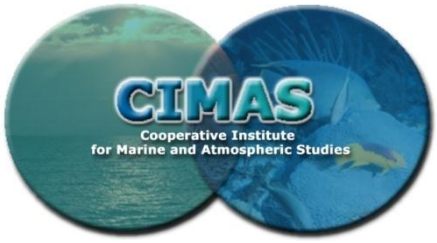
# Cooperative Institute for Marine and Atmospheric Studies




# Tenth Year Annual Report

## NOAA Cooperative Agreement NA17RJ1226
## Continuation Award NA08OAR4320892
## Shadow Award NA08OAR4320889

## July 1, 2010 - June 30, 2011

**Peter B. Ortner, Director**
**David Die, Associate Director**


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

# TABLE OF CONTENTS

# 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). Reflecting the diversity of research conducted at these laboratories, CIMAS carries out research under six inter-related 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 2010 - 2011, Year 10 under the continuing Cooperative Agreement (CA), were reduced after a successful re-competition process and new CA under which the majority of funding was awarded. Funding awarded in Year 10 under the old CA was therefore much reduced from prior years and totaled only $1,666.364. With respect to Task I what is included therein encompassed only the first three months of Year 10 (prior to the inception of the new CA) and specific additional expenditures made on an emergency basis in support of NOAA's Deepwater Horizon (DWH) response effort. With respect to Task II this encompassed only a small specific supplement for DWH response activities. With respect to Task III, ten projects received funding (three of which were out-years of vestigial "shadow award" projects funded by competitive NOAA programs and already reported upon as required by those program offices). Standard individual project reports upon these ten activities are included herein following the template provided. No additional Task IV funding was awarded during July, August or September 2010 and any research projects funding awarded to CIMAS after September 2010 was associated with the new CA. Because some funding for CIMAS Task II employee salaries was expended throughout Year 10 (although awarded previously), the majority of the research activities previously reported upon with respect to the new CA also received some funding under this continuation CA. Such projects are not described herein however they are identified and associated with the appropriate continuing CA research theme.

As previously reported, a total of 113 individuals at UM were directly provided salary support through CIMAS during this project period. Of these, 97 received over 50% of their support from NOAA through CIMAS. Of the 97 research employees who received over 50% NOAA support, 58 worked with AOML, 38 with SEFSC and one with the NHC.

As previously reported, the employees in the Research Associate and Research Scientist ranks have a diverse demographic profile. The population is 41% female. Foreign-born individuals make up 53% of the personnel. Of these, Hispanics make up 23% of the ranks; Asian and Pacific Islander, 18%. The population of CIMAS remains relatively young in comparison with NOAA and has an average age of only 39.

The research program in the CIMAS continued to be productive. During 2010/2011 there were 120 peer-reviewed publications and another 40 non-peer reviewed technical reports or other publications resulting from CIMAS related research. Thirteen (13) peer-reviewed publications and another 3 non-peer reviewed technical reports or other publications were added by the ten additional research projects added herein to the totals previously reported.

Because only ten projects are reported upon in full herein, singling out the research highlights as in prior more comprehensive reports for Y1-9 would be superfluous. The titles of the ten projects and their thematic assignments are as follows:

***Theme 2: Fisheries Dynamics:***

1. Florida Reef Trace Monitoring and Assessment

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

2. The Effect of Turbulence on the Behavior of Pink Shrimp Postlarvae

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

3. Marine and Estuarine Goal Setting (MARES)

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

4. Evaluation and Improvement of Ocean Model Parameterizations for NCEP Operations

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

5. Developing the Operational Calibration/Validation Components for VIIRS SST Retrievals
6. Simulation of the Argo Observing System
7. Observing System Simulation Experiments (OSSEs) in the Gulf of Mexico
8. Biogeochemical Measurements
9. Global Carbon Data Management and Synthesis Project
10. Climate Data Records of Sea-Surface Temperature

# 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) and managed by NOAA's Office of Oceanic and Atmospheric Research (OAR) through the NOAA Cooperative Institute Program Office. CIMAS was established in 1977 through a Memorandum of Understanding between NOAA and the University of Miami.

### *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 has served as a mechanism to promote synergisms between University scientists and those in NOAA. Most of our research is related to Oceanic and Atmospheric Research (OAR) or National Marine Fisheries Service (NMFS) programs and associated with research activity at the adjacent OAR/Atlantic Oceanographic and Meteorological Laboratory (AOML) and the NMFS/Southeast Fisheries Science Center (SEFSC) 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 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 have been 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.*

These 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 is 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 (and in one case at Florida International 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 fostering the development of new CIMAS research activities that benefit both NOAA and the University.

CIMAS activities fall into four Task categories. The administrative and most of the educational functions of CIMAS are carried out under Task I with funding provided by both the University and NOAA. About half of all CIMAS research is carried out under Task II wherein CIMAS provides highly specialized research scientists who work on research projects primarily carried out at NOAA's Miami facilities. The expertise of these CIMAS employees complements that already present within 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.

The remaining research in CIMAS is carried out under Tasks III and Task IV. These Tasks provide funding to University faculty and scientists to conduct research on CIMAS themes. Support for specific projects under these tasks is based on proposals submitted to specific NOAA units or funding programs often but not necessarily in response to a general Announcement of Opportunity or Request for Proposals. Task 3 encompasses collaborations with NOAA scientists and NOAA projects (typically but not necessarily with the Miami laboratories) while Task 4 encompasses projects that support or complement the NOAA mission but are funded by another federal, state or private funding source.

# III. PERSONNEL

## *Distribution of Personnel*

CIMAS personnel participate in a wide range of NOAA-related activities. During the past nine months a total of 113 persons were associated with CIMAS in various capacities. Of these, 97 received over 50% of their support from NOAA sources. Table 1 shows the distribution of these individuals by category and by their association with the local NOAA facilities. Of the 97 who received over 50% NOAA support, 58 are associated with AOML, 38 with SEFSC and one with NHC. Two of these work out of state.

**Table 1: CIMAS Research Personnel 2010**

| Category | Number | BS | MS | Ph.D |
|---|---|---|---|---|
| Research Associate/Scientist | 65 | 18 | 22 | 24 |
| Part Time Research Associate/Scientist | 7 | 2 | 2 | 3 |
| Postdoctoral Fellow | 8 | | | 6 |
| Research Support Staff | 17 | 2 | 2 | |
| **Total (> 50% NOAA support)** | **97** | **22** | **26** | **33** |
| Administration | 5 | | | 2 |
| Task I Undergraduate Students | 5 | | | |
| Task I Graduate Students | 4 | | | |
| Visiting Scientists | 3 | | | |
| NOAA Association | 58-OML<br>38-EFSC<br>1-NHC | | | |
| Obtained NOAA employment within the last year | 1 | | | |

Research Associates, Research Scientists and Postdoctoral Associates are Task II employees who work off campus primarily at the local NOAA facilities. There are also two CIMAS non-research staff who work at the same facilities. A total of 97 persons in these categories were employed under Task II over the past nine months.

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 essential to support of research activities at the University. Advancement is not automatic with time in grade. Additional education, continuing professional achievement, and/or increased responsibility are the basis for advancement to higher-level positions. The progression order is: Research Associate, Senior Research Associate, Assistant Scientist, Associate Scientist, and Scientist. The "Scientist" ranks (Assistant Scientist, Associate Scientist and Scientist) are designed to parallel those of the research faculty at the University (i.e., Assistant Research Professor, Associate Research Professor and Research Professor). Over the last nine

months, there were in addition a total of 8 Postdoctoral Fellows. Postdoctoral Fellows have become an increasingly important part of the CIMAS employee pool during the current Cooperative Agreement.

Research Support Staff are temporary employees, hired for the duration of specific projects. These include persons from a variety of backgrounds including both retired PhDs and local high school students often as a part of CIMAS associated K-12 outreach programs.

It should be noted that although CIMAS has the status of a Division within UM's Rosenstiel 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. Such faculty are not counted in the listing of the 113, not even those who serve as CIMAS Fellows or conduct Task III research projects. All the graduate students who work on CIMAS programs and are included in the 113 total 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*

CIMAS Fellows play a critical role in the governance of the Institute. Prior to the summer of 2010, there were 17 CIMAS Fellows. In addition to the regular members of the Fellows, there were three *ex officio* members, the Dean of RSMAS (R. Avissar) and the directors of the two adjacent NOAA laboratories (R. Atlas, OAR/AOML; B. Ponwith, NMFS/SEFSC). A list of those CIMAS Fellows is given in the *Fellows* section of this report along with their affiliation. 11 CIMAS Fellows were from RSMAS, 5 from the adjacent NOAA laboratories, 1 from the National Hurricane Center and 1 from Florida International University. That Council of Fellows was dissolved last summer after the award of the new CA and completely reconstituted after October 1 with the "Evolutionary Reinvention of CIMAS" resulting from the re-competition process.

## *CIMAS Staff*

CIMAS staff consists of a Director: Dr. Peter B. Ortner, an Associate Director: Dr. David Die, and three full-time administrative personnel. Dr. David Die also served as the Director of the Cooperative Unit for Fisheries Education and Research (CUFER) and administers the NMFS Center for Independent Experts (CIE). While both are housed within CIMAS they are independent. Nonetheless they provide additional important linkages between UM/RSMAS and NMFS/SEFSC. Under the new CA for the reinvented CIMAS CUFER is no longer be independent of CIMAS and the funds provided for it by NMFS are associated with CIMAS Task I.

## *Transition to Federal Positions*

More than thirty five former UM undergraduate/graduate students and/or research CIMAS employees currently hold Federal positions in the three local NOAA facilities. This total represents only a small fraction of the hundreds contributed to the national NOAA workforce. During the past year, 1 more CIMAS employee joined his predecessors in this regard.

## *Demographics of CIMAS Employees*

The CIMAS population is 41% female. Foreign-born individuals make up 53% of the personnel; of these Hispanics make up 23% of the ranks; Asian and Pacific Islanders, 18%. Only 3% are African-Americans despite our efforts to expand this group's participation. The population of CIMAS is relatively young with an average age of 39. The largest age decade is that between 30 and 40, for a

total of 55. Comparison with local laboratory populations and the overall NOAA federal workforce analyses, indicate this is a much younger and more diverse group than the overall NOAA population.

### *CIMAS Student Employees*

There are currently 4 UM/RSMAS graduate students supported through CIMAS Task I. Many others are supported on Task III projects and in other capacities (see *Section X* for a full list ). In addition 5 undergraduates are currently supported. A number of high school students are also being employed as temporary hires (under the category "Research Support Staff"). Most of these are enrolled in the Miami-Dade MAST Academy, a magnet school in the county (see Outreach) which is co-located on the Virginia Key Marine Campus adjacent to AOML and across the street from the UM marine campus

# IV. FUNDING

## *General Funding Trends*

Because the funding awarded herein reflects only that awarded in the final quarter of the federal FY10, it cannot be directly compared to that of prior years. That said, the sum of the operative overlapping CA's awards (continuing and new) for this project period is $1,782K plus $12, 075K or a total of $13.87K which is slightly higher than the $13.6K in Year 9.

The history of funding through CIMAS is shown graphically in Figure 1. Total funding in Years 8 and Year 9 was about equal to that of the first four years of the CA. The average of the last two years of the CA is nearly 2.5 times greater than the average of the first three years.

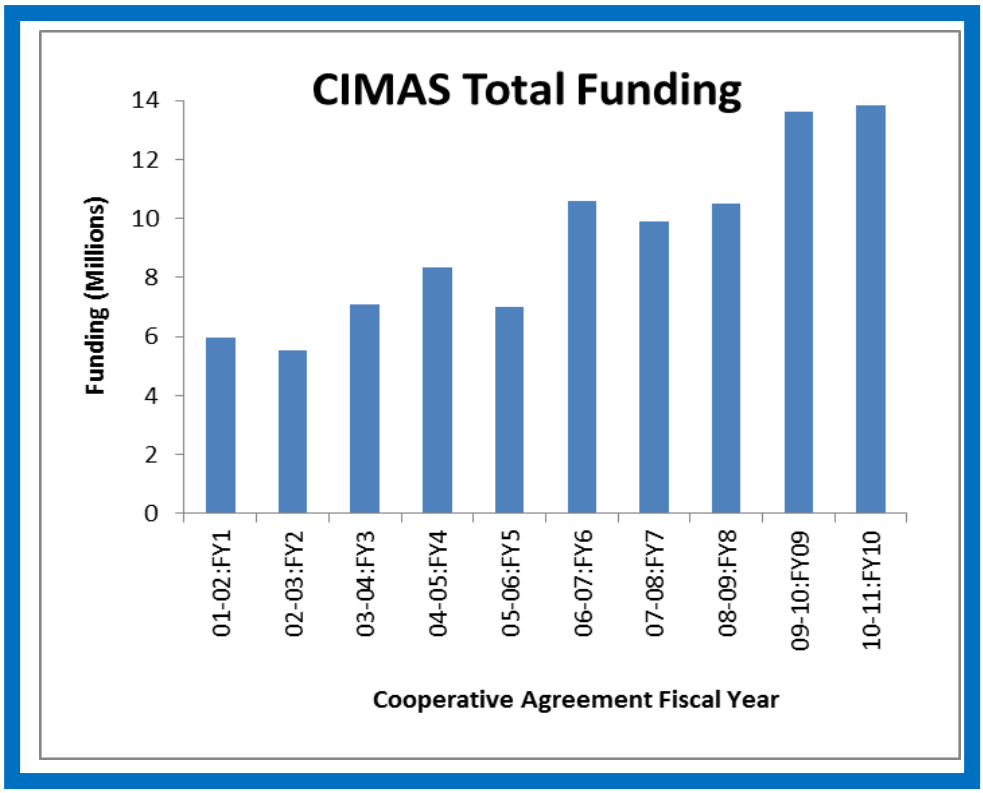



***Figure 1: CIMAS funding***

The sources of the funding received over the three summer months in 2010 are shown in Table 2. The data are again not comparable to that provided for Years 1-9. As a result any analysis of trends would not be useful. That said, OAR as in all prior years, was the primary NOAA source of funding provided CIMAS. The USACE funding indicated was provided through NMFS/SEFSC under an Economy Act transfer and that indicated as USCG through NMFS/SEFSC in association with the Deepwater Horizon response effort.

**Table 2: Funding by Source**

| 1 July 2010 - 30 June 2011 | | |
|---|---|---|
| **Source** | **Funding $M** | **% Total** |
| OAR | .71 | 40% |
| NMFS | .12 | 6% |
| NESDIS | .18 | 10% |
| NOS | .60 | 34% |
| USACE | .07 | 4% |
| USCG | .10 | 6% |
| **GRAND TOTAL** | **1.78** | **100%** |

## *Conclusion*

In our funding summary above we report funds awarded to CIMAS under the continuing CA and noted the data are not comparable to prior years and why. We emphasize once again that there are a substantial number of research programs carried out by RSMAS faculty (particularly CIMAS Fellows) that are complementary to the NOAA-supported CIMAS-linked programs but supported directly by other agencies. The grants obtained by those faculty members are credited not to CIMAS but to the Academic Division in which they reside. Consequently there is considerable leveraging of NOAA funds across the campus which does not appear in the present accounting. One 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 received nearly $3.4M in funding from NMFS but this funding is not reported herein.

# V. RESEARCH THEMES OVERVIEW

## *Organization of CIMAS Themes*

As in all Cooperative Institutes the scientific activities in CIMAS are organized under broad Research Themes. The selection of Theme topics was guided by the major environmental issues that confronted our Nation when the CA was established. 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 continuing Cooperative Agreement, scientific activities in CIMAS are carried out under six themes.

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

## *Theme 1: Climate Variability*

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

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

The CIMAS program ranges includes: involvement in process-oriented field programs involving ships, aircraft, and satellite systems; making climate-oriented long-term observations of oceanic transport processes; the systematic analysis of environmental data sets; modeling of weather and climate. These efforts contribute to the development of climate-prediction capabilities and to the assessment of climate change.

RSMAS pursues a vigorous program in atmospheric and ocean chemistry as related to climate processes and their variability. Research is underway with regards to the role of chemistry in radiative energy transfer processes by direct effects as well as indirect aerosol effects that involve the modification of oceanic cloudiness. Recently RSMAS has expanded its research capability in tropical meteorology with a strong focus on tropical cyclones and hurricanes.

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

with regard to research into the climatic role of the subtropical and tropical Atlantic circulation.

***Theme 1 activities contribute to NOAA Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.***
Research in this theme is consistent with three NOAA Mission Strategies:

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

## *Theme 2: Fisheries Dynamics*

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

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

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

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

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

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

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

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

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

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

## *Theme 3: Regional Coastal Ecosystem Processes*

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

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

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

- *Observations and analyses of atmospheric and ocean chemical and physical variability and their impact upon the health of the regional coastal ocean.*
- *Observations and modeling to elucidate how indigenous biological populations and communities respond to the unique physical and chemical environment of South Florida.*
- *Special integrated studies of critically-stressed or keystone components of the South Florida coastal ecosystem.*
- *Development of theories and methodologies necessary to understand the biological, ecological and oceanic variables controlling and regulating South Florida coastal fisheries populations, their food sources and their habitat.*

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

***Theme 3 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management. They also contribute to***

***Mission Goal 3: Serve society's needs for ... water information.***
Research in this theme is consistent with Mission Strategies dealing with coastal ocean processes and their impact on fisheries and other aspects of the coastal environment.

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

## *Theme 4: Human Interactions with the Environment*

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

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

Researchers use ***integrated assessments*** to study and resolve the complex dynamics of overlapping human and natural systems. This approach goes beyond synthesizing and advancing what is known about a problem - it also ensures that the results are relevant to society. It is the interplay of natural and human systems that creates problems for resource managers and opportunities for stakeholders.

There are three distinct foci in Theme 4:

- ***Human dimensions of climate change and variability*** - to improve our understanding of how social and economic systems are currently influenced by climatic fluctuations, and how human behavior can be affected by using our gained knowledge about variability in the climate system, for example, by using El Niño forecasts in agriculture.
- ***Sustainable use of the world's fisheries*** - to quantify the impact of human exploitation of fisheries and marine ecosystems so that these can be better managed.
- ***Urbanization of the Coastal Zone*** - to assess coastal zone impacts and to identify the dominant ecological risks including habitat alteration, hydrological alteration, and the over-exploitation of natural resources. Half the nation's population lives on coastal lands which comprise only 17% of the total land area. This research leads to the development of new analytical tools with which to identify problems, to characterize sources of environmental degradation, and to monitor progress towards restoration.

***Theme 4 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management. Also, Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.***
Research in this theme is consistent with all five Mission Strategies as related to the human dimensions of environmental change:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network*

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

## *Theme 5: Air-Sea Interactions and Exchanges*

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

The oceans are an important source of the energy that drives large-scale atmospheric circulations; conversely, the wind systems drive oceanic mixing and circulation. The interplay between the ocean and the atmosphere can result in large variations in global weather patterns as demonstrated by the impact of El Niño events. These interactions involve a wide range of properties such as the air and sea-surface temperatures, humidity, wind speed, rainfall, salinity, mixed-layer depth and heat content. Moreover the oceanic biogeochemical cycles can play a role in climate forcing: e.g., $CO_2$, halocarbons, aerosols. Air-sea exchange processes control the amount of these materials transported to the atmosphere and thus the degree to which these species can affect radiative processes and climate.

In CIMAS research on air-sea interactions focuses on processes in the atmosphere and the surface waters of the ocean including the oceanic mixed layer; this interaction is critically important in driving hurricane intensity changes. Our research also extends into maritime cloud climatology and to maritime weather system prediction including tropical cyclones and hurricanes. An equally important area of research focuses on the exchange and interaction between the atmospheric environment of the coastal urban complex and the coastal marine atmosphere; the deposition of pollutants to coastal waters are known to have a substantial impact on coastal ecosystems. The ultimate objective of these various programs is to develop and test physical-chemical models of the atmosphere and ocean and the processes that couple them.

RSMAS has developed a strong program in air-sea interaction studies. University scientists work closely with AOML in research on in situ exchange processes and in the development of new instrumentation. Remote sensing techniques are playing an increasing role in studies of the marine boundary layer and the upper ocean including the interface.

***Theme 5 activities contribute to NOAA Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.***

Research in this theme is consistent with two Mission Strategies:
- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Assess and predict the changes of natural systems, and provide information about the future.*

## *Theme 6: Integrated Ocean Observations*

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

The development of integrated observing systems such as the Integrated Ocean Observing System (IOOS) requires the interplay of numerical models and observing system networks so as to accurately and efficiently estimate the optimal fields of essential oceanic variables. Another objective is to develop the criteria for the acquisition of oceanic data needed to determine and document the role of the ocean in climate change and to monitor these changes.

Observational evidence indicates that the coupled air-sea system is undergoing dramatic changes - for example, increasing surface temperatures and the melting of the Arctic and Greenland ice caps. These changes will have a great impact on transport and mixing in the Atlantic. CIMAS investigators have a long history of tracking Atlantic thermohaline circulation, a major factor in climate variability over longer periods. We currently lack a good understanding of the time and space-scales of the factors that control Atlantic basin-scale and coastal ocean circulation. This requires continued observations in the Atlantic open ocean and coastal ocean and atmosphere coupled with numerical modeling.

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

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

Research in this theme is consistent with three Mission Strategies:

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

# RESEARCH REPORTS

## THEME 1: CLIMATE VARIABILITY

The following project activities received some funding from the continuation award reported herein but were primarily funded under the new Cooperative Agreement (NA10OAR4320143). Full reports on these can be found in the nine month progress report previously submitted with respect to that award (see http://www.ci-mas.org/documents/2011_Annual_Report.pdf).

***Assessing the Sensitivity of Northward Heat Transport/Atlantic Meridional Overturning Circulation to Forcing in Existing Numerical Model Simulations,*** S. Dong (UM/CIMAS); M. Baringer, G. Goni and G. Halliwell (NOAA/AOML)

***Diagnostic and Modeling Studies on impacts, Mechanisms and Predictability of the Atlantic Warm Pool***, S.-K. Lee, Hailong Liu and D. Enfield (UM/CIMAS); C. Wang (NOAA/AOML)

***Predicting the Effects of Climate Change on Bluefin Tuna (Thunnus thynnus) Spawning in the Gulf of Mexico Using Downscaled Climate Models***, Y. Liu, S.-K. Lee, B. Muhling and D. Enfield (UM/CIMAS); J. Lamkin, W. Ingram and M. Schirripa (NOAA/SEFSC

***Natural variability and anthropogenic $CO_2$ increase in the Synthesis and Data Management Project, NOAA Ocean Climate Observation Program (OCO***), T.-H. Peng (UM/CIMAS)

***Design and Testing of a Monitoring Array for the MOC and MHT in the South Atlantic***, R.C. Perez (UM/CIMAS); S.L. Garzoli and C.S. Meinen (NOAA/AOML); R.P. Matano (OSU/COAS)


# THEME 2: FISHERIES DYNAMICS

## *Florida Reef Trace Monitoring and Assessment*

**Project Personnel:** J.S. Ault and S.G. Smith (UM/RSMAS)
**NOAA Collaborators:** J.A. Bohnsack (NOAA/NMFS)

**Long Term Research Objectives and Strategy to Achieve Them:**

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

***Strategy*:** Carry out regional multispecies reef fish assessments, map coral reef habitats and to conduct spatially-based monitoring of coral reef fish composition, occurrence, abundance, and size structure on the Florida Keys reef tract (e.g., Smith et al. 2011)). Use strategic applications of probabilistic sampling design theory and acoustic telemetry methods (e.g., Farmer and Ault 2011) to obtain key spatial population size-structured abundance and movements data to assess population changes, ontogenetic habitat associations, and ecosystem responses to fishing, recreational use, pollution, MPA zoning and, eventually, Everglades restoration.

**CIMAS Research Theme:**

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

**Link to NOAA Strategic Plan Goals:**

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

**NOAA Funding Unit:** NMFS/SEFSC **NOAA Technical Contact:** Theo Brainerd

**Research Summary:**

This research emphasizes assessing the effectiveness and impacts of no-take marine reserves and other resource management measures in Biscayne National Park, the FKNMS, and DTNP towards

meeting their marine ecosystem management goals. No-take marine reserves (NTMRs) in the National Marine Sanctuary (FKNMS) and Dry Tortugas National Park of the Florida Keys are a joint fishery and ecosystem management effort between the NOAA National Marine Sanctuary Program, National Park Service (NPS), and the State of Florida. The FKNMS has implemented three types of no-take areas: (1) 16 small Sanctuary Preservation Areas (SPAs) totaling approximately 46 $km^2$ that protect the high-relief coral reef; (2) one large (30 $km^2$) ecological reserve (ER) that includes several different habitats; and, (3) 4 special-use SPAs designed for research purposes. Two large Ecological Reserves, 206 and 312 $km^2$, are were added in 2001 west of the Tortugas, Florida. The NPS Service implemented a 100 $km^2$ Research Natural Area (RNA) in the western half of Dry Tortugas National Park in January 2007.

We continue to evaluate the performance of the SPAs and TERS in the FKNMS. During the past year we conducted spatially-synoptic sampling of reef fish and coral reef habitats in the Florida Keys. Although still early in the recovery process, our results for the Dry Tortugas and Florida Keys are encouraging and suggest that NTMRs in conjunction with traditional management measures can potentially help rebuild sustainable fisheries while protecting the Florida coral reef ecosystem. This is a win-win scenario; good for the fish, ecosystem, fishermen, and Florida's economy! The black groupers provide a particularly compelling example. Fishing pressure typically results in a shift from larger to smaller animals. If we compare a fished area and two protected areas prior to the establishment of the protected areas (1999-2000) with the same three areas after protection, we see that there are significantly more larger fish in the two protected areas but not in the fished area where the number of large animals continued to decrease [see Figure 1].

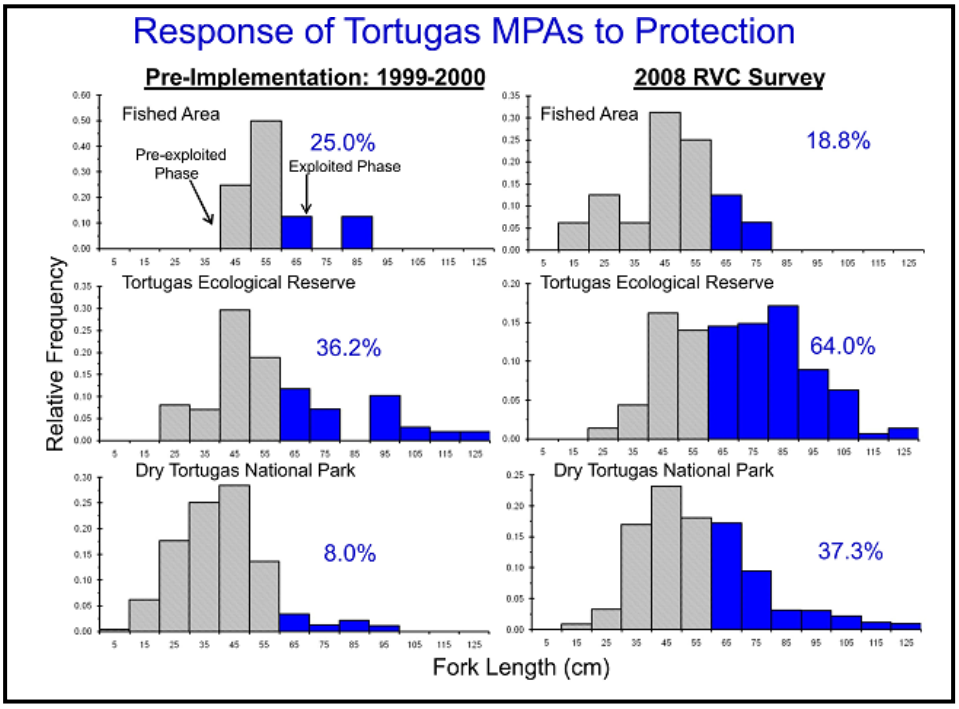



**Figure 1:** Size frequency distributions of black grouper in a control (fished) area versus two protected areas: Tortugas Ecological Reserve and Dry Tortugas National Park in the pre-implementation period (1999-2000) and the recent survey (2008). Solid blue histograms indicate proportion of the regional population in the exploitable phase.

In Spring-Summer of 2010 and 2011, a team of 46 research divers from the University of Miami (UM) Rosenstiel School of Marine and Atmospheric Science, NOAA Fisheries Service, the Florida Fish and Wildlife Conservation Commission, and the National Park Service completed a successful 20-day biennial census to measure how the protected status of the Florida Keys National Marine Sanctuary's Tortugas Ecological Reserve and Dry Tortugas National Park's Research Natural Area are helping the regional ecosystem rebound from decades of overfishing and environmental changes. The unprecedented collaboration allowed the team to complete more than 1,700 scientific dives, which will now help to further establish a baseline for the state of reef fish stocks and coral reef habitats in Florida's dynamic marine ecosystem. We were very encouraged to see that stocks have slowly begun to recuperate since the implementation of 'no-take' marine protected areas in the region. We noted particular improvements in the numbers of snapper, grouper, and coral recruits. We are currently crunching the data collected to see what adjustments may need to be made in order to help guide future management decisions to address the issues of biodiversity protection, restoration of ecological integrity, and fishery management which are critical to this area. This year, the team documented changes in fish abundance and habitat quality in this region which was hit by six major hurricanes since 2004. By statistically comparing this year's findings to previous baseline survey information collected, scientists can determine what effects intense hurricane activity had on this marine environment. If we again look at black grouper data we can see that the extent of occupancy markedly increased after implementation of the protected areas (between 1999-2000 and 2004) but has since been highly variable albeit at a consistently higher level than prior to protection. The natural variability associated with storms and other factors is superimposed upon the change due to management [Figure 2].

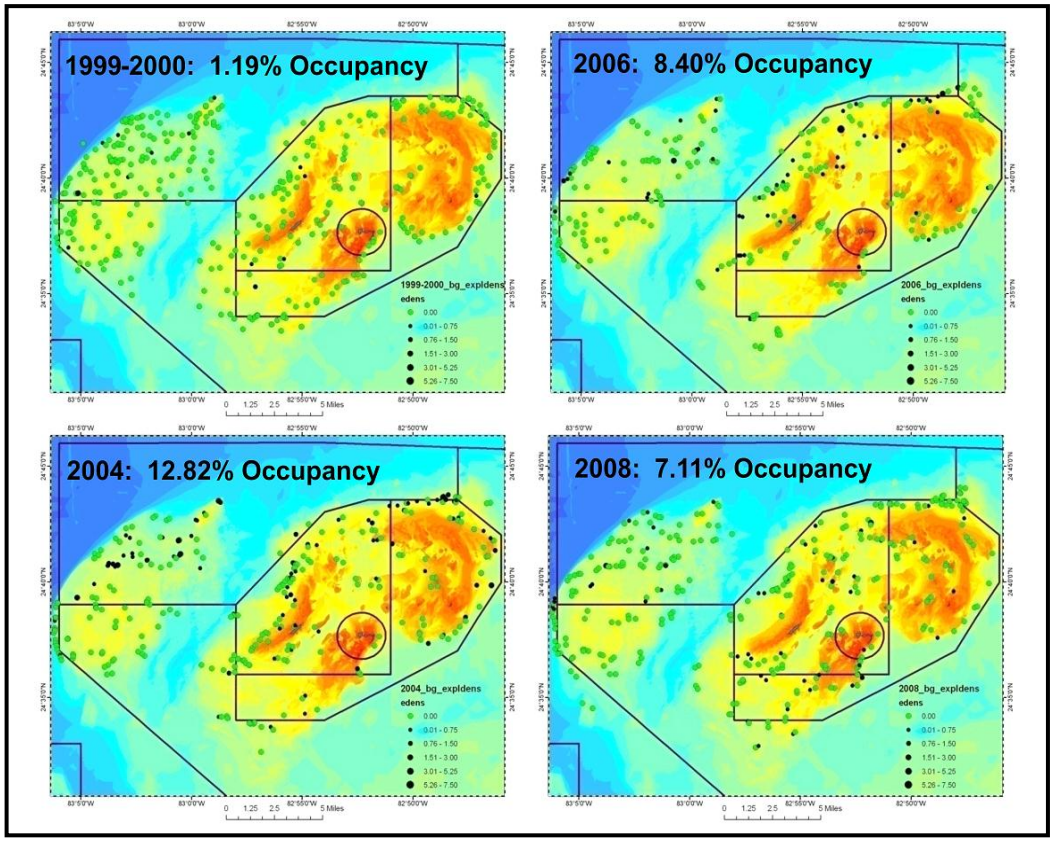



**Figure 2:** Regional black grouper frequency-of-occurrence (occupancy) during survey years 2004, 2006 and 2008 relative to the pre-implementation baseline measured in 1999-2000.

**Research Performance Measure:** All of the following objectives were met**:** (1) Conducted spatially-synoptic monitoring surveys of reef fish and coral reef habitats in the Florida Keys coral reef ecosystem; (2) Conducted quantitative assessments of reef fishery sustainability; (3) Evaluated NTMR efficacy.

The following project activities received some funding from the continuation award reported herein but were primarily funded under the new Cooperative Agreement (NA10OAR4320143). Full reports on these can be found in the nine month progress report previously submitted with respect to that award (see http://www.ci-mas.org/documents/2011_Annual_Report.pdf).

***Simulation of Management Strategies***, E.A. Babcock and D.J. Die (UM/RSMAS); J. Hoenig (Virginia Institute of Marine Science)

***Reef Visual Census (RVC): Reef fish monitoring in the Florida Keys***, J. Blondeau (UM/CIMAS); B. Ruttenberg (NOAA/SEFSC)

***Marine Mammal Stranding and Research***, L. Aichinger Dias (UM/CIMAS); L. Garrison (NOAA/SEFSC)

***Coastal Fisheries Logbook Program***, J. Diaz (UM/CIMAS); D. Gloeckner, M. Judge, N. Baertlein and J. Hall (NOAA/SEFSC)

***Development of a fishery ecosystem model for the Gulf of Mexico,*** D.J. Die and E. Babcock (UM/RSMAS); M. Shirripa (NOAA SEFSC); C. Ainsworth (USF)

***Shallow-Water Grouper Distribution, Habitat Characertistics and Spawning Behavior***, D.J. Die (UM/RSMAS); T. Kellison (NOAA/SEFSC)

***Pelagic Fisheries Logbook Program, K. Erickson*** (UM/CIMAS); D. Gloeckner and M. Maiello (NOAA/SEFSC)

***Investigation of the Movement of Adult Billfish in Potential Spawning Areas***, J. P. Hoolihan (UM/CIMAS); J. Luo (UM/RSMAS); E.D. Prince, D. Snodgrass and E.S. Orbesen (NOAA/SEFSC); C.P. Goodyear (Contractor, Niceville, FL)

***Monitoring Shoreline Fish Assemblages of Biscayne and Florida Bays,*** D. Johnson, B. Teare (UM/CIMAS); J. Luo (UM/RSMAS); J. Serafy (NOAA/AOML)

***Applying Bio-physical Monitoring and Capacity Assessments to Mesoamerican Reef Marine Protected Areas***, E. Malca, S. Whitcraft (UM/CIMAS); J. Lamkin and T. Gerard (NOAA/SEFSC); E. Sosa-Cordero, L. Carrillo-Bibriezca and L. Vasquez-Yeomans (ECOSUR); M.J. González (MARfund)

***Variations in Carbon and Oxygen Stable Isotopes Snapper (Lutjanidae) in Florida Bay and Florida Keys***, B. Muhling, E. Malca and S. Privoznik (UM/CIMAS); J. Lamkin and T. Gerard (NOAA/SEFSC)

***Puerto Rican Small Scale Fleet Costs and Earnings Study, F. Tonioli*** (UM/CIMAS); J. Agar (NOAA/AOML)


# *The Effect of Turbulence on the Behavior of Pink Shrimp Postlarvae*

**Project Personnel:** M.M. Criales and B. Haus (UM/RSMAS); I.C. Zink (UM/CIMAS)
**NOAA Collaborators:** J.A. Browder (NOAA/SEFSC)

**Long Term Research Objectives and Strategy to Achieve Theme:**

***Objectives*:** To improve understanding of processes affecting recruitment of pink shrimp (*Farfantepenaeus duorarum*), a performance measure of the impact of the Comprehensive Everglades Restoration Plan (CERP) on water management changes in the Florida Bay.

***Strategy*:** To carry out coordinated field and laboratory experiments on the different life history stages of pink shrimp in conjunction with water quality, circulation measurements and behavior to model the population changes of this ecologically and economically important species.

**CIMAS Research Theme:**

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

**Link to NOAA Strategic Plan:**

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

**NOAA Funding Unit:** NMFS/SEFSC **NOAA Technical Contact:** Theo Brainard

**Research Summary:**

Our previous field studies in Florida Bay have indicated that pink shrimp postlarvae perform nocturnal vertical migrations synchronized with flood tides to advance upstream into estuarine nursery grounds (CIMAS report, 2009). This behavior, known as Selective Tide Stream Transport (STST), may be achieved by behavioral changes in response to exogenous, tidal current associated cues. Laboratory experiments were conducted during 2010 to determine whether turbulence plays a role in the behavior of this species during flood-tide migrations. Our hypothesis was that postlarvae

may react to increases in turbulence by ascending in the water column and descending in response to decreases in turbulence. Laboratory experiments were conducted in the Air-Sea Interaction Saltwater Tank (ASIST) at RSMAS-UM facilities (Fig. 1A). ASIST water was circulated by a pump while turbulence was selectively induced by vertical, servo motor-driven actuator motions of a cylinder array (Fig. 1D). An experimental chamber with lateral walls of a fine-mesh screen was secured against the wall of the ASIST (Fig. 1A,B). The swimming activity of postlarvae was recorded using a closed-circuit camera system (Fig. 1C,E). One hundred postlarvae were stocked in the experimental chamber per trial (Fig. 1B). Trials were conducted in darkness illuminated with a red light (transmission wavelength 650 - 800 nm) (Fig. 1C,E). Matlab routines were developed to determine postlarval positions within three water column depth bins (top half, bottom half and floor) by tracking the positions of 'bright' particles of a certain size range (relative to shrimp size) after filtering images for background 'noise' and non-moving particles of the selected size range (Fig. 1F).

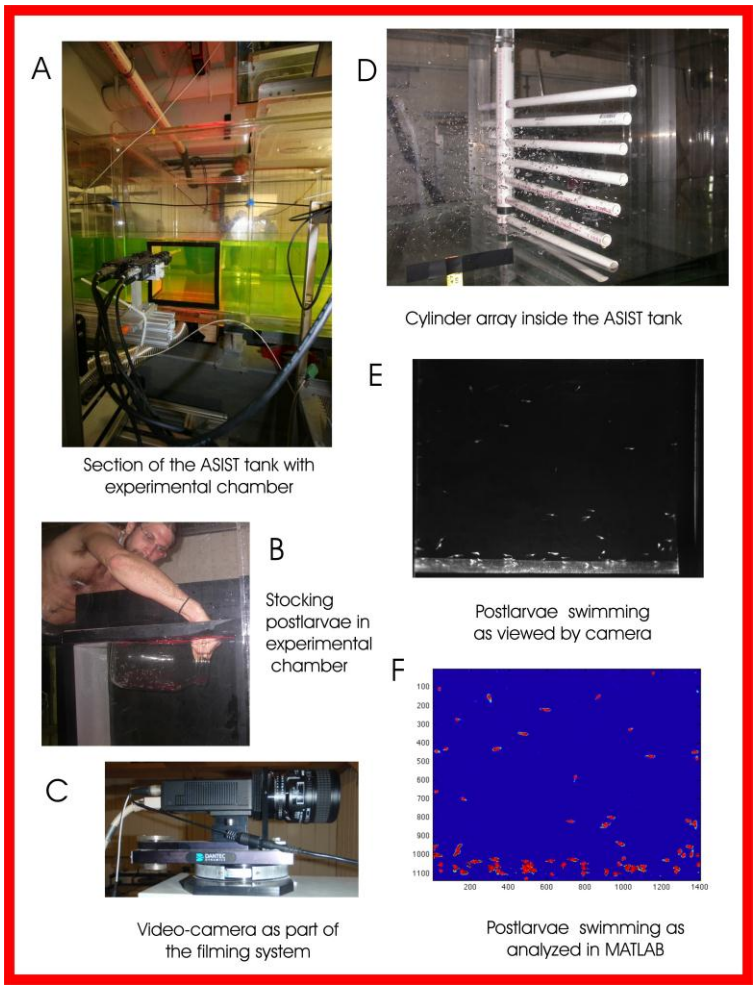



**Figure 1:** A-D. Images captured during the experimental trials conducted in the ASIST tank on the effect of turbulence on the behavior of pink shrimp postlarvae. E-F. Postlarvae swimming in the experimental chamber showing contrast images between E) pictures taken by the video camera and F) after filtering imaging for background 'noise' and non-moving particles.

The first two sets of experiments consisted of varying the current speed using two different modes: 1) discrete and 2) continuous increase and subsequent decrease in speed. Another two sets of experiments consisted of combining discrete current speed steps and at two turbulence levels (Turbulent Kinetic Energy, TKE). Results of the continuous current speed trials indicated that the mean number of postlarvae in the top half of the water column did not substantially increase when subjected to differing current speeds (Fig. 2). This flat response suggests that postlarvae may not react to the changes of current speed of this magnitude (range: 0 to 3 cm/s). In contrast, the swimming activity of postlarvae in the top half of the water column during turbulence trials increased substantially; the highest strength in response was observed at TKE values of 1.39 $cm^2/s^2$ (Fig. 2). This result suggests that turbulence levels in these trials were above a stimulation threshold, causing the observed vertical swimming response as has been noted in similar studies. This project is ongoing as we are working towards observing TKE values at the differing experimental conditions to confirm TKE comparisons to other studies.

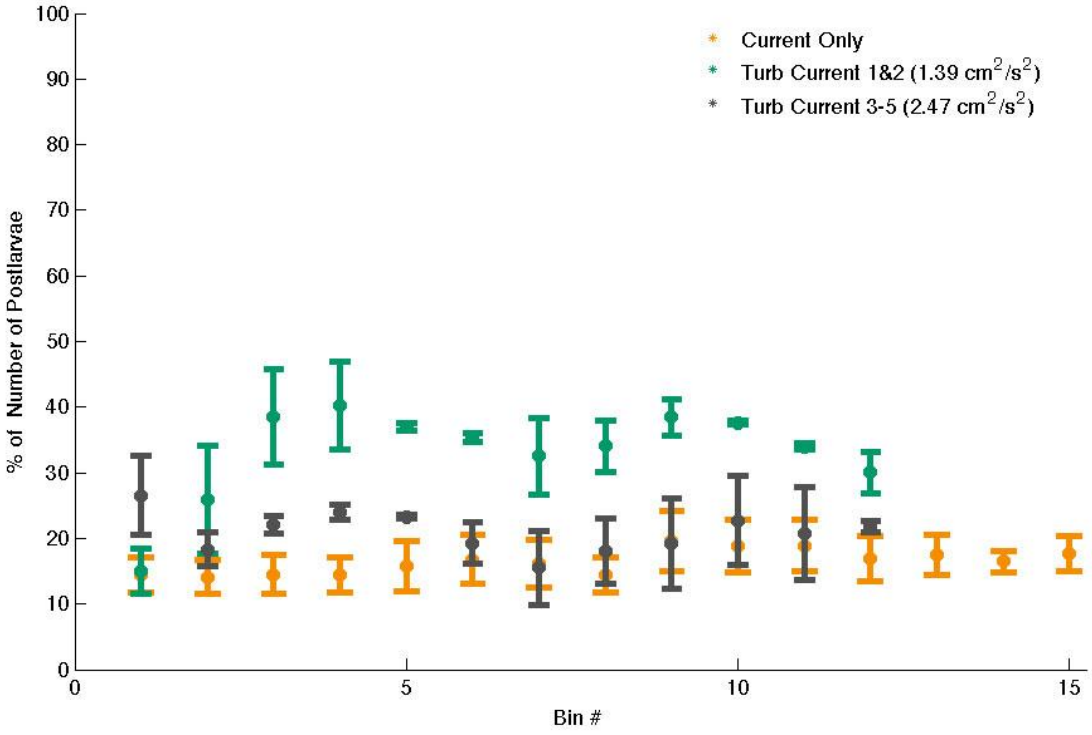



**Figure 2:** Mean percentage ± SE of postlarvae swimming in the top half of the water column during trials with continuous increase and decrease in current speed, and a combination of current speed and discrete increases in turbulence. Notes that the highest percentage in response was observed at trials with TKE values of 1.39 $cm^2/s^2$.

**Research Performance Measure**: The objectives of the project have been accomplished. One manuscript is in preparation.

The following project activities received some funding from the continuation award reported herein but were primarily funded under the new Cooperative Agreement (NA10OAR4320143). Full reports on these can be found in the nine month progress report previously submitted with respect to that award (see http://www.ci-mas.org/documents/2011_Annual_Report.pdf).

***Florida Area Coastal Environment (FACE) Program***, N. Amornthammarong, C. Brown, M. Gidley, L. Visser and D. Wanless (UM/CIMAS); J. Bishop, T. Carsey, J. Craynock, C. Featherstone, C. Sinigalliano and J. Stamates (NOAA/SEFSC); H. Casanova, R. Kotkowski (NOAA Corps)

***Modeling Connections Among Life Stages and Habitats of Pink Shrimp in South Florida***, M.M. Criales and I. Zink (UM/CIMAS); J.A. Browder and T. L. Jackson (NOAA/SEFSC); M.B. Robblee (USGS/SESC)

***Characterization of Ocean Acidification in Coral Reef Waters***, D. Gledhill and D. Manzello (UM/CIMAS); C. Langdon (UM/RSMAS); J. Hendee and R. Wanninkhof (NOAA/AOML); J. Corredor (UPRM/NOAA); G. Piniak (NOAA/CCFHR); C. Sabine (NOAA/PMEL); W. McGillis (CICAR); B. Loose (WHOI); R. Moyer (USGS)

***Biscayne Bay Alongshore Epifauna Community and their Relationship to Salinity***, G.A. Liehr, D.R. Johnson, E. Buck and H. Cardenas (UM/CIMAS); A. Griefen, L.H. Petteway, M. Harangody, J.A. Browder and T.L. Jackson (NOAA/SEFSC); M.B. Robblee (USGS/CWRS)

***AOML's South Florida Program (SFP): Long-Term Measurement of Physical, Chemical, and Biological Water Column Properties in the South Florida Coastal Ecosystem***, N. Melo, G. Rawson, D. Lindo, S. Dolk, K. Seaton, L. Visser and P. Ortner (UM/CIMAS); A.M. Wood, C. Kelble, E. Johns, R. Smith, D. Manzello, J.-Z. Zhang, C. Fischer and S. Cummings (NOAA/AOML)

***Development of an Autonomous Ammonium Fluorescence Analyzer (AAFA) with a View Towards in situ Application***, P.B. Ortner and N. Amornthammarong (UM/CIMAS); J.-Z. Zhang (NOAA/AOML)

***Photo-Identification of Bottlenose Dolphins in Biscayne Bay, Florida***, J. Wicker (UM/CIMAS); L. Garrison, J.P. Contillo, J. Litz and A. Martinez (NOAA/SEFSC)

***Evaluation of ESA listed Acropora spp. Status and Actions for Management and Recovery***, D.E. Williams and A. Bright (UM/CIMAS); M.W. Miller (NOAA/SEFSC) )

***Coral Ecological Restoration in the Florida Keys National Marine Sanctuary***, D.E. Williams, R. Wilborn, A. Bright and L. Johnston (UM/CIMAS); M.W. Miller (NOAA/SEFSC)


## *Marine and Estuarine Goal Setting (MARES)*

**Project Personnel:** P. Ortner (UM/CIMAS); J. Ault, D. Lirman and G. Hitchcock (UM/MBF)
**NOAA Collaborators:** C. Kelble (NOAA/AOML); J. Serafy, J. Bohnsack and J. Browder (NOAA/SEFSC)
**Other Collaborators:** W. Nuttle (Eco-Hydrology); P. Fletcher (UF)

**Long Term Research Objectives and Strategy to Achieve Them:**
***Objectives*:** To reach a science-based consensus about the defining characteristics and fundamental regulating processes of a South Florida coastal marine ecosystem that is both sustainable and capable of providing the diverse ecological services upon which our society depends.
***Strategy*:** Develop ICEM models for critical sub-regions, and based upon these through series of subsequent meetings and briefings identify quantitative ecosystem indicators and establish an annual South Florida coastal ecosystem report card.

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

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

**Funding Unit:** NOAA/NOS/CSCOR **NOAA Technical Contact:** Kimberly Pugliese

**Research Summary:**
MARES (www.sofla-mares.org) is a three year project funded by NOS/CSCOR whose goal is to reach a science-based consensus about the defining characteristics and fundamental regulating processes of a South Florida coastal marine ecosystem that is both sustainable and capable of

providing the diverse ecological services upon which our society depends. MARES represents a unique collaboration amongst academic and government natural and human dimensions scientists working with public and private stakeholders. The first step in the MARS process is to develop conceptual pictoral models and then Integrated Conceptual Ecosystem Models (ICEMs) for critical sub-regions (SW Florida Shelf, Florida Keys and SE Florida shelf. For example, **Figure 1** is one such conceptual model developed to forge concensus upon the relevant processes and factors regulating a specific MARES subregion, the Florida Keys and Dry Tortugas. The next step is to develop an ICEM for the same region (perhaps multiple ICEMs) - **see Figure 2**. These are modifications of the DPSIR (Drivers/Pressures/Stresses/Indicators/Responses) used by the EPA in ecological risk assessment contexts. These models and a series of subsequent meetings and briefings are being used to identify quantitative ecosystem indicators.

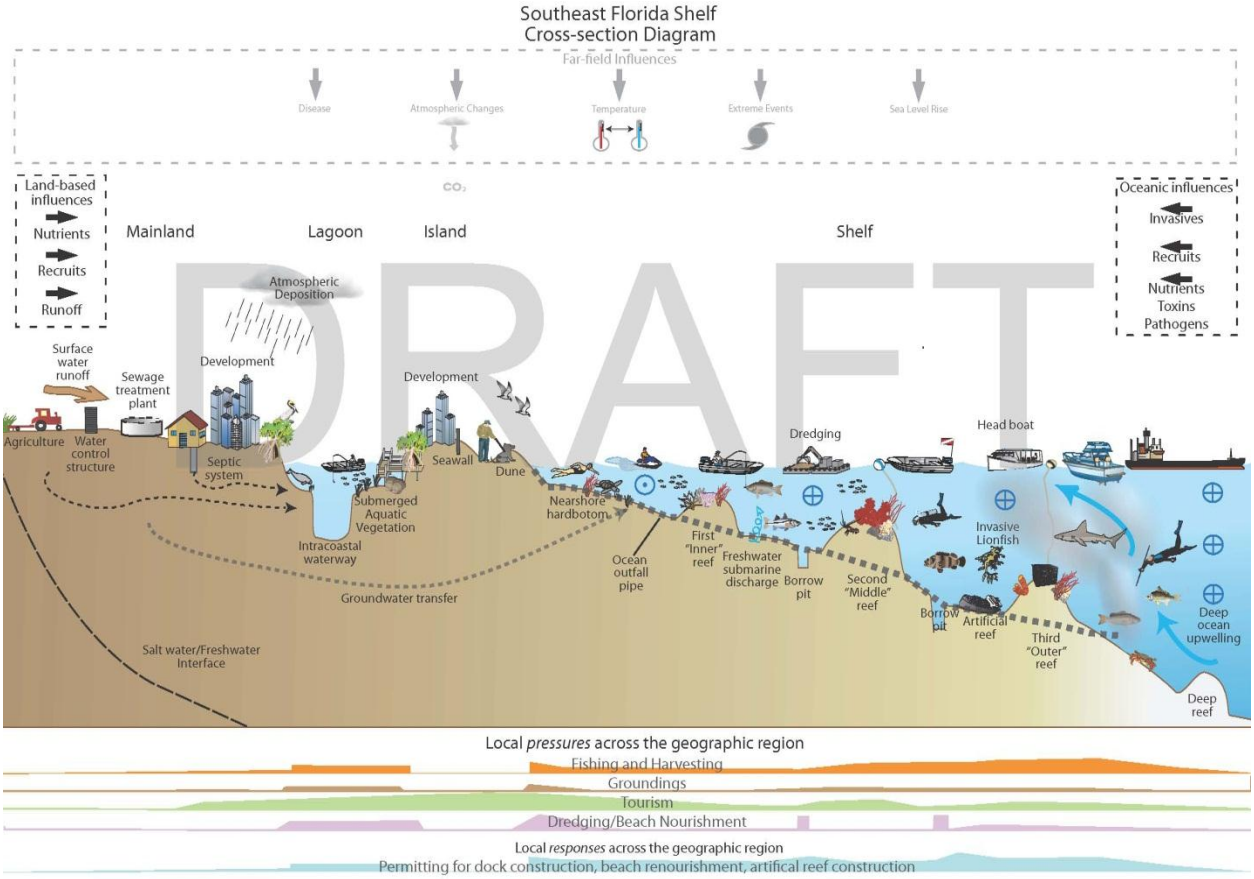



**Figure 1:** Conceptual Model for the SE Florida Shelf Subregion.

MARES will eventually yield a South Florida Marine Ecosystem Report Card that will assist natural resource and environmental managers of South Florida to effectively implement ecosystem based management (EBM). The need to conduct EBM has become the focus of several new NOAA initiatives, Integrated Ecosystem Assessments (IEAs) and Coastal and Marine Spatial Planning (CMSP). Both initiatives are aimed at integrating human- and natural-system needs for the

development of effective EBM. MARES hopes to provide a model process for integrating the human- and natural-system to; 1) develop ICEMS, 2) develop indicators, 3) assess the ecosystem and 4) set ecosystem goals. All four are key components of IEAs and likely CMSP. The development and subsequent utilization of science-based ecosystem goals that incorporate both the human- and natural-systems will represent significant progress towards enacting EBM in south Florida. This MARES process can be emulated in other regions for IEA and CMSP purposes.

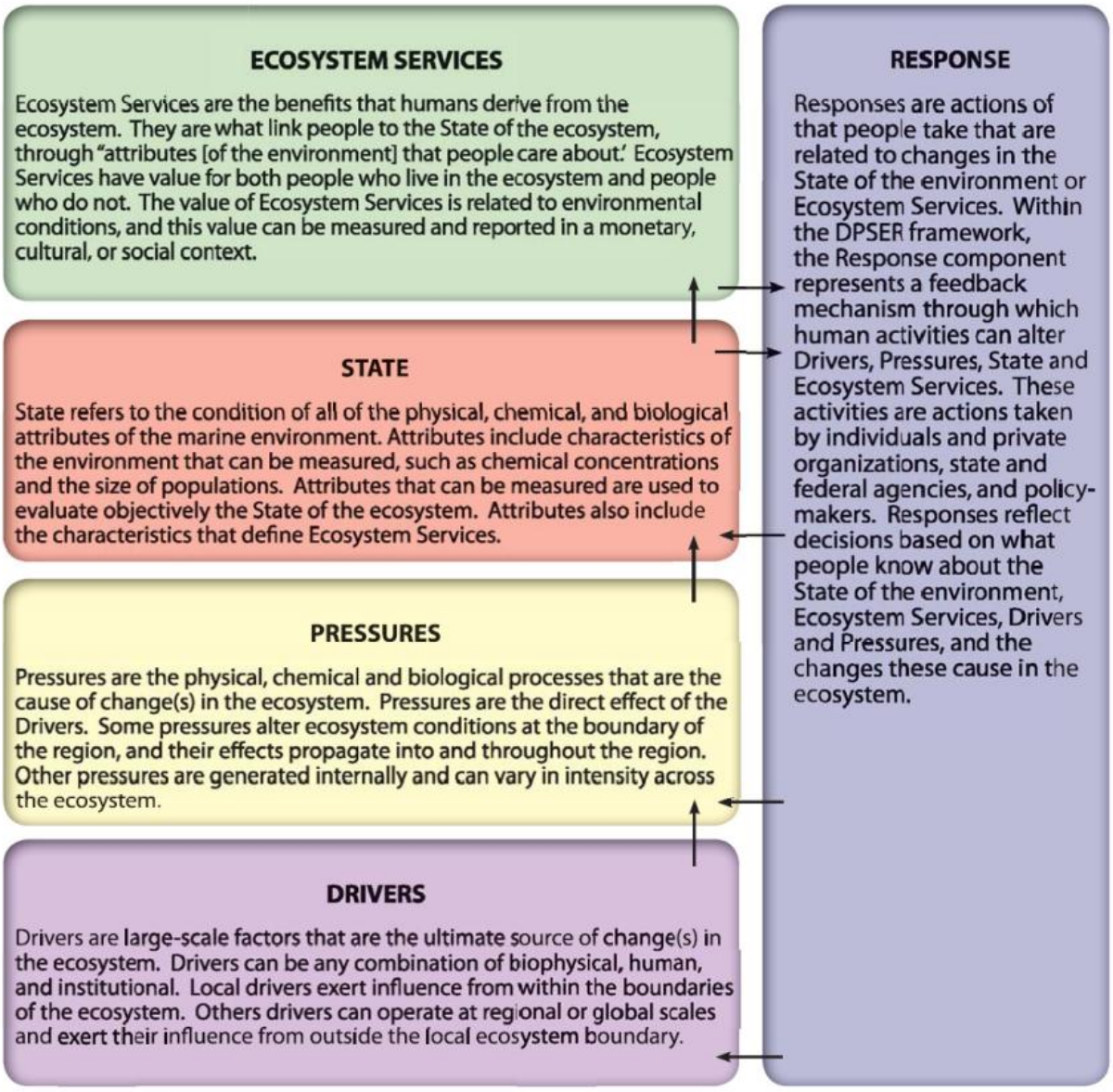



**Figure 2**: An explanation of the components of the MARES ICEMs.

In the period covered by this report the project continued development of the ICEMs and QEIs for the Florida Keys/Dry Tortugas sub-region and conducted workshops to develop the ICEMs for the remaining sub-regions: the SW Florida Shelf and the SE Florida Coast.

In the Fall of 2010, the MARES leadership decided to revise the approach being taken in developing QEIs (see below) based on results obtained by the workshops held in the first year of the project for the Florida Keys/Dry Tortugas sub-region. Through Fall 2010 and Winter 2011 the MARES leadership has been working to develop the strategy it will use to communicate project results to the scientific community, regional managers and stakeholders.

A review of project year-1 activities and the overall approach to the project, as originally laid out in the project proposal, by the MARES leadership resulted in changes with respect to increasing the participation of human dimensions scientists and both the scope and process of developing the QEIs. These are now being implemented and will carry over into the final 12-month period of project activities.

***Increased Participation of Human Dimensions Scientists.*** As the MARES project unfolded in its first year, participation by resource economists in the project assumed a central role. Not recognizing their centrality, the original project budget under-funded participation by resource economists to attend the ICEM and QEI workshops and contribute to writing project reports. Thus, MARES leadership made the decision to increase the participation of two private-sector resource economists (Grace Johns and Donna Lee) so that both attended all three of the workshops in year 1. This resulted in all funds available for human dimensions science to be expended in the first three workshops, leaving no funding available for them to participate in any additional workshops, report writing, or other project-related activities. Because the knowledge and experience with techniques of economic study and their ability to explain and defend these techniques in discussion with natural scientists has been critical to expanding the scope of the ICEMs and QEIs to include human dimensions, the project requested and received $35,000 in supplemental funding from NOAA/CSCOR to ensure that the resource economists associated with the project could continue their involvement.

***Changing the QEI Development Process.*** Results from the first indicators workshop held for the Florida Keys/Dry Tortugas sub-domain demonstrated that the development of indicators is not a straightforward process that can be achieved in the course of a two-day workshop. Thus, the QEI workshops for the SW Florida Shelf and the SE Florida Coast were cancelled and instead working groups were formed for each region to develop indicators. Additionally, it became apparent that there were two distinctly different types of ecosystem indicators that would be developed under MARES. The first type of indicator will be of environmental state, which is similar in concept to the indicators used in the System Status Report. The second type of indicator is for the human dimension aspects of the ecosystem for which there is no precedent to draw from for South Florida. To date, a plan has been developed for developing QEIs for environmental state and clearly laid out in MARES Whitepaper No. 2 *Developing quantitative ecosystem indicators of environmental state*. The development of human dimensions indicators is in progress. It is not anticipated that these changes will delay progress of the project.

By including agency participation within the MARES process (see Table below), the task of delivering the most appropriate (and therefore effective) MARES products to individual management agencies is a distributed one, specific to each agency and dependent upon that agencies own management structure, mandate and requirements. We rely not only upon targeted briefings to senior

managers but also upon the above agency participants to guide how the collaboratively developed consensus regional MARES products can be adapted to their own agencies specific needs. For example, Florida DEP is already using MARES conceptual models to guide their implementation strategy for southeast coast marine protected areas, the FKNMS has decided to adopt the relevant ecological services analysis done by MARES human dimensions scientists in lieu of developing their own and the NPS/Everglades National Park plans to use MARES models and indicators to guide its strategy for indicator development on the southwest shelf.

**Research Performance Measure:** The project is otherwise proceeding on schedule. Over the next 12-months, the MARES project will complete technical reports on the ICEMs developed for all three domains and a number of technical reports on QEIs related to the ICEMs. These technical reports will be published as part of a NOAA technical report series. Plans are for the project to develop a series of briefing papers (4-pagers) to summarize the contents of the ICEM and QEI technical reports for managers and stakeholders. In addition, MARES project staff will work with the PIs on preparation of publications in the scientific literature based on results obtained by the project.

| Participating Agency | Agency Employees/Representatives |
|---|---|
| NOAA/NOS/Florida Keys National Marine Sanctuary (FKNMS) | Billy Causey |
| NOAA/National Marine Fisheries Service (NMFS) | Jim Bohnsack, Joan Browder, John Lamkin, Joe Serafy |
| NOAA/NOS/Coral Reef Conservation Prog. | Dana Wusinich-Menendez |
| NOAA/OAR/ AOML | Chris Kelble, Tom Carsey, Jack Stamates |
| U. S. Department of the Interior (DOI)/National Park Service (NPS) | Carol Mitchell (Leaders Group), Dave Hallac, Bob Johnson, William Perry, Joffre Castro |
| U. S. DOI/Fish & Wildlife Service (FWS) | Patrick Pitts, Todd Hopkins |
| U. S. Environmental Protection Agency | Pat Bradley |
| U.S. Army Corps of Engineers (Jacksonville District) | David Tipple, RECOVER Co-Chair |
| US Geological Service | Lynn Wingard |
| South Florida Water Management District (SFWMD) | Peter Doering, Greg Graves, Dave Rudnick, Patty Sime, Patty Goodman |
| Florida Fish and Wildlife Conservation Commission (FWC) | John Hunt (Leaders Group), Gil McRae |
| Florida Department of Environmental Protection (FDEP) | Chantal Collier, Joanna Waldzak, Katherine Tzadik, Kent Edwards |
| Broward County | Ken Banks |
| Miami-Dade Department of Environmental Regulation and Management | Steve Blair, Susan Markley |

The following project received some funding from the continuation award reported herein but was primarily funded under the new Cooperative Agreement (NA10OAR4320143). A full reports on this can be found in the nine month progress report previously submitted with respect to that award (see http://www.ci-mas.org/documents/2011_Annual_Report.pdf).

***EPA/FIU Molecular Microbial Source Tracking for the Florida Keys Little Venice Service Area***, M. Gidley, D. Wanless, D. Aranda, J. Bartkowiak (UM/CIMAS); C. Sinigalliano (NOAA/AOML)


## *Evaluation and Improvement of Ocean Model Parameterizations for NCEP Operations*

**Project Personnel:** L. K. Shay (UM/RSMAS)
**NOAA Collaborator:** G. Halliwell (NOAA/AOML)
**Collaborators:** H.-S. Kim and C. Lozano (NCEP/EMC)

**Long Term Research Objectives and Strategy to Achieve Them:**

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

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

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

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

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

**Research Summary:**

The initial work focused on testing model initialization schemes primarily in the Gulf of Mexico (GOM) and processing data required for model evaluation. This dataset includes *in situ* Naval

Research Laboratory (NRL) Acoustic Doppler Current Profiler (ADCP) data from Ivan (Teague et al., 2007) and during Katrina and Rita (courtesy of Bureau of Ocean Energy Management Regulation and Enforcement: BOEMRE) as well as measurements acquired during NOAA Hurricane Research Division Intensity Fluctuation Experiments (IFEX) in pre and post Rita in 2005 (Rogers *et al.*, 2006) and Gustav and Ike in 2008 (Meyers, 2011).

Using the Ivan results as a guide, we commenced work on the Katrina and Rita case (2005) using both HYCOM and its predecessor MICOM model (e.g, Miami Isopycnic Coordinate Ocean Model, or MICOM) to document observed levels of cooling in an isolated Warm Core Eddy (WCE: ~0.5 to 1$^{o}$C) and Cold Core Eddy (CCE: 3.6$^{o}$C). Our original goal was to initialize the ocean model with HYCOM analyses produced by the U. S. Navy nowcast-forecast system. Analyses produced during 2005 (and also during 2008 for Hurricanes Gustav and Ike) contained a large cold bias that caused the upper ocean to overcool by a large amount, making it impossible to evaluate and improve the performance of model numerical algorithms and parameterizations. Navy plans to produce a multi-decadal reanalysis with an updated system designed to substantially reduce large biases were delayed and not available during the final year of this project. We therefore proceeded with an idealized study of the impact of ocean features on upper-ocean SST cooling using the predecessor model for HYCOM, the Miami Isopycnic-Coordinate Ocean Model (MICOM). This decision was made to take advantage of the slab mixed layer model, which permits simplified analyses of mixed layer budgets.

Isopycnic coordinate models suppress the spurious numerical dispersion of thermodynamic properties. MICOM consists of four prognostic equations for the horizontal velocity vector, mass continuity or layer thickness tendency, and two conservative equations for salt and heat (Bleck and Chassignet, 1994). The model approach used in Jaimes *et al.* (2011): i) ignores buoyancy fluxes; ii) uses turbulence closure for the oceanic mixed layer (OML) by only considering instantaneous wind erosion by the wind-driven frictional velocity (Kraus and Turner, 1967 :KT) and shear-driven entrainment at the OML base and over the thermocline (Price *et al*. 1986: PWP); iii) initializes idealized quasi-geostrophic (QG) vortices (WCE,CCE) with an analytical model and density structures from airborne expendable CTD (AXCTD) and airborne expendable bathythermograph (AXBT) measurements obtained during Katrina and Rita (Jaimes and Shay, 2009); iv) uses *f*-plane dynamics to prevent self-propagation of the QG vortices, which facilitates analyzing the near-inertial response at fixed points inside the stationary vortex, and v) uses a flat bottom ocean. The computational domain is a 2000×2000 km$^2$ ocean with an initially circular QG vortex (WCE or CCE) of ~150 to 300 km in diameter located at the center (27$^{o}$N) extending to 950 m depth. Horizontal resolutions of ~10 km are adequate for these investigations (Halliwell *et al*., 2011). The initial OML thickness is as a function of the radius of the vortex, the maximum azimuthal velocity, and density profiles from observational data (Jaimes *et al.*, 2011).

Based on observed characteristics of Gulf of Mexico's WCEs and CCEs, four eddies are reproduced where the Rossby number (Ro) ranges from 0.06 to 0.08 The main focus is on eddy features that interacted with Katrina (CCE) and Rita (WCE). For these cases, the KT-PWP parameterization ($R_b$=1 in PWP, where $R_b$ is bulk Richardson number), reproduced OML cooling of about 1$^{o}$C on the right side of the storm track inside the WCE (Fig. 1a), in accord with observational evidence (Shay and Uhlhorn, 2008). In the CCE case, KT+PWP caused cooling of more than 3.5$^{o}$C (Fig. 1b). These results are consistent with the observed cooling during Katrina and Rita (Jaimes and Shay 2009, 2010). We are using these idealized cases from MICOM as a guide for the HYCOM model initialized with a realistic Loop Current and WCE complex. This is where the measurements from

Deepwater Horizon flights provide insight in the initialization of a realistic ocean prior considering the forcing of Katrina and Rita. Such simulations are part of Halliwell's duties in leading an ocean component modeling effort with the AOML modeling group in the development and evaluation of an experimental coupled TC forecast model (HWRF V3.2) based on the operational HWRF model at NCEP. Strategies for ocean model improvement developed under this project will then be tested in HWRF V3.2 at AOML to quantify the impact on actual coupled forecasts before recommendations are made to EMC.

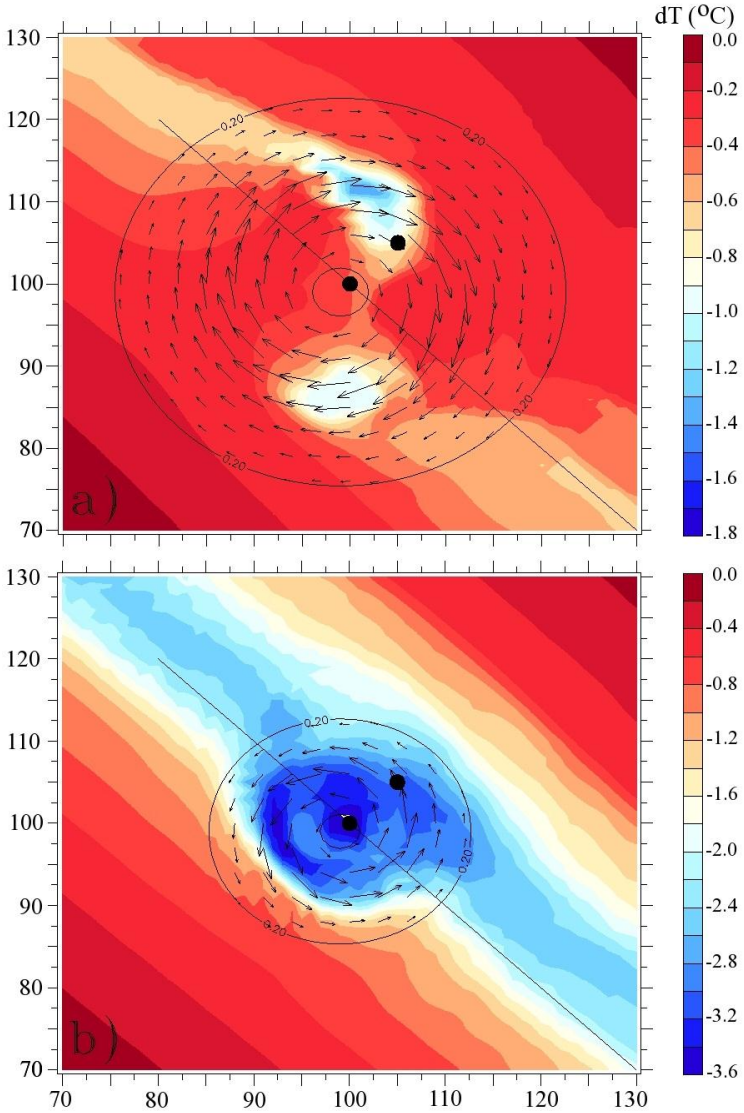



**Figure 1:** OML cooling (°C) in WCE (a) and CCE (b), in terms of the KT+PWP turbulence closure based on differencing pre and post storm analyses. Notice the higher levels of cooling in the CCE compared to that of about 1°C in the WCE consistent with observations (from Jaimes et al., 2011). Black dots are model moorings and arrows represent eddy currents. The straight line is the trajectory of the model storm, moving NW.

**Research Performance Measure:** Over the past year, Shay's and Halliwell's time has been directed toward the oil spill given their fairly extensive knowledge of observing and modeling the Loop Current and its eddy field and the implication of the ocean response on the dispersion of the oil in surface and subsurface layers in the Gulf of Mexico. The results of that work are feeding back into this work as noted above. Thus we are making good progress as noted by the publications as well as assessing the impact of data assimilation schemes using the Deepwater Horizon data set and working with Naval Research Laboratory, which is of interest to NCEP.

The following project activities received some funding from the continuation award reported herein but were primarily funded under the new Cooperative Agreement (NA10OAR4320143). Full reports on these can be found in the nine month progress report previously submitted with respect to that award (see http://www.ci-mas.org/documents/2011_Annual_Report.pdf).

***Ensemble-Based High-Resolution, Ortex-Scale Data Assimilation for Hurricane Model Initialization***, A. Aksoy, K. Sellwood and S. Lorsolo (UM/CIMAS); S.D. Aberson and T. Vukicevic (NOAA/AOML/HRD); F. Zhang (Pennsylvania State University)

***Real-Time Hurricane Wind Analysis***, B. Annane, S. Otero and R. St. Fleur (UM/CIMAS); M. Powell and S. Murillo (NOAA/AOML/HRD); R. Atlas (NOAA/AOML)

***Public Hurricane Loss Projection Model***, B. Annane (UM/CIMAS); M. Powell (NOAA/AOML/HRD)

***Oxygen Winkler Titrations in Support of the Deep Water Horizon Oil Spill Response***, C. Langdon (UM/RSMAS)

***Characterization of the Kinematic and Turbulent Structure of the Hurricane Boundary Layer Using Doppler Measurements***, S. Lorsolo, A. Aksoy and J. Zhang (UM/CIMAS); J. Gamache, R. Rogers, P. Reasor and F. Marks (NOAA/AOML) – **Alan Leonardi – AOML**

***A Fifteen-Year Tropical Cyclone Global Positioning System Dropwindsonde Dataset***, K. Sellwood (UM/CIMAS); S. Aberson (NOAA/AOML)

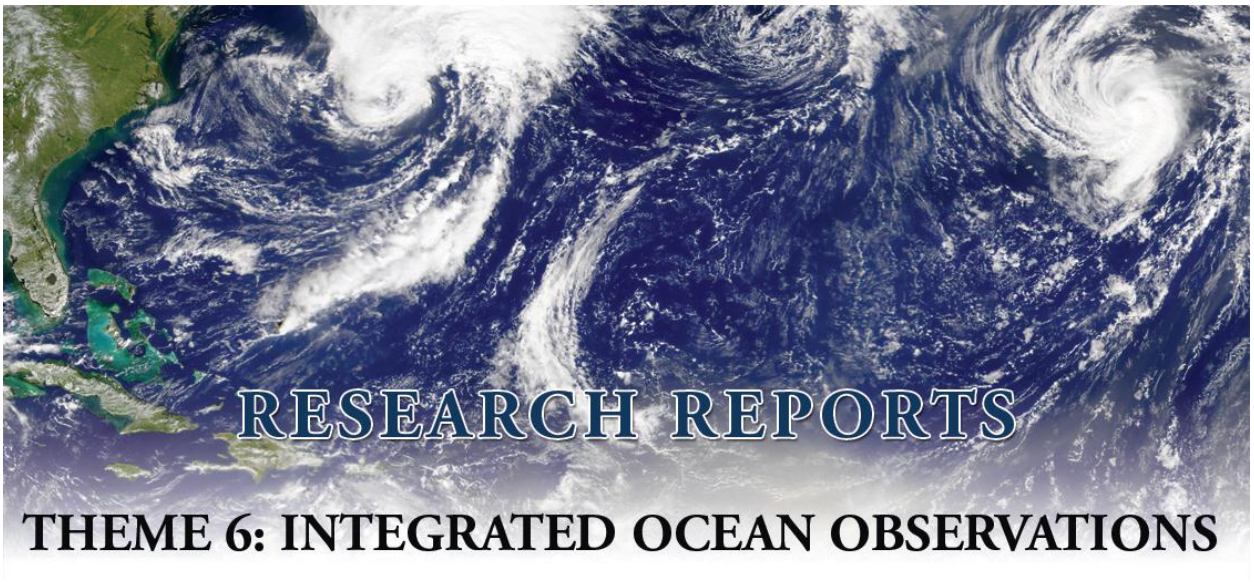
***Upper Ocean Sampling of Currents and Salinity in the Loop Current to Monitor the Deepwater Horizon Oil Spill***, L. Shay (UM/RSMAS) – **Alan Leonardi – AOML**

***Ocean Observing System Simulation Experiments to Improve Ocean Model Initialization for the Hurricane Forecast Improvement Project***, D. Willey (UM/CIMAS); G. Halliwell and Robert Atlas (NOAA/AOML)

***Microphysics of Deep Convection***, P. Willis (UM/CIMAS); F. Marks (NOAA/AOML); A. Heymsfield (NCAR)

***Observational Investigation of the Hurricane Boundary Layer Structure***, J.A. Zhang, S. Lorsolo (UM/CIMAS); D.S. Nolan (UM/RSMAS); R.F. Rogers, F.D. Marks, M. T. Montgomery (NOAA/AOML); P. Zhu (FIU); F. J. Masters (UF)

***Advanced Modeling and Prediction of Tropical Cyclones***, X. Zhang, K.-S. Yeh (UM/CIMAS); S. Gopalakrishnan, T. Quirino, S. Goldenberg and F. Marks (NOAA/AOML); V. Tallapragada, and S. Trahan (NOAA/NCEP)




# *Developing the Operational Calibration/Validation Components for VIIRS SST Retrievals*

**Project Personnel:** R. Evans and P. Minnett (UM/RSMAS)

**Long Term Research Objectives & Strategy to Achieve Them:**
***Objectives*:** To provide consistent, accurate SST fields derived from VIIRS infrared observations.
***Strategy*:** To incorporate VIIRS data and SST retrievals algorithms in the SEADAS processing framework currently supporting AVHRR and MODIS, acquire radiometric in situ observation to validate VIIRS SST retrievals.

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

**Link to NOAA Strategic Goals:**
***Goal 1*:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond – Goal 5: Mission Support

**Funding Unit:** NOAA/DNIP/NESDIS **NOAA Technical Contact:** Heather Kilcoyne

**Research Summary:**
The VIIRS sensor will be first launched on the NPP satellite in Fall, 2011. Our activities are focused on providing at launch SST retrieval algorithms and associated coefficients based on radiative transfer (RT) code simulations and MODIS-in situ matchups transformed to VIIRS band-pass specifications. Following launch, radiometric measurements of in situ SST will be used to validate VIIRS retrievals. Initial implementation of the VIIRS retrieval codes has been tested using MODIS observations and RT simulations. Initial post launch SST retrieval coefficients will be estimated using the NOAA Optimal Interpolation global SST fields derived from in situ, AVHRR infrared and AMSR microwave retrievals. Validation will be based on the in situ radiometric skin temperature measured by the M-AERI infrared interferometer.

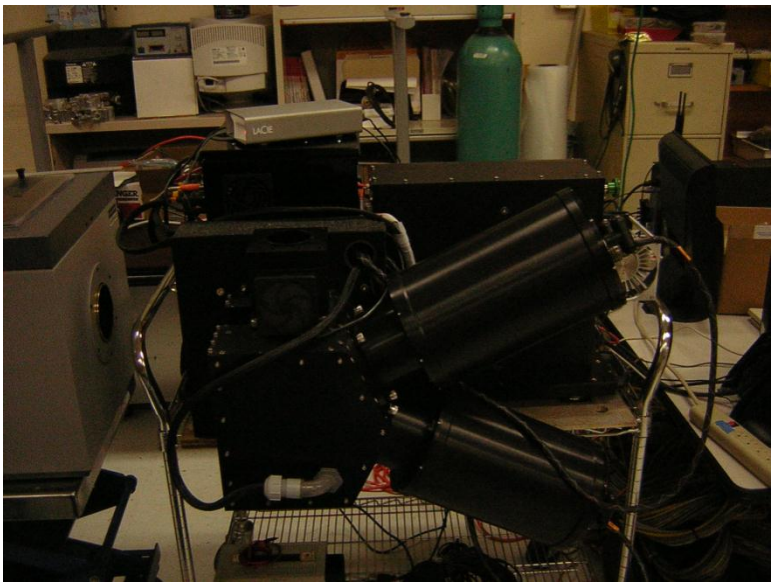


**Figure 1:** M-AERI infrared interferometer, black instrument in center of picture, being calibrated against a NIST traceable temperature source, grey box to the left. The M-AERI is the primary at-sea instruments to measure the skin temperature of the ocean and measures both the up-welling ocean and down-welling atmospheric radiance spectrum. Several on these instruments will be deployed as part of the VIIRS validation program.

**Research Performance Measure:** Delivery of the initial VIIRS algorithms has been completed. The VIIRS SST calibration and validation processing will be undertaken using the SeaDAS code base that has been evolved to include VIIRS SST and to extract satellite-in situ matchups of contemporaneous and co-located in situ, satellite observation pairs.

## *Simulation of the Argo Observing System*

**Project Personnel:** I. Kamenkovich and A. Haza (UM/RSMAS)
**NOAA Collaborator:** C. Schmid (NOAA AOML)
**Other Collaborators:** Z. Garraffo (SAIC)

**Long Term Research Objectives & Strategy to Achieve Them:**

***Objectives*:** To examine how well the Argo observing system determines the state of the global upper ocean, and to understand factors that control accuracy of the reconstruction of the oceanic state.

***Strategy*:** To employ a suite of observation system simulation experiments (OSSE) in ocean general circulation models, to sub-sample oceanic fields in these experiments in ways similar to how the Argo float array samples the ocean, to quantify errors in reconstructions of the oceanic state, and to study factors that control these errors.

**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:** CPO **NOAA Technical Contact:** Joel M. Levy

**Research Summary:**
The aim of this study is to evaluate effects of the oceanic advection and mesoscale variability on the expected accuracy of reconstruction of temperature, salinity and velocities from the Argo measurements and trajectories. For this purpose, we carry simulations of Argo measurements in: (i) a coarse-resolution global ocean model; (ii) an idealized high-resolution ocean circulation model of the North Atlantic; (iii) a comprehensive high-resolution global ocean circulation model.

1) In coarse-resolution simulations, we have analyzed the expected accuracy of the Argo system in reconstructing such important oceanographic variables as temperature, salinity, upper ocean heat content and mixed layer depth. For each of the variables, the analysis is carried for the annual-mean values, the amplitude of the annual cycle, and the amplitude of the interannual difference. The results, which demonstrate an overall good performance of the simulated Argo system, but emphasize the importance of sustained measurements in the regions of strong advection, are described in *Kamenkovich et al.* (2009).

2) In idealized high-resolution simulations, completed during the reported period, we analyze and contrast simulations with and without mesoscale variability, and explicitly separate the effects of the time-mean and mesoscale-eddy-induced advection. The results demonstrate that eddies help to achieve more uniform spatial sampling coverage, but can also cause gaps in the coverage due to the dispersion of the floats. The resulting affects of eddy advection on reconstruction errors are complex, but moderate in the most of the domain (Fig.1). High-frequency variability in temperature and salinity leads to enhancement of the reconstruction errors, especially if the Argo sampling is carried only for a few years. Reconstruction of horizontal velocities from profiler trajectories is capable of detecting detailed multiple zonal jets (Fig. 2), but the reconstruction of the meridional velocities is significantly less reliable.

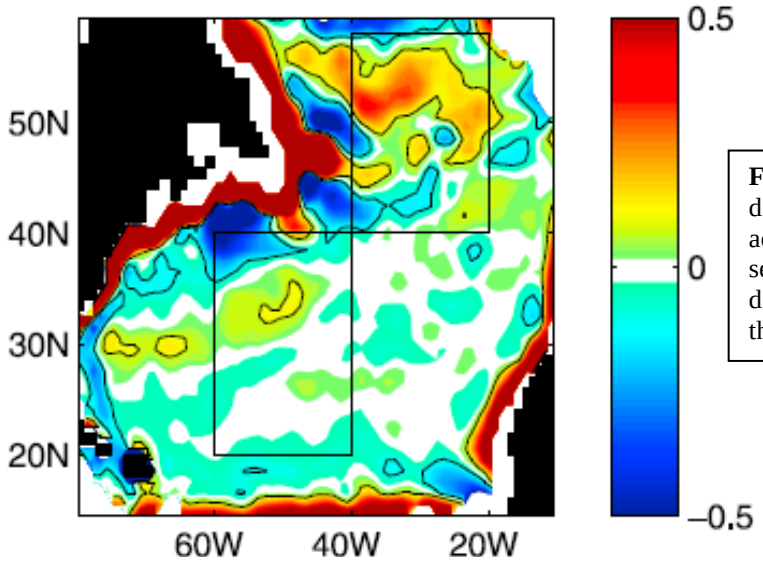



**Figure 1**: Reconstruction errors – the difference between the reconstructed and actual GCM-simulated values – for the sea-sruface temperature (SST, unit: degrees). The contour interval is 0.05K, the contour lines show the +/-0.1K line.

3) The comprehensive high-resolution simulations are currently in progress. They are carried out using a state-of-the-art numerical model of the World Ocean: a high-resolution global Hybrid-Coordinate Ocean Model (HYCOM). These simulations exhibit realistic mean state of the ocean and its mesoscale variability. For this study, we will use a HYCOM global $1/12^{o}$ climatological simulation with 32 vertical layers. HYCOM $1/12^{o}$ global simulations without Argo floats have already been carried and velocity and temperature/salinity fields have been archived. The simulated stratification closely resembles observations and the eddy field is sufficiently realistic.

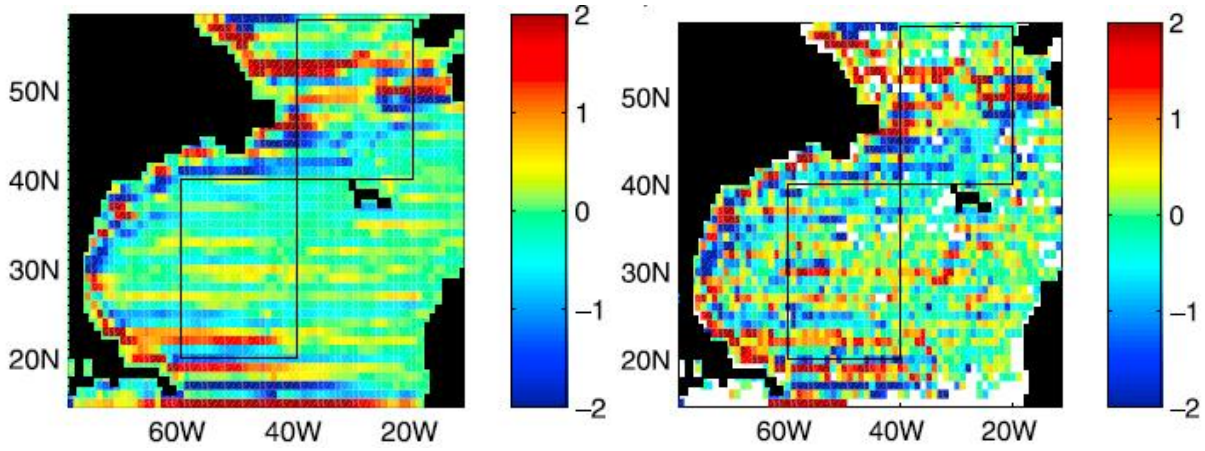



**Figure 2:** Time-mean zonal velocities at 1500 meter depth on a 1x1-degree grid: a) GCM-simulated values; b) values reconstructed from the float trajectories Units are $10^{-2}$ m $sec^{-1}$. Locations with fewer than 5 datapoints (over the 9 year period) are masked (white). Topography is shown at 1500 meter depth.

Float locations and sampling methods most closely match the ones in the real Argo array. Simulated Argo floats are advected at the depth of 1000 meters for nine days, followed by a 6-hour ascent (during which a profile is taken), 12 hours of surface advection, and a 6-hour descent to the 1000-m depth; the floats continue being advected during their ascent/descent. At this stage, the differences in float design are not addressed. The deployment sites and times closely match the actual Argo float locations. Our activities for this reporting period included extracting advective velocities and temperature/salinity data from the HYCOM archives, as well as creating necessary software for the float advection, ascent/descent and vertical profiling, deployment at the locations and times of the actual Array array, and storage of data.

**Research Performance Measure:** The project achieves the original objectives, by analyzing the factors that affect the expected accuracy of the Argo-based reconstructions of the oceanic state.

# *Observing System Simulation Experiments (OSSEs) in the Gulf of Mexico*

**Project Personnel:** V. Kourafalou (UM/RSMAS); M. Le Hénaff and P. Ortner (UM/CIMAS)
**NOAA Collaborators:** R. Atlas and G. Halliwell (NOAA/AOML)

**Long Term Research Objectives amd Strategy to Achieve Them:**

***Objectives* :** Observing *System Simulation Experiments (OSSEs)* are a tool to evaluate the impact of specific observation systems on our ability to accurately hindcast and forecast important physical processes prior to actually collecting observations. Since observing systems are expensive to deploy and maintain, a-priori understanding of the impact of different observing strategies is a crucial component of NOAA's Integrated Ocean Observing Systems initiative. The goal of the OSSE prototype in the Gulf of Mexico (GoM) is to assess the expected performances of various network systems to monitor the Loop Current (LC) dynamics.

***Strategy*:** The development of high resolution, data evaluated models that can perform reliable simulations of the GoM mesoscale variability and be integrated with observations toward data assimilative forecasts.

**CIMAS Research Theme:**

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

**Link to NOAA Strategic Goals:**

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

**NOAA Funding Unit:** AOML **NOAA Technical Contact:** Alan Leonardi

**Research Summary:**

This project has focused on the development of a regional ocean OSSE methodology, in collaboration with AOML (R. Atlas and G. Halliwell), where a parallel methodology for large scale (in space and time) ocean OSSEs is being developed. In particular, we advanced a "toolbox" that can be shared by the RSMAS and AOML ocean OSSE research groups and we have been working toward (a) a nature run in the Gulf of Mexico with suitable data evaluation and performance metrics, (b) a predictive, data assimilative model prototype. In addition, this project is connected to an international initiative on nested, data assimilative coastal and regional models, namely the Global Ocean Data Assimilation Experiment (GODAE) through the Coastal and Shelf Seas Task Team activities of the GODAE/OceanView (where PI Kourafalou is a co-Chair).

The free running Gulf of Mexico Hybrid Coordinate Ocean Model (GoM-HYCOM) simulation with a 1/25-degree resolution has been thoroughly evaluated with observations (Le Hénaff et al., 2011). In particular, the mesoscale dynamics have been investigated. The analysis has focused on the realistic representation of the Loop Current (LC) variability and the dynamics of frontal eddies, which play a major role in the detachment of Loop Current warm core anticyclonic rings. The frontal cyclones appear to have a structure extending to the deep layers of the GoM. They are intensified when the extended LC flows over the northern GoM shelf slope, through a "promontory effect" involving the

aggregation of potential vorticity anomalies in the deep part of the cyclone (Figure 1). This increase in potential vorticity anomaly at depth is responsible for the intensification of the relative vorticity, hence the vertical circulation, of the whole structure, including in the upper layers (Figure 1). The free-running simulation has been found well qualified for a nature run. It represents not only the major GoM mesoscale dynamics, but details in the eddy field, resolved by the 1/25 deg. resolution. In particular, the LC frontal eddies are seen to split, between upper and deep parts, and merge with each other, horizontally or vertically. Such merging is crucial for sustaining or strengthening the cyclone intensity, promoting its ability of later influencing the LC dynamics.

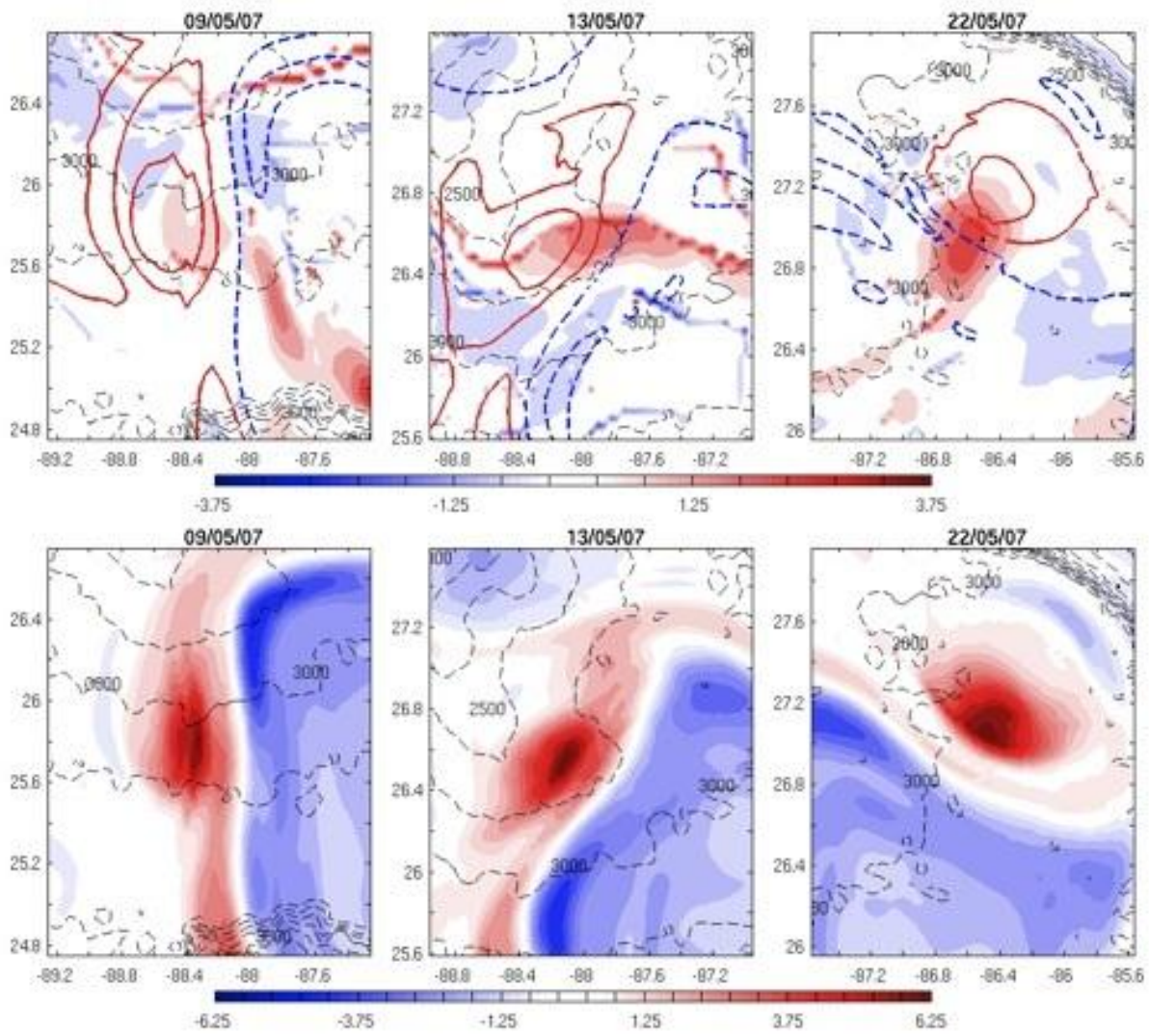



**Figure 1:** (top) model potential vorticity anomaly (PVA, $10^{-5}$ $s^{-1}$) along a frontal eddy trajectory on May 9 (left), May 13 (middle), and May 22, 2007 (right), for the deep layer (colors) and the upper layer (contours every $3.10^{-5}$ $s^{-1}$, in solid red for positive PVA, in dash-dotted blue for negative PVA), and (bottom) model relative vorticity ($10^{-5}$ $s^{-1}$) for the upper layer, at the same locations and dates. Black contours are isobaths, every 500 m (solid) and every 250 m (dashed).

The predictive model is a new, high resolution (1/50 deg.) version of GoM-HYCOM (collaboration with A. Srinivasan, UM/RSMAS and UM/CCS). The model attributes (topography, forcing, initial and boundary conditions) are similar to the free-running, lower resolution (1/25 deg.) GoM-HYCOM. In addition to the higher resolution, the 1/50 GoM-HYCOM employs an advanced data assimilation scheme, the Singular Evolutive Extended Kalman (SEEK) filter. A free-running simulation has also been performed for 2007-2009 to test the realism of the configuration and derive the statistics necessary for the data assimilation steps. The first step has been the evaluation of the impact of assimilating Sea Surface Height (SSH) derived from altimetry. The second step has been the evaluation of the impact of assimilating both along-track SSH, as well as remotely sensed Sea Surface Temperature (SST). It was demonstrated that assimilating only SSH created cold biases that were effectively removed by including the SST assimilation (Figure 2). Starting from the free run, the impact of the SSH in the assimilation scheme allows for the correction of the model surface dynamics in a couple of weeks. The data assimilative model fields can resolve rapid dynamical changes n the GoM mesoscale dynamics, as the correct timing and position of cyclonic eddies during the separation of a Loop Current Eddy (Figure 3).

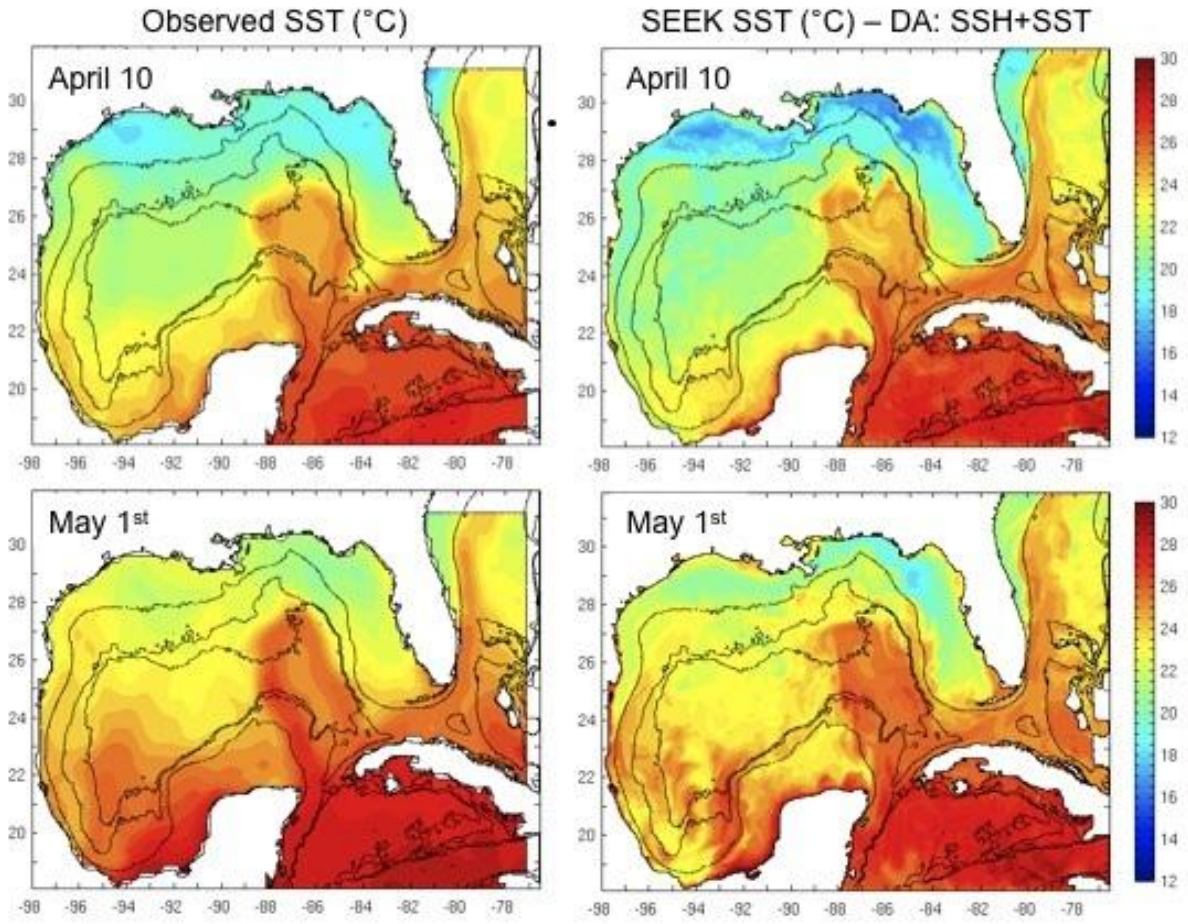



**Figure 2:** (left) Observed Sea Surface Temperature (SST, deg. C) from AVHRR-AMSR satellites, and (right) simulated SST by the data-assimilative 1/50 GoM-HYCOM (2nd experiment), on (top) April 10, and (bottom) May 1st.

The work has also concentrated on identifying specific improvements that are expected to increase the model's forecasting skill. In particular, the vertical resolution at depth would better resolve shelf to offshore interactions; daily discharges from the Northern GoM rivers would improve the representation of baroclinic processes on the shelf; nesting to the global HYCOM model (1/12-degree resolution) might improve inter-annual variability. Finally, the data assimilation module needs to be further tuned to be more accurate in the correction of the mesoscale dynamics. Development and evaluation of these improvements will ensure that the modelling and assimilative systems are well tuned to perform OSSE-type experiments (Kourafalou et al., 2011). An example has already been performed, using the P3 observations during the 2010 oil spill period in the Gulf of Mexico (Halliwell et al., 2011).

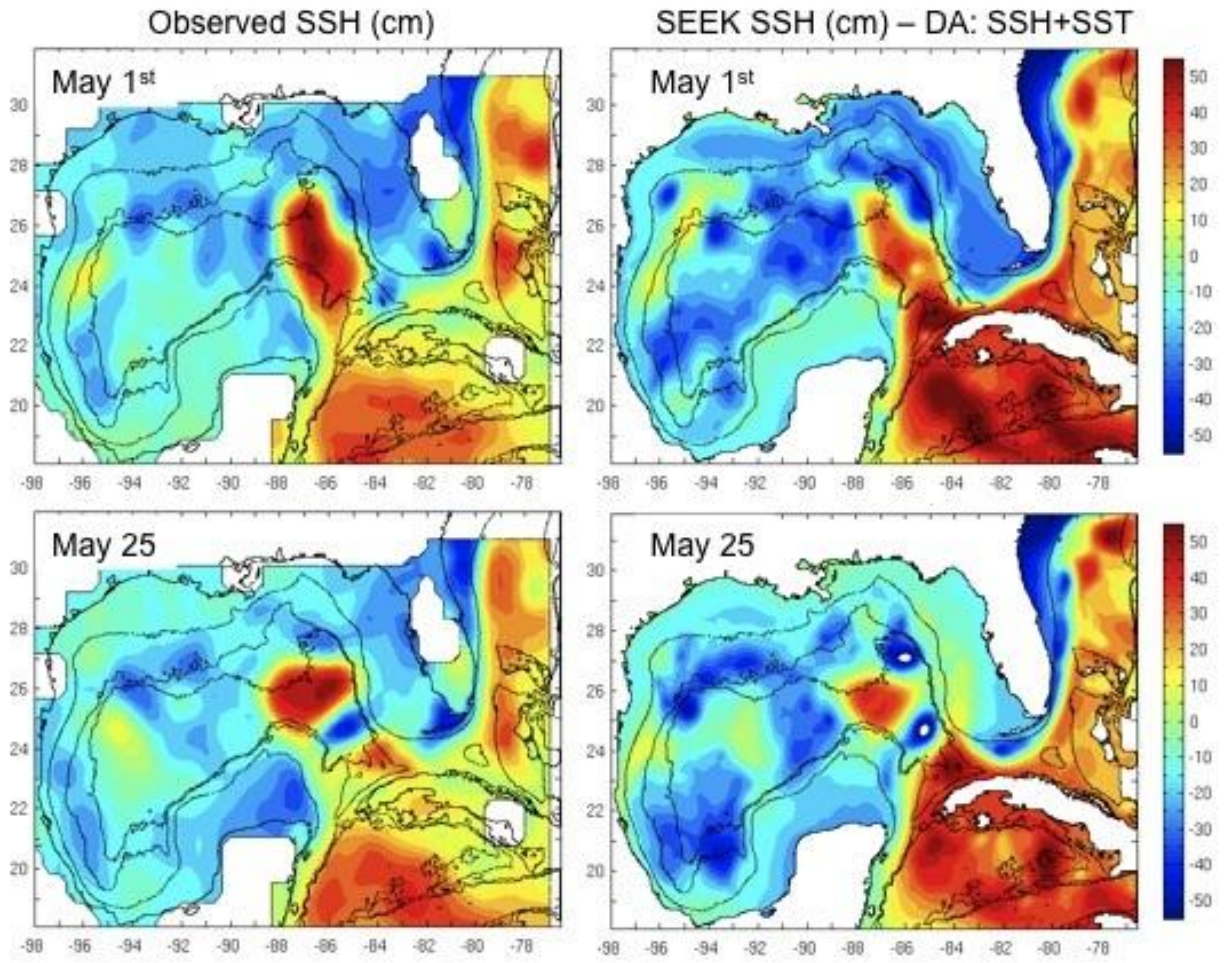



**Figure 3:** (left) Observed Sea Surface Height (SSH, cm) from AVISO, and (right) simulated SSH by the data-assimilative 1/50 GoM-HYCOM (2nd experiment), on (top) May 1st, and (bottom) May 25.

**Research Performance Measure:** The model has been successfully evaluated with several observational data sets. Mean Absolute Dynamical Topography (MADT) maps from Aviso, Reynolds analyzed SST maps from AVHRR and AMSR satellites and NODC/MMS hydrographic data.

# *Biogeochemical Measurements*

**Project Personnel:** C. Langdon (UM/RSMAS)

**Long Term Research Objectives and Strategy to Achieve Them:**

***Objectives*:** To: 1) Determine decadal changes in ocean interior and to constrain ocean $CO_2$ inventories to 2 Pg C/ decade. 2) Determine decadal changes of dissolved oxygen in the ocean interior and use that data to infer changes in the ocean ventilation rate and primary production of overlying waters.

***Strategy*:** Reoccupy transects on a decadal timescale and use the observed changes in dissolved oxygen and nutrients to determine what fraction of the observed change in dissolved inorganic carbon is due to natural processes and what is due to invasion of anthropogenic $CO_2$. Relate changes in the size (vertically and laterally) and location of the ocean's oxygen minimum zones (OMZs) to changes in factors that would affect the rate of subduction water of oxygenated from the surface i.e. winds, temperature, salinity, precipitation and evaporation (all factors that would reflect a change in climate on a decadal time scale). Changes in the rate of primary production in the waters overlying the OMZs and the rate of particle settling (i.e. rain rate) also will be considered.

**CIMAS Research Themes:**

***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:** NOAA/AOML **NOAA Technical Contact:** Alan Leonardi

**Research Summary**:

This project encompasses the participation of Dr. Langdon on A10 from Cape Town, South Africa to Rio de Janeiro, Brazil Aug. 29- Oct. 6, 2011. This cruise is part of the *CLIVAR $CO_2$ Repeat Hydrography Program* which is separately detailed in this CIMAS project. Specifically this project supports Dr. Langdon to oversee the dissolved oxygen measuring capacity of the Ocean Chemistry Division of AOML. This involves the maintenance of the equipment, chemicals and calibrated flasks, the training of personnel, processing and QCing of the data, reporting the final data and going to sea to assist in the sampling. Dissolved oxygen is proving to be sensitive indicator of the effects of climate change on the ocean. Changes in ocean circulation, ventilation of subsurface waters, changes in biological productivity and remineralization all impact the dissolved oxygen concentration of a parcel of water. Estimates of the amount of dissolved inorganic carbon taken up since the start of the industrial revolution (so called anthropogenic carbon) requires precise measurements of dissolved oxygen and nutrient concentrations. In 2008 two publications resulted from this research (Sabine et al. 2008, Mecking et al. 2008). In 2010 Dr. Langdon wrote a chapter on the measurement of dissolved oxygen using the amperometric endpoint method for the new GO-SHIP Hydrographic Methods Manual that is intended to supplant the 15 year old WOCE Hydrographic Methods Manual.

**Research Performance Measure:** This program is attaining all its goals on schedule.

# *Global Carbon Data Management and Synthesis Project*

**Project Personnel:** F.J. Millero, F. Huang and G. Ingram (UM/RSMAS); K. Sullivan, D. Pierrot, J. Trinanes, F. Bringas, G.-H. Park and T.-H. Peng (UM/CIMAS);
**NOAA Collaborators:** R. Wanninkhof (NOAA/AOML); C.L. Sabine, R.A. Feely and S. Hankin (NOAA/PMEL)
**Other Collaborators:** A. Kozyr (CDIAC); R. Key (Princeton); A. Dickson (UCSD)

**Long Term Research Objectives and Strategy to Achieve Them:**

***Objectives*:** NOAA's Office of Climate Observations (OCO) funds researchers from NOAA laboratories Pacific Marine Environmental Laboratory (PMEL) and Atlantic Oceanographic and Meteorological Laboratory (AOML), as well as the Carbon Dioxide Information Analysis Center, Princeton University, University of California San Diego and the University of Miami to participate in a project to manage, synthesize and interpret data in an endeavor to understand how the ocean carbon cycle changes over time. NOAA's Office of Climate Observations (OCO) oversees this group project and recognizes the need for proper data management and synthesis.

***Strategy*:** As a member of this global carbon data management and synthesis project, principal investigators participate in national and international planning efforts to evaluate and improve the global ocean observing system. The principal investigators of this multi institutional project gather data and bring it together. They collaborate to discuss and provide tools and methods to manage the data, insure accuracy and facilitate easy access.

**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:** NOAA/AOML **NOAA Technical Contact:** Alan Leonardi

**Research Summary:**

The goal of the Global Carbon Data Management and Synthesis Project is to work together with the OCO carbon measurement projects to take the fundamental carbon observations and turn them into products that are useful for scientists and the public for understanding the ocean carbon cycle and how it is changing over time. This effort ranges from ensuring that the observations are of the highest quality and are mutually consistent with each other to combining the observations into a common data set that is available and easy for the community to use and explore to evaluating the time rate of change in global ocean carbon uptake and storage. This project brings together ocean carbon measurement experts, information technology experts and data managers to ensure the most efficient and productive processing possible for the OCO carbon observations.

Earlier this year we participated in one CLIVAR S4P cruise in the Antarctic aboard the RVIB Palmer (McMurdo to Punta Arenas, Chiles) and have shipped equipment and personnel for the upcoming Atlantic cruise departing 28 August 2011 Cape Town, South Africa and arriving 2 October 2011 in Rio de Janeiro, Brazil. As a result of the standardized measurements from the Climate Variability (CLIVAR) and Volunteer Observing Ships (VOS) cruises, several publications have resulted.

Millero and Huang (2009) have made new measurements to expand the equation of state of seawater to a wider range of temperature and absolute salinity. A new equation of state has been used to calculate a number of thermal and caloric parameters. Safarov et al. (2009) present new (p, p. T) measurements for standard seawater samples over the extended temperature interval (T=(273.14 to 468.06)K and for pressure up to p=140 Mpa. The results are used to derive an equation of state of seawater that is valid for higher temperatures and pressures than previously possible. The new equation of state puts all of the physical properties in one equation. This makes it convenient for modelers to calculate various properties of seawater.

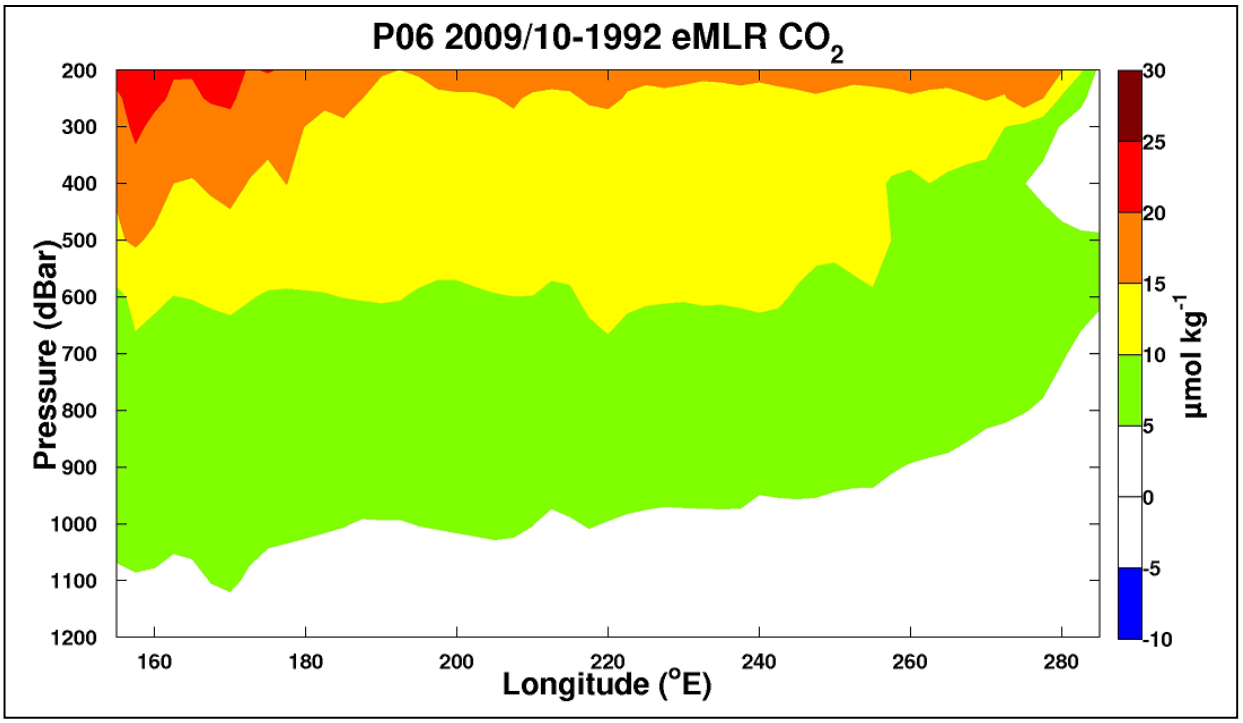



**Figure 1:** Accumulation of anthropogenic $CO_2$ on P06, along 32°S in the Pacific, from WOCE, 1992, to CLIVAR, 2009/10

Spectroscopic measurements of the pH in NaCl brines were made by Millero et al. (2009) in an article in *Geochimica et Cosmochimica Acta*. In another publication, South Pacific Ocean waters were examined on the P18 CLIVAR (Climate Variability and Predictability) cruise to determine the effect of composition on the density of the waters (Millero et al., 2009).

Millero (2010) published a paper on the carbonate constants for estuarine waters. Another by Millero and DiTrolio (2010) will be published in October on the effects of ocean acidification due to $CO_2$ dissolution in *Elements*.

In Millero's lab, short term visiting scholar Giuseppe Manfredi from the Universita degli Studi di Messina, Italy made pH and TA measurements on Leg 2 of the Pacific Ocean cruise (P06) from Papeete, Tahiti to Bahia de Valparaiso, Chile during January and February 2010 aboard the R/V Melville. This work will result in a data report and other manuscripts in preparation.

Several refereed publications, reports and abstracts have been written with the graduate and undergraduate students, and international scholars as co-authors (Millero and Woosley, 2009; Millero et al., 2009a, b,c ; Millero and DiTrolio, 2010; Millero et al. 2010; Trapp et al. 2010a,b; Woosley and Millero 2010; Waters and Millero, 2010)

A RSMAS cruise report on the pH and total alkalinity measurements in the Pacific Ocean P18 was prepared and the data was sent to CDIAC for standardization of all measurements (Millero et al., 2008). CDIAC has prepared a report from all the participating investigators on the chemical data obtained during the *R/V Knorr* Repeat Hydrography Cruises in the North Atlantic Ocean during 2003. The report is a compilation of all the data obtained during the cruise and briefly describes the methods of obtaining data consistent with community standards, issues with the data and the resulting quality data.

**Research Performance Measure:** All objectives have been met.

## *Climate Data Records of Sea-Surface Temperature*

**Project Personnel:** P. Minnett and E. Williams (UM/RSMAS)

**Long Term Research Objectives and Strategy to Achieve Them:**

***Objectives*:** To determine the uncertainty characteristics of satellite-derived sea-surface temperature (SST) fields using ship-board radiometers with calibration traceable to national reference standards, thereby fulfilling the requirements of a Climate Data Record; recommend improved algorithms, and provide meta-data to contribute to the NOAA Scientific Data Stewardship Program.

***Strategy*:** To compare co-located and contemporaneous retrievals of satellite-derived sea-surface temperatures with measurements of skin sea-surface temperatures from well-calibrated Fourier-Transform infrared spectroradiometers and filter radiometers; analyze the resulting data bases to determine the error characteristics in the satellite measurements and determine improvements to retrieval algorithms and procedures.

**CIMAS Research Theme:**

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

**Link to NOAA Strategic Plan Goals:**

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

**NOAA Funding Unit:** OAR/CPO **NOAA Technical Contact:** William L. Murray

**Research Summary:**
Two ISAR's have been mounted on the NYK Lines Ship *Andromeda Leader* throughout the performance period and functioned well. We have completed the matchup process between the entire shipboard radiometer data and AVHRR SSTs, and the analysis of these is continuing.

The PI has visited Drs. LeBorgne and Roquet of Metéo-France to work on the SEVIRI (Spinning Enhanced Visible and IR Imager) data from the Eumetsat Meteosat Second Generation satellite over the Atlantic Ocean. The SEVIRI SST uncertainties display distinct spatial characteristics: atmospheric radiative transfer simulations are being conducted to underhand the basis of these patterns. A summary of the preliminary results will be presented at the GHRSST Science Team Meeting at the University of Edinburgh in June 2011.

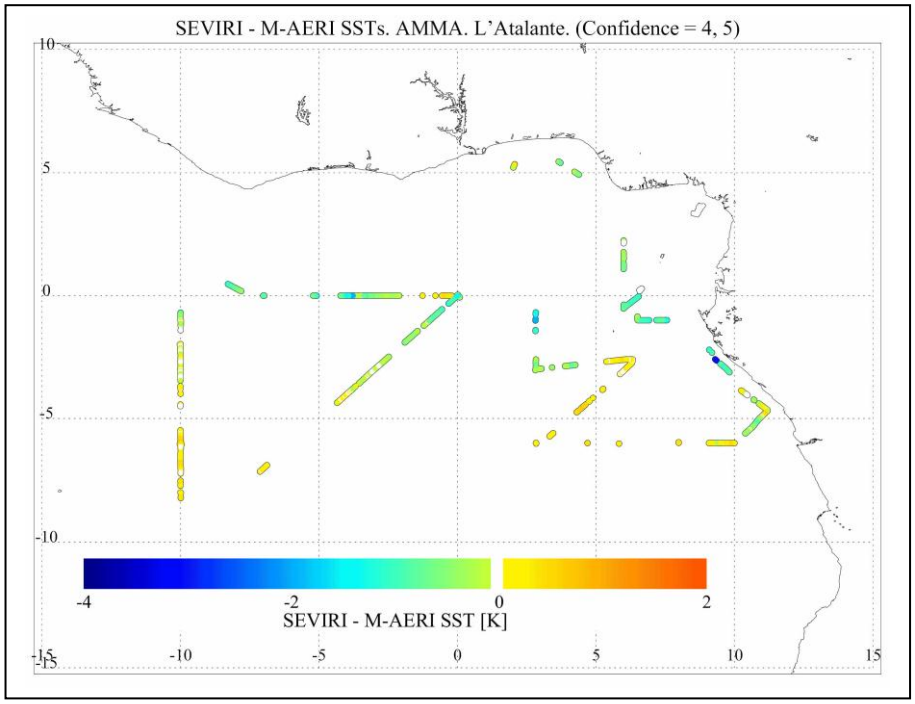



**Figure 1:** The distribution of SEVIRI SST retrieval uncertainties derived by comparison with collocated and near-contemporaneous measurements from the M-AERI mounted on the R/V *L'Atalante* in the Gulf of Guinea during the African Monsoon Multidisciplinary Analyses (AMMA) Campaign in 2006. Numerical radiative transfer simulations have revealed that the spatial coherence of the uncertainties is primarily related to patterns of variability in the vertical distribution of atmospheric water vapor.

**Research Performance Measure:** Progress is being achieved along the lines originally proposed.

The following project activities received some funding from the continuation award reported herein but were primarily funded under the new Cooperative Agreement (NA10OAR4320143). Full reports on these can be found in the nine month progress report previously submitted with respect to that award (see http://www.ci-mas.org/documents/2011_Annual_Report.pdf).

***Global Drifter Program***, S. Dolk and E. Valdes (UM/CIMAS); R. Lumpkin and M. Pazos (NOAA/AOML)

***US Argo Project: Global Ocean Observations for Understanding and Predicting Climate Variability***, S. Dong, E. Forteza, V. Halliwell, V. Hormann and R. Sabina (UM/CIMAS); S. L. Garzoli, E. Ramos and C. Schmid (NOAA/AOML)

***Integrated Coral Observing Network (ICON) Project***, I.C. Enochs, L.J. Gramer, K.P. Helmle, M. Jankulak and D.P. Manzello (UM/CIMAS); J.C. Hendee, M. Shoemaker and J. Craynock (NOAA/AOML)

***Western Boundary Time Series Project***, R. Garcia, G. Berberian, Q. Yao, G. Rawson, N. Melo, K. Seaton, R. Roddy, and E. Valdes (UM/CIMAS); M. Baringer, C. Meinen and S. Garzoli (NOAA/AOML)

***South Atlantic Meridional Overturning Circulation ("SAM") Project***, R. Garcia, R. Perez (UM/CIMAS); C. Meinen, S. Garzoli, M. Baringer and G. Goni (NOAA/AOML)

***Synoptic Estimates of Sea Surface Ocean Acidification***, D. Gledhill and D. Pierrot (UM/CIMAS); R. Wanninkhof (NOAA/AOML); S. Yvon-Lewis (TAMU)

***Development of the Next Generation Ships-of-Opportunity***, P.B. Ortner (UM/CIMAS); E. Williams, P. Minnet, L. Beal and R. Findley (UM/RSMAS); R. Wanninkof and S. Cummings (NOAA/AOML); A. Solokiev (NSU)

***Data Integration and Data Mining Support for Tropical Cyclone Integrated Observing Systems***, M.-L. Shyu (UM/ENG); F. Marks, M. Powell and T. Quirino (NOAA/AOML)

***System Support for the Development and Simulation of Tropical Cyclone Numerical Models in a Linux Cluster System***, M.-L. Shyu (UM/ENG); F. Marks, S. Gopalakrishnan, T. Quirino and R. Rogers (NOAA/AOML)

***Surface Water $pCO_2$ Measurements from Ships***, K. Sullivan, D. Pierrot, F. Bringas, G.-H. Park and L. Barbero (UM/CIMAS); F.J. Millero (UM/RSMAS); G. Goni and R. Wanninkhof (NOAA/AOML); J. Trinanes (Universidad de Santiago de Compostela)

***The CLIVAR $CO_2$ Repeat Hydrography Program***, K. Sullivan, G. Berberian, G.-H. Park and L. Barbero (UM/CIMAS); C. Langdon (UM/RSMAS); R. Wanninkhof (NOAA/AOML)

***Observing System Simulation Experiments for the Atlantic Meridional Overturning Circulation***, C. Thacker and H. Yang (UM/CIMAS); G. Halliwell (NOAA/AOML)

***Ship of Opportunity Program***, Q. Yao, F. Bringas, P. DiNezio, G. Rawson, N. Melo, S. Dong, J. Molina, M. Goes, D. Aranda and C. Gonzalez (UM/CIMAS); G. Goni, M. Baringer and S. Garzoli (NOAA/AOML)

# VII. EDUCATION AND OUTREACH

Only the additional education and outreach associated with the ten projects not previously described are included herein. Other education and outreach activities during the project period 2010-2011 but supported primarily by funding under the new Cooperative Agreement (NA10OAR4320143) can be found in the nine month progress report previously submitted with respect to that award (see http://www.ci-mas.org/documents/2011_Annual_Report.pdf).

## *Observing System Simulation Experiments (OSSEs) in the Gulf of Mexico*

V. Kourafalou (UM/RSMAS); M. Le Hénaff and P. Ortner (UM/CIMAS); R. Atlas and G. Halliwell (NOAA/AOML)

Presentations at the *91st Annual Meeting of the American Meteorological Society*, Seattle, WA (January 2011)

Presentations at the *Layered Ocean Model Workshop*, Miami, FL (February 2011)

Project methodology was integrated in the teaching of the graduate UM/RSMAS course "Coastal Ocean Circulation".

Project results were disseminated in the international Science Team meeting of the Ocean Data Assimilation Experiment (GODAE) Ocean View (GOV), Tokyo, Japan, November 2010.

Project results were disseminated in the public lecture of the UM Solutions Interdisciplinary Forum (Oct. 2010).

## *Global Carbon Data Management and Synthesis Project*

**Project Personnel:** F.J. Millero, F. Huang and G. Ingram (UM/RSMAS); K. Sullivan, D. Pierrot, J. Trinanes, F. Bringas, G.-H. Park and T.-H. Peng (UM/CIMAS);

**NOAA Collaborators:** R. Wanninkhof (NOAA/AOML); C.L. Sabine, R.A. Feely and S. Hankin (NOAA/PMEL)

**Other Collaborators:** A. Kozyr (CDIAC); R. Key (Princeton); A. Dickson (UCSD)

Investigators presented public lectures; and are members of national and international steering committees. During 2010-2011 Frank Millero attended meetings and participated as a member of the national National Research Council (NRC), Ocean Acidification Committee and The International Association for the Properties of Water and Steam (IAPWS) Subcommittee on Seawater (SCSW), and SCOR Working Group 127 on the Thermodynamics and Equation of State of Seawater 2008-2011.

# VIII. CIMAS FELLOWS

The Fellows provide guidance to the Director on matters concerning the ongoing activities and future direction of CIMAS. Until the summer of 2010, there were 17 Fellows, 10 from RSMAS, 5 from the local NOAA laboratories, 1 from the National Hurricane Center and 1 from Florida International University. Normally membership is approximately balanced between RSMAS and NOAA. 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 nominally to meet on a quarterly basis although scheduling has been difficult because of the extensive travel schedules. Many Fellows-related matters are now addressed and implemented by means of email exchanges. Finally, because of the close proximity of the three Institutions and the frequent social activities, there are also many ad hoc meetings and discussions. During Year 10 there were few formal meetings in that the focus of the academic Fellows and CIMAS Administration was upon the Recompetition Process and a distinct separation needed to be maintained between academic and federal Fellows during the lengthy RFP development, proposal response, proposal review and proposal modification processes to avoid even the appearance of a conflict-of-interest. The Council of Fellows membership listed below was dissolved and reconstituted after the recompetition was successful during the summer of 2010.

| 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. 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. Donald B. Olson | UM/RSMAS Meteorology and Physical Oceanography |
| Dr. Edward N. Rappaport | NOAA/National Weather Service |
| Dr. Nick Shay | UM/RSMAS Meteorology and Physical Oceanography |
| Dr. Sharon S. Smith | UM/RSMAS Marine Biology and Fisheries |

| | |
|---|---|
| Dr. Rik Wanninkhof | NOAA/AOML/Ocean Chemistry Division |
| Dr. Hugh E. Willoughby | Florida International University, Dept. of Earth Sciences |

***Ex Officio***

| | |
|---|---|
| Dr. Robert M. Atlas | NOAA/AOML, Office of the Director |
| Dr. Roni Avissar | UM/RSMAS Dean |
| Dr. Bonnie.Ponwith | NOAA/Southeast Fisheries Science Center |

# IX. AWARDS AND HONORS

Only the additional awards and honors associated with the ten projects not previously described are included herein. Other awards and honors during the project period 2010-2011 but supported primarily by funding under the new Cooperative Agreement (NA10OAR4320143) can be found in the nine month progress report previously submitted with respect to that award (see http://www.ci-mas.org/documents/2011_Annual_Report.pdf).

## *Global Carbon Data Management and Synthesis Project*

**Project Personnel:** F.J. Millero, F. Huang and G. Ingram (UM/RSMAS); K. Sullivan, D. Pierrot, J. Trinanes, F. Bringas, G.-H. Park and T.-H. Peng (UM/CIMAS);

**NOAA Collaborators:** R. Wanninkhof (NOAA/AOML); C.L. Sabine, R.A. Feely and S. Hankin (NOAA/PMEL)

**Other Collaborators:** A. Kozyr (CDIAC); R. Key (Princeton); A. Dickson (UCSD)

Frank J. Millero was awarded the Victor Moritz Goldschmidt Medal of the Geochemical Society (2011) and the Florida Award (Florida section of the American Chemical Society (FLACS)) (2011)

# X. POSTDOCTORAL FELLOWS AND GRADUATE STUDENTS

## CIMAS-Supported Postdoctoral Fellows and Graduate Students

### *Postdoctoral Fellows*

Barbero Munoz, Leticia
Enochs, Ian
Hormann, Verena
Le Henaff, Matthew
Liu, Hailong
Liu, Yanyun
Park, Geun-Ha
Yang, Haoping
Zabalo, Joaquin

### *Graduate Students*

**Task I**
Council, Elizabeth
Johnston, Lyza
Jones, Robert
Wylie, Jennifer

**Task III**
Albright, Rebecca
Bhatia, Kieran
Buck, Eric
Ditrolio, Benjamin
Dolan, Tara
Huntington, Brittany
Harford, William
Karmauskas, Mandy
Martin, Elizabeth
Mason, Benjamin
McCaskill, Claire
Meyers, Patrick
Perryman, Holly
Santos, Rolando
Waters, Jason
Woosley, Ryan

**Employees**
Enochs, Ian
DiNezio, Pedro
Forteza, Elizabeth
Grammer, Lewis
Kelble, Christopher
Malca, Estrella
Sellwood, Kathryn
Shiroza, Akihiro

## Other Participants in CIMAS Projects

### *Postdoctoral Fellows*

Sebille, Erick Van
Jaimes, Benjamin

### *Graduate Students*

Bustos, Hector
Chambers, Adam
Drury, Crawford
Ender, Alexandra
Fischer, Michael
Kotkowski, Rachel
Lerner, Justin
Liu, Diantig
Melendez, Melissa
Meng, Teo
Rodriguez, Carmen
Smith, Mathew
Vasquez-Yeomans, Lourdes
Waterhouse, Lynn
Yurek, Simeon

# XI. RESEARCH STAFF

| | |
|---|---|
| Aksoy, Altug | Assistant Scientist |
| Amornthammarong, Natchanon | Assistant Scientist |
| Annane, Bachir | Senior Research Associate III |
| Aranda, Diana | Research Associate II |
| Barbero Munoz, Leticia | Postdoctoral Associate |
| Berberian, George | Research Associate II (PT) |
| Blondeau, Jeremiah | Senior Research Associate I |
| Bright, Alan | Research Associate II |
| Bringas Gutierrez, Francis | Research Associate III |
| Brown, Cheryl | Research Associate II |
| Cameron, Caitlin | Research Associate I |
| Cardenas, Hernando | Research Associate I |
| Di Nezio, Pedro N. | Research Associate III |
| Dias, Laura | Research Associate II |
| Diaz, Jose E. | Research Associate II |
| Dolk, Shaun | Research Associate II |
| Dong, Shenfu | Assistant Scientist |
| Dunion, Jason | Senior Research Associate III |
| Enochs, Ian | Postdoctoral Associate |
| Enfield, David | Scientist (PT) |
| Erickson, Kristin L. | Research Associate III |
| Festa, John | Senior Research Associate III (PT) |
| Forteza, Elizabeth | Research Associate III |
| Garcia, Rigoberto F. | Research Associate III |
| Gidley, Maribeth | Assistant Scientist |
| Gledhill, Dwight | Associate Scientist |
| Goes, Marlos | Assistant Scientist |
| Gonzalez, Caridad | Research Associate II |
| Gramer, Lewis J. | Research Associate III |

| | |
|---|---|
| Halliwell, Vicki | Senior Research Associate III |
| Helmle, Kevin | Assistant Scientist |
| Hoolihan, John | Associate Scientist |
| Hormann, Verena | Postdoctoral Associate |
| Jankulak, Michael L. | Research Associate III |
| Johnson, Darlene R. | Scientist |
| Kelble, Christopher R. | Assistant Scientist |
| Klotz, Bradley | Research Associate III |
| Le Henaff, Matthieu | Postdoctoral Associate |
| Lee, Sang-Ki | Scientist |
| Liehr, Gladys | Assistant Scientist |
| Lindo Atichati, David | Research Associate I |
| Liu, Hailong | Postdoctoral Associate |
| Liu, Yanyun | Postdoctoral Associate |
| Lorsolo, Sylvie | Assistant Scientist |
| Malca, Estrella | Research Associate III |
| Manzello Derek | Assistant Scientist |
| Melo, Nelson | Senior Research Associate II |
| Molina, Jonathan | Research Associate I |
| Muhling, Barbara | Assistant Scientist |
| Otero, Sonia | Senior Research Associate II |
| Park, Geun-Ha | Assistant Scientist |
| Peng, Tsung-Hung | Scientist (PT) |
| Perez, Renellys | Assistant Scientist |
| Pierrot, Denis P. | Assistant Scientist |
| Privoznik, Sarah | Research Associate I |
| Rawson, Grant T. | Research Associate III |
| Sabina, Reyna | Research Associate III (PT) |
| Seaton, Kyle | Research Associate II |
| Sellwood, Kathryn J | Research Associate III |
| Shiroza, Akihiro | Research Associate II |
| St. Fleur, Russell | Programmer Intermediate |

| | |
|---|---|
| Sullivan, Kevin F. | Senior Research Associate III |
| Teare, Brian | Research Associate II |
| Thacker, Carlisle | Scientist (PT) |
| Tonioli, Flavia | Senior Research Associate I |
| Valdes, Erik | Research Associate II |
| Visser, Lindsey | Research Associate I |
| Wanless, David R. | Research Associate II |
| Whitcraft, Samantha R. | Senior Research Associate I |
| Wicker, Jesse A. | Research Associate III |
| Wilborn, Rachel | Research Associate II |
| Willey, Debra | Senior Research Associate I |
| Williams, Dana E. | Scientist |
| Willis, Paul | Research Associate II (PT) |
| Yang, Haoping | Postdoctoral Associate |
| Yao, Qi | Senior Research Associate I |
| Yeh, Kao-San | Scientist |
| Zabalo, Joaquin | Postdoctoral Associate |
| Zhang, Jun | Assistant Scientist |
| Zhang, Xuejin | Assistant Scientist |

# XII. VISITING SCIENTISTS PROGRAM

**Prof. Johann R.E. Lutjeharms**
Professor Emeritus
Department of Oceanography
University of Cape Town
770 Rondebosch
Cape Town, South Africa
1 – 15 November, 2010

November 3, 2010 *"What Do We Know About the Agulhas Current After 30 Years of Research?"*

**Prof. Dr. Edmo J.D. Campos**
Professor Titular – Physical Oceanography
Oceanographic Institute – University of Sao Paulo
Pca. Do Oceanografico 191 – Cid. Universitaria
05508-120 S. Paulo, SP, Brazil
12 December, 2010 – 12 March, 2011

**Dr. Yehe Mathieu Dietoa**
Laboratory of Environment and Aquatic Biology
University of Abobo-Adjamé
01 B.P. 801 Abidjan 02, Côte d'Ivoire
5 January – 15 February 2011

# XIII. PUBLICATIONS

Only the additional publications associated with the ten projects not previously described are listed herein. Other publications during the project period2010-2011 but supported primarily by funding under the new Cooperative Agreement (NA10OAR4320143) can be found in the nine month progress report previously submitted with respect to that award (see http://www.cimas.org/documents/2011_Annual_Report.pdf)

**Table 1: Publication Record 2010-2011**
**(Previously reported)**

| | **Institute Lead Author** | **NOAA Lead Author** | **Other Lead Author** |
|---|---|---|---|
| | **2010-2011** | **2010-2011** | **2010-2011** |
| **Peer Reviewed** | 52 | 26 | 29 |
| **Non-Peer Reviewed** | 22 | 13 | 2 |

**(Current report)**

| | **Institute Lead Author** | **NOAA Lead Author** | **Other Lead Author** |
|---|---|---|---|
| | **2010-2011** | **2010-2011** | **2010-2011** |
| **Peer Reviewed** | 8 | - | 3 |
| **Non-Peer Reviewed** | 2 | - | 1 |

## *Refereed Journal Articles*

Farmer, N.A., and J.S. Ault (2011), Grouper and snapper movements and habitat use in Dry Tortugas, Florida, *Marine Ecology Progress Series*, 433, 169-184.

Le Hénaff, M., V.H. Kourafalou, Y. Morel and A. Srinivasan (2011), Simulating the dynamics and intensification of cyclonic Loop Current Frontal Eddies in the Gulf of Mexico, *J. Geophys. Res.*, in Review.

Lee, K., T.-W. Kim, R.H. Byrne, F.J. Millero, R.A. Feely, and M.-M. Liu (2010), The universal ratio of boron to chlorinity for the North Pacific and North Atlantic Oceans, *Geochim. Cosmochim. Acta*, 74, 1801-1811.

Marion, G.M., F.J. Millero, M.F. Camões, P. Spitzer, R. Feistel, and C.-T.A. Chen (2011), The pH of seawater, *Mar. Chem.*, 126, 89-96, doi: 10.1016/j.marchem.2011.04.002.

Millero, F.J. and F. Huang (2011), The compressibility of seawater from 0 to 95$^{o}$C at 1 atm, *Mar. Chem.*, 126, 149-154, doi: 10.1026/j.marchem.2011.05.003.

Millero, F.J., F. Huang, R.J. Woosley, R.T. Letscher, and D.A. Hansell (2011), Effect of dissolved organic carbon and alkalinity on the density of Arctic Ocean waters, *Aquat. Geochem.*, 17, 311-326, doi: 10.1007/s10498-010-9111-2.

Smith, S.G., J.S. Ault, J.A. Bohnsack, D.E. Harper, J. Luo, and D.B. McClellan (2011), Multispecies survey design for assessing reef-fish stocks, spatially-explicit management performance, and ecosystem condition, *Fisheries Res.*, 109(1), 25-41.

Trapp, J.M., F.J. Millero and J.M. Prospero (2010), Temporal variability of the elemental composition of African dust measured in trade wind aerosols at Barbados and Miami, *Mar. Chem.*, 120, 71-82, doi:10.1016/j.marchem.2008.10.004.

Trapp, J.M., F. J. Millero, and J. M. Prospero (2010), Trends in the solubility of iron in dust-dominated aerosols in the Equatorial Atlantic Trade Winds: The importance of iron speciation and sources, *Geochem. Geophys. Geosyst.*, 11, Q03014, doi:10.1029/2009GC002651.

Woosley, R. and F.J. Millero (2010), The hydrolysis of Al(III) in NaCl solutions-A model for M(II), M(III) and M(IV) ions, *Aquat. Geochem.* 16, 317-324, doi: 10.1007/s10498-009-9075-2.

## *Chapter in Book*

Morel, F.M., D. Archer, J.P. Barry, G.D. Brewer, J.E. Corredor, S.C. Doney, V. J. Fabry, G.E. Hofmann, D.S. Holland, J.A. Kleypas, F.J. Millero, and U. Riebessel (2010), Effects of Ocean Acidification on the Physiology of Marine Organisms, in *Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean*, Chapter 3, pp. 33-42, National Research Council of the National Academies, *National Academies Press*, Washington, DC.

## *Conference Proceedings*

Kourafalou, V.H., M. Le Hénaff, A. Srinivasan, G. Halliwell and R. Atlas (2011), Data assimilative modeling and OSSEs experiments for the monitoring of the Loop Current frontal dynamics – Application to the Deepwater Horizon oil spill. *91st Annual Meeting of the American Meteorological Society*, Seattle, WA. http://ams.confex.com/ams/91Annual/webprogram/Paper185611.html

## *Technical Reports*

McDougall, T.J., R. Feistel, D. G. Wright, R. Pawlowicz, F.J. Millero, D. R. Jackett, B. A. King, G. M. Marion, S. Seitz, P. Spitzer, and C.-T. A. Chen (IOC, SCOR and IAPSO) (2010), *The international thermodynamic equation of seawater - 2010: Calculation and use of thermodynamic properties*. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, UNESCO (English), 171pp. Available from http://www.TEOS-10.org, The International Thermodynamic Equation of Seawater 2010 (TEOS-10).

## *Ph.D. Dissertation*

Bustos-Serrano, H. (2010), The Carbonate System in Natural Waters, Ph.D. Dissertation, 149pp, ISBN 1124402586, University of Miami, Coral Gables, FL.