



## DEPARTMENT OF COMMERCE RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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AWARD INFORMATION	
1. Federal Agency: Department of Commerce / NOAA	2. Federal Award Number: NA15OAR4320064
3. Project Title: Cooperative Institute for Marine and Atmospheric Studies (CIMAS): Administrative Renewal	
4. Award Period of Performance Start Date: 10/01/2015	5. Award Period of Performance End Date: 09/30/2020
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REPORTING INFORMATION	
Signature of Submitting Official: Bonnie Townsend	
16. Submission Date and Time Stamp: 08/30/2019	17. Reporting Period End Date: 06/30/2019
18. Reporting Frequency: <input checked="" type="radio"/> Annual <input type="radio"/> Semi-Annual <input type="radio"/> Quarterly	19. Report Type: <input checked="" type="radio"/> Not Final <input type="radio"/> Final
RECIPIENT ORGANIZATION	
20. Recipient Name: UNIVERSITY OF MIAMI	
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22. Recipient DUNS: 152764007	23. Recipient EIN: 590624458

## ACCOMPLISHMENTS

### 24. What were the major goals and objectives of this project?

CIMAS is structured into seven themes - our accomplishments are organized under these themes as follows:

Climate and Impacts (CI): Understand and predict climate variability from time-scales of days-to-decades. Understand the temporal variability and meridional coherence of AMOC. Examine how ocean circulation impacts extreme weather and climate. We lead multi-institutional efforts to improve operational sub-seasonal to interannual forecasts.

Tropical Weather (TW): Understanding and prediction of hurricanes and other tropical weather. This includes: implementing hurricane research observation experiments designed to improve prediction, evaluation and improvement of HWRF-B, development of multiple moving nests in FV3GFS, and improving TCGI model. Evaluating observing using OSEs and OSSEs experiments (QOSAP). This includes data from APAR, CYGNSS, VIIRS, TROPICS data, Global Hawk dropsondes, HAMS, HIWRAP, and HIRAD. We seek understand how skillful but imperfect hurricane forecast create societal value.

Ocean and Coastal Observations (OCO): Understanding the large-scale setting for regional climate signals, and we contribute to AOML's management of the global ocean observing systems. Specific goals include: collecting profiles of temperature and salinity with an array of 1500 profiling ARGO floats, maintaining high density XBT network, conducting annual cruises to service moorings of the PIRATA array, maintaining a global array of 1300 satellite-tracked surface drifting buoys observations of the mixed layer, measuring the structure and daily variability of the western boundary flows in the Atlantic and the relationship to variations MOC. Constraining regional air-sea CO<sub>2</sub> fluxes, monitoring regional ocean acidification and sub-surface CO<sub>2</sub> and dissolved oxygen.

Ocean Modeling (OM): Development of methodologies to evaluate ocean observing system and model forecasts and understanding of critical dynamical processes. Deploy gliders in the path of hurricanes and use this data to assess and improve coupled forecast. Implement OSSEs to assess observing systems before they are built. Diagnose AMOC variability in models. Examine air-sea feedbacks in the hurricane environment with coupled model experiments.

Ecosystem modelling and forecasting (EMF): Improve forecasting of structure and function of marine ecosystems including the provision of ecosystem services, particularly in the Southeast U.S. coastal ocean, the Caribbean Sea, and GOM. Develop ] models ranging from ecosystems to individual fishery stocks to coastal habitats. Produce forecasts of ecosystem components to improve human health, forecast fish stock abundance and protected species populations

Ecosystem management (EM): Promote research on sustainable coastal development, community resiliency, and in support of NOAA's ecosystem approach of fishery resources and protected species. Evaluate current and alternative management strategies for marine habitats, ecosystems and adjacent watersheds by developing tools and using state of the art scientific methods. Incorporate human- dimensions science in the evaluation of management strategies. Focus on improving the evaluation of success of management of coral reef and open ocean resources.

Protection and restoration of resources (PRR): Develop technology, tools, and approaches to restoration of habitats, rebuilding of overfished stocks, enhancement of populations of protected species and conservation of underwater cultural resources. Support the Comprehensive Everglades Restoration Plan, sustainable management of highly migratory fish stocks and protected species. Use satellite tagging, genomics and close-kin genetics and develop innovative survey techniques. Improve knowledge on connectivity and population structure of resources within marine protected areas.

### 25. What was accomplished under these goals?

CI: Led NMME and SubX to deliver S2S predictions to CPC. Reconstructed a century long time-series as a proxy of southern AMOC variability. Assessed influence of natural variability versus anthropogenic climate change on heat waves in the US.

TW: Suggested changes to G-IV operational sampling strategy. Techniques developed to extract dropsonde observations for ingestion into HWRF model. Conversion of NOAA P-3 and G-IV aircraft data into the ArcGIS environment for a Story Map format. Created retrieval code for rain and ice microphysics observations from NOAA field campaigns. Produce real-time forecasts for tropical cyclones with HWRF-B. Experiments made evaluating the impact of HAMS retrievals. Initiated processing wind observations from HIWRAP. HWRF forecasts with different turbulent parameterizations were analyzed to examine sensitivity of hurricane intensification. Developed infrastructure for basin-scale OSSE system. FV3GFS real Doppler wind lidar observations assimilation from AEOLUS/ADM started. Preliminary assessment of TROPICS radiances on TC analyses and forecasts. Developed capability to simulate APAR and ELDORA observations. Completed first set of experiments assimilating each radar type alongside control aircraft observations using HEDAS.

OCO: The GDP deployed 1101 drifters. Data quality controlled and made available to the general public. Sentinel 3A successfully integrated into operational OHC product suite. Participated in the PNE cruise. PIRATA buoys recovered and redeployed, 12 CTD casts, 14 surface drifters and 22 Argo profiling floats deployed. Performed ~810,000 new pCO<sub>2</sub> measurements. Participated in ECOA-2 cruise. A total of 1738 samples analyzed for discrete dissolved inorganic carbon from 184 CTD casts. Maintained submarine cable measurements of the Florida Current transport, hydrography cruises, measurements with Pressure Inverted EchoSounders. Participated in 11 cruises for a total of 6481 XBT deployments. Field trials of the eAUV conducted.

OM: A Maxey-Riley theory derived for description of the motion of marine debris floating at the ocean surface. Developed the robust diagnostic system for simulation of the AMOC using the CESM with DA. An ensemble of the Uvic ESCM model implemented to test the sensitivity of the AMOC to freshwater forcing in the North Atlantic.

EMF: A procedure to estimate annual discards of red grouper and gray triggerfish from commercial fisheries in the GOM and estimates obtained from this procedure were used in GOMFMC stock assessments. A refined model for red snapper stocks incorporating new information on spawning areas and its sensitivity to oceanographic inputs tested. New ECOSIM and ECOPATH models for components of GOM.

EM: Decision support tools for evaluating management actions and used to support assessments of ICCAT and GOMFMC stocks developed. Simulations to evaluate Management Strategy. Integrated ecosystem-level risk assessments for exploring trade-offs multi-sector systems. Assessments inform resource management decisions, minimize losses of provisioning ecosystem services and promote resilience and sustainability of coastal communities. Supported improvements in the provision, management and analysis of

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**ACCOMPLISHMENTS (cont'd)**

**26. What opportunities for training and professional development has the project provided?**

CIMAS aims to integrating its core science activities with the educational enterprise of its academic partners' graduate academic programs. CIMAS encourage research projects to engage in outreach activities. Such project based activities are reported in the last part of this section.

CIMAS has invested in being part of the training pipeline for NOAA. CIMAS funds have been a large part of this investment through activities: 1) collaborative research teams of faculty, NOAA and CIMAS scientists and graduate students; 2) funding of graduate students with the support of NOAA fellowships and graduate research Asst.ships; 3) participation of NOAA scientists in student mentoring training and teaching of graduate level courses 4) promoting Post-doc opportunities Assoc.d with NOAA and 5) funding students to participate in professional experiences attending scientific meetings, such as those Assoc.d with the US fishery council process and Regional Fishery Management Organizations (RFMOs) such as ICCAT.

Many (currently 14) RSMAS graduate students, especially in the PhD and MS programs, are funded through CIMAS. Students funded through CIMAS research projects are 60% supported by CIMAS and 40% by the UM. Many PhD and MS graduates from RSMAS have joined the NOAA workforce. Many such graduates have joined the NOAA AOML, SEFSC laboratories or are at NOAA headquarters. CIMAS employees working at the NOAA laboratories are eligible for tuition remission. Many have obtained MPS and MS degrees during their employment.

RSMAS offers six undergraduate degree majors: a dual major, BSc in Marine Science and BSc single majors in Meteorology, Marine Biology and Ecology, Oceanography, Geological Sciences and a BA in Marine Affairs. These programs provide opportunities for undergraduate research. These research experiences take advantage of the ongoing research collaboration between RSMAS and the AOML and SEFSC NOAA labs through CIMAS.

NOAA established research and education centers to advance the community of under-represented minority scientists in the US and, especially, in the NOAA workforce. UM is part of the Living Marine Resources Cooperative Science Center (LMRCSC) and the CIMAS Assoc. Director, Dr. David Die serves as UM representative in the LMRCSC science committee. That allow coordination between CIMAS and LMRCSC activities that share the same objectives:

- (1) prepare the future workforce in marine and fisheries sciences,
- (2) strengthen collaborations across universities to enhance academic programs in marine and fisheries sciences,
- (3) conduct research on quantitative Fisheries Science, Fisheries socio-economics, Fisheries Habitat and Aquaculture.

Students enrolled in marine biology, quantitative fisheries, conservation science graduate programs at the undergraduate, MSc and PhD level at RSMAS, USF and FIU conducting research ranging from marine mammal and coral ecology, fisheries stock assessment, ecosystem modelling and socio-economics. ~~Students have received specialized training on stock assessment~~

**27. How were the results disseminated to communities of interest?**

Results from the project are reported in peer-reviewed publications (see attachment), and conference and workshop proceedings too numerous to include here. We also note the results from CIMAS efforts include mission critical data sets such as the Argo floats program, dropwindsonde data from hurricane missions.

Contributed to national and international databases (e.g. such as NCEI, GulfMAP, OBIS-SEAMAP, GoMMAPPS <https://www.boem.gov/GOMMAPPS-Diaries>). Made NCRMP fish datasets available to public through a SEFSC web application, and accessible through web or custom R-package.

Provided input data sets for testing of CPUE standardization methods to ICCAT's stock assessment methods working group, coral larvae specimens to science collaborators conducting research relating to coral restoration and population enhancement.

Provided input to fisheries stock assessments for ICCAT, SEDAR and SERO processes, and stock assessments of marine mammals (e.g. bottlenose dolphin stock in St. Andrew Bay). Contributed to stock Assessment and Fishery Evaluation (SAFE) reports. Participated in providing information to support responses to public comments from such reports.

Produced indicator species updates and other contributions to the congressionally mandated CERP Ecosystem Status Report and the CERP System-wide Performance Measure.

Provided contributions to updates on marine mammal strandings and NOAA Technical Memorandums made available through NOAA websites

Reported research results to National park and protected species managers. Contributed to stakeholder workshops on indicators for Ecosystem Assessments and Red Tide Impacts to Fisheries. Helped in an open house held aboard the NOAA Ship Nancy Foster.

**ACCOMPLISHMENTS (cont'd)**

**28. What do you plan to do during the next reporting period to accomplish the goals and objectives?**

CI: Perform studies on the role of the ocean, & AMOC, in modulating the occurrence of extreme weather events in the US. Continue lead multi-institutional efforts to improve operational sub-seasonal to interannual forecasts.

TW: We continue to advance the understanding and prediction of hurricanes. This includes: data impact studies with the latest version of CYGNSS and dropwindsonde (Global Hawk) data among others; state-of-the-art OSE and OSSE research to continue to assess observing systems; evaluation of sub-grid scale parameterization in HWRF and HAFS in terms of hurricane intensity and implementation of movable nests in FV3GFS; Create and disseminate NOAA Story Maps describing instrumentation on the NOAA P-3 and G-IV Hurricane Hunter.

OCO: Conduct ocean and climate studies to understand the large-scale setting for regional climate signals. Research emphasizes interannual and longer time scales, and we contribute to AOML's management of global ocean observing systems. Specific planned activities: to produce an annual plan for global distribution and deployment of 1000 drifters; Joint operations between NOAA and MBARI to field test two eAUVs to collect samples for OMIC analysis; Maintain underwater glider observations in the Caribbean Sea and in North Atlantic Ocean; Analyses data collected from PIRATA and satellite and in situ data sets and numerical models; cruises will be conducted to collect data from moored instruments and maintain SAM array; complete Atlantic Ocean transect A13.5 and Indian Ocean transect I05; US Argo DAC will continue improving the processing. US Argo DAC will continue to participate in deployments of floats in the Atlantic Ocean; maintain the High Density XBT Network by sustained XBT observations along repeat transects; perform a scientific study about a comparison of sampling strategies between Argo and XBT.

OM: Develop methodologies and tools to evaluate ocean observing system and model forecasts, further understanding of dynamical processes and air-sea interactions. Add incremental insertion to MOM6's capabilities. Continue research on EKE in Southern Ocean and Maxey-Riley theory will be validated using results from field experiments.

EMF: Develop assessment model for scamp and procedures for estimating indices of abundance of reef fish and commercial discards from GOM coastal fishery observer data. Develop distribution models for additional Atlantic Ocean species to investigate changes in species targeting and bycatch issues. Calibration of the entire GoM Ecosim model and compile data for the spatial component of Ecospace.

EM: Contribute to ecosystem condition status reports for GOM, KFNMS and Barataria Basin and metrics for NCRMP status report for USVI, Puerto Rico and Florida. Document impacts of red tide on fish, protected resources, habitat, and fishing communities, including research on human dimensions. Complete centralization of metadata for fishery databases and development of automated extraction of observer and commercial landing data.

**PRODUCTS**

**29. Publications, conference papers, and presentations**

Please see attached publication file (PDF and Excel files).

## PRODUCTS (cont'd)

### 30. Technologies or techniques

Under this award a number of technologies and techniques have been developed. These include:

- Produced computer code to run TCGI in real-time and was turned over to NOAA NHC in Fall 2018. Developed ensemble data assimilation using the HWRF model and HEDAS system.
- OceanViewer and Hurricane OceanViewer (<https://cwcgom.aoml.noaa.gov> [https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/index\\_hrd.html](https://cwcgom.aoml.noaa.gov/cgom/OceanViewer/index_hrd.html)).
- Capability to assimilate TROPICS radiance and retrieval observations in GSI using variational data assimilation and ensemble Kalman filter techniques. Sharing the design of our optical system with a group funded by EUMETSAT, with the hope that they use the same instrumentation.
- Native grid visualization package for FV3GFS model developers.
- CIMAS employees developed software for delayed time scientific quality control of underwater glider data. This software allows for an interactive analysis of glider profiles, and will help in ensuring that good data is broadly distributed.
- The GDP applies quality control procedures to edit these data (position and temperature) and interpolates them to 6-hour intervals using an optimum interpolation procedure called kriging, which is commonly used for two and three-dimensional analyses.
- Development of a low-cost, high-precision underwater temperature sensor.
- Utilized the SAS designed in-house. The SAS and SAsE are both new tools, but intentionally created as open-source to make high quality water chemistry and eDNA research more financially accessible to researchers.
- Used ECO-PAR light sensors, SeaFET pH sensors, Tilt meters and ADCP current sensors, and STR temperature sensors.
- Developed in-house temperature loggers.
- Daily mean voltage-derived transports for the Florida Current are obtained using out-of-use and in-use telephone cables spanning the Straits of Florida.
- Developed and implemented new version of the MSR, which became operational on April 1st, 2014. Since then, the system hosted at AOML has received and processed over 18,000 MSR reports from approximately 3,000 distinct commercial vessels.
- CIMAS staff participated in the development of a prototype ocean OSSE system
- Continued production of multi-model operational (NMME) and real-time (SubX) seasonal predictions used by CPC operational forecasters.
- Developed new algorithms for estimation techniques for total commercial discards in numbers and weight and Assoc.d variances for coastal observer program data. Developed and updated algorithms to extract, transform, and QC fishery data from multiple relational databases to generate automated reports. Coded an algorithm framework for Management Strategy Evaluation in R.
- Used High-frequency Acoustic Recording Packages (HARPs) to record the acoustic data for Bryde's whales. Triton acoustic data analysis software was used for manual detections. A generalized power-law detection algorithm, whistle and moan detector, and spectrogram correlation detector were used for detector development. In the future we will develop 1) protocols for pilot eDNA studies for GoMex Bryde's whales and their potential prey, 2) a pilot study using UAS (unmanned aerial systems, or drones) to assess body condition/health of GoMex Bryde's whales, and 3) the collection of echosounder data in the project study site.

### 31. Inventions, patent applications, and/or licenses

A patent for a low-cost, high-precision underwater temperature sensor is pending.

CIMAS personnel continued to support the the development of the first prototype of XBT data acquisition device, the "AOML XBT Recorder (AXR)". The AXR performs the same operations as its costlier counterpart, the MK-21 manufactured by Lockheed Martin and is expected to have a production cost estimated as 5% of the commercial unit. A XBT Weather Station (AXWS) was also recently designed to deliver high accuracy relative humidity, temperature, and atmospheric pressure during XBT transects, which will provide for weather forecasting and severe weather warnings at sea, and used to used to calculate surface heat and moisture fluxes.

## PRODUCTS (cont'd)

### 32. Other products

Other Products Include:

- Surface wind analyses
- Fortran code for second static nest will soon be incorporated into main branch of FV3GFS git repository.
- The GDP produces a wide variety of products that assist colleagues, and the general public. Such products range from data access portals, data packets, information packets, deployment value maps, and assists with lesson plans for students studying ocean currents.
- The data collected by the gliders were made publicly available in near-real time through the Global Telecommunication System, and on NOAA/AOML website, and distributed through the Integrated Ocean Observing System glider Data Assembly Center . In addition, a web page was also developed in partnership with CoastWatch/OceanWatch for displaying real-time ocean observations during hurricane season can be visualized in a web page.
- We have developed the Equivalent OHC to account for regimes (such as the ITCZ, Eastern Pacific) of strong stratification across the base of the mixed layer that accounts for thermal and haline structure. See attached figure.
- Current work of this project involves the effort in developing a subseasonal-to-seasonal heat wave outlook for the U.S. This is in collaboration with NOAA/AOML, NOAA/Climate prediction Center, and the University of Miami.
- Near-real time model forecasts of hydrodynamic fields (7-day forecasts, web-based dissemination of forecast maps).
- PNE cruise data is made publicly available through the NOAA/AOML web page, and mooring data is made publicly available through the NOAA/PMEL web page. New enhanced PIRATA (ePIRATA) data product is made available through NOAA/AOML web page.
- PostgreSQL Database for in\_situ data
- The SAM project is producing, and making publicly available, full-water-column daily estimates of temperature and salinity at each mooring site in the array. These data are served via the project web page. The software program developed and used to download PIES data via acoustic telemetry is now being made publicly available via the AOML web page.
- The project team is making publicly available the daily MOC volume transport anomaly estimates for the upper limb of the MOC. These data are served via the project web page.
- Dataset from FY19 cruises submitted to public repositories with citable DOI: <https://doi.org/10.25921/yyb2-7m52>
- The US Argo DAC maintains a website that provides documentation and information about the operations as well as statistics and graphics presenting the collected data at <http://www.aoml.noaa.gov/phod/argo/index.php>. This web page is updated automatically on a daily basis.
- An updated and modern XBT Network website was implemented in 2018 with the objectives of improving communication, data-distribution, and making it more user-friendly.
- Data products available on the project web page (<http://phodnet.aoml.noaa.gov/phod/wbts/index.php>)
- Many databases have been developed, including photography collections for fish survey and benthic sites. Produced user manuals, and training videos for selected databases and videos and photos for outreach products and web-based content including seasonal, spatially-explicit density estimates for cetaceans and marine turtles. Contributed to larval fish and plankton collections and tissue

## PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

### 33. What individuals have worked on this project?

S. Aguilar – SRA III – 12 mos.  
C. Aguilar Hurtado – Postdoc – 12 mos.  
Debra Abercrombie SRA I - 12 mos.  
Aichinger Dias – RA III – 12 mos.  
A. Aksoy – Scientist – 12 mos.  
S. Alhale – SRA I – 12 mos.  
G. Alvey – RA II – 12 mos.  
N. Amorntthammarong – Asst. Scientist – 12 mos.  
B. Annane – SRA III – 3.5 mos.  
K. Apodaca – Assoc. Scientist – 12 mos.  
S. Atkinson – SRA II – 12 mos.  
C. Atluri – SRA I – 12 mos.  
L. Barbero Munoz – Asst. Scientist – 12 mos.  
Z. Barton – RA II – 12 mos.  
D. Bates – Asst. Scientist– 12 mos.  
G. Berberian – RA II – 12 mos.  
S. Blake – SRA I – 12 mos.  
A. Bright – SRA I – 12 mos.  
A. Brossard – RA II – 12 mos.  
S. Casey – Assoc. Scientist – 12 mos.  
S. Chakravorty – Postdoc – 0 mos.  
H. Christophersen – Asst. Scientist – 12 mos.  
J. Christophersen – RA II – 12 mos.  
B. Dahl – RA II – 12 mos.  
S. Davies – RA II – 12 mos.  
A. Debich – SRA I – 12 mos.  
J. Diaz – RA III – 12 mos.  
S. Diaz – Software Engineer – 12 mos.  
S. Dolk – SRA I – 12 mos.  
R. Domingues – SRA II – 12 mos.  
J. Dunion – Assoc. Scientist – 12 mos.  
E. Ehrbar – Programmer II – 12 mos.  
J. Festa – SRA III – 12 mos.

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (cont'd)**

34. Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Personnel who joined CIMAS:

Debra Abercrombie  
Sydney Alhale  
George Alvey  
Karina Apodaca  
Sarina Atkinson  
David Bates  
Cyril Germineaud  
Rafael Goncalves  
Corinne Holder  
Richard Jones  
Dongmin Kim  
Anderson Mayfield  
Kelly Montenero  
Da Nguyen Dac  
Joel Ortega-Ortiz  
Paulo Paz  
Brett Pierce  
William Ramstrom  
Keren Rosado  
Steven Smith  
Andres Vidal  
Nicole Vollmer

Personnel who left CIMAS:

Ghassan Alaka  
Jeremiah Blondeau  
Lisa Bucci  
Leah Chomiak  
Elizabeth Dutra  
Ian Enochs

35. What other organizations have been involved as partners?

N/A Personnel who joined CIMAS:

Debra Abercrombie  
Sydney Alhale  
George Alvey  
Karina Apodaca  
Sarina Atkinson  
David Bates  
Cyril Germineaud  
Rafael Goncalves  
Corinne Holder  
Richard Jones  
Dongmin Kim  
Anderson Mayfield  
Kelly Montenero  
Da Nguyen Dac  
Joel Ortega-Ortiz  
Paulo Paz  
Brett Pierce  
William Ramstrom  
Keren Rosado  
Steven Smith  
Andres Vidal  
Nicole Vollmer

Personnel who left CIMAS:

Ghassan Alaka  
Jeremiah Blondeau  
Lisa Bucci  
Leah Chomiak  
Elizabeth Dutra  
Ian Enochs

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (cont'd)**

36. Have other collaborators or contacts been involved?

S. Aberson  
L. Anderson  
M. Applegate  
F. Arocha  
R. Atlas  
J. Ault  
E. A. Babcock  
A. Baker  
D. Bakker  
B. Balmer  
M. Baran  
M. Baringer  
V. Barker  
B. Barnes  
K. Barry  
J. Bazelais  
L. Beerkircher  
R. Bennartz  
U. Bergen  
F. J. Beron-Vera  
D. Berry  
M. Bethel  
M. Bernardi Bif  
J. Birch  
J. Bishop  
R. Black  
T. Black  
W. Blackwell  
E. Blake  
J. Boeck  
K. Boswell  
M. Bourassa  
A. Bozec  
U. S. Coast Guard

**IMPACT**

37. What was the impact on the development of the principal discipline(s) of the project?

Developed attribution analysis of US heat waves and demonstrated that the Monsoon is a source of predictability for U.S. Great Plains heat waves. Shown that most of the AABW recirculates in the Southern Ocean or upwells in the Indo-Pacific basin, with very little transport going into the Atlantic basin, and the strength of the AMOC is not related to its stability. Produced SubX and NMME that used to inform NOAA operational forecasts.

Characterize hurricane forecast uncertainty in a more rigorous, model-driven fashion. HWRF-B work provided a guideline for the improvement of operational HWRF in NOAA/EMC. Helped improve operational hurricane model. Evaluated potential utility of a new radar technology for improving orecasts of tropical cyclones. Demonstrated ability to evaluate several observational arrays. Evaluated data assimilation and vortex initialization methodology for prediction. Providing a standard set of metrics for OSE and OSSEs.

Enabled the NOAA VIIRS satellite products to remain calibrated/validated. Unexpected jump in the VIIRS products was corrected. Less expensive temperature sensor developed allowing a global assessment of coral bleaching. Argo provides a data set to study daily to decadal variability of ocean conditions. PIRATA publicly available data of surface measurements used for ocean, climate and ecosystem studies. XBT observations providing novel scientific advances in main project disciplines related to (1) ocean currents; (2) meridional heat transport; and (3) ocean heat content. Generated daily estimates of the MOC in the South Atlantic, allowing unalised estimation of the seasonal and interannual variability of the MOC.

Collection activities contributed to annual Global Carbon Budget, improvements to modeling CO2 fluxes & estimates of pCO2 from satellite data, continued monitoring of the surface pCO2 in the oceans. Low-cost sampler developed allows better datasets related to carbonate chemistry. Data from cruises are compared to data from previous surveys (e.g., WOCE/ JGOFS during the 1990s and the CLIVAR/CO2 campaign from 2003-2012) to measure changes in biogeochemistry.

Theory explaining differences in oceanic turbulence as a function of latitude has been developed and i tested. Improved interpretation of Lagrangian ocean measurements, search and rescue operations at sea, modeling of macroalgae such as Sargassum. Progress towards MOM6 forming the basis for a unified national ocean model. Advanced fishery science by applying probability survey estimation techniques to analysis of fishery dependent data. Provided further guidance on standardization of CPUE data. Completed first comprehensive age and growth analysis for Atlantic blue marlin and a robust method for determining influence of larval supply across management jurisdictions. Decision support tool has improved stock projections and fishery benchmarks. Collaborations between stock assessment and social scientists have inspired the formulation of new hypotheses about stock dynamics, thus improving the stock assessment process.

*Attach a separate document if more space is needed for #6-10, or #24-50.*



**IMPACT (cont'd)**

**38. What was the impact on other disciplines?**

Produced SubX and NMME that are used by a number of different disciplines include water resources managers, agriculture planning and extreme event (e.g., floods, droughts, heat waves, cold spell, hurricanes, extreme winds, fire) response planning. For example, an improved knowledge of the physical mechanisms driving the occurrence of heat waves will aid in the improvement of their predictions, future projections, and their attributions and mitigations. These findings have direct impact on human health, air quality, agricultural and crop yield, and natural resources (e.g., water) management.

A completed, high quality HAFS will be used by forecasters and emergency managers to inform evacuation and warning decision, and also help the general public to better understand and prepare for tropical cyclone threats.

Improved tropical Atlantic, MOC and Gulf of Mexico measurements impact weather prediction and data assimilation, satellite calibration and validation, and ecosystem and biogeochemistry monitoring and research and coastal resilience planning. For example, drifter data are used to improve weather forecast models and severe weather events, improve our understanding of eddy fluxes and their role in modifying air-sea heat fluxes and water mass formation, and track larval/species migration patterns. Formation of widening, deepening and intensifying hypoxic zones in the ocean is rapidly becoming the next big concern about ocean health. Disciplines that concern themselves with food from the sea and health of marine ecosystems will need to take note. Effort was also extended to VIIRS nighttime data, which are of critical value in monitoring marine disasters. The Florida Keys IEA project has led to collaboration between a variety of organizations and disciplines, from biologists and fisheries scientists to policy makers and resource managers.

Many real-time products, such as the Harmful Alga blooms Observing system (HABSOS) put out by the NOAA National Ocean Service, require accurate ocean color products. These products depend on the accurate calibration made possible by our data set and measurements. Our research led to the development of a public-health satellite-based product to monitor waterborne diseases. OceanViewer supports operational oceanography and hurricane research. The debris and work on Sargassum (using USF's AFAL fields) meet the needs of the following disciplines: fisheries, economy, public health and ecology.

The project focuses on improving the ocean component of coupled models for hurricane prediction. The coupled models have, therefore, benefited for improving the accuracy of their forecasts.

The standardization and documentation techniques of fishery dependent data adopted during the automation process of this project can be applicable to data needed by other disciplines, such as the social sciences.

The combined Gulf of Mexico projects, including the one on red tides, have helped foster collaboration between a variety of organizations and disciplines, from biologists and fisheries scientists to economists and social scientists. Social scientists and stock

**39. What was the impact on the development of human resources?**

CIMAS has strongly invested in being part of the training pipeline for NOAA jobs, preparing post-doc for future employment and even the development early career faculty at UM and partner institutions. The project is training the next generation of ocean and atmosphere scientists with key skills to work in ocean chemistry and biology, hurricane intensification, climate change, ocean circulation, acidification and ocean deoxygenation. CIMAS providing training and development for postdoctoral fellows, RAs and scientist.

SEFSC and CIMAS staff has been trained or improved their skills in R programming, larval transport modeling, fish ageing, stranding data auditing, quantitative evaluation of impact of potential fishery and conservation management actions. Some key personnel have acquired leadership, team-work and problem-solving skills. Many graduates from RSMAS and the MRA program at USF have gone to work for US government agencies, academia and the environment private-sector. The following scientists have joined the federal workforce: Ghassan Alaka, Lisa Bucci, Ian Enochs and Xuejin Zhang.

## IMPACT (cont'd)

### 40. What was the impact on teaching and educational experiences?

CIMAS has strongly invested in being part of the training pipeline for NOAA jobs. CIMAS funds have been a large part of this investment through activities such as 1) collaborative research teams of faculty, NOAA and CIMAS scientists and graduate students; 2) funding of graduate students with the support of NOAA fellowships and graduate research Asst.ships; 3) participation of NOAA scientists in student mentoring training and teaching of graduate level courses 4) promoting Post-doc opportunities Assoc.d with NOAA labs and 5) funding students to participate in professional experiences along with NOAA scientists attending scientific meetings, such as those Assoc.d with the US fishery council process and Regional Fishery Management Organizations (RFMOs) such as ICCAT.

The Rosenstiel School of Marine and Atmospheric Science offers graduate instruction leading to the Doctor of Philosophy (Ph.D.), Master of Science (MS) and Master of Professional Science (MPS) degrees. Degrees are aligned with the five departments of the school: Atmospheric Sciences, Marine Biology and Ecology, Marine Ecosystems and Society, Marine Geosciences, and Ocean Sciences. In addition there is an interdisciplinary, cross-departmental program Meteorology and Physical Oceanography. During the course of 2017-2018 there were close to 200 students enrolled in the RSMAS PhD and MSc programs, 80% of whom are in the Ph.D. programs. About 150 students are registered in the RSMAS MPS program. Many RSMAS graduate students, especially in the PhD and MSc programs, are partially funded through CIMAS research projects and a few receive partial academic fellowships. Students funded through CIMAS research projects are 60% supported by CIMAS and 40% by the UM.

CIMAS funds support several PhD and MPS students:

Morris, J; Simmons, V; Van Buskirk, H; Young, B; Zilberfarb, A; Williamson, O; Cain, E; Hoenig, D; Norelli, A; Pacini, C; Rider, M; Rykowski, M; Neufeld, S; Gibbs, B.

The Rosenstiel School now offers six different undergraduate degree majors: a dual major, BSc in Marine Science and BSc single majors in Meteorology, Marine Biology and Ecology, Oceanography, Geological Sciences and a BA in Marine Affairs. These programs provide enhanced opportunities for undergraduate RAd with upper level courses. Many of these research experiences take advantage of the ongoing research collaboration between RSMAS and the AOML and SEFSC NOAA labs that are available through CIMAS.

RSMAS faculty, graduate students, including CIMAS-linked personnel participates in education related activities at local high school by delivering lectures and hosting students for internships and teachers for professional experiences.

UM CIMAS employees working at the adjacent NOAA laboratories are eligible for tuition remission. Many have obtained MPS and MSc. degrees during their employment period. In all these cases, their internship experience or thesis research overlaps and complements their primary CIMAS duties.

### 41. What was the impact on physical, institutional, and information resources that form infrastructure?

CIMAS activities support physical, institution and informational resources that form infrastructure. For example:

- The HWRF-B website provided information about current hurricane activities and the future developments. This website was used as a resource for HRD Map Discussions and the NOAA Hurricane Field Program.
- VIIRS data have been incorporated in the Sargassum Watch System (SaWS, <https://optics.marine.usf.edu/projects/saws.html>) to monitor and track Sargassum. VIIRS data have also been incorporated in the Integrated Redtide Information System (IRIS; <https://optics.marine.usf.edu/projects/iris.html>) to monitor and track red tides.
- The data collected by the gliders were made publicly available in near-real time through the Global Telecommunication System, and on NOAA/AOML website.
- The OHC product suite was improved by adding two new altimeters to the algorithm by increasing track resolution and reducing errors. National Centers use the Ocean Heat Content product suite to improve hurricane forecasts which directly impact the general public in both the United States and neighboring countries.
- Work is developing new infrastructure to increase spatial and temporal sample coverage with reduced reliance on research vessels, resulting in improved operational efficiency and cost savings.
- Support near-real time model forecasts of hydrodynamic (publicly disseminated).
- SubX and NMME forecast data made publicly accessible in real-time to both NOAA and non-NOAA data portals.
- The project infrastructure required upgrades and new components within the organization. New Virtual Machines were allocated to support the project's goals, aimed to provide processing, storage and data distribution capabilities. The data & products & applications generated by this project integrate within the organization infrastructure.
- The project has generated a number of data set that have become part of the information infrastructure required to support the NMFS goals regarding sustainable management of ocean resources.
- The National Coral Reef Monitoring Plan (NCRMP) is one of the few fishery independent datasets for reef fish resources. Information collected includes species IDs, abundance, and fish size, all used in federally mandated stock assessments. Research on observer monitoring of the Pelagic Longline fleet is contributing to achieve the management goal of 8% observer coverage. This research supplies data on catches of target species and protected and non-protected bycatch. The project has also improved timeliness and quality of recreational fishery datasets and enhanced data used for legally mandated management of protected species.
- The automation project streamlines the production of data products used in assessments, leading to consistent, timely, and well-documented datasets that support management decisions. Ultimately, these automation products will increase efficiency in the assessment process and augment the value of fishery datasets.

*Attach a separate document if more space is needed for #6-10, or #24-50.*

## IMPACT (cont'd)

### 42. What was the impact on technology transfer?

CIMAS research has led to important technology transfer. For example:

- All techniques have been published in refereed journals accessible by all researchers around the world. Field data have been submitted to NOAA.
- Our project is currently collaborating with the Marine Biodiversity Observation Network (NOAA and USF) to create web based interactive conceptual models, to be completed by the partner in August 2019.
- The GDP is working closely with colleagues from the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) and NOAA's Pacific Marine Environmental Laboratory (PMEL) to convert drifter data to NetCDF Discrete Sampling Geometry (DSG) formats, as well as additional metadata for discovery and use.
- Members of the CIMAS and AOML glider piloting team held a glider pilot training course in Miami which was attended by 5 personnel from the University of Puerto Rico, CariCOOS, and IOOS. Additional training was conducted in Puerto Rico to provide valuable technical knowledge which will allow the same personnel to aide in the preparation and shipment of the gliders back to Miami.
- This project resulted in a transfer of technology (computer code for running TCGI in real-time) to NHC.
- The updated algorithm including Jason-3 and Sentinel-3A was implemented at NOAA NESDIS.
- This results of this study will provide information on the expected utility of APAR as a replacement for the ELDORA radar from the standpoint of data assimilation applications.
- These experiments add to existing knowledge on data targeting and are crucial for developing new data assimilation technology for high-gradient regions that evolve on short timescales, such as in and near tropical cyclones.
- Technological advances, both in terms of software and hardware, are made available to partner institutions at no cost, as follows: AMVER-SEAS, AOML's proprietary data recording software is made freely available to users at: <https://www.aoml.noaa.gov/phod/goos/seas/>; AOML's XBT Auto-Launcher system provided to partner institutions: UFRJ, Brazilian Navy, University of Cape Town, and Institute of Research for Development; AOML's XBT Auto-Launcher system permanently installed in the NOAA Research Vessel Okeanos Explorer; AOML's Iridium-based data transmission system provided to partner institutions: UFRJ, Brazilian Navy, Scripps, and Argentinian Coast Guard.
- The improvements in the model will eventually be transitioned to the operational HAFS forecast model.
- This research adds to existing knowledge on OSEs and OSSEs, and provides a novel tool for understanding data impact for tropical cyclone prediction. This project establishes a set of guidelines for performing OSSEs aimed at event-based forecasts, such as tropical cyclones.
- The CVIDS software was successfully transferred to NOAA, with refinements ongoing. The source code is being made available to NOAA, though it is hoped that continued collaboration will result. There were no licensing agreements or fees Assoc.d with this transfer due to NOAA funding the initial development of the base of the software system.
- The relevant retrieval code and scripts were transferred to AOML/HRD for further historical data retrieval. Training on sophisticated

### 43. What was the impact on society beyond science and technology?

The economic value of hurricane, subseasonal and seasonal forecasts can be linked directly to societal value. Provided new tools to NHC for objectively predicting the formation of tropical cyclones in the Atlantic and eastern/central North Pacific, and our subseasonal and seasonal forecasts are made readily available to operational NOAA forecasters, the public and the commercial sector.

Observing programs are of direct societal benefit: search and Rescue missions are aided by the use of drifter data. Additionally, drifter data is used to quickly identify severe weather events, which enable the public to better prepare for storms affecting coastal communities. PIRATA produces a publicly available time series of surface measurements that are used to improve weather and climate forecasts, and are used for ocean, climate and ecosystem studies. PIRATA measurements increase the skill of Atlantic hurricane season outlooks. The results of research using the Argo data have helped understanding ocean's variability and improved the knowledge about it to predict catastrophic events. Argo data have been used to improve hurricane forecasts which helps communities to be better prepared for storms which can save lives and reduce economic loss.

Conducted rapid response assessments to harmful algal blooms on the Gulf coast of Florida to better understand the impacts of red tide on human health, fisheries, and ecosystem functions. Our work with SaWS has been used to monitor and track Sargassum. Caribbean Sea and Gulf of Mexico are being strongly impacted by the arrival of Sargassum mats. Providing a framework for predicting the motion of such mats that will enable mitigating their effects on local ecosystems and regional economy. Our work impacts status of reef health in the Florida Keys. These impacts extend to policy decisions for reef structure persistence which directly impacts industries like fishing and tourism. The MSR objective is to help: (1) conserve endangered whale species; and (2) improve overall safety of maritime navigation. The system provides a resource to educate mariners on plight of right whales.

Provided scientific products for sustainable management of fishery, protected species, and marine ecosystems. Products that improve guidance on stock status and future catch limits for data-limited fisheries in Gulf of Mexico and US Caribbean and data-rich fisheries (e.g. Atlantic Bluefin tuna), to avoid overfishing and achieve optimal yields. Contributed to increase value of reef fish resources by providing scientific advice on the establishment of MPAs in US Caribbean.

Provided advice on sources of exposure to anthropogenic mortality and injury caused by fishing gear, habitat degradation, vessel strikes, plastic pollution and oil spills, to managers responsible for implementing provisions of endangered species act and the marine mammal protection act.

Coral reef research has provided managers of Tortugas Ecological Reserve, Florida Keys National Marine Sanctuary and Biscayne National Park with information to document status and distribution of reef fish, stony corals, and benthic assemblages. Provided a foundation for future monitoring activities for these protected areas, thereby reducing future management costs.

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**IMPACT (cont'd)**

**44. What percentage of the award's budget was spent in foreign country(ies)?**

0 , Approximately 1.27% of CIMAS funds were spent in foreign countries. This percentage is made up of a sub-award to the University of Compostela in Spain, representing less than half of the 1.27%, and the remaining was spent on foreign travel for CIMAS employees to attend international conferences/workshops in Italy, Japan, Canada, Germany, Colombia, Ecuador, Argentina, Spain, Brazil and others. There are a few employees that participate in research cruises. A very small portion of the percentage was spent on foreign Visiting Researchers as well as individuals that participate in the XBT program to deploy oceanographic equipment from cargo ships. Most of these individuals reside in Cape Town, South Africa.

**CHANGES/PROBLEMS**

**45. Changes in approach and reasons for change**

Some relatively minor changes in specific activities are noted below:

- CYGNSS data sets available until just now have had major quality issues. Even the latest version has some quality issues and we have studied various approaches to quality controlling the data. Because the data for mature TCs has greater quality issues, our current approach is to experiment during the development stage of TCs.
- The OSEs focus on cases of sparsely observed periods of the TCs early lifecycles, when wind speeds are not too strong, and cases when the operational HWRF forecasts had relatively high intensity error. These cases include hurricanes Harvey, Irma, Katia, Maria, Florence and Michael.
- We have added new stations further north on the Gulf coast of Florida to monitor for red tide.
- Initial use of FV3 forecast system was restarted following documented discovery in Jan 2019 of model biases, as well as in Apr 2019 due to an HPC system software change.
- As a result of the US Government shutdown (Jan. 2019), many drifter shipments were not made, with others requiring express service. As a result of this unforeseen event, the GDP will work hard to reduce the remaining operational budget to remain within the annual allotment.
- The Government shutdown caused various delays in activities of the project, including: reschedule of sampling surveys, because of the delays in planning and lack of access to government facilities.
- To improve consistency and align parallel research efforts conducted elsewhere, we began the integration of NOAA's GoM IEA team members into the Louisiana Trustee Implementation Group (TIG) and Unified Federal Team (UFT) working groups for the Mid-Barataria Sediment Diversion project Environmental Impact Statement (EIS), Restoration Plan, and Monitoring and Adaptive Management (MAM) Plan.
- One of the first oceanographic models used for connectivity research appeared to produce some unrealistic patterns in current flows. Sensitivity analyses determined that this could have a substantial impact on predictions of larval fish movements. Additional time has been spent obtaining alternate oceanographic models for connectivity simulations.
- Historical data audits of bottleneck identification criteria confirmed the challenges of consistently identifying individuals over time. Adjustments to field and laboratory protocols to improve accuracy of such identifications are under consideration for adoption by field survey teams.

**CHANGES/PROBLEMS (cont'd)**

**46. Actual or anticipated problems or delays and actions or plans to resolve them**

Specific project actual or anticipated delays are noted here:

- The originally planned cruise survey (funded by JPSS) in May 2019 has been canceled due to unexpected maintenance requirement on the ship. An alternative plan is being considered by NOAA.
- Because of the recent US Government shutdown (Jan. 2019), it is possible the GDP will not meet its goal of 1000 drifter deployments. In order to meet this goal, the GDP may need to spend more money to transport these drifters expeditiously, which was not originally planned.
- Changes in ship routes is a recurrent issue that can negatively impact the realization of planned XBT transects. To overcome this issue, project personnel is constantly seeking alternatives for ship recruitment, coordinating the logistics, and working towards implementing new partnerships with different shipping companies.
- The government shutdown caused some delays in individual activities, including those that were linked to NOAA workshops conducting assessments and reviews of stock status of marine resources. Such delays did not have significant impact in the outcomes of the project.
- Some surveys and sample collection were prevented by rough sea states and bad weather, including the passage of hurricane IRMA and Maria. The later hurricane significantly delayed research conducted by our Caribbean partners that had much of their facilities made useless for a long period. These hurricanes, however, provided an opportunity to study the impacts of the passage of such storms on nearshore estuarine communities.
- There were some delays in the start of a few research activities because of the delays in the transfer and subcontracting of funds from UM to other CIMAS partners or collaborators. Conversely, delays in reporting by some CIMAS partners have occurred. CIMAS has established guidelines for CIMAS scientists to minimize such delays by proactively plan sub-contract and reports well ahead of starting dates.
- Delays in hiring new personnel (e.g. post-docs) due to the competitiveness of the market and the difficulty of hiring procedures for foreigners have slowed down progress of some components of the project. CIMAS has adjusted hiring offers to be more reflective of market conditions. Losses of specialized personnel (e.g. modelers) that were part of the project and left to join new positions has led CIMAS to re-organize personnel responsibilities or re-hire. Such losses, however, are a testament of the quality of human resources available at CIMAS. The lack of replacement of key FTE positions at SEFC has also affected some research activities, but CIMAS has no influence in decisions related to new CIMAS hires.

**47. Changes that had a significant impact on expenditures**

The largest impact has been those associated with the increase of personnel who had a significant part of their salary paid by CIMAS. This reporting period, there were 22 new employees hired through CIMAS and 16 staff departures. Another change that had an impact on expenditures this reporting period is the purchase of 8 sea gliders.

**CHANGES/PROBLEMS (cont'd)**

**48. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents**

When required, CIMAS research operate under University of Miami approved protocols on the use of human subjects, vertebrate animals, biohazards, and/or select agents. Each project P.I. is responsible to obtain such approval before research starts. Because of the continue increase in activities, there was the need to request a ceiling increase.

Due to the recently discovered SCTLD coral disease, preventative measures are in place to prevent disease transmission among corals manipulated at University of Miami facilities and in the field. Survey tools and divers' gear, which come into contact with diseased corals, are washed in a bleach solution between each dive.

**49. Change of primary performance site location from that originally proposed**

One CIMAS scientist that was hosted by the SEFSC has now moved to the facilities of the University of the Virgin Islands in St Thomas, USVI, a CIMAS partner. This has not had any negative impact on the project and allowed the project to continue as planned.

## PROJECT OUTCOMES

### 50. What were the outcomes of the award?

CI: Continued production of real-time SubX and operational NMME prediction. Performed model experiments forced with diabatic heating anomalies to study the teleconnection patterns associated with the East Asian Monsoon. Produced a study on attribution of US heat waves. Reconstruction of a century-long timeseries of volume and heat transport in the South Atlantic.

TW: Supported RtoO with an advanced version of HWRF model. Findings indicate that strength of turbulent mixing regulates the boundary layer inflow affecting hurricane intensity. Reducing turbulent mixing in operational HWRF based on observations led to improvement in forecasts. Development of prototype HAFS model. Implemented code changes for FV3GFS to permit a second static nest. Showed that single nest forecast results are bitwise identical to baseline code. Developed python codes to visualize FV3GFS netCDF.

Developed capability to simulate observations for ELDORA and APAR radars for use in OSSEs. Showed that Dropwindsonde data improve both track and intensity forecasts. Showed a positive impact from using Global Hawk Dropsondes for track and intensity. Progress on converting P-3 and G-IV hurricane flight data to visualization in ArcGIS.

OCO: Completion of 4 glider missions with collection of 5,006 temperature and salinity profiles; implementation of a testbed system to evaluate impact of ocean observations on forecasts. GDP accomplished: maintaining a global array of 1300 drifters, disseminating real-time data, and providing quality-controlled data to public. US Argo DAC has distributed about 85,000 profiles. Have deployed 50 new floats in the Atlantic Ocean. Approximately 360,000 SSS and SST thermosalinograph records from 4 ships of opportunity and 11 research vessels. Jason-3 and Sentinel-3A altimetry data were integrated into operational ocean heat content product.

Completion of a dual automated water sampling system for use in coral reef carbonate chemistry research. Completion of the design phase of the SASE tool. Have made about 810,000 new pCO<sub>2</sub> measurements. Made improvements to modeling CO<sub>2</sub> fluxes and to estimates of pCO<sub>2</sub> from satellite data. ECOA-2 cruise DIC analyses completed. Several short cruise datasets including all FY18 Ecomon cruises sent to NCEI.

OM: A new theory explaining the slope of structure functions and spectra of velocity data change as a function of latitude related to Coriolis forces. Ocean OSSE system Developed over the North Atlantic hurricane region and has demonstrated ability to evaluate several obs. arrays. Applications in hurricane prediction include evaluation of expendable profilers and in-situ moored vs. drifting platforms. Development of robust diagnostic system for simulation of AMOC.

Improvement of quality of pelagic observer data has increased the quality of the scientific analysis of stock status and ability of fishery managers to improve policy and enforcement of regulations. New information derived from fishery-independent Southeast Florida Fish and Benthic Sampling for NCRMP has provided a foundation for future monitoring activities, thereby reducing monitoring costs for Florida MPAs.

## DEMOGRAPHIC INFORMATION FOR SIGNIFICANT CONTRIBUTORS (VOLUNTARY)

<b>Gender:</b>  <input type="radio"/> Male  <input type="radio"/> Female  <input type="radio"/> Do not wish to provide	<b>Ethnicity:</b>  <input type="radio"/> Hispanic or Latina/o Not  <input type="radio"/> Hispanic or Latina/o Do not  <input type="radio"/> wish to provide
<b>Race:</b>  <input type="radio"/> American Indian or Alaska Native Asian  <input type="radio"/> Black or African American  <input type="radio"/> Native Hawaiian or other Pacific Islander  <input type="radio"/> White  <input type="radio"/> Do not wish to provide	<b>Disability Status:</b>  <input type="radio"/> Yes [ ] Deaf or serious difficulty hearing  [ ] Blind or serious difficulty seeing even when wearing glasses  [ ] Serious difficulty walking or climbing stairs  [ ] Other serious disability related to a physical, mental, or emotional condition  <input type="radio"/> No  <input type="radio"/> Do not wish to provide

Attach a separate document if more space is needed for #6-10, or #24-50.