 104-189 mm SL) in the array. Twenty-two of the snappers were caught and released up-stream in the estuary in association with oyster reef habitat, and 22 were caught and released downstream in association with mangrove/seagrass habitat. The surgically implanted tags are expected to transmit for approximately 400 days (Fig. 2). Data are downloaded monthly and initial results suggest strong site fidelity and clear diurnal/nocturnal movement patterns in the mangrove habitat. Range-testing of the receivers along the salinity gradient and in differing habitats is underway with an estimated average range of approximately 170m, decreasing significantly in obstructed-rich habitat such as mangroves.

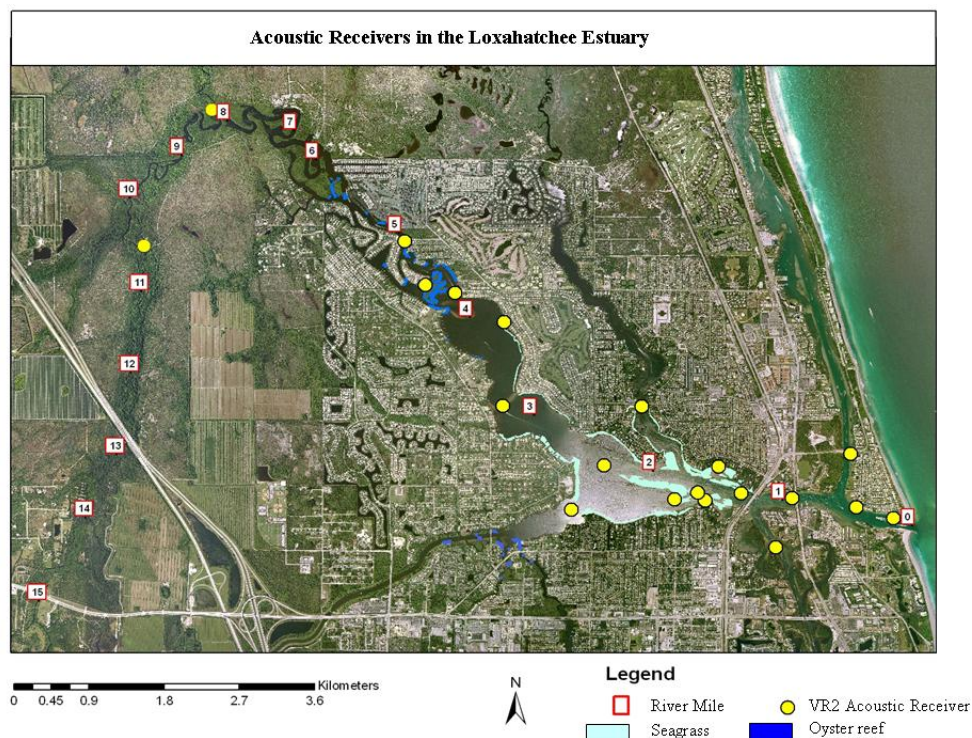


Figure 1: Vemco VR2 acoustic receivers array in the Loxahatchee River and Estuary; 22 juvenile gray snapper were captured and released in seagrass habitat and 22 were captured and released in oyster reef habitat.

Additional receiver placement is now being concentrated at the mouth and other inlets of the estuary, as “migration gates” in order to determine snapper movement out to the adjacent reef area. New partnerships in these efforts include the Layman Lab at Florida International

University, the Loxahatchee River District, VEMCO, and Jonathan Dickinson State Park. Additionally, in summer 2007, the Florida Fish and Wildlife Conservation Commission (FWC) deployed 22 VR2 acoustic receivers along the off-shore reef adjacent to the mouth of the estuary to track movements and potential spawning aggregations of adult gray snappers. The Bimini Shark Lab also deployed 9 receivers just off-shore of the Loxahatchee Estuary to track lemon shark migrations along the coast. And finally, the Loxahatchee River District is deploying an additional 5 acoustic receivers up-river linking freshwater and estuarine habitats in the watershed.



Figure 2: (A) Venezuelan graduate student assistant, Carmen Montaña, recovers a tagged fish in the mangrove habitat at Bird Island, Loxahatchee Estuary. Tissue samples are collected for stable isotope analysis in conjunction with tracked movements. (B) VEMCO tags (Model # V7; wt. in water = 0.7g; length = 17.5 mm; transmitting at 69 kHz, coding scheme R64K) were surgically implanted in 44 juvenile snappers that we then released and tracked.

We are actively partnering with each of these projects to form a cohesive and comprehensive acoustic tracking array of 57 receivers that covers approximately 45 km of ecosystem connecting river, estuary, near-shore and off-shore reef habitats. Because each individual project uses the same acoustic frequencies in their tagged fish, and the same VEMCO VR2 equipment specifications, we anticipate increasing the amount of data and ecosystem-level information we can collect, from river to reef, by exchanging fish-tag-code data. Additional species are also being tagged and tracked on the extended array including snook (*Centropomus undecimalis*) and lemon sharks (*Negaprion brevirostris*).

Concurrently, initial results of stable-isotope analysis of fin-clips taken during juvenile snapper tagging surgery suggest a clear differentiation in juvenile gray snapper foraging between mangrove and oyster reef habitats.

Research Performance Measure: All objectives are being met as planned; we are actually ahead of schedule.

Assessment of Candidate Corals

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

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To: 1) document the present distribution of elkhorn and staghorn coral (*Acropora* spp.) in the Florida Keys; 2) document the threats (disease, predation etc.) impacting the remaining *A. palmata* populations in the upper Florida Keys and determine the relative importance of each ‘threat’; 3) document and identify sources of change (recruitment, mortality etc.) in the Florida Keys *Acropora* spp. population; and 4) compare other populations of Caribbean *Acropora* spp. based on annual surveys.

Strategy: To: 1) survey shallow reef areas and map *Acropora* spp. presence and absence using GPS; 2) assess on a quarterly basis the status of individually-tagged colonies of coral at several sites in the upper Florida Keys; 3) perform annual or biennial assessments of other Caribbean *Acropora* spp. populations.

CIMAS Research Theme:

Theme 3: Regional Coastal Ecosystem Processes (*Primary*)

Theme 2: Fisheries Dynamics (*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: NMFS/SEFSC

NOAA Technical Contact: Margaret 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 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.) present in those populations. This project consists of two complementary components: demographic monitoring and regional-scale mapping. The mapping component of this project aims to survey shallow reef areas and mark the location of *Acropora* spp. colonies using GPS. These points along with surveyed tracks are entered into a GIS database, providing current data on both presence and absence for all surveyed areas. These data are being directly used for the designation of critical habitat as part of the ESA listing process. The resulting spatial data will also provide a valuable tool for monitoring long-term changes in the status of this threatened species.

Two surveys were conducted at the Florida Keys survey sites. Annual surveys were conducted at previously established survey sites in Curacao, Antigua and St. Vincent. A new survey site

was established at Navassa Island (US Territory). Mapping was conducted in the Upper Florida Keys, Navassa Island and Antigua.

For the monitoring component of this project, we survey individually tagged *Acropora palmata* colonies quarterly 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). Data from the Florida Keys population indicates continued decline of the adult *A. palmata* population, and an alarming failure of asexual and sexual recruitment. This decline was the direct result of the 2005 hurricane season. *Acropora palmata* in our other survey areas have not shown similar declines.

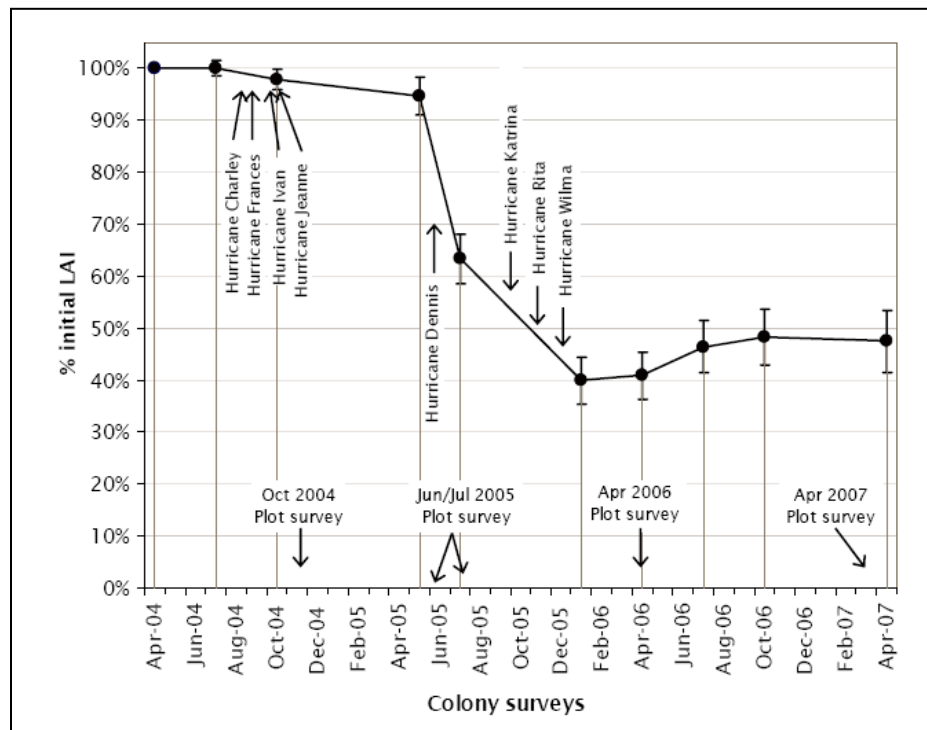


Figure 1: Percent change in the live *A. palmata* tissue estimated using the Live Area Index (LAI) for the tagged *A. palmata* colonies summed for each plot, then averaged for all plots ($n=15$, mean $\pm$ 1 SD). LAI is calculated as the average dimension of a colony squared then multiplied by a visual estimate of the % live tissue cover on the colony. The timing of hurricanes and all plot surveys are shown by arrows.

Research Performance Measure: All major objectives of this project are ongoing and progress is approximately on schedule.

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

D.E. Williams, and K.L. Kramer (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: 1) quantify the monthly larval settlement rate of the important herbivorous sea urchin, *Diadema antillarum* in the F.K.N.M.S., 2) culture larvae of reef-building coral species including *Acropora palmata* (E.S.A. Threatened) and *Montastraea faveolata*, and attempt to ‘seed’ them onto damaged or depauperate reef areas of the F.K.N.M.S., particularly the Wellwood restoration structures (WRS), and 3) periodically characterize the benthic cover of restoration structures in the F.K.N.M.S. so as 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: NOS/SEFSC

NOAA Technical Contact: Margaret Miller

Research Summary:

We addressed the issue of coral restoration in the Florida Keys National Marine Sanctuary (F.K.N.M.S.) by targeting three research areas. First, we assessed the monthly larval settlement rate of the important herbivorous sea urchin, *Diadema antillarum* in the F.K.N.M.S. *D. antillarum* populations declined dramatically in the 1980s due to a Caribbean-wide disease outbreak, and the eventual recovery of this intensive grazer will likely drive improvements in coral recruitment and survivorship by enhancing coral settlement, and by mitigating substrate competition and macroalgal overgrowth of corals. We are therefore very interested in the status of recovery of this species via natural recruitment. To quantify settlement in the F.K.N.M.S., experimental substrates were deployed at two sites (Molasses Reef, Pickles Reef), and were examined monthly for juvenile *D. antillarum* settlers. For comparison, we collaborated with Ms. Stacey Williams, a graduate student at the Univ. of Puerto Rico Mayaguez, who conducted similar settlement experiments in Southwest Puerto Rico. Puerto Rico, unlike the Florida Keys, has experienced substantial recovery of adult populations of *D. antillarum*.

In the Florida Keys, overall rates of *D. antillarum* settlement were variable but generally very low compared to Puerto Rico. These results confirm that ongoing settlement of *D. antillarum* is occurring in the Florida Keys, but that the level of settlement appears to be qualitatively lower than that occurring seasonally in Puerto Rico, where adult *D. antillarum* population recovery has occurred. It is likely that both larval supply and post-settlement survivorship (predation, physical disturbance in some habitats) are important in limiting *D. antillarum* recovery in the Florida Keys.



Figure 1: Settlement plates suspended from sub-surface moorings were used to estimate monthly settlement of the spiny urchin, *Diadema antillarum*, and were placed at two reef sites in the Florida Keys National Marine Sanctuary (F.K.N.M.S.). *D. antillarum* was once a key herbivore in Caribbean coral reef ecosystems, but has not recovered from a disease outbreak in the early 1980s.

Coral restoration objectives in the F.K.N.M.S. were also addressed by culturing larvae of reef-building coral species, and attempting to ‘seed’ them onto damaged or depauperate reef areas. In August 2006, we collected spawn from three species of broadcasting species, *Acropora palmata*, *Montastraea faveolata*, and *Diplora strigosa*. Although we obtained mediocre fertilization rates, thousands of resultant coral larvae for each species were cultured in the laboratory. After approximately one week, larvae were seeded either to experimental substrates in the laboratory including natural reef rubble, marble tiles, and ceramic branch lengths (‘Ecoreefs’), or to field restoration structures including the Wellwood Restoration Structures (WRS) and three ‘Ecoreef modules’ (ceramic staghorn-shaped structures).

The success of seeding of lab substrates was much higher than observed in previous years, with short term (over ~ 6 weeks) survivorship averaging 61-84%. Surviving laboratory coral settlers were deployed to a field grow-out ‘nursery’ at Sand Island, Key Largo. Medium-term survivorship of *A. palmata* settlers in this field situation was around 1% over 8 months, similar to previous years.

Our third coral restoration objective was to evaluate the recovery of the benthic community colonizing the FKNMS restoration structures. We conducted an approximately annual survey of coral recruitment and benthic cover on the artificial reef restoration structures at Molasses Reef (WRS), and Looe Key reef at the site of the *R/V Columbus Iselin* grounding in 1999 (Iselin Restoration Structures (IRS)). Restoration ‘boulders’ were carefully scrutinized for coral recruits, and coral assemblages at IRS were compared to past years.

Coral assemblages on the restoration boulders are dominated by a ‘weedy’ species of coral, *Porites astreoides*, and there was no trend toward increased coral diversity. Transect surveys were conducted to characterize benthic assemblages ‘on’ and ‘off’ restoration structures, and the overall benthic community differs greatly from adjacent natural reef substrates. Notably, a ‘black puff ball’ cyanobacteria (tentatively *Dictothis utahensi*) as well as other cyanobacteria were substantially and significantly more abundant on restoration structures. We have hypothesized that the lack of successful recruitment to these structures by spawning, reef-building coral species may be related to this higher abundance of cyanobacteria. Subsequent pilot settlement experiments in 2006 with coral larvae suggested that settlement was inhibited by exudates of the cyanobacterial mat dominating WRS. These experiments will be expanded and repeated in 2007, and we have begun collaborating with a chemical ecologist, Dr. Valerie Paul of the Smithsonian Field Station, to investigate the potential chemical mechanisms of settlement inhibition.

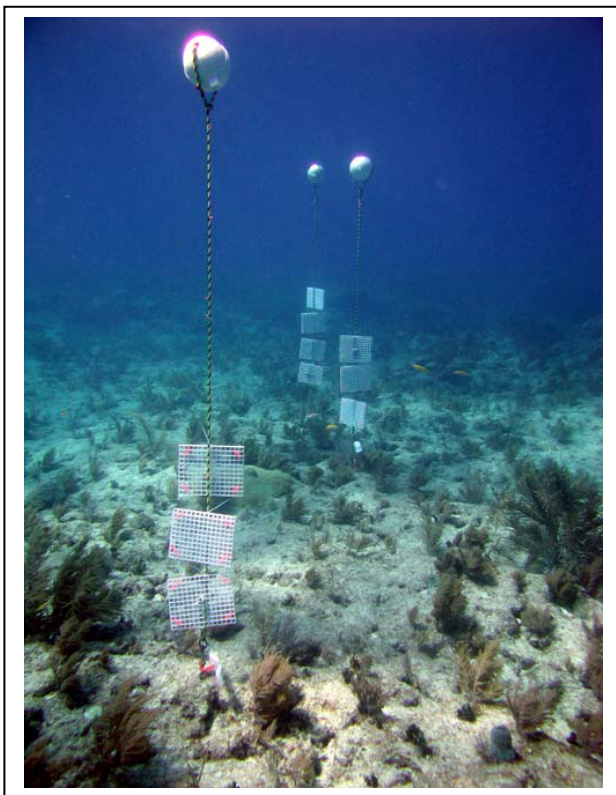


Figure 2: Gamete collectors were placed over selected coral colonies (*Acropora palmata* in this photo) during the broadcast spawning events in August 2006. Collected gametes were fertilized and cultured for eventual ‘seeding’ on restoration structures in the F.K.N.M.S.

Dr. Alina Szmant (Univ. of North Carolina, Wilmington) served as a co-principal investigator on all coral restoration research. Other collaborators include Drs. Monica Medina (University of California, Merced) and Mary Alice Coffroth (State University of New York, Buffalo) participated in the spawn collection and early phases of larval culture. F.K.N.M.S. (via Bill Valley) and The National Undersea Research Center (N.U.R.C)/ University of North Carolina, Wilmington (U.N.C.W)) (via Otto Rutten) provided logistical support during coral spawning activities.

Research Performance Measure: All major annual objectives have been met.

Theme 4: Human Interactions with the Environment

Impacts of Water Resources Management Choices in Ceara, Brazil: Roles of Stream Forecasts, Rainfall and Participatory Decision-Making

K. Broad and V. Mueller (UM/RSMAS); A. Pfaff (Earth Institute, Columbia University); U. Lall (Earth and Environmental Engineering and the International Research Institute for Climate and Society, Columbia University); R. Taddei (Comitas Institute for Anthropological Study and the International Research Institute for Climate and Society, Columbia University)

Long Term Research Objectives and Strategy to Achieve Them:

Objective: To measure the vulnerability of households to water scarcity in the Jaguaribe Valley in Ceara, Brazil, accounting for self-insurance mechanisms and adaptive behavior.

Strategy: To survey households over two years (2006 and 2007) on their actual production, consumption, off-farm income generating activities, and asset liquidation and accumulation; to monitor how their actual behavior changes with a change in water availability.

CIMAS Research Themes:

Theme 4: Human Interactions with the Environment (*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 (*Primary*)

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

NOAA Funding Unit: OGP (Sector Applications Research Program)

NOAA Technical Contact: Jim Laver

Research Summary

In our 2006 household survey, we asked farmers on irrigated land to report their on-farm and off-farm income generating behavior for two hypothetical water availability scenarios: sufficient and less than sufficient to produce on all of their irrigated land. We are currently using this data to write two papers on the extent farmers appear to be vulnerable when water is scarce and the adaptive behaviors that emerge to mitigate their vulnerability.

We also collected information on *actual* consumption, savings, borrowing, assets, on-farm and off-farm income, and migration behavior in our 2006 survey. This year, we conducted a follow-up survey collecting the same information in order to have a panel of household data. We will use the actual information from the 2006 and 2007 household surveys to estimate the households' abilities to cope (or smooth consumption) given water variability using an economic framework. Household coping behavior may shed light on the need for institutional development in the area of risk-mitigation, through the creation of micro-credit institutions and insurance mechanisms, or use of technological innovations, like using climate forecast information to improve the distribution of water.

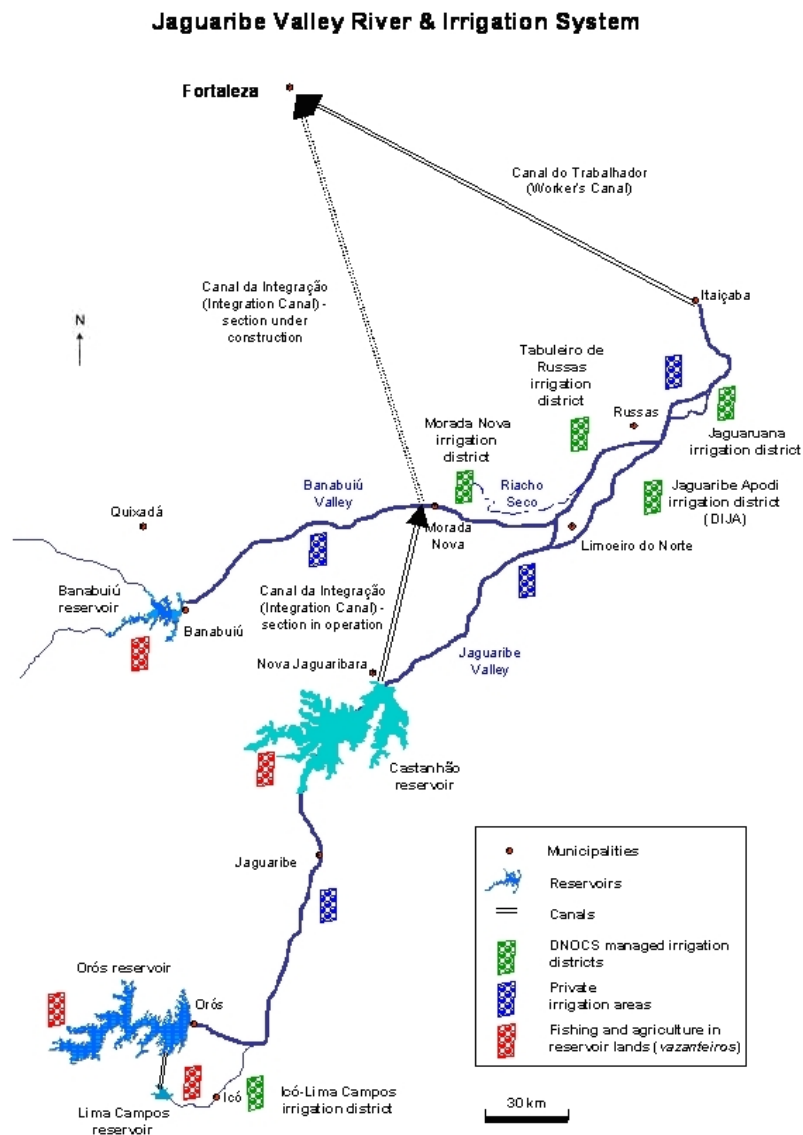


Figure 1: Map of the geographic area of interest. The figure shows the three reservoirs that we are focusing on in integrating streamflow forecast information in the water management scheme: the Oros, Banabuiu, and Castanhao. The figure also presents the geographical distribution of the water user groups in the area.

We are currently writing two papers using the hypothetical survey data in 2006 that reflect how farmers on irrigated land in this region are vulnerable to water scarcity. The first paper is aimed for an interdisciplinary audience, where we show the losses from water scarcity in the form of farm and off-farm income and assets for heterogeneous households using summary statistics from the data. We define five farmer types: fisherpersons, floodplain farmers, fruit farmers, corn/beans/rice farmers, and animal product farmers. This characterization reflects differences in wealth, geography, water use, and political clout; all characteristics that likely would affect measures of vulnerability. We also compare how our measurement of vulnerability differs upon consideration of various adaptive behaviors. In particular, we observe how access to retirement pensions (which are sizeable welfare payments), various irrigation technologies, and alternative sources of water (multiple vs. single source use, and

different primary sources when water is scarce) affect our measures of vulnerability in terms of reducing losses in income and assets. The second paper will be written using an econometric framework to illustrate how vulnerable households are in terms of the marginal impact of water availability on multi-output production. We will also evaluate how adaptive behaviors can affect that marginal impact of water.

We are currently conducting a follow-up survey in the region to complete our household panel dataset. The data will be ready for conducting our intended analysis at the end of September, 2007.

Research Performance Measure: The program is on schedule in meeting its objectives.

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

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

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To improve environmental detection technologies for assessment 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, and terrestrial runoff.

Strategy: To: 1) develop and/or test new detection methodologies for fecal indicator bacteria, alternative fecal indicator bacteria, human-source microbial markers, and selected pathogens of public health interest; to assess their effectiveness for environmental monitoring of microbial contaminants in coastal waters; and 2) 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 4: Human Interactions with the Environment (*Primary*)

Theme 6: Integrated Ocean Observations (*Secondary*)

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: 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). This is done by collecting bacteria from a known volume of water on a filter, incubating that filter on a differential media agar, and then counting colonies of bacteria that give a particular diagnostic reaction on that media. 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 (such as the coastal waters of Florida, the Gulf Coast States, Hawaii, etc.). There is growing consensus that more rapid and sensitive molecular-based assays need to be employed in the monitoring of these indicator bacteria, and that alternative indicators which may better represent the actual public health risks in these environments should also be developed and deployed. 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. Current culture methods do not discriminate the origins of fecal indicator bacteria.

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. These molecular-based techniques include specific gene-amplification of targeted bacterial types by the Polymerase Chain Reaction (PCR), by electrochemical detection, by Luminex flow cytometry, and by quantitative real-time PCR (qPCR). We now have molecular assays for the rapid environmental detection of traditional indicators such as enterococci and *E. coli*, alternative human source-track indicators such as *Bacteroides* spp. containing the HF8 and HuBac gene targets, dog-specific source-track *Bacteroides* indicators, human-source enterococci containing the *esp* gene, 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. Much work has also involved the development and optimization of environmental nucleic acid extraction and inhibition controls to accurately correct for variables of extraction and enzyme inhibition from these sometimes problematical environmental samples. Specifically, *Lactococcus lacti* has been integrated into our sampling protocols as an extraction control and a qPCR assay was developed to assess extraction efficiency.

We have now 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), Hobie Beach sand and water quality (investigating bather and animal load impacts on recreational water quality), Hurricane Katrina impacts on local environmental water quality of New Orleans, and a water quality study in Taylor County, FL. While most of the indicator assays are quantitative, several of the pathogen assays are still based on presence/absence PCR formats. Future work on this project will involve adaptation of most of

these assays to the quantitative qPCR assay format to allow for both rapid detection and abundance measurements of these microbial contaminants.



Figure 1: Dr. Christopher Sinigalliano prepares samples for traditional and molecular assays aboard the *R.V. Nancy Foster*. The cruise was part of a NOAA-led water quality research and monitoring program studying water released into the Southern Florida coastal zone.

Research Performance Measures: Major objectives have been met and program to field-test assays are on schedule.

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Quantifying Fishing Activity Within and Adjacent to NE Gulf of Mexico MPAs

S. G. Smith and N. Zurcher (UM/RSMAS)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To determine the amount, type, and spatial pattern of fishing activity within the Madison-Swanson and Steamboat Lumps marine protected area (MPAs) as well as within adjacent areas open to fishing on the west Florida shelf.

Strategy: To: 1) develop field sampling methods using fixed-wing aircraft for obtaining georeferenced data on fishing and other vessels operating within the Madison-Swanson and Steamboat Lumps MPAs and adjacent areas; 2) develop a statistical sampling design and conduct seasonal aerial surveys of vessels in the target MPAs and adjacent areas; and 3) develop statistical analysis procedures for quantifying fishing and other vessel activity within the survey domain.

CIMAS Research Theme:

Theme 4: Human Interactions with the Environment

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: Miles Croom

Research Summary:

In July 1999, the National Marine Fisheries Service officially established two areas closed to most fishing in the northeastern Gulf of Mexico to evaluate the utility of closed areas in the protection of spawning aggregations of gag grouper. A key factor to the success of marine protected areas (MPAs) and one often assumed in the determination of their effects is zero fishing mortality within the closed areas. UM/RSMAS researchers and NOAA flight personnel initiated a study in 2004 to develop and implement aerial surveys to quantify the amount of fishing activity within and adjacent to the Madison-Swanson and Steamboat Lumps MPAs.

The survey domain was delineated as a 20 by 160 nautical mile area encompassing the deep-reef habitat (water depths ranging from 55 to 140 m) of the west Florida shelf (Figure 1). The domain is located about 100 nautical miles west of Tampa, Florida, where NOAA flight operations are based. We developed an in-flight data recording system to collect real-time information on vessel location, type (e.g., commercial longline, recreational/charter), and disposition (e.g., fishing, cruising). The main components of the system were a laptop computer interfaced with a global positioning (GPS) unit, GIS software, and a digital camera. Flights were conducted during two seasons, January to April and May to September. Flight days within each season were randomly allocated among several time strata: (i) spawning seasons of target species; (ii) commercial and recreational open/closed fishing seasons for red snapper and groupers; and, (iii) midweek and weekend/holiday time periods.

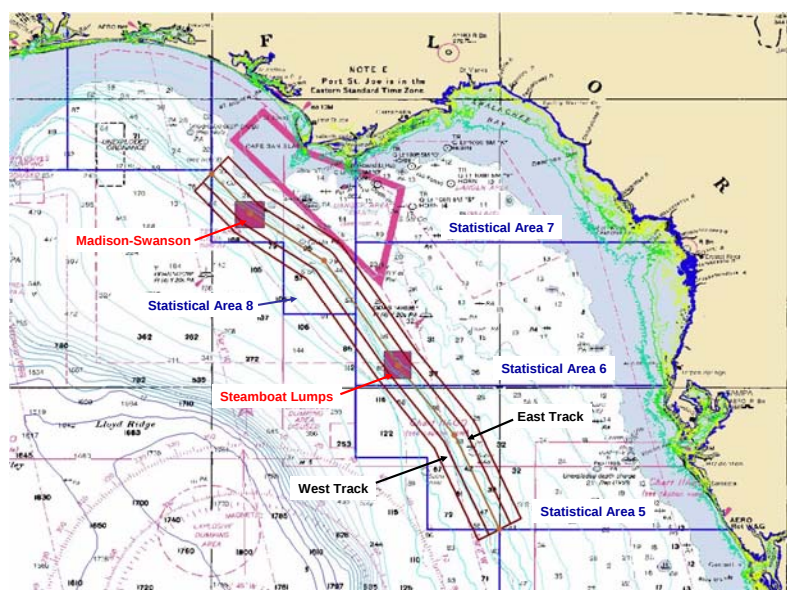


Figure 1: Aerial survey sampling domain and flight tracks in the west Florida shelf region. MPAs within the domain are shown as solid pink boxes; blue lines are boundaries of statistical fishing areas.

Commercial fishing vessels were the principal vessel type observed irrespective of day of the week category or fishing season in each time period. Summary maps of vessel location and disposition for the May to September season are shown in Figure 2 for commercial fishing vessels and Figure 3 for recreational fishing vessels. During January to April, 1.9% of commercial vessels engaged in fishing activities were observed inside MPAs, whereas 5.3% of recreational vessels engaged in fishing activities were observed in MPAs. These percentages were 1.7% for commercial vessels and 3.1% for recreational vessels during May to September.

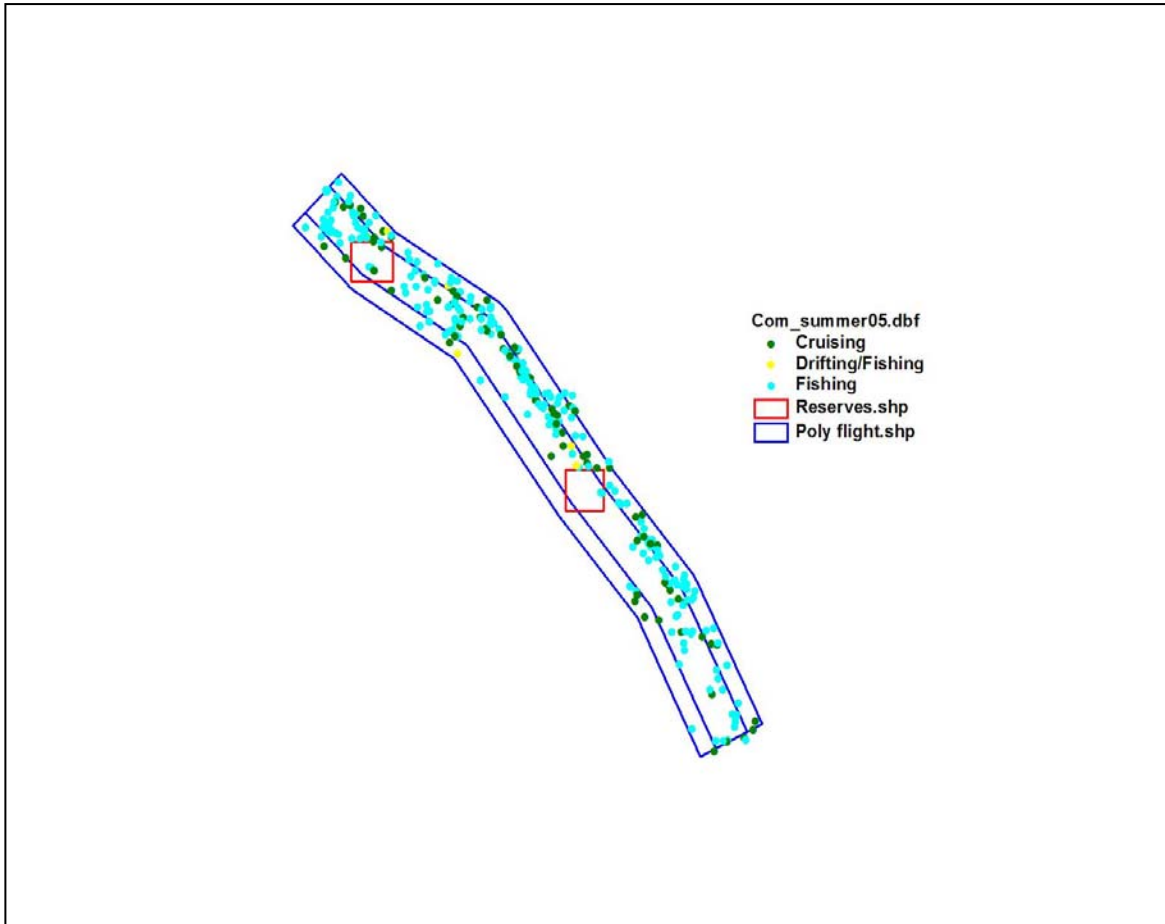


Figure 2: Summary map of location and disposition of commercial fishing vessels for May-September 2005 flight surveys.

Ongoing research, scheduled for completion in Fall 2007, is using the aerial survey database to develop statistical methods for estimating: (1) spatial boater use by season, vessel type, and disposition; and (2) spatial fishing effort by season, fleet (commercial, recreational), and gear.



Figure 3: Summary map of location and disposition of recreational fishing vessels for May-September 2005 flight surveys.

Research Performance Measure: The study is on track to conclude during Fall 2007.

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

G. P. Podestá, D. Letson, N. Breuer and K. Broad (UM/RSMAS);
J. W. Jones, C. W. Fraisse, S. Jagtap, C. Porter and K. T. Ingram, (UF/Agricultural and
Biological Engineering), P. E. Hildebrand (UF/School of Natural Resources and the
Environment); K. W. Migliaccio (UF/Tropical Research & Education Center);
J. J. O'Brien, D. Zierden, J. Bellow, T. LaRow (FSU/COAPS); G. Hoozenboom,
D. Stooksbury, J. Paz, A. Garcia y Garcia, T. Crane and Pam Knox (Univ.
Georgia/Biological and Agricultural Engineering); C. Roncoli (Univ.
Georgia/Anthropology); J. Christy and R. McNider (Univ. Alabama)

Long Term Research Objectives & 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: COP

NOAA Technical Contact: Caitlin Simpson

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 these new seasonal climate forecasts and decision aids and to provide mechanisms for users to give feedback to researchers.

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

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

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:

We have developed and adopted some common methodologies in our approach to identify climate variability patterns in temperature and precipitation associated with ENSO events and the assessment of related agricultural and water resource impacts.

We are working with our collaborators to resolve the complete spectrum of anomalous climatic behavior required for agricultural and climate study purposes including the development of “downscaling” the model results to useful region sizes.

We 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 is an integration of climate, biophysical, socioeconomic, 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. Using this framework to study the

value of the climate information, a new framework to strategize crop insurance options has also been developed and is in process of improvement.

We are analyzing how increased or better use of climate information can lead to better, more cost-effective decisions for sustainable management of agriculture and water resources. We are developing a decision support (DS) framework, using system dynamics modeling approach, to evaluate and compare different short- and long-term agriculture and water management policies. In addition to climate, the integrated DS framework considers other major factors that influence water demand and availability including: demographic changes, land use changes, economy, and environment. These interconnections among important variables that influence water demand and availability.

UM also leads an assessment effort that seeks to understand potential adoption and applications by end users of seasonal climate forecasts in Georgia, Alabama and Florida. We elicit regular feedback from end users to guide our research and development activities.

University of Florida:

The *AgClimate* [<http://AgClimate.org>] web-based decision aid system has been further tested and improved during 2006. We now continue quarterly climate outlooks along with updates as necessary and outlooks for important commodities in the southeast.

In addition to seasonal outlooks, prototype decision aid tools were improved in response to stakeholder feedback.

Agricultural outlooks that provide customized climate information and forecast to producers were released as appropriate during the year for a range of crops and other agricultural commodities, including: 1) winter vegetables; 2) forestry; 3) pastures; 4) row crops, such as peanut and cotton; 5) temperate fruits, such as peach, nectarine, apple, pear, blueberry, and strawberry; 6) subtropical fruits, such as lychee, longan, loquat, and mango; 7) tropical fruits, such as sapote, carambola, papaya, guava, and banana; and 8) citrus outlook. Links to these outlooks can be found in the main *AgClimate* page.

A tool was developed to display county-level yields during different ENSO phases for six crops: cotton, peanut, soybean, sugarcane, winter wheat, and tobacco. Maps display yield residuals, that is, departures from average using National Agricultural Statistical Services data. This tool has been fully implemented on *AgClimate*.

We are linking climate forecasts and water quality simulations as a guide to water resources management. Previous work has shown that ENSO phase affects the risk of nutrient contamination of streams and lakes. The Little River Watershed (LRW) work will ultimately contrast results of nutrient load simulations using the larger integrated models WAM and SWAT, versus those from a direct spectral approach, Wavelet Analysis. We have compared P loading to Lake Okeechobee for different ENSO phases for the S-191 watershed. In addition, using 38 years of data from the USDA-ARS at Tifton, GA for a basin of the LRW, Wavelet Analysis was performed on sea surface temperatures (SST) from the NINO 3.4 index, precipitation, stream flow, and phosphorus and nitrate loads. Wavelet Analysis in this study extracts low-frequency climate information (corresponding to El Nino's 3-7 year period) from the nutrient load data, and finds regions of high power in both time and frequency domains of the deconstructed time series. High power in each time series, and shared power and

covariance between SST and nutrient loads was seen in the 3- to 7-year period, indicating a strong relationship.

We are developing a decision tool that will forecast county-level cotton yields. The weak relationship between ENSO phase and summertime climate in the SE-USA make it difficult to use ENSO to predict crop yields. We have explored the uncertainty associated with the use of regional atmospheric circulation and surface temperatures from a GCM (ECHAM 4.5) to predict county scale cotton yields. We discovered a meridional wind field in the high troposphere that is very different during years when cotton yield is high and when it is low. Atmospheric circulation patterns that favor high humidity, temperature, and rainfall during summer months were associated with low cotton yields in the SE USA. Up to 52% of the inter-annual variability of lint yield in counties was explained from observed meridional winds at 200 hPa and surface temperatures. Although the predictability of yields using the GCM was lower than that based on reanalysis data, 58% of the counties showed statistically significant ($p < 0.05$) potential predictability based on continuous measures, and 98% of the counties based on categorical measures. This research indicates that uncertainties in predicting cotton yields may be reduced using atmospheric and land and sea surface temperatures.

We have developed a series of maps showing the probability that the Lawn and Garden Moisture Index value will be less than -1.5, which is a severe water deficit, during 10-day periods throughout a year for each ENSO phase. These maps are currently being evaluated in the staging site of *AgClimate* and are expected to be released on *AgClimate* by mid-2007. This activity is being conducted is exploring methods that allow automatic updates to the drought index forecasts.

We have established mechanisms and institutional arrangements for transitioning *AgClimate* from research to an operational mode in Florida. In our state, the approach being proposed is to develop an integrated computer and database system that will house both *AgClimate* and FAWN, the Florida Automated Weather Network. FAWN is an operational weather network operated by the Florida Cooperative Extension Service. Considerable progress was made on this activity. We purchased two servers with sufficient capacity to provide service for both climate and weather information systems and to house databases for *AgClimate*. The IT office of UF was contracted to implement *AgClimate*-UF as a mirror site to *AgClimate* in FSU. Software was purchased and installed to make the servers mirror sites, and the *AgClimate* software was transferred from FSU to UF. Databases were installed and work was done to evaluate what needed to be done to implement *AgClimate* here at UF. An effort to implement *AgClimate* partially was successful, so that a version of *AgClimate* is partially implemented and accessible on our servers. Extension will provide the continuing operating and maintenance costs, after the first two years. Institutional arrangements were made with Extension and the IT office.

Florida State University:

FSU has led activities on the acquisition and analysis of historical climate data, research on climate variability in the Southeast U.S., dynamic climate modeling, and the production of climate forecast information for incorporation in decision support systems which target the end user.

Historical weather data is critical to all aspects of this project and provides the basis for all climate information used in the decision support tools, including the wildfire risk forecast. In

addition, the historical weather data drives the crop development models whose output is used in peanut, tomato, and potato decision aids. The historical weather data must have a long period (at least 50 years) of relatively homogeneous records and must have a spatial resolution fine enough to reveal detailed climate information at the county level for the states of Florida, Georgia, and Alabama. The preparation of a historical weather observation database for the Southeast is now complete. The weather observations are compiled from the National Weather Service's Cooperative Observer network (NCDC TD 3200) and contain daily values of maximum temperature, minimum temperature, and precipitation for a period of record of at least 50 years extending through December of 2004. The stations are selected based on 1) length of record, 2) data completeness, 3) homogeneity, and 4) representativeness to surrounding agricultural areas. The state climate offices in Florida, Georgia, and Alabama rely on their local expertise and familiarity with the coop network in making the station selections. The final data set contains historical weather records from 92 stations in Florida, 64 stations in Georgia, and 58 stations in Alabama.

In the past, most climate studies have concentrated on the ENSO cycle, the primary driver of interannual climate variability in the Southeast United States. However, ENSO variability falls short in providing predictive skill to some parts of the Southeast (north Alabama, north Georgia), certain times of the year (warm season), and at other time scales (interdecadal variations, long-term trends). Understanding other modes of variability, such as the Atlantic multi-decadal oscillation, PDO, etc. may provide an additional layer of predictability to the climate system. At the very least, this research leads to a better understanding and communication of uncertainties and limitations of forecast products. For example, we have recently examined temperature trends in the U.S. in the daily maximum and minimum temperature data from 758 COOP stations in 19 states. For each station, the maximum and minimum temperatures are first sorted in ascending order for every two years (to remove annual variability) and divided into ten equal parts (or deciles). The first decile represents the coldest temperatures, and the last decile contains the warmest temperatures. From these decile plots, patterns and trends can be seen over the 56 year period. To determine if a station has experienced warming or cooling over the period, a linear least-squares interpolation is applied to each decile for the maximum and minimum temperatures. Regional maps show the spatial patterns of the warming and cooling trends. Local effects often play a much more important role than large-scale shifts in dictating the significant temperature changes observed at a station. Results of this study are presented in a GIS-based web tool at COAPS: <http://www.coaps.fsu.edu/gis/decile.php>

Studies have shown that very limited benefit exists in climate forecasts focused on shifts of temperature or precipitation near the mean or climatological average. We feel that the greatest benefit lies in the forecast of extremes, events near the tails of the historical probability distribution. Further research is needed that addresses the likelihood of such extremes, whether torrential rainfall, drought, freeze, or other severe weather. For example, we have recently examined the worst and best case scenarios for each climatic phase and the combination of phases that produce the greatest monthly extremes. Data from Canada, Mexico, and the United States are gathered from the Historical Climatology Network (HCN), and data from these stations are bootstrapped in order to expand the time series. Bootstrapping is the stochastic simulation of monthly data by the utilization of daily data with identical ENSO, PDO, and PVO (NAO) characteristics. Because the polar vortex occurs only during the cold season, the PVO is used during January, and the NAO is used during other months. The bootstrapped data are arranged, and the tenth and ninetieth percentiles are analyzed. The

magnitudes of temperature and precipitation anomalies are the greatest in the western Canada and the southeastern United States during winter, and these anomalies are located near the Pacific North American (PNA) nodes. Summertime anomalies, on the other hand, are weak because temperature variance is low. The magnitudes of the anomalies and the corresponding phase combinations vary regionally and seasonally.

FSU has led the development of new tools and climate variables for inclusion in *AgClimate*. Tools displaying ENSO climate variations in such quantities as chill accumulation, growing-degree days, absolute minimum and maximum temperatures have been added to the basic climate variables available through *AgClimate*. A systematic study of chilling for blueberry, peach, and strawberry in AL, FL, and GA was made and the significant impacts of ENSO on chill was characterized for counties and on a regional basis. The chill accumulation tool allows producers select their crop and location to examine forecasts for chilling for bi-weekly and seasonal periods. The forecasts are presented in a probabilistic format and are modulated on the current JMA ENSO phase. This permits users to examine not only the total amount of chilling that will be accumulated in a year, but also the distribution of chilling through the dormant season. Users are also able to examine how the forecast differs from expected conditions in their county and historical data over the preceding five years to help relate seasonal patterns to historical crop performance at their location (Figure 1). Also, regional maps are provided to users that indicate the probability of chill accumulation for winter fruit crops to exceed the expected values for their location. Users are able to specify the bi-weekly forecast period throughout the winter that they wish to observe and ENSO based forecasts specific to their chosen crop are displayed.

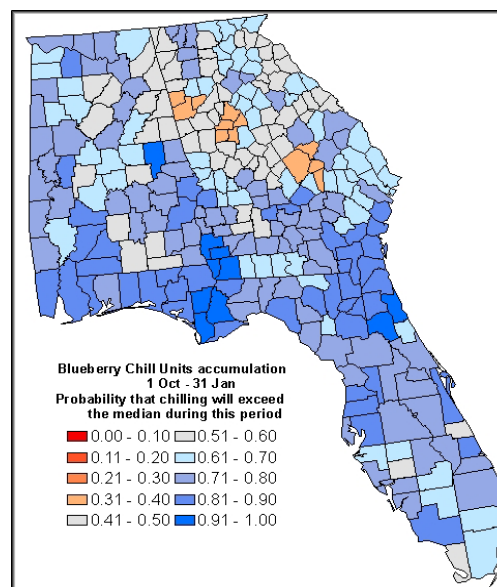


Figure 1: Example of regional chill forecast for Oct 31 through Jan 31 during an El Niño event as seen at *AgClimate*.

FSU has also developed a dynamically downscaled regional forecasts for agriculture in the southeastern US. Our approach is to improve downscaled climate forecasts by using nested models within the cells of a global circulation model (GCM) using the University of Florida statistical method described above. The goal of this work is to demonstrate that forecasts from dynamical downscaling have higher prediction skill than those based on ENSO phase alone when applied to biophysical models. Previous agricultural applications of climate forecasts have generally used statistical analysis of historical climate and ENSO phase to arrive at climate scenarios for adaptive management which reduces risk. While progress has also been made in applying GCM-based forecasts using statistical methods for spatial and temporal downscaling, the use of dynamical downscaling presents an alternate approach and the accuracy and usefulness of the resultant forecasts has not been carefully evaluated for use in simulations of crop yields. A highly developed global with an embedded high resolution regional model is expected to provide more accurate site- and year-specific predictions of maximum and minimum temperature, precipitation frequency and amount, and net radiation than forecasts based on historic or ENSO climatology. Hence their use to force prediction models or agricultural yields, surface and sub-surface hydrology, and forest growth and carbon sequestration is likely to result in improved applied forecasts in these important areas. Even though their skill levels are still being assessed, the examination of the regional climate models linked to agricultural production models is warranted as an avenue to improve relevant information for use by agricultural decision makers and for the contribution that diagnostics of biological responses to climate variables may provide to further refine the regional model itself. The downscaling procedure uses the global climate outputs from the FSU/COAPS coupled Atmospheric-Oceanic General Circulation Model to generate local surface temperature, solar radiation, and rainfall in Southeastern US. Downscaled outputs significantly improved the skill of raw GCM forecasts of temperature, radiation, and precipitation. Crop yields forecast using downscaled climate data as inputs to crop simulation models have higher skill (~ 0.60 or better) than traditional GCM forecast climate data. Figure 2 shows peanut prediction yields using the FSU regional spectral model as daily weather inputs.

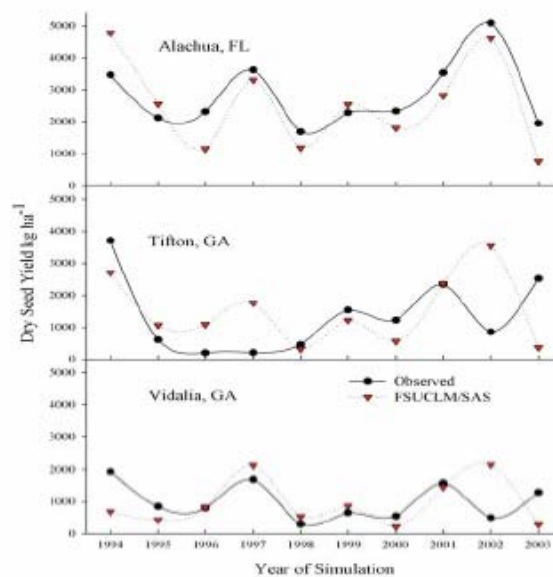


Figure 2: Peanut yield predictions using the FSU regional spectral model as daily weather inputs.

We have also developed a wildfire activity potential forecast based on the Keetch-Byram Drought Index (KBDI). Because of the chaotic nature of weather, all climate forecasts (including this wildfire threat forecast) are presented in terms of probabilities. Because the KBDI is driven by daily weather and can change drastically based on one or more rainfall events, the maps show the probability of exceeding the threat level *at least 7 days during the month*, rather than for the month as a whole. Counties are given a plus sign to indicate a greater than normal threat during that month, and given a minus sign to indicate a risk level below than climatology. The forecast is based on both current KBDI values and expected climate patterns associated with ocean temperatures in the tropical Pacific. For this reason, the forecast is updated monthly throughout the season as conditions change in the field. The initial forecast is made in January for the months of January through July, and then updated monthly as the season progresses. The wildfire threat forecast is available via *AgClimate*. The SECC evaluation team completed an assessment of the wildfire threat forecast system in 2006. State forestry officials, private forest managers, extension specialists, and other forestry interest were introduced or reacquainted with the KBDI forecast products, then interviewed on their presentation and utility.

University of Georgia:

We developed climate and commodity outlooks in close collaboration with other SECC members and Research and Extension Faculty. These outlooks were disseminated through various communications media to stakeholders including county agents and growers. A significant outcome is 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.

We have started initial work on the development of a *HydroClimate* web site by reviewing the current *AgClimate* web site to determine the areas of overlap and to assess the usefulness of the web site design for use in *HydroClimate*. Based on this review, it was concluded that a similar basic design could be used to parallel the *AgClimate* site. This may allow us to piggyback on the improvements of the *AgClimate* site with the new *HydroClimate* site with minimal extra work. Some products associated with *AgClimate* could also be used with only minor changes to provide relevant information to water managers across the state.

Historical data are the basis for our climate information and decision tools. We obtained daily weather data for Alabama (44 locations), Florida (58 locations), and GA (62 locations) from the Cooperative Observer Program (COOP) network. Solar radiation data for the 2005 are being generated. Soil profiles on DSSAT format are almost complete. For the three states, three representative soil profiles data of each county were obtained from the soil characterization data base of the USDA-National Resources Conservation Service (<http://ssldata.nrcs.usda.gov/>), the Characterization data for selected Florida Soils (UFL and USDA), the Characterization data for selected Georgia soils (Perkins, 1987), and the Soil Data Mart of the USDA-NRCS (<http://soildatamart.nrcs.usda.gov/>). 90% of the counties for Alabama and Florida are covered and Georgia counts with more than 70% coverage. Georgia's coverage includes mainly the Northern, Southeast, South Central, and Southwest regions.

We developed numerous modular numerical tools for the systematic, reproducible, statistical analysis of hydroclimatic data. These tools will form a common platform for hydroclimatic data analysis throughout the SECC. The modular structure approach simplifies the

implementation, maintenance, integration of new applications. The core modules rely on a Python library (Numpy) specifically designed for the manipulation of multidimensional arrays. We rewrote a section of this library to improve the handling of missing data. The corresponding package has been submitted for inclusion in the main Python library available to all Python users. Modules were developed for date, season and ENSO phase handling, automatic data retrieval from the USGS and NCDC site, time series plotting and basic statistical analysis. They provide the framework the development of specific applications, while adhering to the concept of “reproducible research.”

- o In an example of application of numerical tools developed above, we developed two algorithms for the automatic detection of change-points in a time series. The first algorithm is an improvement on the least squares based two-phase regression method, the second an iterative algorithm using robust (rank-order) statistics. We applied these two algorithms to the average monthly precipitation and temperature anomalies recorded for climate division 7 in central Georgia since 1895, and to the monthly average streamflows anomalies recorded since 1957 on the Flint River at Newton, GA. We did not observe any significant trend or change in trend for rainfall anomalies over the last 100 years. However, restricting the analysis on the same period for which streamflow data are available (last 50 years) showed a slight but significant decrease in the May precipitations over the last 50 years. The analysis further showed a significant decrease of temperatures from May to September over the last 100 years. The analysis of streamflows confirmed a decrease in recorded discharges and a significant drop in streamflows in spring (March to May) in the late seventies, early eighties (manuscript in preparation).
- o The analysis shows the limits of these two change point detection methods. Because the two-phase technique is based on least squares, it is very sensitive to outliers and on the normality of errors. The robust detection technique is based on a test initially designed to assert the difference in medians between two populations, and is therefore ill adapted to the detection of a change in trend. Moreover, both methods rely on the assumption that the data points are independent, when some strong autocorrelation exists up to 4-5 months in the case of streamflows data. At last, none of these methods takes into account the fact that different time scales may be involved. Therefore, we are trying to overcome the limitations of these methods by investigating two other methods that take the potential variation of temporal trends at different time scales: SiZer maps and wavelets (continuous and discrete). As before, no significant trends were detected for the monthly rainfall anomalies. However, a SiZer map analysis showed a significant increase of the squared anomalies in the last 30 years, compared to the earlier data (manuscript in preparation).

The Climate Impact Analysis Simulation tool was developed as a way to rapidly run crop simulation for the SECC (based on DSSAT experimental files) so that output data for the online yield tool can use the outputs as inputs for the database. The tool operates by using input data from the attribute database associated with the SECC map coverage, which is populated with information on soil profiles and available weather years. Using these data, the simulation tool generates individual, customized seasonal X-files for each county selected. Counties can be selected via a region on the map or by querying the underlying database. The results are as varied as the inputs and any combination of crops and crop management with the DSSAT system can be simulated.

Cotton is the main row crop grown in Georgia. A prototype model for cotton has been developed adapting the DSSAT-Cropping System Model for simulating climate effects on cotton growth and yield. In collaboration with Florida, we are planning to continue with the evaluation of this model under farmers' field conditions, using their management practices, as well as under different irrigation management strategies with data collected at experimental stations.

We conducted an assessment to obtain stakeholders' feedback on the KBDI and to understand current and potential uses of the forecast. The assessment was based on phone interviews with 20 representatives of federal, state agencies, producer and industry organization, environmental organizations and forest managers at the local level. In most cases, respondents were asked to access the *AgClimate* website during the interviews and comment on the presentation of the KBDI tool and potential uses of the information. Stakeholders' recommendations have led to improvements in the KBDI page.

University of Alabama -- Huntsville

We have developed an improved soil moisture index as an agricultural decision aid. The Lawn and Garden Moisture Index (LGMI) is a high resolution (4 km), shallow soil moisture index based on antecedent precipitation totals from which a potential evapo-transpiration (PET) value is subtracted daily. At present the PET value is dependent only on time of year, being a simple climatological value. Our goal is to create a daily, dynamic PET and actual evapo-transpiration value based on satellite measurements of solar insolation and water demand from specified crops using biophysical simulation models, such as DSSAT. We have put in place the satellite algorithms necessary for the acquisition of high resolution solar insolation data. During this reporting period we have tested the solar insolation estimates generated with DSSAT under a variety of conditions with that generated independently by these satellite observations.

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

Theme 5: Air-Sea Interactions and Exchanges

Process Studies of Marine Boundary Layer Cloud and Structures over the Eastern Pacific

B. Albrecht (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:

Objectives: To: 1) determine how cloud and boundary layer structures vary over the southwestern Pacific stratocumulus regime and elucidate the processes responsible for this variability; 2) explain the occurrence and the temporal variability of drizzle from shallow stratocumulus clouds over this region.

Strategy: To use observations from instrumented research vessels in collaboration with NOAA ESRL scientists to study cloud and boundary layer properties and processes that affect and maintain these structures.

CIMAS Research Theme:

Theme 5: Air-Sea Interactions and Exchanges (*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 (*Primary*)

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

NOAA Funding Unit: CPPA

NOAA Technical Contact: Jin Huang

Research Summary:

Cloud, drizzle, and boundary layer structures associated with stratocumulus clouds over the southeast Pacific have been studied using observations from research cruises that included extensive instrumentation operated and deployed by NOAA ESRL. These studies involve a continuing collaboration with NOAA ESRL scientist Dr. Chris Fairall. The cloud and boundary layer analyses use observations made during EPIC 2001 and the Stratus 2003 and Stratus 2004 cruises. During the 2004 cruise two UM graduate students, Efthimios Serpetzoglou and Virendra Ghate, assisted with the operation of the observing systems on board the R/V *Ron Brown*. For all three cruises our analysis, focused on cruise legs that extend across the southeast Pacific stratocumulus decks and 4-5 day periods in the vicinity of the Stratus Ocean Reference Station (Stratus ORS) located at 20°S, 85°W and operated by the Woods Hole Oceanographic Institution (WHOI) Upper Ocean Processes (UOP) group. Mr. Ghate (Ph.D. student) participated in the 2005 and 2006 cruises and oversaw the operation of the University of Miami X-Band radar that was deployed on NOAA's R/V *Ronald Brown* to support the scientific efforts during these cruises. Distinct variations in the mean boundary layer structure were observed during the three cruises. These cloud and boundary layer observations are being combined with the surface flux measurements obtained from the NOAA ETL flux tower and large-scale temperature, moisture, and wind fields from the NCEP reanalysis to examine the processes that are responsible for the observed variability in cloud and boundary layer structure. These observations provide an unprecedented description of

cloud, drizzle, and boundary layer variability in cloud fields that are climatically important. Key findings indicate the sensitivity of cloud structures to boundary layer decoupling processes, the positive dependence of drizzle occurrence on cloud depth, and the lack of correlation between drizzle occurrence and moisture conditions above the boundary layer. The comprehensive and integrated data sets that have been developed through this analysis provide an important base line for model evaluation and development. The results are presented in manuscript that has been submitted to the *Journal of Climate*.

Observations from the stratocumulus cruises were combined with those from the Stratus ORS WHOI buoy located at 20°S, 85°W. A technique for estimating fractional cloudiness using observed downward longwave fluxes and clear sky fluxes was developed and evaluated using ceilometer fractional cloudiness and longwave observations made on the 2001 and 2003 cruises. This technique was then applied to observations made from the Stratus ORS to estimate hourly values of fractional cloudiness at this site using observations from 2001-2006. This cloud fraction retrieval allows for estimates of the seasonal cycle of cloudiness and the seasonal variation in the diurnal cycle at the ORS that can be correlated with surface fluxes, advective processes, and lower tropospheric properties from NCEP reanalyses (Fig. 1). Corresponding longwave and shortwave cloud forcings have been calculated using this same data set. This work is in progress and provides a unique set of observations for studying the annual cycle and the diurnal variability of the stratocumulus clouds over the buoy, the processes that may affect this variability, and the effect of these clouds on the surface energy budget.

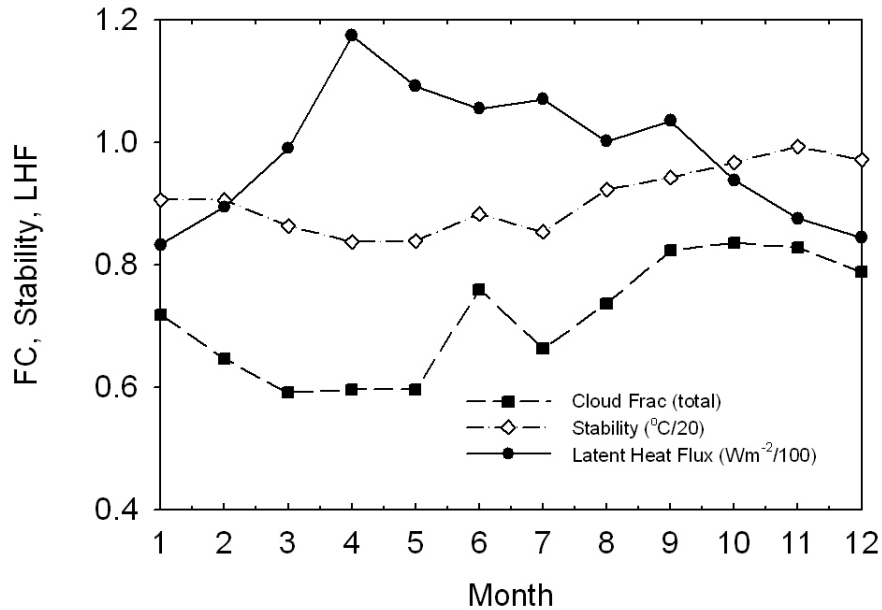


Figure 1: Seasonal variation of retrieved buoy cloud fraction (CF), scaled stability factor ($(\theta_{700\text{mb}} - T(K)_{\text{sfc}})$), and buoy surface latent heat flux for 2001-2005. The stability parameter is based on the 700 mb potential temperature ($\theta_{700\text{mb}}$) from NCEP reanalyses and the surface temperature ($T(K)_{\text{sfc}}$) from the WHOI buoy.

In a project jointly funded by ONR, giant hygroscopic aerosols were introduced into a solid marine stratocumulus cloud (200 m thick) by burning hygroscopic flares mounted on an aircraft. The cloud microphysical response in two parallel seeding plumes was observed using

an instrumented aircraft making 16 transects of the seeding plumes. The observations tracked the time response of the cloud to the introduction of the giant nuclei. A well defined broadening of the drop size distribution and a 5-fold increase in the number of large drops (20 - 40 μm) relative to the background cloud occurred 30 minutes after the seeding. The cloud effective diameter increased from about 11 μm in the background to 13 μm in the plumes. Although the giant nuclei were only a small fraction of the total aerosols produced by the flares, they dominated the cloud response. This was the first ever demonstration of this technique for the potential initiation of drizzle in marine stratocumulus clouds. This approach demonstrates the merit of the seeding approach for controlled observational studies of aerosol-cloud interactions in marine stratocumulus and opens a new area of research. This work is described in a *Geophysical Research Letter* paper.

Research Performance Measure: The results to date represent a major portion of the proposed work; the program is on schedule.

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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 & Strategy to Achieve Them:

Objectives: To improve our understanding of the wind systems in tropical cyclones.

Strategy: To: 1) apply advanced computing methodologies to integrate cyclone data; and 2) 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

NOAA Funding Unit: OAR/AOML

NOAA Technical Contact: Mark Powell

Research Summary:

The HRD Real-time Hurricane Wind Analysis System (H*Wind) is a distributed system that ingests real-time global tropical cyclone observations measured by land-, sea-, space-, and air-borne platforms adjusting them to a common framework, 10m marine exposure. These observations are stored in 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 satellites, METAR, C_MAN, Buoys, Ships, mobile Towers, MESONET data from FSL MADIS Group.

The H*Wind Quality Control (QC) Client is the focal point of the H*Wind system. The QC Client allows scientist to interact with the data stored in the database. QC graphically displays the data and allows close inspection, editing or removal of data from the analysis, 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.

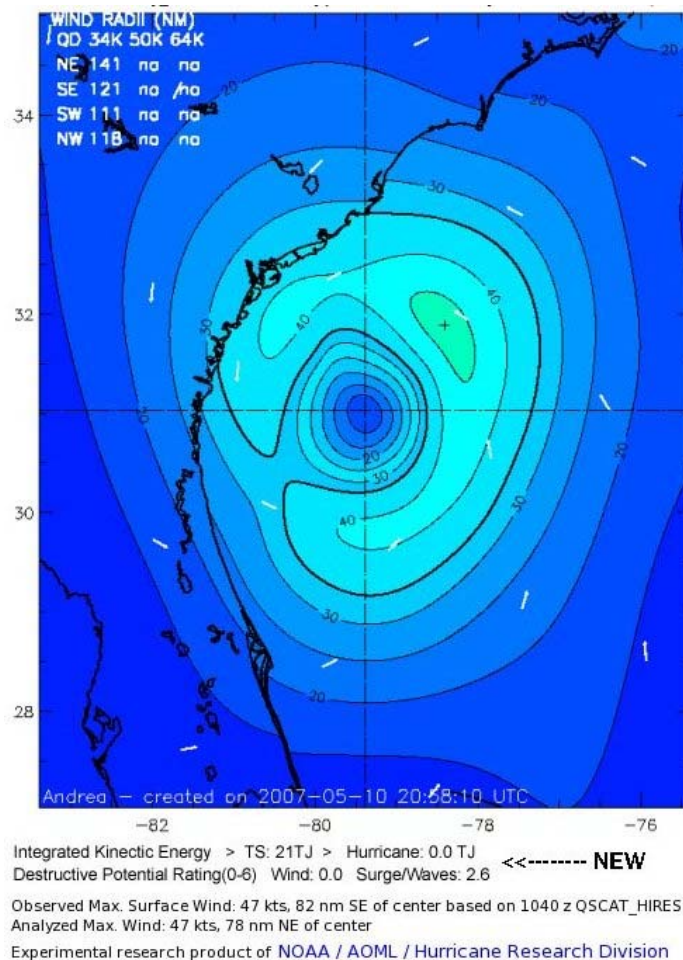


Figure 1: Subtropical storm Andrea, May 9, 2007, 1330 UTC. Note the new annotation for kinetic energy values.

Drastic changes in network logistics occurred during this year, impacting continuing research. The mandate by the National Hurricane Center (NHC) to terminate the hosting of the project's servers caused a rush to transfer data of several years of service from an old database to the

new open-source database at AOML, a task to be yet fully completed. In parallel, routines for an automated quality control of observations were investigated and prototyped. Based on a data mining technique known as spatial clustering, the routine finds patterns within the data according to the density of observations, while detecting noise. This algorithm would save scientists time when trying to identify those observations that do not match neighboring ones, and therefore, should be eliminated from entering an analysis. Eventually, we could produce an objective analysis product that goes through a non-interactive quality control process.

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

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Air-Sea Flux Estimation in High Wind Boundary Layers

W. Drennan and J. Zhang (UM/RSMAS);
P. Black (NOAA/AOML); J. French (U. Wyoming)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To improve forecast accuracy for hurricanes and tropical systems within the context of the CBLAST initiative.

Strategy: To provide direct measurements of the air-sea fluxes of momentum, heat and moisture in hurricane conditions, all of which are important input parameters to coupled hurricane models.

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

NOAA Technical Contact: Peter Black and John Gaynor

Research Summary:

The air-sea fluxes of momentum, heat and moisture in hurricane conditions are important input parameters to coupled hurricane models. As part of the CBLAST (Coupled Boundary Layer Air-Sea Transfer) experiment, we carried out turbulence and supporting measurements from P3 aircraft during Atlantic hurricanes Edouard, Isidore and Lili (2002), Fabian and Isabel (2003), and Frances (2004). We have calculated the air-sea fluxes of humidity, heat, enthalpy, and momentum, along with their bulk transfer coefficients. These data, the first for wind speeds above 20m/s, extend the known wind speed range to almost 30 m/s.

The bulk humidity and heat transfer coefficients (Dalton and Stanton numbers, respectively) are found to be consistent with the earlier COARE-3 relation (Fairall et al. 2003, *J. Climate*) and HEXOS dataset (DeCosmo et al 1996, *J. Geophys. Res.*), with no wind speed dependence for winds up to 30m/s. This implies that any significant effect of sea spray on the humidity

flux is limited to even higher wind speeds. The bulk momentum flux or drag coefficient was found to be consistent with earlier parameterisations (i.e. to increase with wind speed) up to 25 m/s, and then to become constant for higher winds. The ratio of enthalpy to drag coefficients was found to be close to, but below, the Emanuel (1995) threshold for tropical cyclone development (Fig. 1). In addition, the structure of the hurricane boundary layer has been investigated using GPS sondes and aircraft profiles. It is found to differ fundamentally from conventional atmospheric boundary layers.

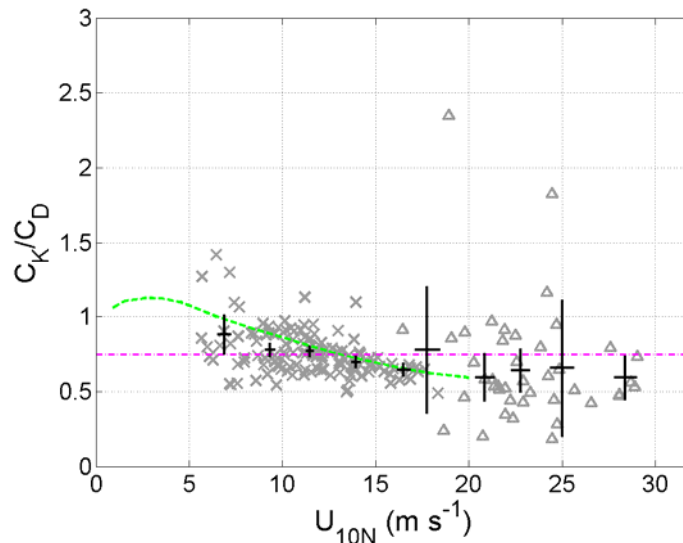


Figure 1: Wind speed dependence of the ratio of bulk enthalpy to drag coefficients (C_K/C_D). The symbols show CBLAST (Δ) and HEXOS (x) results. After binning observations by wind speed the mean and 95% confidence intervals as determined from a t-distribution of the combined HEXOS and CBLAST field data are shown in black. Revised COARE relationship is shown (---), along with the threshold value of 0.7 suggested by Emanuel.

Research Performance Measure: Most of the annual goals of the project were achieved; the program is on schedule.

* * * * *

Structure of Secondary Circulations in Hurricane Boundary Layers

S. Lorsolo (UM/CIMAS); P. Black (NOAA/AOML)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To test the hypothesis that coherent turbulent features exist in the hurricane boundary layer and play a significant role in boundary layer vertical fluxes by diagnosing the structure and statistics related to secondary circulations in the hurricane boundary layer.

Strategy: To: 1) analyze data from the new airborne Integrated Wind and Rain Atmospheric Profiler (IWRAP); to develop software to display horizontal secondary circulation features (roll vortices) at the surface and at one or two levels in the boundary layer; and 2) carry out statistical analysis of the size, shape and magnitude of these circulation features.

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:** Peter G. Black

Research Summary:

The initial research objective is to test the hypothesis that coherent turbulent features exist in the hurricane boundary layer and play a significant role in boundary layer vertical fluxes by first defining statistical properties of coherent structure perturbations at multiple levels within and above the hurricane boundary layer as a function of storm radius, quadrant and wind shear between the top and bottom of the hurricane boundary layer, especially statistics on dominant special scales. The second objective is to estimate radial and tangential momentum fluxes as a function of altitude and special scale, radius, storm quadrant and boundary layer shear. The third goal of the project, and key to hypothesis-testing, is to diagnose a schematic of the scale and shape of perturbation circulation features in height vs. radius coordinates and to relate these structures to damage streak patterns observed in land-falling hurricanes. Insofar as is possible from available data sets, we will make a comparison of perturbation statistics, momentum flux quantities and radial schematics between over-ocean and inland occurrence. We will also diagnose the dependence of coherent features on underlying ocean conditions, depending on availability of collateral data. We expect to be able to use the resulting statistics and structure information to validate ongoing studies aimed at incorporating Large Eddy Simulation (LES) models into the Hurricane Weather Research and Forecasting (HWRF) operational coupled hurricane track and intensity prediction model. This model, which is being brought on line in 2007, represents a new generation of improved hurricane forecast numerical models.

Research plans for the first year include obtaining WP-3D IWRAP data sets for two flight days in Hurricane Rita (Sept 22 and 23, 2005) and developing routines to read and process this data into radial, tangential and vertical winds relative to the storm center. The software developed for use on portable land-based Doppler radar will be utilized in this effort. Efforts will include development of software to display horizontal secondary circulation features at the surface and at one or two levels. In addition, data transformation routines will be developed to map the perturbations on to a height vs radius plot in a storm-relative coordinate system. Vertical profiles of horizontal and vertical wind from the airborne Tail Doppler radar will be compared with the IWRAP profiles to determine an optimum radar resolution for resolving these secondary flows.

Research Performance Measure: This project is only 2 months old; planning is on schedule.

Investigating the Boundary Layer in Hurricanes Using Unmanned Aircraft Systems

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

Long Term Research Objectives & 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 Hurricane Ophelia (2005) 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: OAR/AOML

NOAA Technical Contact: Joseph Cione

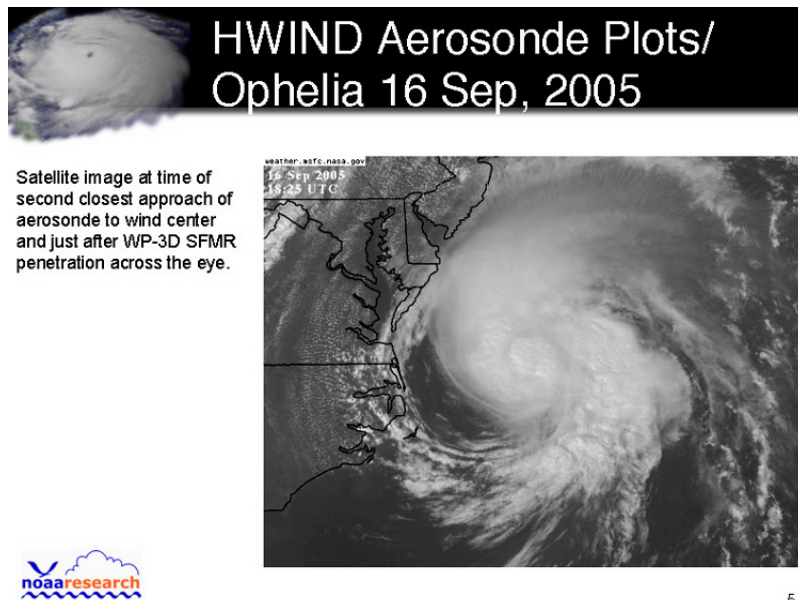
Research Summary:

The Aerosonde is a unique unmanned aircraft system that has been designed to fly in the core of hurricanes and 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 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 September 16th 2005, when it sampled Tropical Storm Ophelia, including its inner core, for 4 hours (Figure 1). The research is in its first year, and the focus has been on data analysis. Guy Cascella (1st year graduate student) has been collecting and processing data from 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). While the data from the other platforms had been routinely quality-checked and are reliable, several challenges remain to extract meaningful fields from the Aerosonde data. The in-situ temperature and wind measurements are currently undergoing validation. We are also investigating issues with the KT-11 surface temperature sensor that is mounted on the Aerosonde. While no Aerosonde flights were possible in 2006, it is hoped that further flights will be conducted in August-October 2007, during which the Aerosonde aircraft will be based at the Naval Air Station, Key West.

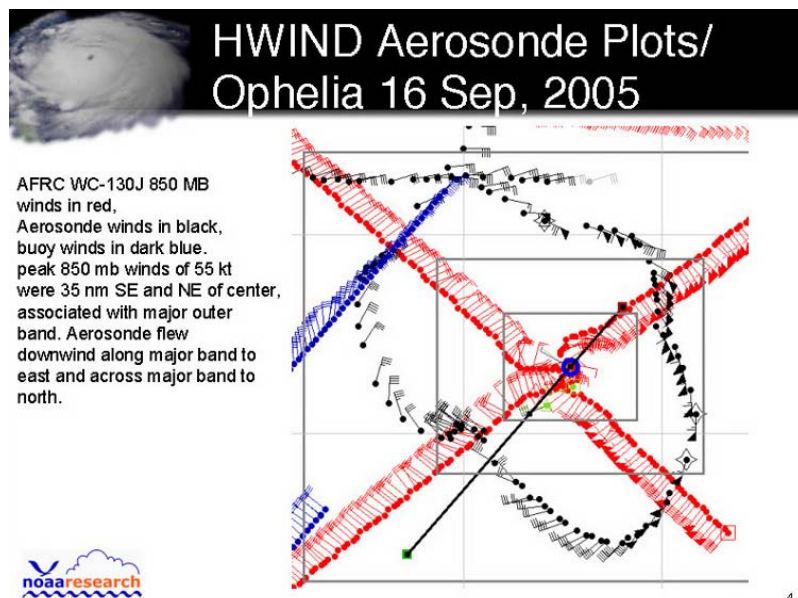
In addition to preparing and analyzing the data, Guy Cascella has also received training on the Hurricane Research Division's H*WIND surface analysis software, which is used widely in research and operations. One of the goals of our research is to diagnose the changes to the surface wind field that are made by introducing the Aerosonde data.

(A)



5

(B)



4

Figure 1: (A) Satellite image of Ophelia at the time of passage by the Aerosonde. (B) Aerosonde winds (black), buoy winds (blue), USAF C-130 850 hPa winds (red). The altitude of the Aerosonde winds is 750m, with the aircraft dropping to 450m during two sections. Figure courtesy of NOAA.

Research Performance Measure: The research objectives in Year 1 have been met.

Initial Steps Towards a Global Surface Water pCO₂ Observing System

F. J. Millero (UM/RSMAS); R. Wanninkhof and S. Cook (NOAAOML);
R. Feely (NOAA/PMEL); N. Bates (BBSR, Bermuda);
T. Takahashi (LDEO/Columbia Univ.)

Long Term Research Objectives & Strategy to Achieve Theme:

Objectives: To determine the changes in the pCO₂ in the Atlantic and Pacific Ocean waters in order to examine the uptake of fossil fuel CO₂ by the oceans over time.

Strategy: To use volunteer observing ships (VOS) in the Atlantic and Pacific oceans to carry out routine synoptic measurements.

CIMAS Research Theme:

Theme 5: Air-Sea Interactions and Exchanges

Link to NOAA Strategic 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: OAR

NOAA Technical Contact: Joel Levy

Research Summary:

In order to make informed policy decisions regarding climate, it is necessary to understanding the global carbon cycle and to determine the regional sources and sinks of carbon. These data are also necessary for forecasting long term climate trends. Projections of long-term global climate change are closely linked to assumptions about feedback effects between the atmosphere, the land, and the ocean. To understand how carbon is cycled through the global climate system, ocean measurements are of utmost importance. In this effort, NOAA is outfitting research and commercial vessels with automated carbon dioxide sampling equipment to analyze the seasonal variability in carbon exchange between the ocean and atmosphere. This task is coordinated at national level with the U.S. Global Carbon Cycle Science program and its subcommittee on Ocean Carbon and Climate Change (OCCC). To date it has benefited from the International Ocean Carbon Coordination Project (IOCCP) for international coordination exercises. The IOCCP is a joint endeavor of the SCOR/IOC CO₂ panel and the IGBP-IHDP-WCRP Global Carbon Project. Formal ocean basin ties are being formed in the Atlantic through a Memorandum of Understanding with the European Union project Carbo-Oceans. Pacific collaboration is established through the PICES working group 13.

Documenting carbon sources and sinks relies critically on other efforts undertaken by the Climate Observations and Services Program(COSP) including implementation of the ship lines, and moored and drifting arrays. The surface water pCO₂ programs support climate services by providing knowledge and quantification of climate forcing of the radiatively important gas, carbon dioxide. The near-term focus is on completion of the Northern Hemisphere ocean carbon observing system to assist in determining carbon dioxide sources and sinks over the coterminous United States in partnership with the atmospheric CO₂ observing system.

Two separate proposals have been joined into the underway pCO₂ observing program on volunteer observing ships (VOS) and research ships. It is a partnership of AOML, AOML/GOOS, PMEL, LDEO of Columbia University, RSMAS of the University of Miami, and the Bermuda Biological Station for Research (BBSR). Data from the project is being served from three websites that are linked and accessible from each.

1. <http://www.aoml.noaa.gov/ocd/gcc>
2. <http://www.pmel.noaa.gov/co2/uwpc2/>
3. <http://www.ldeo.columbia.edu/res/pi/CO2/>

The U. Miami group works together with Dr. Rik Wanninkhof's NOAA/AOML group to determine pCO₂ and TA on VOS ships in the Atlantic Ocean. We have been instrumental in constructing pCO₂ systems that will be used by NOAA investigators and other international workers to make measurements of CO₂ on VOS ships. To ensure uniformity in measurements, a prototype pCO₂ system is being constructed by General Oceanics under our supervision and the systems are available for other researchers making pCO₂ measurements. The company has built six pCO₂ systems for European and NOAA investigators. We are cooperating with other scientists in the development of a software package to standardize the reduction of the oceanic pCO₂ data. We have also been involved with the construction of TCO₂ coulombic systems that will be used by Miami and NOAA labs (AOML and PMEL).

The group adheres to quality control procedures to insure the integrity of data and have developed methods for the collection and management of the data. The responsibility of the RSMAS group focuses on the analysis of the TA/DIC samples and instrument development. A typical VOS ship is the *Skogafoss* (Fig. 1) which sails between Iceland and Boston and covers a critical high latitude region that has been shown to be a large CO₂ sink. Large seasonal variations are observed. During the early spring, pCO₂ values well above atmospheric levels are measured over most of the ocean transect due to entrainment of deep water to the surface. In late spring, values decrease significantly as a result of high biological productivity during this time.



Figure 1: Container Ship Skogafoss is outfitted with a pCO₂ system that provides data for quantifying carbon dioxide sources and sinks in the North Atlantic.

Research Performance Measure: The program is achieving its goals on schedule.

Eastern Pacific Ocean Heat Content Estimates For SHIPS Forecasts

L. K. Shay (UM/RSMAS); M. M. Mainelli (NOAA/TPC);
M. DeMaria (NOAA/CIRA)

Long Term Research Objectives & Strategy to Achieve Them:

Objective: To improve hurricane intensity forecasting using oceanic heat content (OHC) estimates in the Eastern Pacific Ocean (EPAC) at NOAA's Tropical Prediction Center (TPC) and the Central Pacific Hurricane Center (CPHC).

Strategy: To estimate and evaluate satellite-derived OHC variations using in situ data in the EPAC and assess its relationship to hurricane intensity structure and change.

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: Joint Hurricane Testbed Program

NOAA Technical Contact: John Gaynor

Research Summary:

Studies in the Atlantic Ocean Basin clearly show that tropical cyclone (TC) intensity changes are sensitive to OHC variations. Examples which support this hypothesis are hurricanes Katrina, Rita and Wilma in 2005. The Eastern Pacific Ocean (EPAC) is a region of significant oceanic variability given the warm pool and the cold tongue and warm eddies forced by coastal winds all of which impact TC intensity change. Given the TC activity from May through October and large sea surface temperature (SST) gradients, OHC estimates are needed for use in the Statistical Hurricane Intensity Prediction Scheme (SHIPS) to forecast storm intensity. In the EPAC, the seasonal thermocline at the base of the ocean mixed layer (OML) is sharp where large gradients start about 40 m beneath the surface. Since it is a prime region for rapid intensification (i.e. hurricane Juliette in 2001), the approach involves developing an oceanic climatology; monitoring OHC from satellite-derived altimetry and SST measurements; and, incorporating these daily fields into SHIPS for hurricane intensity forecasts by TPC and CPHC.

Ocean structure data sets from Volunteer Observing System ship transects, NOAA Tropical Atmosphere Ocean buoys, and field measurements acquired NOAA/NSF Eastern Pacific Investigation of Climate program are being used to evaluate satellite-derived OHC and isotherm depths. These measurements are crucial to establish an accurate seasonal OHC climatology using the U.S. Navy's Generalized Digital Environmental Model data base in conjunction with radar altimeter measurements of the surface height anomaly (SHA) and SST fields from multiple platforms.

Warm ocean rings in the EPAC contain about one-third the OHC that is usually observed in the Gulf of Mexico warm core rings. However, the strength of the ocean stratification at the OML base causes substantial differences in the ocean response to TC forcing. The approach was modified for this EPAC application since the stratification is much stronger in the EPAC. At the base of the OML, the stratification or buoyancy frequency (i.e. the vertical derivative of

the density structure) has a value of more than 20 cycles per hour (cph) compared to values of 12 cph in the Atlantic basin, which impacts ocean mixing and SST cooling.

SSTs, 26°C isotherm depths and OHC values from the TAO mooring at 10°N and 95°W (as well as CTD profiles from *R/V Ron Brown*) were compared to satellite-derived fields based on the blended altimeter data and the GDEM climatology. In situ SSTs are in good agreement with those from the satellite derived SSTs over the time series (Figure 1). The approximate 0.5°C differences are attributed to the fact that satellites sense skin temperature whereas the TAO data represent a more bulk measurement in the upper part of the OML. Satellite inferred 26°C isotherm depth shows a much higher correlation to this observed isotherm depth, and as a warm eddy passes the mooring, isotherm depths reflect a deeper warmer layer. The OHC values range from about 20 kJ cm⁻² to 40 kJ cm⁻² prior and during warm eddy passage. The TAO mooring data suggests slightly larger values during eddy passage. We continue to evaluate the approach using *in situ* data from TAO mooring and EPIC experiment. Currently, daily values of the EPAC OHC are placed on our experimental WEB page. We had a slippage because of the delays in initial funding, and accessing the most recent climatology to use in the estimation procedure. We expect to transition the approach and climatology to TPC/NHC by the end of the year after these comparisons are completed.

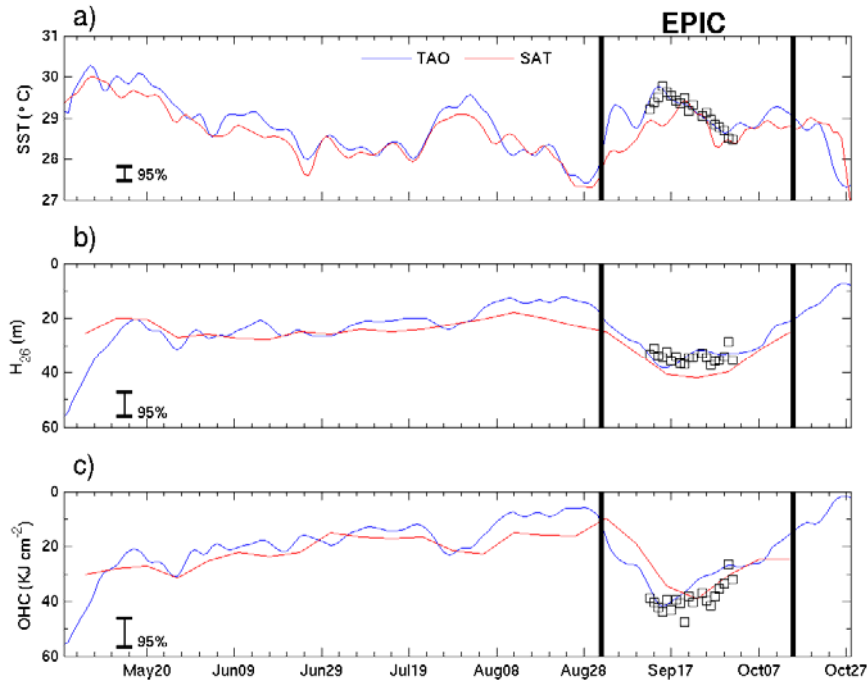


Figure 1: Time series comparisons of a) SST (°C) , b) H₂₆ (m) and c) OHC (kJ cm⁻²) from TAO mooring at 10°N, 95°W (blue), satellite-derived (red) based on GDEM V3, and CTD profiles (boxes) from the NOAA *R/V Ron Brown* acquired at the TAO mooring during the NSF/NOAA Eastern Pacific Investigation of Climate (EPIC) experiment from 1 Sept to 15 Oct 2001. The 95% confidence interval is based on the *student-t* test for comparing two sets of mean quantities.

Research Performance Measure: Despite the slippages noted above, we are meeting the objectives in a timely fashion.

Theme 6: Integrated Ocean Observations

Atlantic High Density XBT Lines

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

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To study the upper ocean thermal structure and associated ocean dynamics and estimate the poleward temperature transport in the Atlantic Ocean.

Strategy: To measure the upper ocean thermal structure in the center of the subtropical gyre in the North Atlantic and South Atlantic Ocean using high-density XBT lines and 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 in key regions of the Atlantic Ocean (Figure 1). The seasonal to interannual variability in upper ocean heat content and transport is monitored 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) have been 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 milestones: *to occupy volunteer observing ship (VOS) lines for high accuracy upper ocean and surface meteorological observations, by 2007.*

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 offer the only means to measure subsurface temperature fields in spatial and temporal scales designed to map the mean and fluctuating components of the ocean thermal structure. Data obtained from these lines, called AX25, AX18, AX08, AX10 and AX07, 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.

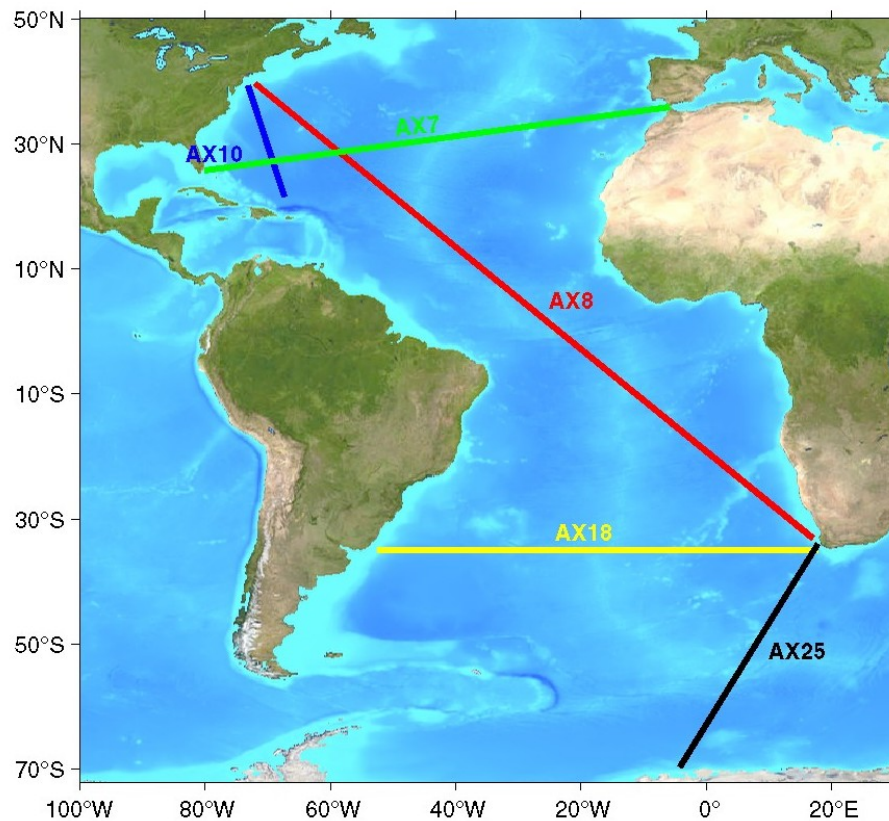


Figure 1: Map of station locations for the five high density lines maintained by NOAA/AOML.

This project includes extensive operations that collect the data: up to eighteen cruises are conducted each year, including in excess of 225 days at sea and more than 2500 XBTs deployed. 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/hdenxht/> for additional details). Additionally, satellite altimetry data are being used to complement the observations provided by the XBT transects.

Research Performance Measure: All research goals were met during this year.

Global Drifter Program

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

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To: 1) 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; 2) collect and validate data from the Global Telecommunications System (GTS) and provide for its dissemination; and 3) provide uniform quality-controlled data from the historical data sets of SST and surface velocity.

Strategy: To: 1) produce an annual plan for the global distribution and deployment of 950-1000 drifters through interaction with international partners; 2) coordinate drifter objectives with NOAA field personnel, contractors, shipping companies and various ship personnel; 3) verify deployment status and update Drifter Database; 4) monitor on a daily basis GTS sensor failure and remove these sensors from the GTS; 5) place newly deployed drifters onto the GTS; and 6) create global population maps showing drogued and undrogued drifters and to make drifter data promptly available on the web.

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 the principle 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). *Drifter Operations Center* (DOC) maintains 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. The *Drifter Data Assembly Center* (DAC) collects and validates data from the Global Telecommunications System (GTS) and provides for its dissemination. 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 continues to evolve. An example is the recent introduction of the mini drifter. Nonetheless the qualitative characteristics and water-following properties have remained relatively steady 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 help us to 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 profiling float program and 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 and accessible manner.

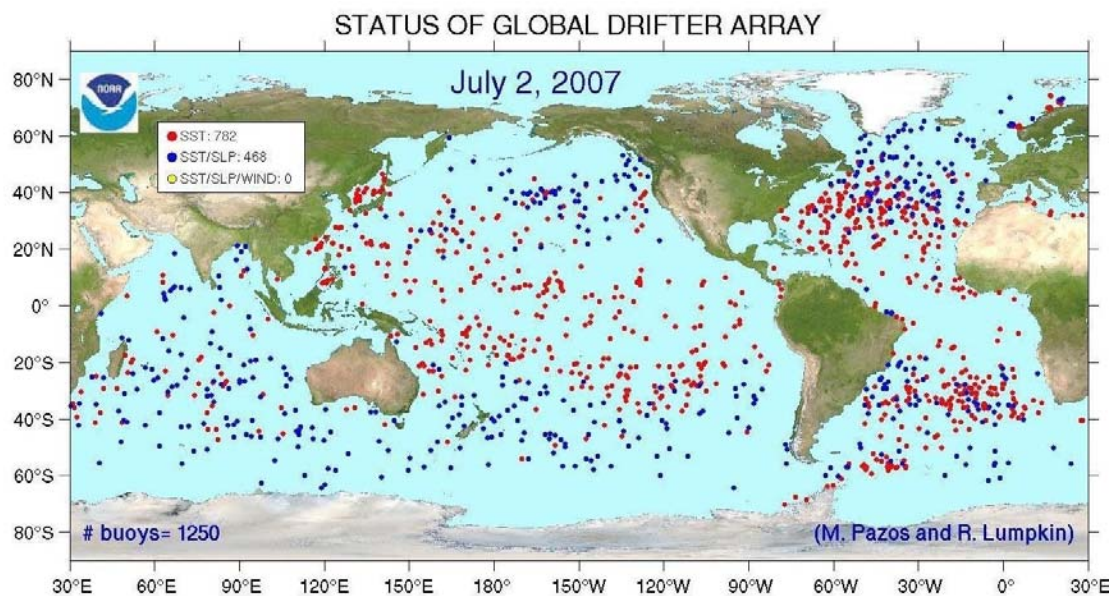


Figure 1: Status of the Global Drifter Array (updated weekly)

The Global Drifter program has been given the added task of evaluating the observing system for surface currents (Rick Lumpkin and Gustavo Goni, NOAA/AOML; Pedro DiNezio, CIMAS). In this study, we derive the status of the observing system for surface currents obtained from quality-controlled, drogued Lagrangian drifter observations. 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 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 during this year.

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

X. Xia, E. Forteza, H. Yang, S. Dong and C. Alex (UM/CIMAS);
C. Schmid, R. L. Molinari, R. Sabina, Y.-H. Chong Daneshzadeh (NOAA/AOML)

Long Term Research Objectives and Strategy:

Objectives: To improve our understanding of interannual to multidecadal ocean variability and its role in climate.

Strategy: To monitor ocean parameters over large areas of the ocean through the deployment of 1500 profiling floats as a part of a global array of 3000 floats.

CIMAS Research Theme:

Theme 6: Integrated Ocean Observations

Link to NOAA Strategic Plan Goal:

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

NOAA Funding Unit: OAR/AOML

NOAA Technical Contact: Reyna Sabina

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 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 will eventually consist of a total of 3000 profilers.

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:

- 443 floats were deployed by the USA
- 133 of these floats were deployed by AOML
- 1523 US floats are actively reporting
- 47192 profiles sent to GTS by the US DAC
- US DAC is processing 109 Argo-equivalent floats (i.e. not funded by Argo) from different institutions and organizations (Florida State University, NAVOCEANO, University of Hawaii and National Buoy Data Center) and 16 donated floats.

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//HomePage/home.html>)

As part of the South Atlantic Regional Argo Data Assembly Center the final quality control steps are being developed. They involve comparing Argo profiles after scientific quality control by float providers with each other and with other independently obtained profiles (for example those collected during research cruises) to determine if additional corrections are needed. Software has been developed to derive time series of the differences between the profiles of each float and climatology as well as nearby profiles from other instruments (e.g. XBT, CTD) at multiple levels. Summery statistics for each float are derived to allow the detection of floats with problems. Future developments involve the derivation of robust criteria for the detection of floats with potentially erroneous calibrations and the creation of reports for the float provider.

Quality controlled Argo profiling data are also used to calibrate thermosalinograph (TSG) data. Float data have to be measured within one week and 150km distance from the TSG measurement for this purpose.

Research Performance Measure: This program has attained all objectives and has met all time schedules.

NPOESS/VIIRS Sea Surface Temperature (SST): Pre-launch Performance Analysis and Option Improvement Development

R. Evans, P. Minnett, K. Kilpatrick, W. Baringer, V. Halliwell, and S. Walsh
(UM/RSMAS); A. Ignatov (NOAA/NESDIS/Office of Research and Applications);
D. May (NOAA/NESDIS/Naval Oceanographic Office)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To assist in the pre-launch verification of the SST algorithm proposed for the VIIRS sensor by the Contractors Raytheon and Northrup Grumman.

Strategy: To evaluate the VIIRS algorithm using the MODIS AQUA and TERRA Matchup databases and full resolution MODIS brightness temperature as a proxy for VIIRS.

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: NPOESS Integrated Program Office

NOAA Technical Contact: Robert Murphy

Research Summary:

For NOAA to meet the strategic goal of understanding climate variability, it is necessary to characterize the bias and uncertainties in satellite SST measurements. The AVHRR sensor is planned for replacement by the VIIRS sensor aboard the NPOESS satellite program. NOAA has entered into agreements with private industry contractors to obtain the next generation of satellite SST algorithms and data from the VIIRS instrument.

Researchers at the University of Miami are serving as a team of independent outside advisors to NOAA and the Integrated Program Office (IPO) for the NPOESS VIIRS SST mission. The University of Miami/ RSMAS objectives in this joint effort with NESDIS and NAVOCEANO is to verify the proposed VIIRS algorithm. Specific objectives for the first year were:

1. To verify the VIIRS algorithm using the MODIS AQUA and TERRA matchup databases (MMDB).
2. To test the VIIRS algorithm on full resolution MODIS data.
3. To prepare high resolution predicted error fields of the VIIRS algorithm.

The contractor-proposed VIIRS algorithm was successfully integrated into a GHRSSST-like program which provides a robust testing environment for the algorithm. Sets of select global images were processed and evaluated using NGST-supplied coefficients and Miami-derived coefficients from the Matchup database. The contractor's Dual Split Window algorithm (DSW) was found to have significant discontinuities at the boundaries between different regimes (e.g. cold-dry atmosphere to cold-moist atmosphere) as seen in Figure 1. A meeting was hosted by the University of Miami between the federal scientists and the contractor, Northrup Grumman, in November to compare results. Because of the extremely poor performance of the NGST algorithm revealed in testing by both NGST and Miami, all parties

agreed that the results were not acceptable in an operational environment. The contractor was encouraged to consider integrating the heritage NLSST algorithm into the VIIRS software.

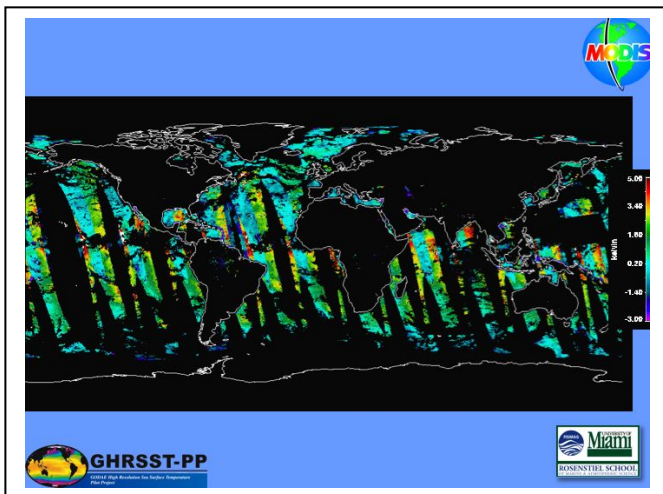


Figure 1: Difference image for August 24th, 2004 Daytime VIIRS SST- AMSR-E SST. Computed using NGST supplied coefficients and algorithm applied to MODIS Brightness Temperatures as a proxy for VIIRS sensor. Results show dramatic discontinuities at regime boundaries in the Contractor supplied algorithm.

Research Performance Measure: All research objectives for the first year were accomplished on time and within budget.

* * * * *

Development, Maintenance, and Migration of the Pathfinder Sea Surface Temperature Algorithm and Associated Data Systems

R. Evans, K. Kilpatrick, V. Halliwell, and S. Walsh (UM/RSMAS);
K. Casey (NOAA-NODC)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To: 1) produce global V5 4km Pathfinder SST fields, 2) introduce methods of minimizing the remaining major sources of error in the Pathfinder SST time series, and 3) begin the process of transferring the Pathfinder SST technology from the research to operations arena.

Strategy: To continue the production of the global Pathfinder SST fields including: 1) derivation of the time-dependent Pathfinder algorithm coefficients, 2) data screening improvements that will reduce the remaining errors in the SST estimates 3) Outline a strategy to transfer activities to NODC for long term data stewardship.

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

Research Summary:

Sea surface temperature (SST) estimates are derived from a variety of satellite sensors, but none have continuously acquired global observations for as long as the Advanced Very High Resolution Radiometer (AVHRR). The Pathfinder SST program was originally initiated as a cooperative research project in 1991 between the University of Miami, Rosenstiel School of Marine and Atmospheric Science (RSMAS) and the NASA JPL Physical Oceanography Distributed Active Archive Center (PO.DAAC). Beginning in 2002, NODC began partnering with RSMAS to successfully improve the Pathfinder SST CDR, improve its long-term stewardship, and broaden its usage. This highly successful project is currently in the 3rd year of a 3 year demonstration project. RSMAS has been responsible for production of the daily, weekly, monthly, and yearly SST fields; an example is shown in Figure 1. The activities also include generation of SST algorithm retrieval coefficients and validation of the retrieved satellite SST through analysis of a collocated satellite, in situ matchup database. The global fields are then transferred to NODC for additional metadata and quality control and then on to the PO.DAAC to enhance distribution to the user community. The current user community includes climate-change scientists, weather and hurricane research, ecosystem managers, and shipping and maritime interests located at US and international academic institutions as well as a wide range of US federal, international, operational, and commercial agencies.

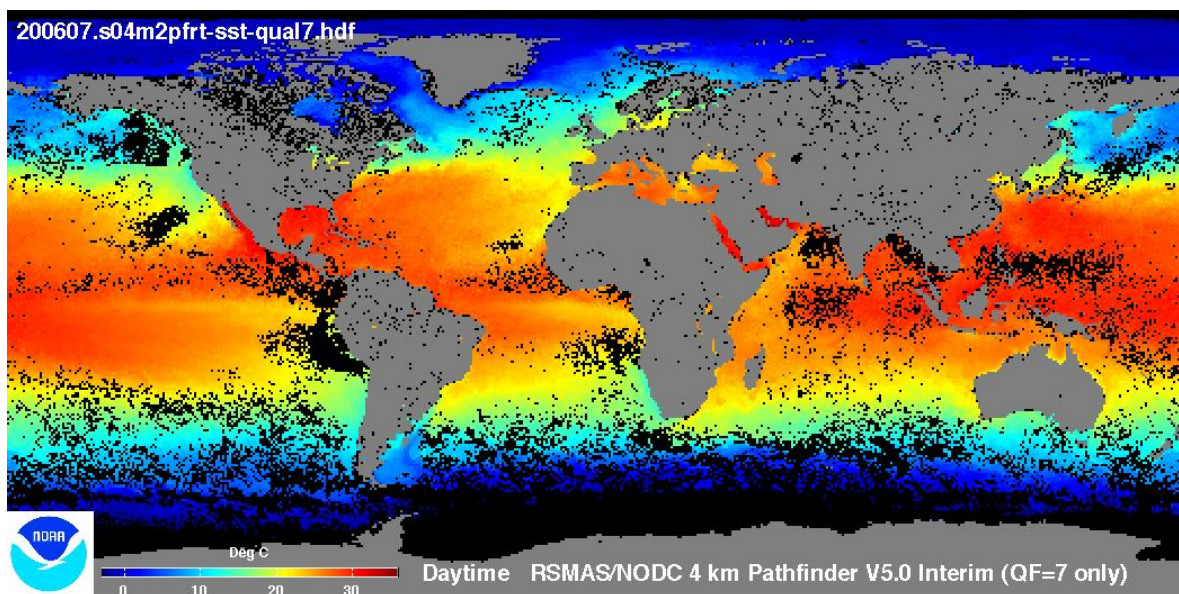


Figure 1: AVHRR 4km Version 5 Pathfinder daytime SST monthly composite for July 2006. Highest quality (QF=7) retrievals only.

Research Performance Measure: The program is on schedule and producing products in a timely manner.

Integrated Coral Observing Network (ICON) Project

L. Gramer, M. Jankulak and D. Manzello (UM/CIMAS);

C. Langdon and M. Collazo (UM/RSMAS);

J. Hendee, M. Shoemaker and J. Craynock (NOAA/AOML)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To: 1) facilitate *in situ* observations at coral reef areas; 2) 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; 3) 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 environment at 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 (*Primary*)

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

NOAA Funding Unit: Coral Reef Conservation Program

NOAA Technical Contact: Jim Hendee

Research Summary:

Through continuous data collection and real-time monitoring, the Integrated Coral Observing Network (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 North Norman's Reef near the Island of Exuma, Bahamas; 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 2006-2007 year, the project continues to focus its efforts in two primary areas: 1) integration of data and the ability to draw automated, real-time inferences about ecological and physical events on the basis of that data; and 2) continued deployment of new, and maintenance of existing stations and *in situ* sensors, based on a continually evolving structural hardware design, that offers incrementally increased stability and reliability of the instrumentation at each new (or updated) study site. The ICON/G2 expert system combines station observations from instruments such as pCO₂ sensors, multi-spectral light instruments, temperature loggers, meteorological and hydrographic instruments and others, together with data from satellite sensors including 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. These ecological forecasts are then distributed via email to researchers, and via the ICON/G2 Ecoforecast website at <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. Notably, this past year saw the successful installation of a new ICON station (“DBJM1”) at Discovery Bay in Jamaica; the deployment of a newly redesigned ICON station (“SRVI2”) at the Salt River site in St. Croix; and installation and collection of data from pCO₂ monitoring systems at each of the La Parguera and Discovery Bay ICON stations, and at the SEAKEYS station (“MLRF1”) on Molasses Reef, Florida. These systems continue to collect valuable data, providing direct *in situ* measurements of dissolved carbon in the water column that are now being used as source data for both boundary conditions on, and verification of regional models for air-sea carbon transfer.



Figure 1: A photograph of the May 2007 installation of the new ICON monitoring station “DBJM1”, in Discovery Bay, Jamaica.

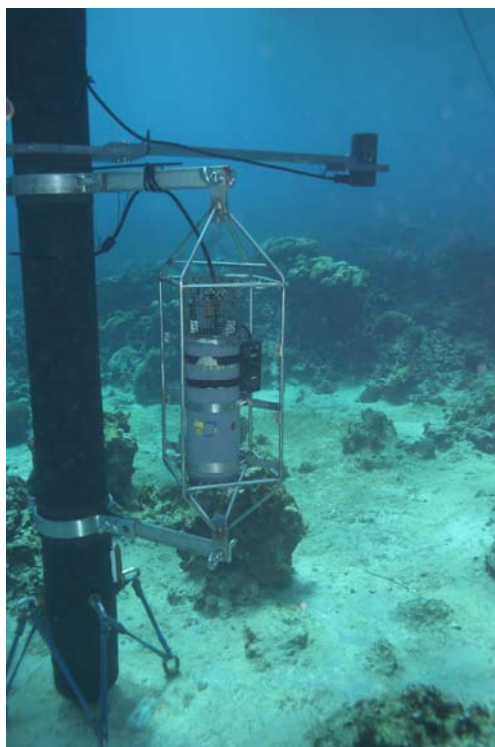


Figure 2: A photograph showing the Sunburst Sensors “SAMI” automated pCO₂ sensor operating now at ICON station “LPPR1”, near La Parguera, Puerto Rico.

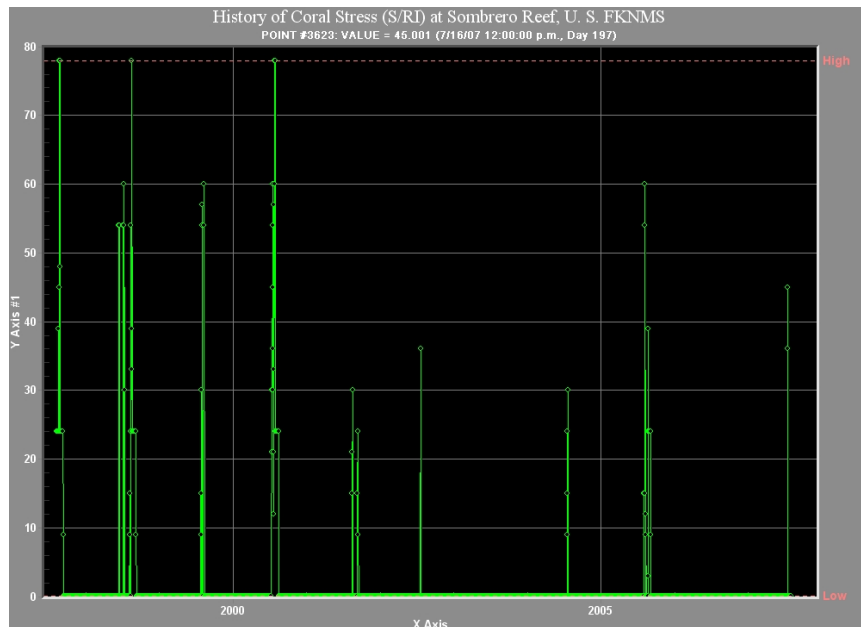


Figure 3: A plot showing the environmental index of coral community stress (Stimulus / Response Index or “S/RI”) from 1997-2007, at SEAKEYS station “SMKF1” on Sombrero Reef, U. S. Florida Keys National Marine Sanctuary.

Research Performance Measure: All objectives were reached.

Surface Water pCO₂ Measurements From Ships

K. Sullivan, D. Pierrot and H. Lueger (UM/CIMAS); R. Wanninkhof (NOAA/AOML)

Long Term Research Objectives & Strategy to Achieve Them:

Objectives: To constrain regional ocean CO₂ fluxes to 0.2 Pg C/yr.

Strategy: To make sustained observations using automated pCO₂ systems on volunteer observing ships (VOS).

CIMAS Research Theme:

Theme 6: Integrated Ocean Observations (*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: Office of Climate Observations (OCO)

NOAA Technical Contact: Mike Johnson

Research Summary:

The ship-based surface pCO₂ program is designed to document regional oceanic carbon sources and sinks on seasonal timescale by measuring surface water and marine boundary pCO₂ on ships of opportunity. The program contributes to the goal of creating regional flux maps on seasonal timescales to quantify uptake of anthropogenic CO₂ 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-05 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, Atlantic and Caribbean.

We continue to focus on the coordination of similar efforts on a global scale. We have taken the lead in providing uniform autonomous instrumentation for installation on ships of opportunity (SOP). 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.

Research Performance Measure: The program is meeting its goals on schedule.

Mean Annual Air-Sea Flux for 2000 (NCEP II Wind, 2,791K, $\Gamma=.24$)

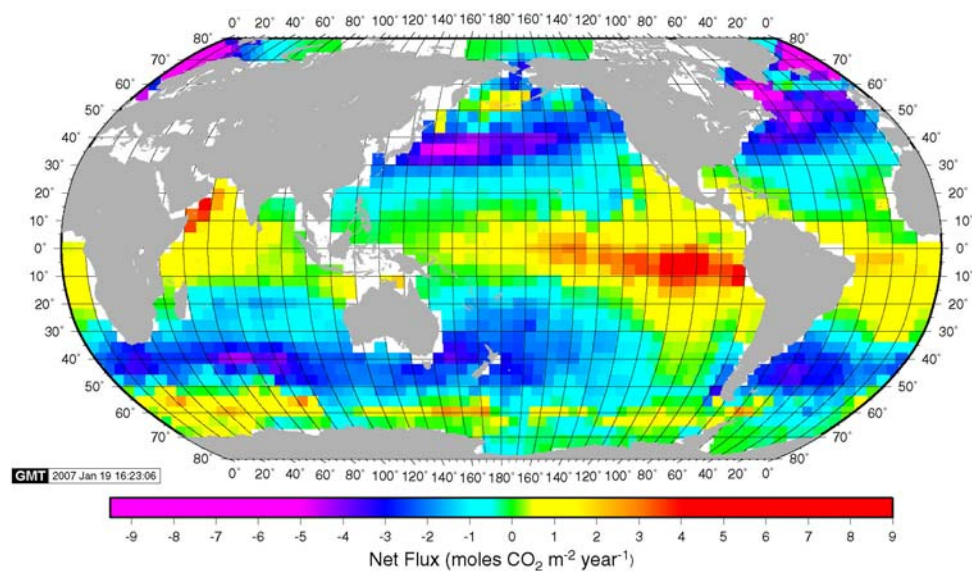


Figure 1: Map of updated air-sea CO₂ climatology that was produced by Dr. Taro Takahashi of LDEO in 2007. Data from this project was used extensively in this update.

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., fisherman), 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 often designed to serve as an outreach function. We do not list these here.

Explorer of the Seas Programs

The Rosenstiel School and Royal Caribbean Cruise Lines (RCCL) with support from NOAA and NSF, and with the close cooperation of NOAA and CIMAS scientists are engaged in a unique collaboration to study the ocean and atmosphere during routine cruises of the RCCL ship *Explorer of the Seas*. <http://www.rsmas.miami.edu/rccl/>. *Explorer* is a new state-of-the-art cruise ship (142,000 tons, 1020 feet LOA, 157.5 ft beam; 3114 passengers; cruising speed, 23.7 kts) which started operations out of Miami in October 2000. During much of the year the *Explorer* makes weekly cruises across the Gulf Stream to ports in the Caribbean and the Bahamas. RCCL provides free-of-charge two science laboratories to RSMAS and AOML, an atmospheric sciences laboratory and an oceanographic laboratory. Laboratory instrumentation was obtained with funds provided by RCCL, NOAA, and NSF. RCCL also provides at no charge two passenger cabins for RSMAS, AOML and visiting scientists and technicians. All data are made available to the general scientific community and to the public.

CIMAS and NOAA Research on the Explorer

The ship carries a wide range of instrumentation that allows continuous unattended measurements of a wide range of ocean and atmospheric properties. Data is returned via various communication links to data centers at RSMAS, National Weather Service, NOAA's National Data Buoy Center at Stennis Space Center, and the GLOBE (Global Learning and Observations to Benefit the Environment) program. A number of research programs supported through CIMAS make use of the *Explorer* as described elsewhere in this annual report. The program is designed to facilitate the participation of scientists outside the UM and NOAA communities as described on the *Explorer* web site.

<http://www.rsmas.miami.edu/rccl/participate.html>

Outreach Aboard the Explorer

The research facilities were designed to facilitate observation and educational activities by the vacationing passengers. The passengers can observe data being collected in real time. Also all scientists who participate on the one-week cruises must provide one or more lectures to the passengers. Educational materials are provided to passengers as well. Scientists from the local NOAA laboratories and from RSMAS-CIMAS routinely participate on these cruises and lead the outreach activities.

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. Some examples:

- During the past year, students actively participated in two SEFSC-CIMAS programs: Monitoring Coral Reef Fish Utilization of MPA's and Inshore Habitats in Florida, and Monitoring Coral Reef Fish Utilization of MPAs and Recruitment Connectivity between the Florida Keys and Meso-American Reefs, both programs led by Dr. Monica Lara of CIMAS, and funded through CIMAS. The programs 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.
- Several UM undergraduate students participate in the bi-monthly cruises that take place as a part of the program: Long-Term Measurement of Physical, Chemical, and Biological Water Column Properties in the South Florida Coastal Ecosystem, a program led by Dr. T. Lee, RSMAS, and funded through CIMAS.

Global Ocean Surface Current Web Outreach

CIMAS provides partial support for a web site that presents information of ocean surface currents. The site, still under development, is designed to provide students with general information about oceanography but with a specific focus on ocean currents. The current information is derived from a data-assimilative hybrid isopycnal-sigma-pressure (generalized) coordinate ocean model (called HYbrid Coordinate Ocean Model or HYCOM). HYCOM is a multi-institutional effort funded by the National Ocean Partnership Program (NOPP), as part of the U. S. Global Ocean Data Assimilation Experiment (GODAE). A web-based reference site on ocean currents intended for students is accessible at <http://oceancurrents.rsmas.miami.edu>. The site contains introductory material for the non-specialist, a glossary, descriptions of named currents, etc.

A critical problem in ocean modeling and data assimilation is making both the observational data and model output available to (a) the members of our consortium for HYCOM and data assimilation code development, (b) the wider oceanographic and scientific communities, including climate and ocean ecosystem researchers; and (c) the general public. We are making a special effort to create modules that appeal to students in elementary and high school. The real-time global and basin model outputs are being made available to the community at large within 24 hours via the U.S GODAE and Miami Live Access Servers (LAS). The web activity is under the direction of Dr. Arthur Mariano (RSMAS, Div. Meteorology and Physical Oceanography).

University of Miami, a Minority Serving Institution

The National Oceanic and Atmospheric Administration (NOAA) has established research and education centers to advance the community of under-represented minority scientists in the US and, especially, in the NOAA workforce. The 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 underrepresented 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. J. Ault, a RSMAS faculty member. 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 led by Dr. R. Cowen, RSMAS, with NOAA funding through CIMAS. The program initially focused on RSMAS billfish pop-up satellite tagging 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 successfully 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. For details, see: <http://www.preschallenge.com/aab/aab.html>

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 some CIMAS funds and lead by the CIMAS-CUFER coordinator, Dr. David Die RSMAS and a CIMAS Fellow. Graduate and undergraduate students as well as university professors train high school students in marine science field sampling techniques, as well as research protocol, data synthesis and 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. Currently involved in the program are students from three South Florida high schools (MAST Academy, South Broward High school and Palmer Trinity), undergraduate students from the University of Miami Marine Science Program, and graduate students from RSMAS. 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>

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-SEFSC's Community Open House; and during the 2007 field season, we give *The Connectivity Project* presentation at The Nature Conservancy's SeaCamp summer program at Blowing Rocks Preserve, West Palm Beach, in conjunction with their mangrove snorkeling day. We estimate that over the past year, we directly reached approximately 4000 students and adults with our coastal conservation message via outreach presentations, activities, and website.

We actively partner with FIU-Layman Lab's web-based Adopt-a-Fish/Adopt-a-School Program (www.adoptafish.net) to post current data from our fish tracking study along with our education program and materials on a publicly available, interactive webpage. Through our interactive presentations in the community and then on the website itself, students and/or 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.

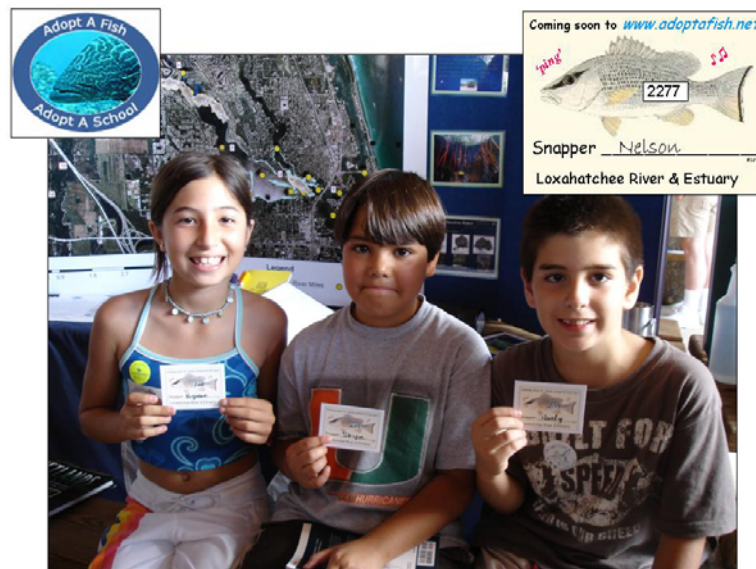


Figure 1: Local students “adopt” and name a tagged fish in the Loxahatchee Estuary and take home fish ID card to track its movements on www.adoptafish.net.

Assessment of Candidate Corals

D. Williams and L. Kramer (RSMAS) and M. W. Miller (SEFSC) lead a research program whose overall objectives of this project 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 produces scientifically useful data.

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, 12 from RSMAS, eight from the local NOAA laboratories, one from the National Hurricane Center and one 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.

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 6 there were four formal meetings: 16 June 2006, 22 September, 2006, 7 December, 2006 and 22 February, 2007. In addition there are frequent meetings of focus groups. Also many matters are 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	NOAA/AOML Office of the Director
Dr. Edward N. Rappaport	NOAA/National Weather Service
Dr. William J. Richards	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, Department 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. Alex Chester	NOAA/Southeast Fisheries Science Center

IX. AWARDS AND HONORS

Real-Time Hurricane Wind Analysis

Nicholas Carrasco, Bachir Annane, Sonia Otero and Russell St. Fleur (UM/CIMAS)

Dr. Mark Powell (NOAA/AOML)

- The entire AOML/Hurricane Research Division received NOAA's 2006 Bronze Medal award for innovation and commitment to the NOAA Hurricane Mission during Katrina's Louisiana landfall while recovering from the South Florida landfall.

Global Drifter Program

Jessica Redman, Shaun Dolk and Erik Valdes (UM/CIMAS)

Dr. Rick Lumpkin and Mayra Pazos (NOAA/AOML)

- J. Redman, E. Valdes and S. Dolk received certificates of Appreciation for their participation in making the NOAA 200th Anniversary Open House a great success.

Surface Water pCO₂ Measurements from Ships

Kevin Sullivan, Denis Pierrot and Heike Lueger (UM/CIMAS)

Rik Wanninkhof (NOAA/AOML)

- The CO₂ group received the Dept. of Commerce Gold medal in conjunction with colleagues at PMEL.

Investigation of the Movement of Adult Billfish in Potential Spawning Areas

Robert K. Cowen (UM/RSMAS), Eric D. Prince (NOAA/SEFSC), Joe E. Serafy (NOAA/SEFSC & UM/RSMAS)

- *North. American Journal of Fisheries Management* featured a 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.

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

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

- Monica Lara has been invited to be one of the three keynote speakers at the XV Reunion Nacional de la Sociedad Mexicana de Planctologia and VIII Meeting of the Mexican Society of Planktology to take place at CINVESTAV, Merida, Mexico in March 2008.

Iron Arrow Honor Society

Joseph Prospero, Director of CIMAS.

- Dr. Prospero was admitted to the Iron Arrow Honor Society. Iron Arrow, founded in 1926 at the time of the founding of the University, is the highest honor attainable by faculty, students, and staff at the University of Miami in recognition of scholarship and leadership among other factors.

X. POSTDOCTORAL FELLOWS AND GRADUATE STUDENTS

CIMAS-Supported Postdoctoral Fellows and Graduate Students

CIMAS Postdoctoral Fellows

Kang, HeeSook
Kerstetter, David
Lorsolo, Sylvie
Lueger, Heike
Valle-Esquivel, Monica
Walter, John

CIMAS-Supported Graduate Students

Brinson, Ayiesha
Castelao, Guilherme
DiSilvestro, Anthony
Gleason, Arthur
Grasso, David
Lopez, Cassandra
Mathews, Joe
McCrea, Ashley
Rice, Patrick
Tomoleoni, Joseph
Tust, Michael

Other Postdoctoral Fellows and Graduate Students Associated with CIMAS Programs

Other Postdoctoral Fellows

Baums, Iliana
Baigorría, G.
Crane, T.
García y García, A.
Guerra, L.
Hoolihan, J. P.

Huang, Jingfeng
Mathis, Jeremy
Miller, Tim
Pierrot, Denis
Solis, Daniel
Vasquez-Yeomans, Lourdes

Other Graduate Students

Berg, Robert
Bolson, Jessica
Carrasco, Nicholas
Chanson, Mareva
D'Allesandro, Evan
Farmer, Nick
Faunce, Craig
Feeley, Michael
Foresee, Jessica
Gerard, Trika
Ghate, Virendra
Gramer, Lewis
Kapul, Atul
Keener, V.
Johnston, Lyza
Kelble, Chris
Kelly, Patrick
Kleisner, Kristin
Koch, Veronique
Larkin, Mark
Luo, Yanxin

Manzello, Derek
Mason, Benjamin
Molina, Helena
Montaña, Carmen G.
Pathak, T.
Quattrochi, John
Ruzicka, Robert
Sellwood, Kathryn
Schiller, Rafael
Smith, Ryan
Swanson, Dione
Tonioli, Flavia
Trapp, J. Michael
Uhlhorn, Eric
Wanless,, David
Waters, Jason
Whitcraft, Samantha
Woli, P.
Woosley, Ryan
Zhang, Jun

XI. RESEARCH STAFF

Absten, Michael	Research Associate II
Alex, Carmen	Research Associate II
Annane, Bachir	Senior Research Associate III
Bringas, Francis	Research Associate II
Carrasco, Hector N.	Research Associate II
DiNezio, Pedro	Research Associate II
Dolk, Shaun	Research Associate I
Dong, Shenfu	Assistant Scientist
Dunion, Jason	Senior Research Associate III
Fonseca, Carlos	Research Associate II
Forteza, Elizabeth	Research Associate II
Frias-Torres, Sarah	Assistant Scientist
Garcia, Rigoberto	Research Associate II
Gramer, Lewis	Research Associate I
Hazra-Smith, Destiny	Research Associate II
Huang, Xiaolan	Assistant Scientist
Jankulak, Michael	Research Associate II
Jones, David	Research Associate I
Kelble, Christopher	Senior Research Associate I
Kramer, Katherine	Research Associate II
La Gier, Michael	Assistant Scientist
Lara, Monica	Associate Scientist
Lee, Sang-Ki	Assistant Scientist
Litz, Jenny	Research Associate III
Malca, Estrella	Research Associate I
Melo, Nelson	Research Associate III
Morisseau-Leroy, Nirva	Assistant Scientist
Otero, Sonia	Research Associate III

Pierrot, Denis	Assistant Scientist
Rawson, Grant	Research Associate II
Redman, Jessica	Research Associate II
Seaton, Kyle	Research Associate I
Sinigalliano, Christopher	Assistant Scientist
Stefanick, Andrew	Research Associate I
Stokes, Lesley	Senior Research Associate I
Sullivan, Kevin	Senior Research Associate II
Uhlhorn, Eric	Senior Research Associate III
Valde, Krystal	Research Associate I
Wanless, David	Research Associate II
Whitcraft, Samantha	Senior Research Associate II
Wicker, Jesse	Research Associate II
Williams, Dana	Assistant Scientist
Xia, Xiangdong	Research Associate III
Yang, Huiqin	Research Associate II
Yao, Qi	Research Associate III

XII. VISITING SCIENTISTS PROGRAM

Prof. Friedrich A. Schott

IfM-Geomar Leibniz-Institut für Meereswissenschaften
Düsternbrooker Weg 20, D-24105 Kiel, Germany

14 February – 13 March, 2007

Dr. Paul Ginoux

Geophysical Fluid Dynamics Laboratory
National Oceanic and Atmospheric Administration
Princeton, NJ

14 March, 2007: *“African Dust and North Atlantic Climate: Positive Feedback Between Dust and the Azores Anticyclone”*

Dr. Omar Torres

Joint Center for Earth Systems Technology
University of Maryland

27 March, 2007: *“The Global Distributions of Dust and Smoke: Measuring Aerosol Absorption with OMI Observations”*

Mr. Ernie Lewis

Brookhaven National Laboratory
Atmospheric Sciences Division
Upton, NY

23 April, 2007: *“Sea Salt Aerosol 101”*

24 April, 2007: *“Sea Salt Aerosol: Advanced Topics”*

XIII. PUBLICATIONS

We list all publications for the years 2006-2007, presented in categories. The category “Conference Proceedings” lists only publications that derive from presentations at meetings, it does not include oral presentations.

In Table 1 we summarize the record of publications over the period 2001 – 2007, 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 2001-2007

	Institute Lead Author				NOAA Lead Author				Other Lead Author			
	2001 -02	2002 -03	2003 -04	2004 -05	2001 -02	2002 -03	2003 -04	2004 -05	2001 -02	2002 -03	2003 -04	2004 -05
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 -06	2006 -07	2007 -08	2008 -09	2005 -06	2006 -07	2007 -08	2008 -09	2005 -06	2006 -07	2007 -08	2008 -09
Peer Reviewed	37	37			17	32			37	47		
Non Peer Reviewed	9	18			7	3			15	13		

Refereed Journal Articles

Ault, J. S., S. G. Smith, J. Luo, M. E. Monaco, and R. S. Appeldoorn (2007), Length-based assessment of sustainability benchmark for reef fishes in Puerto Rico, *Environmental Management*, accepted.

Bandstra, L., B. Hales, and T. Takahashi (2006), High-frequency measurements of total CO₂: Method development and first oceanographic observations, *Mar. Chem.*, 100(1-2), 24-38.

Bartholomew, A., J.A. Bohnsack, S.G. Smith, J.S. Ault, D.E. Harper, and D.B. McClellan (2007), Influence of marine reserve size and boundary length on the initial response of exploited reef fishes in the Florida Keys National Marine Sanctuary, USA, *Landscape Ecology*, accepted.

- Baringer, M. O., and S. L. Garzoli (2007), Meridional heat transport determined with expendable bathythermographs Part I: Error estimates from model and hydrographic data, *Deep-Sea Res., Part I*, 54(8), DOI:10.1016/j.dsr.2007.04.013, 1390-1401.
- Baums, I. B., M. W. Miller, and M. E. Hellberg (2006), Geographic variation in clonal structure of a reef-building Caribbean coral, *Acropora palmata*, *Ecol. Monogr.*, 76(4), 503-519.
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