Annual Progress Report
Northern Gulf Institute

Reporting Period covering
July 1, 2017 - June 30, 2018

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MISSISSIPPI STATE UNIVERSITY

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Dauphin Island Sea Lab · Alabama

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NOAA

NGI Northern Gulf Institute a NOAA cooperative institute

NGI Progress Report

Award NA16OAR4320199

Reporting Period: July 1, 2017 – June 30, 2018

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INTRODUCTION

This Northern Gulf Institute (NGI) Annual Progress Report reviews and summarizes the research, education, and outreach activities accomplished during the reporting period of July 1, 2017 to June 30, 2018. The items in this report cover the research conducted under NOAA award NA16OAR4320199. The report consists of two (2) sections and appendices. The first section provides the General Description of NGI, the NGI Direction, Organization and Operations, Key Research and Economic Impact, and Distribution of NGI funding from NOAA. The second section, "Project Reporting," describes the project objective and research conducted for each project and other project details, along with contact information and related NOAA sponsors and strategic goals. Appendix A provides the total count of publications for this reporting period and Appendix B summarizes the total number of employees and students supported by NOAA funding at NGI. Appendix C lists other agency awards NGI received during this reporting period.

NGI General Description and Core Activities

The Northern Gulf Institute (NGI) is a National Oceanic and Atmospheric Administration (NOAA) Cooperative Institute--a partnership of six complementary academic institutions and NOAA that addresses important national strategic research and education goals. Mississippi State University leads this collaboration, partnering with the University of Southern Mississippi, Louisiana State University, Florida State University, Alabama's Dauphin Island Sea Lab, the University of Alabama in Huntsville, and NOAA scientists at various laboratories and operational centers in the Gulf of Mexico region.

NGI develops, operates, and maintains an increasingly integrated research and transition program, whose results raise awareness and understanding of the Gulf region. NGI was recognized by the NOAA Cooperative Institute Science Review Panel in October 2009 for its significant efforts to address important questions related to the NOAA Strategic Goals. NGI has been recognized as critical and well positioned to provide baseline, current, and future science and outreach needs to the region. The necessity of such a role for NGI is acutely demonstrated by Gulf of Mexico catastrophes like Hurricane Katrina and the Deepwater Horizon incident.

The Institute contributes to NOAA's priority interests in the four NGI research themes of: Climate Change and Climate Variability Effects on Regional Ecosystems; Coastal Hazards; Ecosystem Management; and Effective and Efficient Data Management Systems Supporting a Data-driven Economy. Important recent research accomplishments by NGI researchers, in collaboration with multiple NOAA researchers, focus on the issues and resources of the Gulf with many tools and protocols transferrable to other coastal environments. Additional details are available in the second section on Project Reporting.

The NGI Education and Outreach Program provides an integrated comprehensive approach to educating the public on issues prioritized by and associated with NGI research and to facilitating the transition of NGI research to NOAA operational centers. The program connects universities to NOAA and works closely with educational programs at the Gulf of Mexico Alliance, the various Gulf of Mexico Sea Grant programs, and the NOAA Gulf of Mexico Regional Collaboration Team. Together, we develop communication and significant long-term messaging campaigns to address identified priority issues.

As part outreach and part research planning, NGI participated in or hosted a variety of workshops during this reporting period. The NGI Education and Outreach Program disseminates content and reports of research accomplishments through a multi-media

approach, including listserv emails, Twitter, Facebook, and continual updates to the institution's website with news relevant to NGI's audience. Content includes recent information about research activities and transitioned results, essential components of the collaboration, operation updates, and other outreach items of interest (*see:* www.NorthernGulfInstitute.org).

The NGI Education and Outreach Program strives to enhance NOAA workforce development by including students in several aspects of the cooperative institute. They are involved in research project performance and reporting, internships, career fairs, NGI associated volunteer opportunities, and network support.

NGI Management, Mission, and Vision

The NGI leadership team adopted a ten year NGI Strategic Plan on June 24, 2011 (http://www.northerngulfinstitute.org/about/documents.php). With input from its university and NOAA partners, the NGI Program Office strives to make complex collaborations as efficient and easy as possible for participants with regular teleconferences and meetings.

Mission and vision statements

NGI Mission: NGI conducts high-impact research and education programs in the Northern Gulf of Mexico region focused on integration – integration of the land-coast-ocean-atmosphere continuum; integration of research to operations; and integration of individual organizational strengths into a holistic program. The program shall measurably contribute to the recovery and future health, safety, resilience and productivity of the region, through sustained research and applications in a geospatial and ecosystem context.

NGI Vision: NGI will be a regional leader providing integrative research and education to improve the resiliency and conservation of the Northern Gulf of Mexico.

Organizational structure

The NGI Program Office's strategic location at Stennis Space Center, Mississippi facilitates close interactions with multiple NOAA activities and key stakeholder groups including the NOAA Gulf of Mexico Regional Collaboration Team, regional Sea Grant programs, and the Gulf of Mexico Alliance. The Mississippi State University (MSU) Science and Technology Center at Stennis Space Center, which houses NGI and NOAA activities, provides NGI with the foundation and building blocks to maintain and grow its role in Gulf of Mexico environmental research and education. NGI sustained its international engagement in the Gulf of Mexico through continued interactions with the Consorcio de Instituciones de Investigación Marina del Golfo de México y del Caribe (CiiMar-GoMC).

Since its initial award on October 1, 2006, the NGI's leadership has worked diligently to build collaborations between its six associated academic institutions and NOAA research and education programs. NOAA's support for NGI in year one under award NA16OAR4320199 totals $6.6 million. NGI continues to use NOAA's investment to contribute to the recovery and future health, safety, resilience and productivity of the Gulf of Mexico region, through sustained research and applications in a geospatial and ecosystem context. NOAA cooperative institute metrics summarizing published research and staffing support are provided in the appendices.

In 2006, the NGI Council of Fellows, consisting of a senior investigator from each of the member institutions, established an Executive Office at MSU in Starkville, Mississippi and a Program Office at Stennis Space Center, Mississippi. Funding for the NOAA led research began in the spring of 2006 and research initiatives at the NGI partner institutions began in February 2007.

Significant efforts are being made to address important questions related to NOAA's long-term goals of Climate Adaptation and Mitigation, Weather-Ready Nation, Healthy Oceans, Resilient Coastal Communities and Economics, and NOAA enterprise-wide capabilities. The second five-year cooperative agreement began in October 2011. In 2016, NGI successfully competed to continue as a Cooperative Institute in the Gulf of Mexico. The University of Alabama in Huntsville was added to the CI at this time.

Figure 1 illustrates the NGI organizational structure and collaborative connections. The top row reflects the oversight role of MSU. The Director of NGI, a tenured professor who reports to the MSU Vice President for Research, has his principal office on the MSU campus, but often visits Stennis Space Center, MS. The Director's responsibilities are to serve as primary liaison to NOAA's Executive Council and as the principal point of contact for the Cooperative Institute Program Manager. At the direction of the Director, the NGI Co-Directors assist in this role.

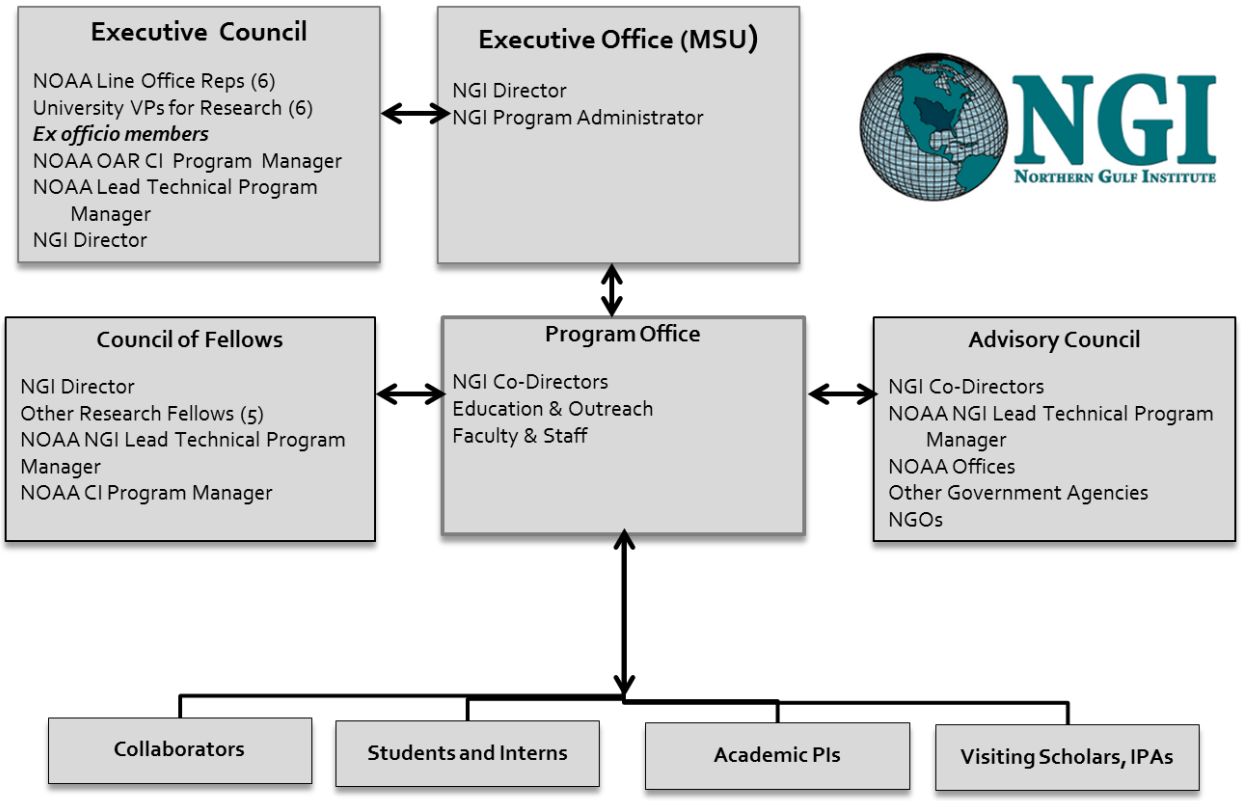


Figure 1. NGI organization diagram

NGI program operations and implementation are guided by the NOAA October 1, 2016 cooperative agreement award, adoption of a Memorandum of Agreement between MSU and NOAA, and compliance with the NOAA Cooperative Institute Interim Handbook. The Executive Office and Program Office staff coordinate with the NOAA Office of Oceanic and Atmospheric Research on amendments to the original award which support research and education by NGI in support of activities of NOAA line offices. These include the Office of Oceanic and Atmospheric Research, National Marine Fisheries Service, National Environmental Satellite Data and Information Service, and the National Ocean Service.

The NGI Program Office located at the Stennis Space Center, MS, is staffed by MSU employees, including the MSU Co-Director and research and outreach faculty. The Program Office is responsible for maintaining regular interaction with the Council of Fellows and the NGI Advisory Council. It also has prime responsibility for the day-to-day management of the Institute, including project management; development of student internships; and facilitating on-site meetings of the Council of Fellows, contractors, and visiting scholars at Stennis. The Program Office constantly upgrades services to research and education affiliates and applies adaptive management approaches to improve program stewardship.

NGI has 3 councils that make management and advisory contributions to the Institute: (1) The Council of Fellows, (2) the NGI Executive Council, and (3) the NGI Advisory Council. The Council of Fellows, chaired by the NGI Director or designee, is composed of senior scientific/technical representatives from each NGI member academic institution, as well as the NOAA OAR CI Program Director. The Council of Fellows is the principal vehicle for NGI concept development, program strategy, annual research plans, peer review, resource allocation, research and technology coordination, and achieving the overarching goal of regional and disciplinary integration.

The Council of Fellows

For the period of July 1, 2017 through June 30, 2018, the NGI Council of Fellows consisted of:

Robert Moorhead, Ph.D., Mississippi State University (Chair, NGI Director)
Steve Ashby, Ph.D., Mississippi State University (MSU Co-Director)
Monty Graham, Ph.D., University of Southern Mississippi (USM Co-Director)
Eric Chassignet, Ph.D., Florida State University
Robert Twilley, Ph.D., Louisiana State University
John Valentine, Ph.D., Dauphin Island Sea Lab
Kevin Knupp, Ph.D., University of Alabama in Huntsville
Robert Atlas, Ph.D., NOAA/AOML Director, NOAA NGI Lead Technical Program Manager
Candice Jongsma, Ph.D., NOAA CI Program Director

The Fellows participate in regular teleconferences to remain up to date between face-to-face meetings.

The NGI Executive Council

The NGI Executive Council consists of six Senior NOAA officials and the Vice Presidents of Research from all six NGI academic partner institutions. Ex-Officio members include the NOAA Cooperative Institute Program Director, the NOAA Lead Technical Program Manager (TPM), and the NGI Director. The Executive Council's primary responsibility is broad policy and program direction for the NGI. This Council transmits NOAA strategic plans and priorities to the NGI management to ensure program alignment with NOAA priorities. NGI is committed to transparency, accountability, governance control, and effective integration through the Executive Council.

Representative Council Members:

Robert Atlas, Ph.D., OAR AOML, Director, NOAA Lead Technical Program Manager
Alan Leonardi, Ph.D., OAR OER Director; Chair
John Cortinas, Ph.D., OAR OWAQ Director

Steve Goodman, Ph.D., NESDIS GOES-R Program, Senior (Chief) Scientist
Paul Scholz, Ph.D., NOS Office for Coastal Management, Deputy Director
Mel Landry III, Ph.D., NMFS NOAA Restoration Center
David Shaw, Ph.D., MSU VP for Research and Economic Development
Gordon Cannon, Ph.D., USM VP for Research
Gary K. Ostrander, Ph.D., FSU VP for Research
K.T. Valsaraj, Ph.D., LSU VP for Research and Economic Development
Ray Vaughn, Ph.D., UAH VP for Research and Economic Development
John Valentine, Ph.D., DISL Director
Robert Moorhead, Ph.D., MSU, NGI Director

The NGI Advisory Council

The NGI Advisory Council serves as the principal interface to the regional stakeholder community of the NGI. It has broad representation from the region and meets regularly to identify and prioritize research and educational needs in the Gulf of Mexico region. The Advisory Council provides input on the current research and education/outreach programs of the NGI. NGI supports the formation and efforts of workgroups around each of the major themes of the NGI and accepts direction from the Advisory Council when they identify the need.

Advisory Council members are:

Steven Ashby, Ph.D., MSU/NGI Co-Director (Co-Chair)
Monty Graham, Ph.D., USM/NGI Co-Director (Co-Chair)
Duane Armstrong, NASA Stennis Space Center
David Brown, Ph.D., NOAA National Weather Service, Southern Region
Alyssa Dausman, USGS, RESTORE Council
Lisa Desfosse, NOAA National Marine Fisheries Service
Ayesha Gray, Grand Bay National Estuarine Research Reserve
Judy Haner, The Nature Conservancy
Karl Havens, Ph.D., Florida Sea Grant College Program
Julien Lartigue, Ph.D., NOAA RESTORE Act Science Program Director
Kristen Laursen, NOAA Fisheries Service
Larry McKinney, Harte Research Institute
Sharon Mesick, NOAA National Centers for Environmental Information
Jamie Miller, Mississippi Department of Marine Resources
Helmut Portmann, NOAA National Data Buoy Center
Matt Romkens, USDA National Sedimentation Lab
Ben Scaggs, EPA Gulf of Mexico Program
Buck Sutter, Ph.D., Gulf Coast Ecosystem Research Council
LaDon Swann, Ph.D., MS-AL Sea Grant Consortium
Suzanne Van Cooten, Ph.D., NOAA National Weather Service LMRFC
Jeff Waters, US Army Corps of Engineers
Chuck Wilson, Ph.D., GOMRI Chief Scientist

Philosophy of Operations

NGI program operations and implementation will be guided by the NOAA cooperative agreement award, adoption of a Memorandum of Agreement between MSU and NOAA, and compliance with the NOAA Cooperative Institute Interim Handbook. The Executive Office and Program Office staff will coordinate with the NOAA Office of Oceanic and Atmospheric Research on amendments to the original award which support research and education by NGI

in support of activities of NOAA line offices. The fundamental philosophy of operations for this CI revolves around integration – integration of the land-coast-ocean-atmosphere continuum; integration of research to operations; and integration of individual academic institutional strengths into a holistic research and educational program specifically geared to the needs of the Gulf of Mexico stakeholders.

The following precepts fit into this philosophy, and will drive the functions of the CI:

- Stakeholder Community Driven (e.g., State Coastal Resource Management Agencies) and Client Focused (e.g., Gulf of Mexico Alliance)
- Transition Oriented (i.e., most research and all technology activities must have a pathway to inform management decisions)
- Regional in Research Focus; Basin-Scale in Coordination
- Closely aligned with the Needs and Resources of its Federal Partner, NOAA (Headquarters, Line Units, and Laboratories)

Project Selection

NGI will work with its Advisory Council to select research projects that meet the following criteria: (1) projects that address the most pressing issues in the Gulf of Mexico and match NGI member expertise, capability, and capacity to address those issues; (2) projects for which NOAA labs and programs will provide funding at an appropriate level; and (3) projects that have sufficient funding longevity to provide appropriate graduate student and post-doctoral support.

Progress Review

Progress will be evaluated based on the measures of success stated on page 4 of the NGI Strategic Plan (http://www.ngi.msstate.edu/about/documents/strategicPlan2011-2021.pdf). In short, progress requires the creation of new or improved knowledge and technology, and their transition to applications for improved ecosystem-based management in the Gulf of Mexico.

Performance Measures

The success of NGI depends upon the extent to which the creation of new or improved knowledge and technology in core research areas is relevant and applicable to the Research Themes in the Gulf of Mexico. Determining success requires that we develop a Metrics Plan to track the NGI trajectory. The primary metrics we will use to determine success are: (1) research metrics that track progress towards accomplishing research goals and objectives; and (2) organizational metrics that track the level of engagement and contribution to educating a new workforce. Research project metrics drive organizational metrics. Together, these provide indicators about the effectiveness of NGI as a research institution and about the value of NGI research to stakeholders, thereby raising its visibility and stature in both research and management communities.

NGI will track two types of research use: (1) external use by the scientific community, resource managers, and those involved in engagement and education efforts; and (2) internal use by other NGI funded researchers. External indicators include documentation of NGI-funded research in peer-reviewed journals, an established metric for measuring the quality, rigor, and significance of research; the degree to which NGI projects align with the needs of state and federal management agencies, including information about leveraging resources, extending impact, and strengthening NGI ties with stakeholders; and the contribution that NGI makes to science workforce development, accomplished by following the career trajectories of students who conducted research while mentored by NGI partners. Increasing NGI's visibility broadens

recognition of the quality of its work and its value as an organization. Increasing knowledge about NGI among its institutional partners promotes effective internal operations and coordinated, collective external communication.

Beyond the metrics indicated above, the NGI Metrics Plan will provide periodic updates in the following areas:

- Formal and informal recognition of NGI research
- Internal use of NGI research to support existing research or advance new opportunities
- Established framework that prepares research for use or improves the usability of research
- Leveraged efforts that extend the impact of NGI
- Acquisition of resources that sustain and grow NGI
- Allocation and alignment of resources with NGI goals
- Implementation plans that align with regional priorities and emphasize multi-institutional collaborations
- Collaborations and strong relationships with key stakeholders in the scientific and resource management communities and with partners involved in engagement and education efforts
- Effective internal processes and working relationships
- A comprehensive mechanism to preserve, discover, and access this data and information to maximize the investment made by the Government and various agencies by allowing multiple uses of the data while minimizing duplication of effort

The intent is to be transparent and strategic, while having the flexibility to adapt rapidly to correct course or take advantage of novel opportunities.

Executive Summary of Important Research Activities

Many of NGI's research projects are providing new and improved tools and capabilities in support of NOAA's Weather-Ready Nation goal as briefly summarized below.

- Analysis by Florida State University (FSU) researchers of stepped-frequency microwave radiometers' (SFMR) measurements of wind-induced emissivity collocated with dropsondes identified two distinct wind speed regimes for which the distribution was statistically different. It was found that the 10 to 20 m/s SFMR wind-induced emissivity measurements had a low bias compared to the modeled wind-induced emissivity, but no apparent storm relative azimuthal asymmetry. For the 20 m/s or greater SFMR wind-induced emissivity measurements, there was a storm relative azimuthal asymmetry identified.
- Research continues to produce fields of surface turbulent air-sea fluxes and the flux related variables (winds, SST, near surface air temperature, near surface humidity, and surface pressure) for use in global climate studies. The FSU winds (monthly averages of gridded winds over the tropical oceans) were produced and made available to a wide range of users such as ENSO and fisheries forecasters.
- The NOAA Office of Dissemination is evaluating the use and applications of NOAA Weather Radio All Hazards to determine user requirements to transform the current NOAA Weather Radio All Hazards broadcast network into a new integrated weather information distribution/dissemination system. The project team at the University of Alabama is currently conducting case studies of actual events to study modalities.

- Analyses of profiler and radar data continued to document the variability in low-level clouds, thermodynamics, and wind (wind shear) for cold-season tornado events. Ceilometer data were examined to determine cloud base height distributions and cloud cover fraction around tornadic storms (supercell vs. QLCS) to address the hypothesis that cloud fraction (cloud base height) tends to be high (low) for tornadoes in the Southeast.
- Activities of the U.S. Research Vessel Surface Meteorology Data Assembly Center (DAC) at the Florida State University (FSU) included continued implementation of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative (http://samos.coaps.fsu.edu/). The SAMOS initiative is focused on improving the quality of and access to surface marine meteorological and oceanographic data collected in situ by automated instrumentation on research vessels. During the reporting period (7/1/17-6/30/18), 28 research vessels routinely transmitted daily emails containing one-minute averaged meteorology and surface oceanographic data to the DAC. This project ensures that the highest quality marine meteorological and near surface oceanographic data are collected by research vessels, primarily from the U.S. fleet, and that they are distributed and archived in a manner that makes the data accessible and useful to a diverse research and operational user community.
- Additional assessment of data from the National Buoy Data Center (NDBC) provided validation and case study analyses of NOAA experimental HWRF products such as HWRF-HYCOM, HEDAS, and basin-scale HWRF. Tropical cyclone-tornado research from a previously funded AOML grant provided leverage in the validation and analyses.
- An Interactive Sea Level Model (*GeoCoast*) has been developed. Lidar data collected in 2015 for the 3 coastal counties of Mississippi were used to develop a 10-ft resolution DEM (digital earth model) as a base for assessing the impact of sea level rise on the road network. A road centerline dataset, developed in an earlier MDEM (Mississippi Digital Earth Model) award, was merged with the elevation raster cells to transfer elevation measures to segments of the road centerline dataset.
- A web-based GIS (*GeoDawg*) has been developed with the general public in mind. Popular spatial datasets (e.g., census of population, economics) may be accessed with a collection of commonly used GIS tools.

Studies are ongoing in support of NOAA's Healthy Oceans goal.

- Research on the endangered smalltooth sawfish continued and provided new insights into their mating grounds. During the reporting period, 12 large juveniles and adults of the endangered smalltooth sawfish were captured and tagged. This is the first time researchers have captured adult males and females together in the three different regions during the same season. Interestingly, all three adults captured in Coot Bay showed very fresh signs of mating, with wounds and scars from rostral teeth on the dorsal and ventral surfaces. This is the first time that mating grounds have been verified. In addition to numerous news reports, the findings will also be included in Shark Week 2018.
- Research continued with expanded water quality sampling in tributaries and estuaries in the Northern Gulf of Mexico (NGOM). This research is creating a baseline trace element and strontium isotope map of primarily the Pearl River and also a few of the rivers draining into Lake Pontchartrain. This map will be used to better understand habitat use of Gulf Sturgeon in the system and will be used in conjunction with data previously collected in the Alabama and Florida panhandle in the eastern GULF OF MEXICO.
- An evaluation of the applicability of using UAS for oil spill detection in the Gulf of Mexico is currently underway. The focus of this task is to use an ultraviolet light source to "excite" hydrocarbons associated with oil deposits on the sea surface.

- A proceedings report from the 6th Annual Hypoxia Research Coordination Workshop was completed, identifying the partners and mechanisms necessary to implement and sustain a Cooperative Hypoxic Zone Monitoring Program. The complete report is available at: https://www.ncddc.noaa.gov/activities/healthy-oceans/gulf-hypoxia-stakeholders/workshop-2016/proceedings/.
- An ongoing project with the objective to provide a range of realistic scenarios of future environmental changes in the northern Gulf of Mexico (including the shelf region) for the research community and fisheries resource managers continues to develop the regional ocean model (GOM8). GOM8 reproduces reasonably well main circulation and hydrographic patterns, such as the Loop Current, mesoscale eddies, hypoxic region over Texas and Louisiana shelves, SST, and surface chlorophyll for a comparison between model and satellite chlorophyll. Modeling of small and large plankton components allows for a better representation of ecological processes in the coastal and oceanic domain. Seasonal variability of phytoplankton biomass shows significant regional differences across the northern Gulf of Mexico. The next phase of this project will be to obtain future projections over the 21st century of physical & biogeochemical processes in the northern Gulf of Mexico under high and medium-to-low CO2 emission scenarios, using the model configured from task 1 and projected atmospheric fields from the Coupled Model Intercomparison Project phase-5 (CMIP5).
- Analysis of the Biscayne Bay water quality data indicated that following a significant bloom of a picophytoplankton (*Synechococcus*) in September of 2005, the oligotrophic system had shifted to a more phytoplankton dominated system than the benthic/submerged aquatic vegetation system that dominated prior to the 2005 bloom. Results of this analysis (with others ongoing) are being used to develop process studies for additional data collection that will be incorporated into a coupled hydrodynamic model for ecological assessments that will be used to inform watershed management and habitat restoration decisions.
- Calibration and validation of ocean products on NOAA VIIRS for monitoring oceans continued with several outcomes. As a result, new ocean products have been developed from the VIIRS orbital overlap and have been validated. Measurements of diurnal changes in ocean color in turbid coastal regions in the Gulf of Mexico were characterized using above water spectral radiometry. Protocols were developed for collection and processing of in situ optical data used for ocean color calibration and validation. These included the IOP floating hyperpro and above water ASD instruments. Results of protocols and all data from the ocean color cruises were transitioned to NOAA and put into cruise reports. The WavCIS platform is transitioning daily data to NASA and NOAA for calibration and validation of the Ocean Color on VIIRS satellite. These data are being used for maintaining high quality VIIRS products.

Data management activities with an emphasis on product development were initiated.

- An enduring mapping center to address research and development needs that advance the science and practice of hydrography and cartography has been established at the University of Southern Mississippi. The research plan encompasses five thrusts (e.g. Sensors/Platforms, Positioning, Water Levels, Data Management, Data Portrayal). An initial effort included the use of Lidar data for several significant sections of the Northern Gulf Cast for comparison to shorelines depicted on existing charts.

- The *Continuation of Comparative Metagenomics to Indicate Sites Under Anthropogenic Pressure* project has greatly reduced a backlog of previously acquired data sets. Bioinformatic analysis of several new projects to serve core missions of NOAA was initiated.

Preparations were initiated to embark on field operations to test the viability of 1) environmental sample processors on AUVs to match the sampling fidelity of shipboard sampling; 2) larval community metabarcoding to match the fidelity of manual counting; and 3) free environmental DNA as a proxy for recent fish population counts.

Distribution of NOAA Funding

NGI receives funding for all three NOAA CI tasks as well as each one of NGI's themes, with several projects having multiple themes (Figs. 2 and 3).

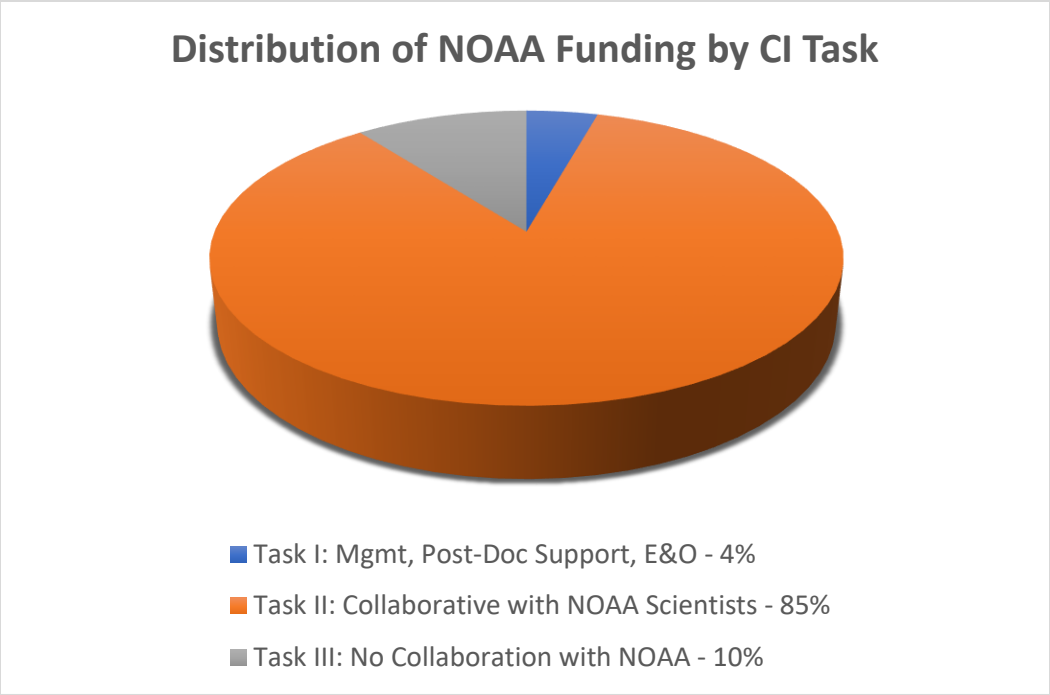


Figure 2. Distribution of NOAA funding by the three cooperative institute task categories

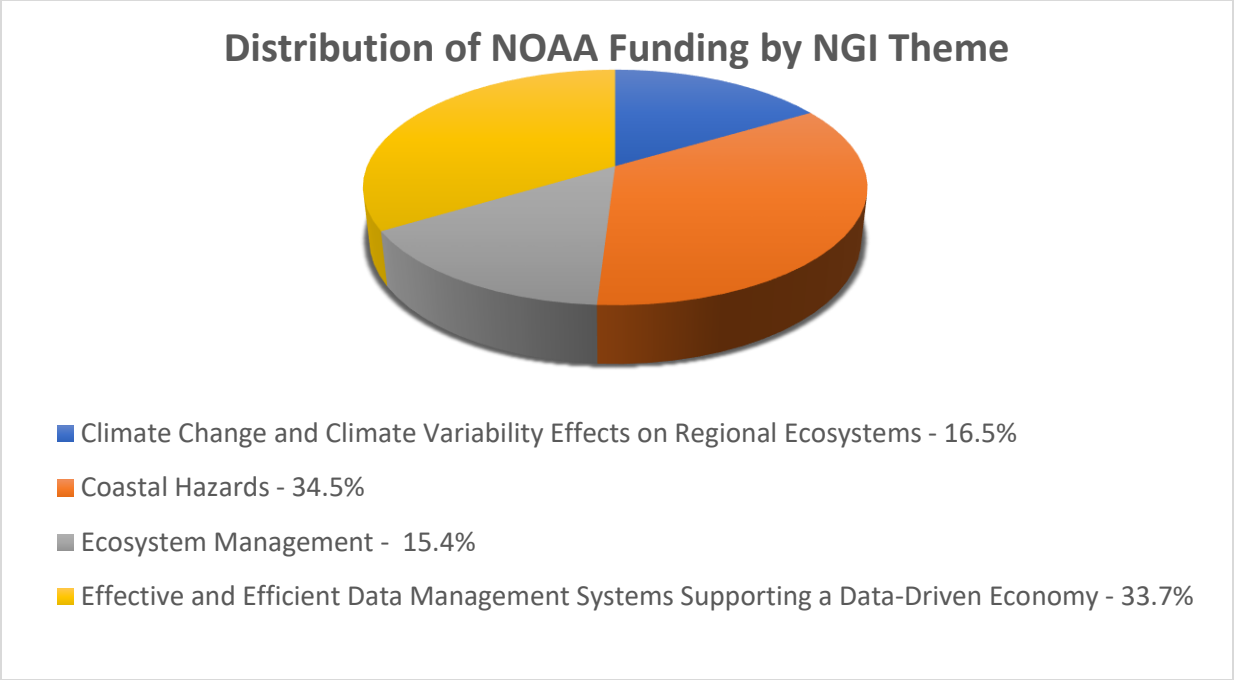


Figure 3. Distribution of NOAA funding by the four NGI themes

Task I Activities

Task I funding supports the central management and coordination of the six complementary academic partners working together with NOAA. Task I funding was used to support the administration of NGI, student activities, and education and outreach (Fig.4). Administration included leading the efforts of the CI as well as program and project management for each of the traditional CI projects active during the reporting period.

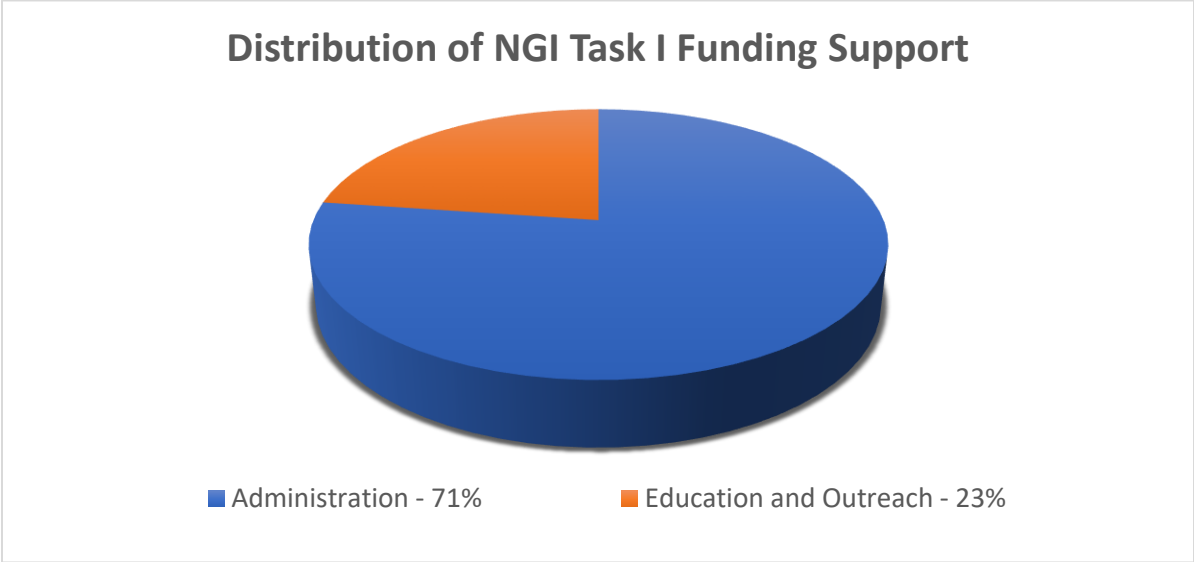


Figure 4. Distribution of NGI Task I funding

The NGI Education and Outreach Program connects universities to NOAA and works closely with the educational programs at the Gulf of Mexico Alliance, the various Gulf of Mexico Sea Grant programs and the NOAA Gulf of Mexico Regional Collaboration Team. Together we develop communication and significant long term messaging campaigns to address identified priority issues and to disseminate content and reports of research accomplishments through a multi-media approach including listserv emails, Twitter, Facebook, and continual updates to the institution's website with NGI audience relevant news. Content includes recent information about research activities.

Education and outreach is something NGI has taken seriously since its inception. We are constantly developing coastal, marine and atmospheric science courses, curriculum and fieldwork for distribution to regional and even national educators to use as supplemental material for their classrooms. Some Projects NGI is involved in include:

Professional development for teachers including continuing education opportunities for teachers and industry professionals in conjunction with the MSU Geosciences Program. Additionally, NGI develops "Travelling Trunk Shows". Generally speaking, these trunks include Art and Science based curriculum designed to support state educational requirements. We typically include the "science, literature and arts behind the scenes" that includes targeted classwork and lessons of discovery for, specifically in our case, oceanography, marine and fisheries science, and weather. These trunks provide STEAM focused interaction with large numbers of schoolchildren, their parents, teachers and administrators.

We have also developed a "Scientists Get Involved"program that includes science, engineering and mathematics faculty from departments spanning all NGI partner institutions, giving visiting, timely, guest lectures in classrooms of local schools, children's museums,public events and festivals all along the Gulf Coast. All this we undertake in addition to outreach opportunities provided by displays and presentations made while travelling to state and national science teaching association meetings, as well as national industry specific conferences including most earth and atmospheric sciences conferences, high performance computing conferences, and those that involve UAS and AUV technologies.

The NGI Education and Outreach Program is positioned to provide high impact, curriculum based support to both the public, and educators throughout our region. We look forward to working to provide a better future to our communities through educational opportunities concerning their environment.

Some outreach events for this reporting period include:

- Regional geospatial modeling workshops were attended by a wide variety of end users. During the period of this progress report (July 1, 2017 through June 30, 2018), 13 workshops were offered to 121 participants.
- In conjunction with the VORTEX-SE project, guided tours of the Severe Weather Institute and Radar & Lightning Laboratories (SWIRLL) building are conducted on a regular basis. Approximately 33 tours have been provided since July 2017. Groups include senior citizens, social clubs, K-12, foreign groups, Senate staffers, prospective graduate students, and other visitors.
- Public outreach events during the period included the COAPS Open House (February 2018), during which DAC staff demonstrated the operation of marine meteorological instrumentation and computer programming concepts. This included demonstrations using a Lego robot to engage students and the general public in basic programming tasks and a

second display of the scales of computing used by COAPS generally and the DAC specifically. Dr. Mark Bourassa also participated in outreach activities, including the DAC (with support from COAPS personnel) developed a fact sheet focused on “Making use of a sea of data” (see Appendix D). The fact sheet focuses on the acquisition, evaluation, and dissemination of marine weather observations and gives examples of how these observations impact weather forecasting and decision making in several sectors of society. The goal of this project is to deliver a pilot series of a set of courses developed for a training program in social science applications to meteorologists and meteorology professionals in FY18. The program consists of 5 courses, 15 hours total. Training program students will learn how to interpret social science research, as well as conduct basic social science research in their field discipline.

- NGI participated in the Bays and Bayous Conference and provided a display that included highlights of ongoing research.
- NGI began production of both the “Portal” and Portal “Blog” to provide current outreach and information to the public about ongoing research along the Northern Gulf of Mexico Basin.
- NGI began development of STEM curriculum, free to be accessed by educators nationwide and hosted on our Portal Website.
- NGI Began developing and issuing “Travelling Trunk” STEM experiment packages to educators.
- NGI Participated in the Mississippi Science Teachers Association’s annual conference, and provided a demonstration of targeted curriculum for STEM classroom use.
- NGI Participated in both the Gulf of Mexico Alliance and American Geophysical Union annual conferences with displays of ongoing projects and uses of UAS systems.
- NGI developed a summary document of research activities that was included as a handout at the NOAA display at the State of the Gulf Summit, GOMA All Hands Meeting, and the Restore America’s Estuaries Conference
- Dr. Steve Ashby also participates on the steering committee of the GOMA Education and Engagement Team. As part of this effort, GOMA and the NOAA Marine Debris Program have developed several collaborative projects.
- Collaboration with other partners included interactions with the Naval Research Laboratory, the National Aeronautics and Space Administration, the US Environmental Protection Agency, the US Fish and Wildlife Service, the Gulf of Mexico Alliance, The Nature Conservancy, Ocean Conservancy, Pacific Marine Environmental Laboratory, the Gulf Coast Ocean Observing System, several national and international societies and academic consortiums, and several state and local resource management agencies.

PROJECT REPORTING (Note that the last 2 digits of the NGI File # correspond with the amendment # to NA16OAR4320199)

NGI File # 16-NGI3-03

Project Title: National Weather Service Social Science Curriculum Delivery

Project Lead (PI) name, affiliation, email address: Laura Myers, The University of Alabama, laura.myers@ua.edu

Co-Principal Investigator: Vankita Brown, National Weather Service, vankita.brown@noaa.gov

Project objectives and goals

The goal of this project is to deliver a pilot series of a set of courses developed for a training program in social science applications to meteorologists and meteorology professionals in FY 17. The program consists of 5 courses, 15 hours total. Training program students will learn how to interpret social science research, as well as conduct basic social science research in their field discipline. The courses are designed to provide training program students with an applied social science research overview, developed through each course of the program, culminating in a presentation with policy recommendations from their research. Dr. Laura Myers will be the social science SME working in collaboration with NOAA social scientists and OCLO to deliver the courses in FY 17.

Description of research / milestones accomplished

The course content for all five courses was developed and presented to OCLO in June 2016 for approval and feedback. The feedback was used to revise the course content and processes, prior to actual eLearning construction. ELearning construction of all courses and modules took place from June until September, 2016. This process involved the recording of the content and the placement of the recordings in the eLearning environment with visualization of the content. The first course of the pilot was delivered in February 2017. Courses two through four were delivered online with participants. Webinars and feedback were provided to participants from April through June 2017. The final course was delivered in person in July 2017. All students brought back final project revisions and feedback was given. Dr. Myers and Darrell Arnold continue supporting next phases of work with students, since presenting at the Annual American Meteorological Society (AMS) meeting in January 2018.

During the final course in Kansas City in July 2017, class participants each presented their research proposal ideas. Dr. Laura Myers discussed many of the research proposals in her presentation at AMS in January 2018. Four (4) research proposals are already in progress with hopes of publishing data sometime in 2018. One class participant is already using what he learned in SSMC to complete social science related coursework in the Pacific Leadership Academy. A Facebook group was established to discuss social science related research, news, and ideas.

Description of significant research results

- LMS eLearning work completed.
- Course content edited in preparation for pilot delivery of courses in February 2017.
- Worked with Dr. Brown and Training Center to develop request for participants.
- Worked with potential participants and their supervisors to help Training Center select participants for the pilot delivery.
- Developed all course activities and integrated them into LMS.
- Worked with Training Center to set up LMS for participants.
- Delivered first course of five in person (1 week) to 30 participants in February 2017 in Kansas City at the NWS Training Center.

- Provided feedback to all course activities as completed by the students in preparation for the final report due at last course delivery in person in July 2017.
- Provided regular webinars on course topics for participants from April to June 2017.
- Final course delivered July 2017.
- Various projects presented at AMS Annual Meeting in January 2018. Final projects to be completed in 2018-2019.

Information on collaborators / partners (if applicable):

Vankita Brown, National Weather Service
Darrell Arnold, CAPS Team, The University of Alabama
Sara Gallman, CAPS Team, The University of Alabama

Information on any outreach activities:

- Provided abbreviated social science application materials to meteorologists in the field seeking to conduct social science research.
- Provided social science assistance to meteorologists in the field wanting to partner with a social scientist or to enlist their expertise and opinion.

Economic Development Activities: N/A

Publications and Presentations

Conference and workshop presentations complete (16-NGI13-03):

NWS Greer Integrated Warning Team Workshop, Charlotte, NC, October 25, 2016, Title: Public Response to Severe Weather Graphics and Warnings

NWS Greer WFO workshop, Greer, SC, October 26, 2016, Title: Societal Response to the 2014 Atlanta/Birmingham Snowstorm

NWS Tallahassee Integrated Warning Team Workshop, Thomasville, GA, November 3, 2016, Title: Messaging

Weather Enterprise Partner Workshop, Tuscaloosa, AL, November 18, 2016, Title: Improving the Weather Warning Process

Cox Media Television Conference for Broadcast Mets, Atlanta, GA, May 7, 2017, Title: Public Response to Severe Weather Graphics and Warnings

Lawton OK Integrated Warning Team Workshop, June 27, 2017, Title: Communicating Weather Warning Information: The Public's Understanding of the Message

AMS, 2018, Austin, TX, Social Science in Meteorology Curriculum

NGI File # 16-NGI3-04

Project Title: Development of Trace Element and Strontium Isotope Water Chemistry Baseline Data for the Pearl River Watershed

Project Lead (PI) name, affiliation, email address: Peter Allen, Associate Professor, Dept. Wildlife, Fisheries and Aquaculture, Mississippi State University, peter.allen@msstate.edu

Co-Principal Investigator name, affiliation, email address: Brenda Pracheil, Aquatic Ecologist, Environmental Sciences Division, Oak Ridge National Laboratory, pracheilbm@ornl.gov

Project objectives and goals

The goal of this project is to develop a watershed map of trace element and strontium isotope water chemistry for the Pearl River Watershed. This goal was accomplished through the following objectives:

Objective 1: Collect water samples throughout the Pearl River Watershed and nearby watersheds flowing into Lake Pontchartrain, LA.

Objective 2: Analyze water samples for trace elements and strontium isotopes (i.e., ^{87}Sr and ^{86}Sr).

Objective 3: Use data to develop a map of water chemistry in the Pearl River Watershed.

Description of research / milestones accomplished

Objective 1: Water samples were collected in the Pearl River and Bogue Chitto River Basins. Water samples were also collected from drainages along the northern edge of Lake Pontchartrain and Lake Maurepas, LA, including the Tchefuncte, Tangipahoa, Tickfaw and Amite Rivers. Water was collected from the limits of accessibility to sturgeons in the upper reaches to regions near confluence with saline water.

Objective 2: Water samples were evaluated for trace elements using solution inductively coupled plasma mass spectrometry (ICPMS) and are currently being analyzed for strontium isotope concentrations using solution multi-collector ICPMS.

Objective 3: Water chemistry maps for trace elements (Sr, Ba, Mn, Mg, Zn) and strontium isotopes (Sr^{87}/Sr^{86}) in the Pearl River Watershed were developed using water chemistry data.

Description of significant research results

Water trace element and strontium isotopes were evaluated for the Pearl and Bogue Chitto Rivers, and the four main drainages into Lake Pontchartrain and Lake Maurepas: the Tchefuncte, Tangipahoa, Tickfaw, and Amite Rivers.

Water Chemistry

The upper Pearl River (above the Bogalusa sill dam) and the Bogue Chitto River had distinct trace element patterns, presumably facilitating the ability to differentiate fish derived from either drainage. In the upper Pearl River, Sr/Ca, Ba/Ca, Mn/Ca, Zn/Ca, Mg/Ca and ^{87}Sr/^{86}Sr were all lower than values in the Bogue Chitto River. In addition, there were gradually decreasing gradients from upper watershed to lower watershed for trace elements and strontium isotopes within each drainage, potentially allowing for detection of movements of fish within drainages. Watershed gradients in strontium isotopes have been useful for retrospectively determining within river habitat use of Gulf Sturgeon (Allen et al. 2018). Dissolved oxygen was high in both of these rivers, which would be beneficial for many species of fish and

life stages, including developing embryos and juvenile life history stages of Gulf Sturgeon. Salinity was not detectable in either portion of the drainages.

In the lower Pearl River, trace element and strontium isotope patterns were more complex than in either the upper Pearl River or the Bogue Chitto River. The lower Pearl River is a braided channel with hydrology impacted by sill dams near Bogalusa, LA on the Pearl River and a sill dam on the Bogue Chitto River near its confluence with the Pearl River. In addition, there are a number of channel modifications that influence hydrology in the lower Pearl River. Trace element and strontium isotopes generally followed a decreasing gradient. In the lower Pearl River, trace element and strontium isotope ratios were influenced more strongly by the upper Pearl River than the Bogue Chitto River, with values often continuing the declining gradient observed in the upper Pearl River.

Unlike the upper Pearl and Bogue Chitto Rivers, the lower Pearl River is influenced by tidal cycles and salinity near the braided mouth of the river. Salinity rises and dissolved oxygen decreases to hypoxic levels (51% saturation) in areas of saltwater intrusion. The lower Pearl River is also characterized by a broader floodplain than the upper Pearl River, and a number of slow moving, hypoxic, anastomosing channels through dense vegetation. These areas appeared unlikely to hold Gulf Sturgeon based on requirements for oxygen in sturgeons (Sulak et al. 2004; Ross et al. 2009; USFWS and NMFS 2009), which is suggested to be at a minimum of 58% saturation or 4mg/L for most sturgeon species (Cech et al. 1984; Jenkins et al. 1993; Secor and Gunderson 1998; Cech and Crocker 2002; Kahn and Mohead 2010).

In the Lake Pontchartrain Watershed, the Tchefuncte, Tangipahoa, Tickfaw and Amite Rivers were fairly similar in their trace element and strontium isotope composition. These rivers have much smaller watersheds and much lower discharge than the Pearl River. Compared to the other rivers, the Amite River showed the greatest difference in trace element and strontium isotope patterns. Differentiating trace element and strontium isotope patterns within these rivers would be more difficult, although Sr/Ca, Mn/Ca, and Zn/Ca could potentially be used to differentiate the Amite River's water chemistry from the other three rivers. The Tchefuncte, Tangipahoa, and Tickfaw Rivers had few differences in trace element composition, which would make it difficult to differentiate habitat use within these rivers based on water chemistry. Notably, the downriver areas of several of these rivers, particularly the Amite and Tchefuncte, were hypoxic, and likely not suitable for Gulf Sturgeon habitat. While seasonal variability in dissolved oxygen in the lower portions of these rivers is possible, these areas are characterized topographically by a low gradient and slow flow. Studies have shown that several sturgeon species are sensitive to even mild hypoxic conditions, which can impair their respiratory metabolism, foraging activity, and growth rates (Detlaff et al., 1993; Crocker and Cech, 1996; Blevins 2011). Dissolved oxygen has also been shown to be one of the most important factors on the rate of embryo development (Jobling 1995; Blevins 2011).

Soil Types

The far upriver portions of the Pearl and Bogue Chitto Rivers and the entirety of the Amite River are in the Southern Mississippi Valley Loess. This area generally has low dissolved solids and very soft water (MLRA 2006). The upper Pearl and Bogue Chitto are also in a geological and mineral area of mostly clays and sands, and some gravel (Thompson 2009, 2011). These soil components presumably contribute to the low Sr/Ca, Zn/Ca, Mn/Ca, Ba/Ca, Mg/Ca and $^{87}Sr/^{86}Sr$ in the Upper Pearl River and to the somewhat higher ratios in the Bogue Chitto and Amite Rivers.

As the upper Pearl and Bogue Chitto Rivers move into the Southern Coastal Plain with harder water and more dissolved solids, trace element and $^{87}Sr/^{86}Sr$ increase. Trace element and $^{87}Sr/^{86}Sr$ continue to increase gradually as the lower Pearl River moves into the Eastern Gulf Coast Flatwoods. The Tchefuncte River is exclusively in The Eastern Gulf Coast Flatwoods, as well as the lower Tangipahoa and upper to mid Tickfaw River. These areas all have medium to high Sr/Ca, Zn/Ca, Mn/Ca, and Ba/Ca, with the exception of the lower Tchefuncte River, which has some points with low Sr/Ca and Mg/Ca. Where saltwater intrusion occurs, Sr/Ca and Mg/Ca increase dramatically, while Zn/Ca, Mn/Ca, and Ba/Ca decrease to very low ratios. The Eastern Gulf Coast Flatwood areas generally have low dissolved solids and higher salinity than the other areas (MLRA 2006).

Synthesis

This study indicates that trace element and strontium isotope patterns within the upper Pearl River and Bogue Chitto Rivers are distinct and would likely allow for retrospective analyses of habitat use of fishes utilizing these areas. The gradual longitudinal gradients in trace elements and strontium isotopes would presumably facilitate within river habitat use. Large differences in trace element and strontium isotopes between freshwater and saline habitats would allow for clear identification of movements between these two habitat types. Distinguishing retrospective habitat use in the drainages flowing into Lake Maurepas and Lake Pontchartrain would be more difficult based on the similarity of trace element and strontium isotope ratios among rivers. Discharge in these rivers is much lower than in the Pearl River Watershed and habitats in many of the lower rivers were typified by slow flow and hypoxia. These conditions would presumably not be conducive to utilization by Gulf Sturgeon, although there may be seasonal variability facilitating habitat use.

Table 1. Mean ± standard error water quality data for upriver (UR) and downriver (DR) sections of the Pearl and Bogue Chitto Rivers.

Location	n	DO (%)	DO (mg/L)	Conductivity (uS)	Specific Conductivity (uS)	Salinity ($^0/_{00}$)
Pearl UR	12	81.52 ± 3.38	6.19 ± 0.25	145.56 ± 16.79	134.26 ± 16.09	0.07 ± 0.01
Pearl DR	2	55.85 ± 5.90	4.23 ± 0.46	1763.65 ± 1173.34	1618.4 ± 1076.64	0.85 ± 0.53
Bogue Chitto	7	88.83 ± 1.28	6.91 ± 0.10	59.13 ± 2.46	55.67 ± 2.56	0.00 ± 0.00

DO = dissolved oxygen, Upriver Pearl River = above Bogalusa sill dam

Maps of the Pearl River and Lake Pontchartrain Watershed areas with major land resource areas:

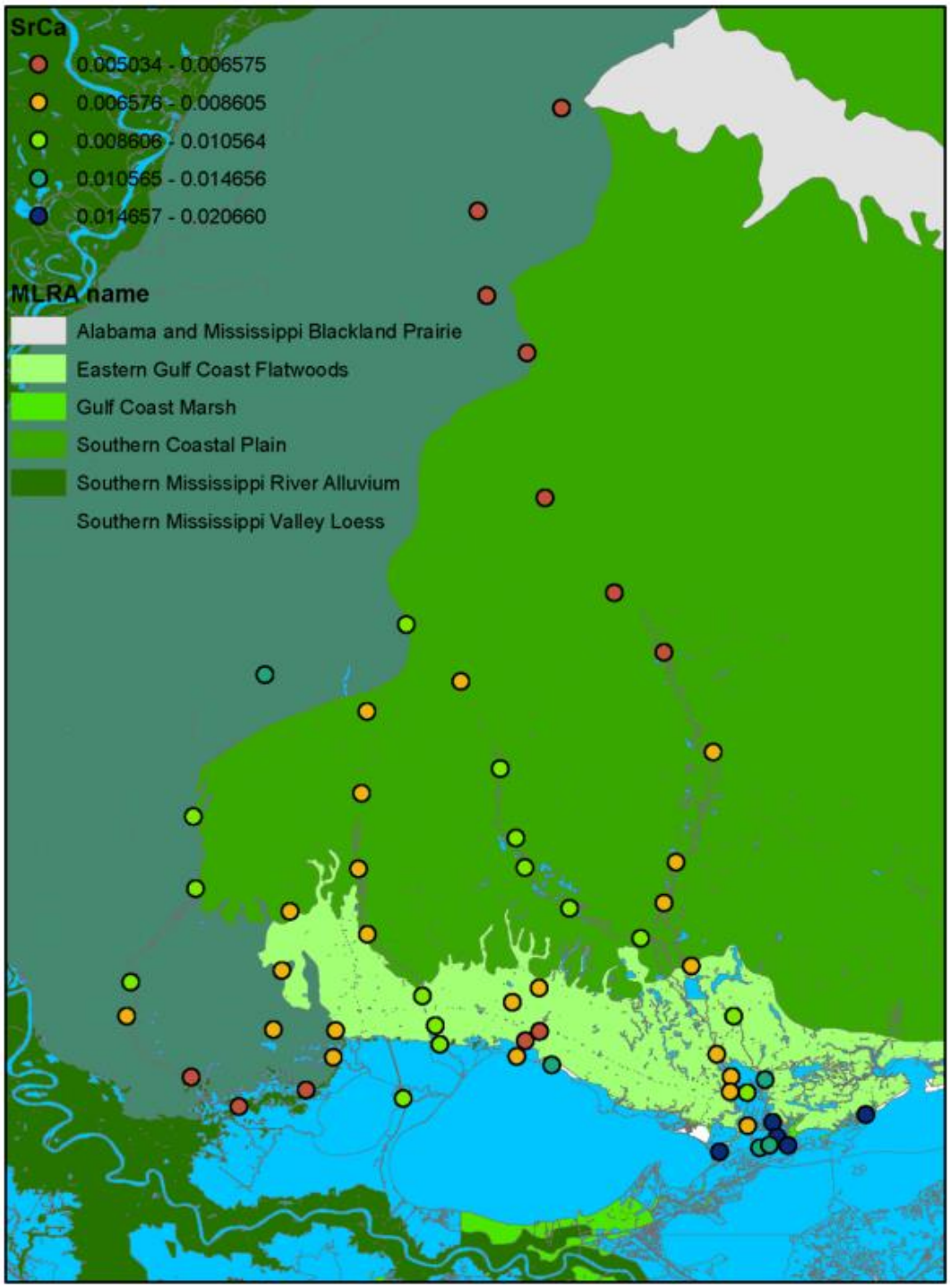


Figure 1. Sr/Ca map

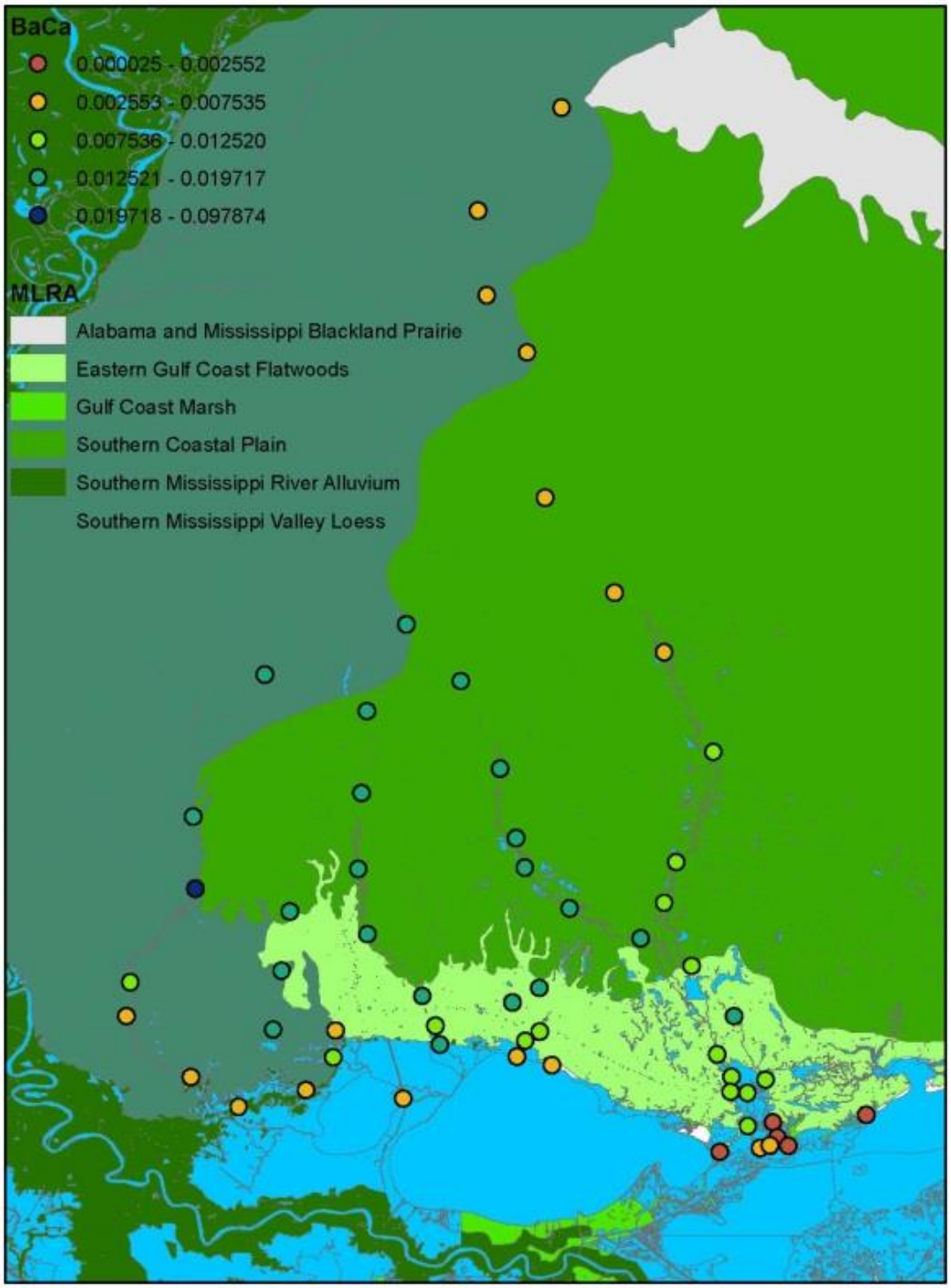


Figure 2. Ba/Ca map

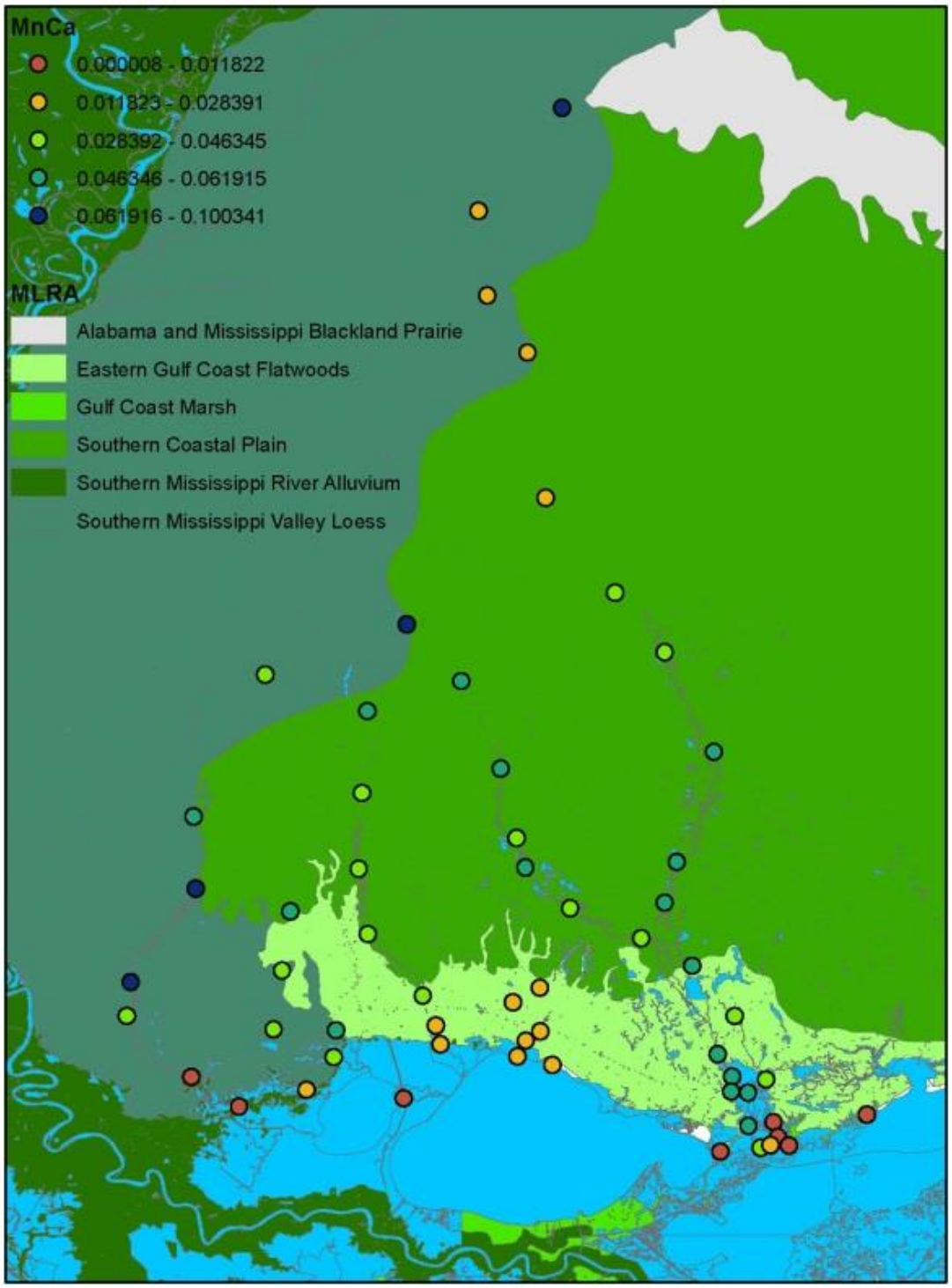


Figure 3. Mn/Ca map

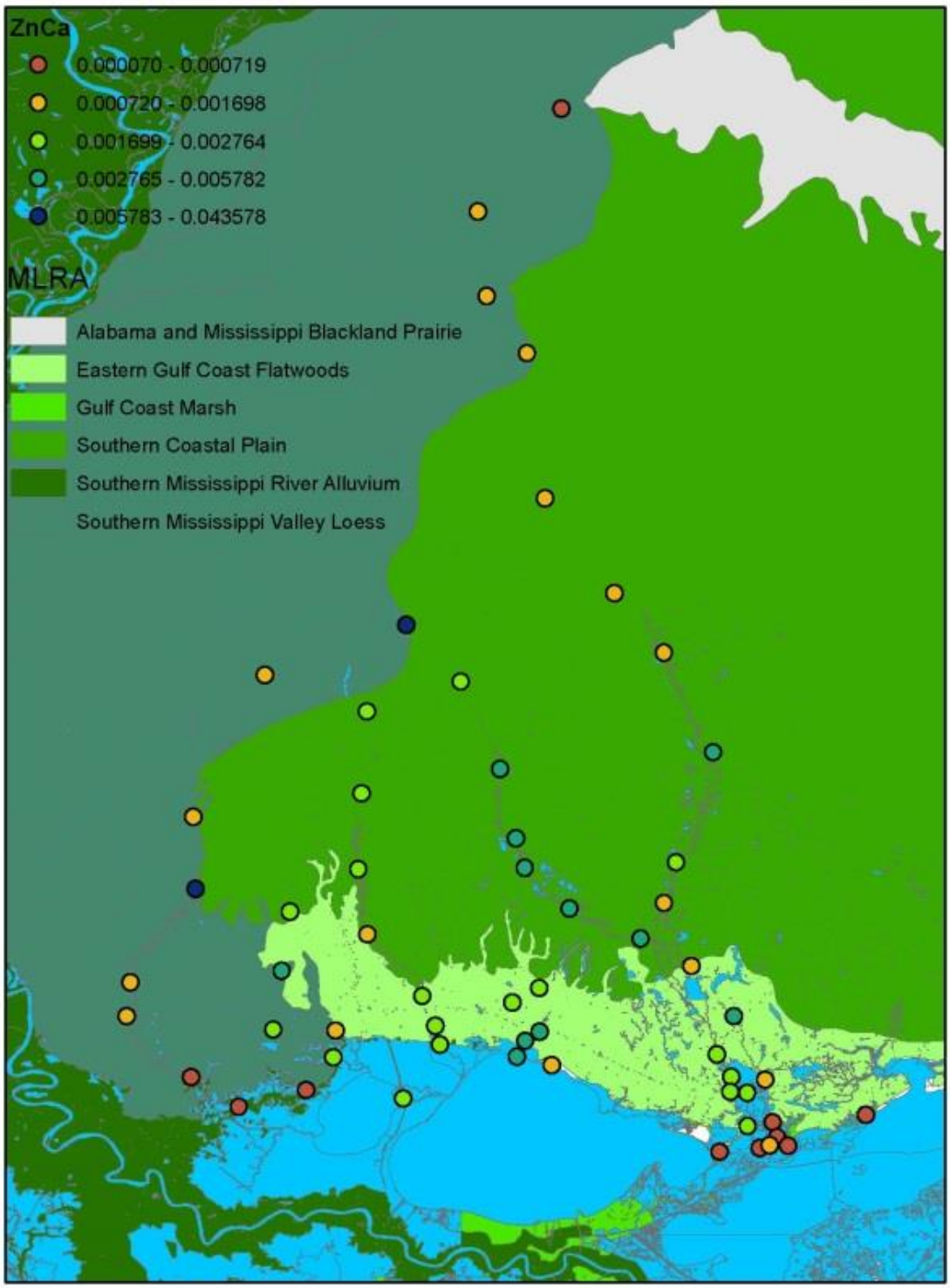


Figure 4. Zn/Ca map

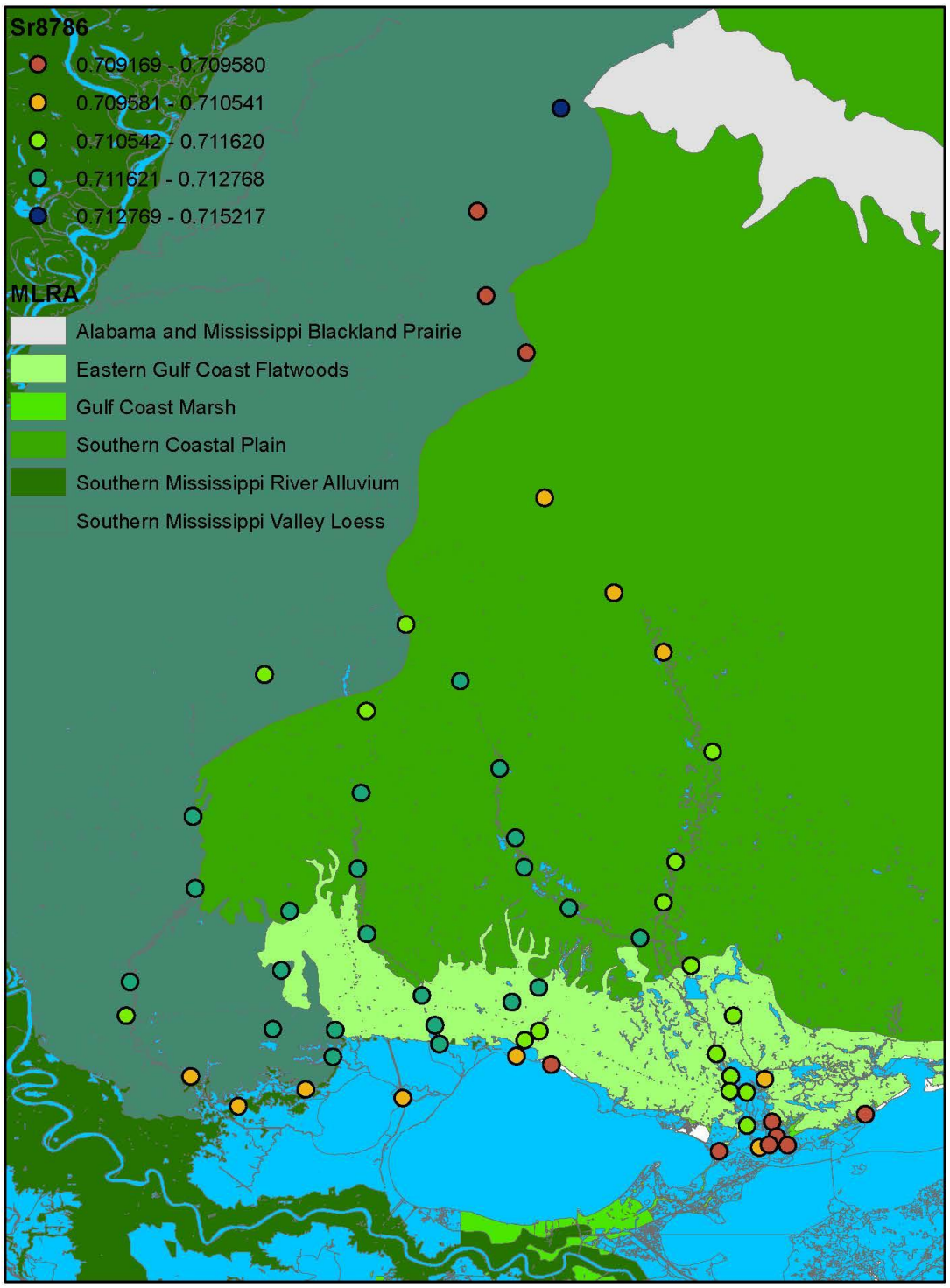


Figure 5. 87Sr/86Sr map

NGI File # 16-NGI3-11

Project Title: Core infrastructure enhancements, operations, and preliminary research activities supporting VORTEX-SE 2017 field campaign activities - Phase 2

Project Lead (PI) name, affiliation, email address: Kevin Knupp, University of Alabama in Huntsville, kevin.knupp@uah.edu

Project objectives and goals

This project included two primary activities:

(A) Provide existing infrastructure, research platforms, and operational support for the 2017 VORTEX-SE (VSE) field campaign operations between March 1 and April 30, 2017
(B) Conduct preliminary VSE data quality control and analysis of data collected during the 2017 VSE field campaign.

This report includes activities under Objective B. Work under Objective A was completed prior to the start of the 12-month reporting period. This project is currently in its second year, for which it was granted an extension. Consequently, the Spring 2017 field campaign activities are not included within this report and the project funds were depleted in December 2017 during a no-cost extension period.

Description of research conducted during the reporting period and milestones accomplished and/or completed

For completeness, project activities during the 9 month period prior to July 1, 2017 included preparing for and executing field campaign activities, including use of the SWIRLL facility for forecasting and research operations during Intense Operational Periods (IOPs), data collection during IOPs and Unofficial Field Operations (UFOs) using the UAH Advanced Radar for Meteorological and Operational Research (ARMOR), Mobile Alabama X-band (MAX) radar, Mobile Integrated Profiling System (MIPS), Rapidly Deployable Atmospheric Profiling System (RaDAPS, Mobile Doppler Lidar and Sounding System (MoDLS), additional soundings from the SWIRLL facility, and a mobile mesonet.

After the field campaign (during this reporting period), data quality control and archival activities were completed as follows: ARMOR and MAX radar data were examined and uploaded to the VORTEX-SE web site at UCAR (http://data.eol.ucar.edu/master_list/?project=VORTEX-SE_2017). Profiler data from the MIPS, RaDAPS, and MoDLS platforms have also been archived.

Research activities during the reporting period included the following:

a) Examination of the observed characteristics of low-level stratocumulus clouds that accompany cool season severe/tornadic QLCS events. Specific topics included average cloud base, cloud fraction, and sub cloud lapse rate, all of which are parameters not accurately simulated by operational mesoscale models (e.g., Cohen et al. 2017). This will be documented in a companion report (NGI file 191001-363513-4B).
b) Investigation of tornadogenesis within cool season QLCS events, in which horizontal shearing instability (HSI) is hypothesized to play an important role. This effort is documented in an M.S. thesis (Conrad, 2017).
c) Case study of an isolated tornado event in central Alabama involving considerable mesoscale variability in both convective available potential energy and low-level shear (storm-relative helicity). This is also documented in NGI file 191001-363513-4B.

Description of significant research results, protocols developed, and research transitions

Research results

Case study of the 1 March 2016 isolated tornado in central Alabama
On March 1, 2016, an EF-2 tornado occurred south of Birmingham, Alabama within a boundary layer environment that was heterogeneous in space and unsteady in time. Typically, a sounding close in time (30 min) and distance (30 km) of a sounding site would be considered an excellent proximity sounding, but in this case the actual sounding and the SPC mesoanalyses significantly underestimated CAPE and wind shear. Tornadogenesis occurred near a weak, but frontogenetical, thermal boundary, where antecedent light showers had also increased dewpoint values. A local maximum in surface dewpoint (and instability) and a local maximum in low-level wind shear (storm-relative helicity) both existed near this boundary. As a pre-existing QLCS moved into this region of higher CAPE air, part of it became supercellular, and tornadogenesis occurred near the center of the local maximum in surface dewpoint shortly thereafter. Details of this case are published in Coleman et al. (2018).

Tornadogenesis within cool-season QLCS via horizontal sheering instability

Dual Doppler observations of two Quasi-Linear Convective Systems (QLCS) were analyzed to determine the role that Horizontal Shearing Instability (HSI) plays in the role of mesovortexgenesis. One QLCS occurred on 4 Jan 2015 and produced a tornado. The second QLCS occurred on 28 Nov 2016 and did not produce any mesovortices. Storm characteristics such as wind speed, wind shift angle, and the contraction of the wind shift are investigated. Rayleigh and Fjrtoft stability criteria, which are required for HSI, are also presented. The criteria presented are satisfied for the 4 Jan 2015 QLCS, but not the 28 Nov 2016 QLCS. Dual polarization signatures such as ZDR columns and ZDR arc/KDP foot separation are reviewed as potential indicators to favored locations for mesovortexgenesis. ZDR columns are shown to be located in locations favorable to mesovortexgenesis while ZDR arc/KDP foot separation showed some correlation with mesovortexgenesis location. Details of this case are documented in a M.S. Thesis by Dustin Conrad (Conrad 2017).

Analysis of stratocumulus clouds accompanying cool-season tornadic QLCS events

This is a continuing effort by a M.S. student, Chris Lisauckis. The goal is to document the characteristics of stratocumulus clouds that commonly occur during cold season tornado events, both from supercells and QLCSs. The preliminary results show that the stratocumulus cloud fraction for QLCS's was 97%, and 83% for supercells. Stratocumulus clouds first appear an average of 200 min (QLCSs) and 90 min (supercell) prior to tornadogenesis. The mean LCL height for all QLCS cases was 660 m for QLCS, and 650 m for supercell cases. The sub cloud lapse rate also appears to be stable, as indicated by ceilometer and microwave profiling radiometer measurements. Thus, the boundary layer does not fit into the classical model of the cloud-topped mixed layer, in which the sub cloud layer exhibits a dry adiabatic lapse rate. Thus, large bulk shear magnitudes of 14 and 18 m/s can be maintained within the respective 0-0.5 km and 0-1.0 km layers due to the suppression of turbulent mixing (buoyant generation term in the TKE equation is negative, and therefore suppresses turbulence).

References

1. Coleman, T. A., A. W. Lyza, K. R. Knupp, K. Laws, and W. Wyatt, 2018: A significant tornado in a heterogeneous environment during VORTEX-SE. Electronic J. Severe Storms Meteor., **12**, in preparation.
2. Conrad, D.M., and K. R. Knupp, 2017: The Role of Horizontal Shearing Instability in Mesovortexgenesis in the 04 January 2015 Quasi-Linear Convective System. Oral presentation, 38th Conference on Radar Meteorology, 28 August – 1 September 2017, Chicago, AMS.
3. Conrad, D.M., 2017: Doppler Radar Observations Of Horizontal Shearing Instability In Quasi-Linear Convective Systems. M.S. Thesis, University Of Alabama In Huntsville, 68 pp.

NGI File # 16-NGI3-13

Project Title: Continuation of Comparative Metagenomics to Indicate Sites Under Anthropogenic Pressure: Year 2

Project Lead (PI) name, affiliation, email address: Shiao Wang, University of Southern Mississippi shiao.wang@usm.edu

Project objectives and goals

Despite the many emerging applications of 'omics for marine science and commerce, our ability to supply bioinformatics expertise has not kept pace with the generation of sequence data. This has created a data backlog that hinders transition of data collected into actionable information. The primary goal of this project is to address this gap by analyzing ’omics datasets that address numerous aspects of the NOAA mission, developing bioinformatics workflows for transition to project applications, developing bioinformatics capacity through training and community resources, and working with international partners to develop the next generation of ’omics monitoring standards.

Dr. Luke Thompson, a recognized expert in the analysis of microbial communities, is the chief scientist on the project addressing the following specific objectives:

1. Develop and assess multi-omics bioinformatics workflows for transition to ’omics projects.

2. Apply workflows to characterize microbial communities in the Gulf of Mexico, the California Current, the Great Lakes, other aquatic environments, and the global microbiomes of Earth.

3. Provide training and community resources to develop NOAA’s bioinformatics expertise.

4. Engage with academic and governmental bodies from the U.S., Europe, and beyond to develop and promote metadata and data standards critical for inter-operability and environmental contextualization of ’omics data streams.

Description of research conducted during the reporting period and milestones accomplished and/or completed

During the past year, Dr. Thompson has developed workflows for analysis of marker gene (amplicon sequencing) data from a variety of marker genes, from bacteria to fish. Additionally, multi-omic analysis methods are being developed, for example, to simultaneously analyze metagenomic (whole-DNA) and metabolomic (whole-metabolite) data from the same set of samples. These workflows have been compared to other workflows in two separate cross-comparison benchmarking studies. Our workflows have been used in a range of studies, from the open ocean to mammal guts to a massive set of environmental microbiomes (as described in the results summary, below). In the coming year, these workflows will be implemented in our work on metagenetics, metagenomics, and environmental DNA (eDNA) in the California Current and Great Lakes. Dr. Thompson is also providing his bioinformatics and marine microbiology expertise to analyze and publish two older datasets from the Gulf of Mexico. One contains data from the Gulf of Mexico water column prior to the Deepwater Horizon spill and will help determine to what degree hydrocarbon-degrading microbes were present before the spill. The other dataset comes from the microbiome of a rare deep-sea polychaete invertebrate, the methane ice worm, which possesses unique abilities for hydrocarbon utilization and other metabolic processes.

Description of significant research results, protocols developed, and research transitions

The results of Dr. Thompson’s research on marine and terrestrial microbial communities have yielded several publications over the past year. Dr. Thompson was the lead author of a *Nature* paper (Thompson et al., 2017, DOI: 10.1038/nature24621) on the Earth Microbiome Project. This massive survey of

microbiomes from across Earth revealed some of the basic principles driving microbial community structure on our planet. This study also created a database of microbial samples and sequences and a framework for investigating further patterns, which will benefit our efforts to understand aquatic systems important in NOAA's mission. For example, the Ocean Sampling Day project, which Drs. Thompson, Goodwin, and Wang are involved with, has benefitted from the 'microbial trading cards' and source-tracking approach used in the Earth Microbiome Project.

Two additional studies of marine microbes have benefited from Dr. Thompson's bioinformatics expertise, both involving whole DNA sequencing, or "shotgun metagenomics", of microbial communities. One study examined the differential aerosolization of bacteria and viruses in sea spray, which was recently published in *Nature Communications* (Michaud et al., 2018, DOI: 10.1038/s41467-018-04409-z). The results show that certain bacterial taxa are better aerosolized, and viruses in general are less well aerosolized. This helps us identify taxa relevant to atmospheric processes and a framework to further elucidate aerosolization mechanisms influencing microbial and viral transport pathways. A study of Red Sea metagenomes has provided insight to the taxa responsible for nitrogen metabolism in the ocean. This study, published in *FEMS Microbiol Ecol* (Kharbush et al., 2018, DOI: 10.1093/femsec/fiy063), helps shed light on the producers of a major marine biomarker: hopanoid producers are taxonomically affiliated with the major marine nitrite oxidizers, *Nitrospinae* and *Nitrospirae*. These results suggest that the relationship between hopanoid production and nitrite oxidation is conserved across varying biogeochemical conditions in dark ocean microbial ecosystems.

Dr. Thompson's work has also touched on the gut bacteria of animals, a research area of growing interest. He analyzed a dataset of gut microbiomes from voles inside and outside of the Chernobyl Exclusion Zone to help understand the effects of radiation on the mammal gut microbiome. This study, published in *The ISME Journal* (Lavrienko et al., 2018, in press), is the first to quantify how the gut microbiome of wild animals is affected by exposure to environmental pollutants. Dr. Thompson was also a co-author on a massive crowd-sourced human gut microbiome project, the American Gut Project, published in *mSystems* (McDonald et al., 2018, DOI: 10.1128/mSystems.00031-18), and a study of whether phylogeny or diet better predicts the gut microbiome in primates, published in *The ISME Journal* (Amato et al., 2018, in press).

Information on collaborators / partners

a. Name of collaborating organization: NOAA AMOL
b. Date collaboration established: September 1, 2013
c. Does partner provide monetary support to project? Indirectly. Support is provided through a NOAA cooperative agreement to NGI.
d. Does partner provide non-monetary (in-kind) support? Yes, NOAA partners helped with research prioritization and design.
e. Short description of collaboration/partnership relationship: Regular contact by telephone and email to discuss projects and allocation of time/effort by research personnel. We also discuss outreach activities and new training opportunities.

We have a number of collaborators both nationally and internationally. For example, Rob Knight at UC-San Diego is a world-renowned microbiome scientist and our main collaborator on the Earth Microbiome Project. Andy Allen at the J. Craig Venter Institute is our main collaborator on the California Current microbiome project (NCOG). Collaborators on eDNA projects include scientists at the Monterey Bay Aquarium Research Institute, NOAA's Southwest Fisheries Science Center (SWFSC), and researchers that are part of the Marine Biodiversity Observing Network (MBON). We continue to work with groups in Europe on Ocean Sampling Day and Global 'Omics Observatories.

Information on any outreach activities

Dr. Thompson has been involved in multiple teaching activities over the past year, which have enabled him to transfer bioinformatics and computational skills to the next generation of scientists. He developed an online data science course called Python For Data Analysis, which is hosted on GitHub

(https://github.com/cuttlefishh/python-for-data-analysis) and YouTube (https://www.youtube.com/channel/UCVZrIrWtcvTzYlrNx7RcDyg), having over 440 subscribers.

Dr. Thompson co-taught two short courses on bioinformatics analysis:

a. SIO Transcriptomics Workshop, Scripps Institution of Oceanography, October 2017
b. Advanced Bioinformatics for Metagenomics and Population Genomics, University of Oulu, Finland, March 2018

Dr. Thompson participated in two workshops on bioinformatics:

a. TDWG 2017: Biodiversity Information Standards, Ottawa, Canada, October 2017 – He co-chaired a session called "Towards robust interoperability in multi-omic approaches to biodiversity monitoring". This meeting laid the foundation for the 'Omic Biomonitoring Workshop held in February 2018 (below).
b. 'Omic Biomonitoring Workshop, Max-Planck-Institute for Marine Microbiology, Bremen, Germany, February 2018 – This was the first workshop in a series dedicated to enhancing the interoperability and coordination of long-term observatories with 'omic capabilities. The objective of these workshops is to facilitate the creation of a well-integrated, global network of 'omic observatories delivering coherent insight into ecosystem health and functioning. As an international task force, we are creating a strongly collaborative consortium sharing data, methods, calibration standards, and vision. Collectively we seek to interface with national and international biomonitoring frameworks as well as standards communities to shape a more coherent and sustainable future for 'omic observation.

Publications and Presentations

Amato, K.R., J.G. Sanders, S. Song, M. Nute, J.L. Metcalf, L.R. Thompson, J.T. Morton, A. Amir, V. McKenzie, G.Humphrey, G. Gogul, J. Gaffney, A. Baden, G. Britton, F. Cuozzo, A. Di Fiore, N. Dominy, T. Goldberg, A. Gomez,M.M. Kowalewski, R. Lewis, A. Link, M. Sauther, S. Tecot, B. White, K. Nelson, R. Stumpf, R. Knight & S. Leigh. "Evolutionary trends in host physiology outweigh dietary niche in structuring primate gut microbiomes." 2018. *The ISME Journal.* (In Press)

Kharbush, J.J., L.R. Thompson, M.F. Haroon, R. Knight & L.I. Aluwihare. 2018. "Hopanoid-producing bacteria in the Red Sea include the major marine nitrite-oxidizers." *FEMS Microbiology Ecology.*

Knight, R., A. Vrbanac, B.C. Taylor, A. Aksenov, C. Callewaert, J. Debelius, A. Gonzalez, T. Kosciolek, L. McCall,D. McDonald, A.V. Melnik, J.T. Morton, J. Navas, R.A. Quinn, J.G. Sanders, A.D. Swafford, L.R. Thompson, A.Tripathi, Z.Z. Xu, J.R. Zaneveld, Q. Zhu, J.G. Caporaso & P.C. Dorrestein. 2018 "Best practices for analyzing microbiomes" *Nature Reviews Microbiology.*

Lavrinienko, A., T. Mappes, E. Tukalenko, T.A. Mousseau, A.P. Møller, R. Knight, J.T. Morton, L.R. Thompson & P.C. Watts. "Environmental radiation alters the gut microbiome of the bank vole Myodes glareolus." 2018. *The ISME Journal*. (In Press)

McDonald, D., E.R. Hyde, J.W. Debelius, J.T. Morton, A. Gonzalez, G. Ackermann, A.A. Aksenov, B. Behsaz, C. Brennan, Y. Chen, L. DeRight-Goldasich, P.C. Dorrestein, R.R. Dunn, A.K. Fahimipourg, J. Gaffney, J.A. Gilbert,G. Gogul, J.L. Green, P. Hugenholtz, G. Humphrey, C. Huttenhower, M.A. Jackson, S. Janssen, D.V. Jeste, L.Jiang, S.T. Kelley, D. Knights, T. Kosciolek, J. Ladau, J. Leach, C. Marotz, D. Meleshko, A.V. Melnik, J.L. Metcalf, H. Mohimani, E. Montassier, J. Navas-Molina, T.T. Nguyen, S. Peddada, P. Pevzner, K.S. Pollard, G. Rahnavard, A. Robbins-Pianka, N. Sangwan, J. Shorenstein, L. Smarr, S. Song, T. Spector, A.D. Swafford, V.G. Thackray, L.R. Thompson, A. Tripathi, Y. Vazquez-Baeza, A. Vrbanac, P. Wischmeyer, E. Wolfe, Q. Zhu, The American Gut Consortium & R. Knight. 2018. "American Gut: an open platform for citizen-science microbiome research." *mSystems.*

Michaud, J.M., L.R. Thompson, D. Kaul, J. Espinoza, R.A. Richter, Z.Z. Xu, C. Lee, K.M. Pham, C.M. Beall, F. Malfatti, F. Azam, R. Knight, K.A. Prather, C.L. Dupont & M.D. Burkart. 2018. "Taxon-specific

aerosolization of bacteria and viruses in an experimental ocean–atmosphere mesocosm." *Nature Communications*.

Thompson, L.R., J.G. Sanders, D. McDonald, A. Amir, J. Ladau, K.J. Locey, R.J. Prill, A. Tripathi, S.M. Gibbons,G.Ackermann, J.A. Navas-Molina, S. Janssen, E. Kopylova, Y. Vazquez-Baeza, A. Gonzalez, J.T. Morton, S. Mirarab, Z.Z. Xu, L. Jiang, M.F. Haroon, J. Kanbar, Q. Zhu, S. Song, T. Kosciolek, N.A. Bokulich, J. Lefler, C.J. Brislawn, G.C. Humphrey, S.M. Owens, J. Hampton-Marcell, D. Berg-Lyons, V. McKenzie, N. Fierer, J.A. Fuhrman, A. Clauset, R.L. Stevens, A. Shade, K.S. Pollard, K.D. Goodwin, J.K. Jansson, J.A. Gilbert, R. Knight & The EarthMicrobiome Project Consortium. 2017. "A communal catalogue reveals Earth's multiscale microbial diversity." *Nature.*

NGI File # 17-NGI3-17

Project Title: Continuation of Secure Archival Storage for NOAA/NMFS Preserved Specimens at USM's Plankton Archival Facilities

Project Lead (PI) name, affiliation, email address: Monty Graham, University of Southern Mississippi, monty.graham@usm.edu

Description of research conducted during the reporting period and milestones accomplished and/or completed

This project covers space rental costs of two bunkers located at Stennis Space Center for NOAA to store/archive samples as part of a continuing arrangements.

NGI # 17-NG13-18

Project Title: Improvements to TAO Delayed-Mode Data Processing: Phase II Enhancements

Project Lead (PI) name, affiliation, email address: Pat Fitzpatrick, Mississippi State University, fitz@gri.msstate.edu

Co-PI name, affiliation, email address: Yee Lau, Mississippi State University, lau@gri.msstate.edu

Project objective and goals

The Tropical Atmosphere Ocean (TAO) array (renamed the TAO/TRITON array in 2000) consists of approximately 50-70 moorings in the Tropical Pacific Ocean, telemetering oceanographic and meteorological data to shore in real-time via the Argos satellite system. The array is a major component of the El Niño/Southern Oscillation (ENSO) Observing System, the Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS). The data is available from the National Data Buoy Center (NDBC) at: http://tao.ndbc.noaa.gov.

Existing procedures to process the 55 delayed-mode TAO data currently requires numerous legacy programs in different programming languages, and in multiple machines with different operating systems residing at separate physical locations within the NDBC's Mission Control Center (MCC). This process is fragmented, labor-intensive, and can also cause errors in the input. A unified JAVA GUI-based TAO delayed-mode data processing and quality control software package was delivered in a previous NGI project (File Number: 16-NG12-139). This new software package in Windows 7 operating system significantly reduces data processing time and operator errors. However, additional improvements, including the current meter data processing, long-wave radiation and rain data processing, out-of-range pressure flagging, log and output file adjustments, default setting updates, and throughout software testing were still needed. This phase II project targeted these required enhancements to create a bona fide accurate, reliable, and effective software package to replace the existing tedious procedures entirely.

Description of research conducted during the reporting period and milestones accomplished and/or completed

During the project period of July 1, 2017 – September 30, 2017, Yee Lau met with NDBC MCC Data Analysts every week and periodically provided the software package in reasonable developmental stages to get timely feedback for the enhancements. The iterative process of meetings, software development, email exchanges, and NDBC staff testing continued throughout the entire project period, resulting in a user-friendly and comprehensive TAO delayed-mode data processing and quality control software package. This package provides a convenient JAVA GUI-based master application for the data analyst to access and control all other (legacy or new; MATLAB, JAVA or PERL) scripts and applications.

The accomplished Phase II enhancements included the following:

- Modified existing format of processing events log
- Updated and enhanced the GUI defaults and user-interface
- Corrected the "find_low_press" flagging script
- Incorporated the current velocity data processing from point-source current meters (the Sontek)
- Completed the longwave radiation processing
- Corrected the "calibrate_ts" processing hanging problem
- Finalized rain processing procedures and corrected MATLAB loading problem
- Added capabilities to save and export data and metadata
- Tested and debugged entire software package
- Provided a comprehensive software package user guide

Description of significant research results, protocols developed, and research transitions

A unified user-friendly GUI, known as TaoGUI, has been developed for the Windows 7 operating system as the gateway to the existing TAO delayed-mode data processing and quality control programs. The free and popular open source NetBeans IDE and Java Scene Builder applications have been used to facilitate rapid GUI prototyping as well as software program development and management. This Java GUI requires a main configuration file to set up default directories and variables, and an SQL configuration file to connect to the MYSQL database. It utilizes a cascading style sheet (css) to provide a convenient way to customize the look and feel of the GUI.

The GUI has 3 main sections. The top section displays the current user name, the current selected station and deployment information, and 7 convenient action buttons. These buttons allow the user to look at a summary log, flag data, transfer final data files to web-staging area, send email to TAO group members, clear the message area, stop the current process, and read the user guide.

The middle section is the main processing area. It contains 12 main task (tab) pages and 13 sub-task pages. Each tab page (except the very 1st one) corresponds to an existing TAO delayed-mode data processing step. In general, each tab page (processing step) should be completed in sequence according to its order of appearance in the tab page. The color rectangle around each tab label indicates if the tab page has been processed before. The default colors are red for unprocessed tabs, and yellow for processed tabs. The 12 main tasks and 13 sub-tasks are as follows:

1. “Station/Deployment”
2. “copy_lab”
3. “Preprocess” (sub-tasks: “concat_tube”, “viewArgonaut”, “get_calfile”)
4. “Create ram files” (sub-tasks: “processRefresh”, “current meter”)
5. “trim”
6. “Plotting” (sub-tasks: “plotmod”, “plottube”, “plotsontek”, “plotsalc”)
7. “Editing” (sub-tasks: “taoedit”, “editRainData”)
8. “Pressure” (sub-tasks: “find_low_press”, “editFlagForSontek”)
9. “flag”
10. “calibrate”
11. “reformat”
12. “davg”

The bottom section has a message area which displays GUI status as well as the program output and error messages.

Detailed description of the TaoGUI and each TAO delayed-mode data processing step can be found in the documentation “TAO Delayed-Mode Data Processing Graphical User Interface User Guide”. The TaoGUI and the user guide are proprietary to NDBC.

Collaborators/partners

Karen Grissom, Matthew Winterkorn, Daniel Pounder, Robert Weir (NDBC)

Outreach activities
Not applicable.

Economic activities
Not applicable.

NGI File # 17-NG13-19

Project Title: NOAA Weather Information and Dissemination All Hazards Stakeholder Needs Assessment Verification Project

Project Lead (PI) name, affiliation, email address: Laura Myers, The University of Alabama, laura.myers@ua.edu

Project objectives and goals

The NOAA Office of Dissemination is evaluating the use and applications of NOAA Weather Radio All Hazards to determine user requirements to transform the current NOAA Weather Radio All Hazards broadcast network into a new integrated weather information distribution/dissemination system. A significant component of this evaluation involves stakeholder engagement at all levels of the weather enterprise. The SME/PI will provide high-level research and evaluation guidance and support to the Office of Dissemination (DIS) team for the specific engagement of stakeholders relevant to the evaluation of the NWR.

Description of research conducted during the reporting period and milestones accomplished and/or completed

Prior to October 1, 2017, Dr. Myers developed a strategy to obtain NWR user needs from relevant stakeholders to provide input on (1) future system requirements, (2) potential technologies to augment and/or replace obsolete equipment, and (3) design and engineering scope. The strategy incorporates the protocol for the research design to reach and engage with various identified types of stakeholders—including the methods for data collection: (1) on-line surveys, (2) phone contact, and (3) in-person modalities. This strategy was used to collect extensive amounts of data starting in August 2016 to develop multiple reports for the Office of Dissemination.

Since July 2017, we have:

- Continued to collect data from stakeholders as directed by the Office of Dissemination and conducted multiple case studies to do in-depth analyses of events by location: Georgia tornadoes 2017, Mississippi tornadoes 2017, California mudslides 2018, Hurricane Harvey in Texas 2018, Hurricane Irma in Florida 2018, Hurricane Maria in Puerto Rico 2018.
- Attended December 2017 Partners' meeting at request of Office of Dissemination to discuss modalities and provide research results in discussion.
- Developed business case analysis framework at request of Office of Dissemination for future use.
- Conducted analyses of modalities to determine functional alternatives for dissemination: Everbridge alert notifications, Alert FM, weather mobile apps, sirens, WEA alerts, social media.
- Conducted in-depth analysis of Everbridge in Tuscaloosa.
- Conducted workshops with vulnerable populations in Tuscaloosa to determine their usage of modalities and to educate on alert notification.

Description of significant research results

<u>July 1, 2016-June 30, 2017</u>

- Began data collection in August 2016 and engaged in extensive phone and in-person interviews, focus groups, and workshops to collect data.
- Developed and presented Phase 1 report of stakeholder needs in October 2016.
- Engaged in multiple webinars on report for feedback from Dr. Brown's team.
- Developed and presented Phase 1 results for AMS Partners meeting in January 2017.
- Continued data collection with new partner groups and started revisting original respondents with Phase 1 results for their feedback.

- Developed functional requirements gap report and presented to Team in March 2017.
- Conducting case studies of actual events to study modalities, February 2017 to present.
- Developed models of dissemination report in June 2017.

July 1, 2017-June 30, 2018

- Info graphics developed on stakeholder engagement activities, to include type of stakeholders reached, different geographical locations focused on, different hazards focused on, any special modalities focused on.
- Created presentation for use by Office of Dissemination with infographics and research results.
- Brief report of the completed case studies highlighting key findings. Including, differing views and opinions of NOAA weather radio, identifying what sector and location those views are held in. Case studies of 2017 Georgia tornadoes, 2017 Mississippi tornadoes, 2018 California debris flows, and the Fall 2018 hurricanes. Highlighted phenomenon discovered such as the increase of NOAA weather radio usage/purchases during Harvey/Irma/Maria.
- Developed business case analysis framework for future use.
- Continued to conduct stakeholder engagement to test and garner support for changes to the warning process system. Conducted additional analyses and case studies of these systems in transition to help inform the modification processes.
- Conducted data collection at the National Weather Association Conference in Annaheim, California, September 2017.
- Conducted multiple meetings with Alert FM to study this alternative modality.
- Worked with Office of Dissemination team on a bi-weekly basis to integrate study results into their evolving process.
- Poster presentation at NWA 2017 and oral presentation at AMS 2019.

Information on collaborators / partners (if applicable):

Tyra Brown, National Weather Service
Susan Jasko, California University of Pennsylvannia
Sara Gallman, CAPS, The University of Alabama

Information on any outreach activities:

- Provided Phase 1 results on modality functionalities to meteorologists in the field seeking to improve warning dissemination to vulnerable and impacted populations.

Economic Development Activities: N/A

Publications and Presentations

Traffic Records Forum. New Orleans, LA, August 7, 2017, Title: Law Enforcement Storm Spotter Information Sharing for Transportation Management during Weather Events." (Conference Proceedings)

NAPSG Conference, Tuscaloosa, AL, August 8, 2017, Title: Innovations in Public Safety Technology (Conference Proceedings)

WeatherBrains Webcast. September 12, 2017, Title: Weather Brains 608: Warning Modalities and Hurricane Messaging. (Presentation)

National Weather Association Conference. Garden Grove, CA, September 19, 2017, Title: The Weather Warning Communications Process and the Role of Warning Modalities. (Presentation)

VORTEX-SE Workshop. Huntsville, AL, November 16, 2017 – November 17, 2017, Title: Collaborative Research: Understanding How Uncertainty in Severe Weather Information Affects Decisions. (Workshop Proceedings)

Alabama Vortex-SE Focus Group. Huntsville, AL, November 28, 2017, Title: Jefferson County Focus Group on Warning Modalities and the Warning Process. (Presentation)

Office of Dissemination Partners Meeting. Silver Springs, MD, December 5, 2017 – December 7, 2017, Title: Warning Modalities Research Results. (Presentation)

American Meteorological Society Conference. Austin, TX, January 7, 2018 – January 11, 2018, Title: Warning Received: The Use of Weather Warning Tools and Impact Based Decision Support Services. (Conference Proceedings)

NGI File # 17-NGI3-20

Project Title: Climate Variability in Ocean Surface Turbulent Fluxes

Project Lead (PI) name, affiliation, email address: Dr. Mark A. Bourassa, Center for Ocean-Atmospheric Prediction Studies, Florida State University, bourassa@coaps.fsu.edu

Co-Principal Investigator name, affiliation, email address: Mr. Shawn R. Smith, Center for Ocean-Atmospheric Prediction Studies, Florida State University, smith@coaps.fsu.edu

Project objectives and goals

FSU produces fields of surface turbulent air-sea fluxes and the flux related variables (winds, SST, near surface air temperature, near surface humidity, and surface pressure) for use in global climate studies. Surface fluxes are, by definition, rates of exchange, per unit surface area, between the ocean and the atmosphere. Stress is the flux of horizontal momentum (imparted by the wind on the ocean). The evaporative moisture flux would be the rate, per unit area, at which moisture is transferred from the ocean to the air. The latent heat flux (LHF) is related to the moisture flux: it is the rate (per unit area) at which energy associated with the phase change of water is transferred from the ocean to the atmosphere. Similarly, the sensible heat flux (SHF) is the rate at which thermal energy (associated with heating, but without a phase change) is transferred from the ocean to the atmosphere. The SHF directly changes the temperature of the air whereas the LHF releases energy only after the water vapor condenses. In the tropics, the latent heat flux is typically an order of magnitude greater than the sensible heat flux; however, in the polar regions the SHF can dominate.

FSU produces both monthly in-situ based and hybrid satellite/numerical weather prediction (NWP) fields of surface winds (the 'FSU Winds') for the tropical Pacific and Indian Oceans. We are also developing a much higher quality surface flux product that assimilates satellite and in situ data. Our long-term monthly fields are well suited for seasonal to decadal studies. They are available in time for monthly updated ENSO forecasts, within eight days after the end of the month. The flux-related variables are useful for ocean forcing in models, testing coupled ocean/atmospheric models, ENSO forecasts, and for understanding some aspects of climate-related variability.

The tasks pertain to the continued development/production of products and the dissemination of scientific results. We continue to routinely produce the operational FSU tropical Pacific and Indian Ocean products in compliance with GCOS climate principles.

Work Plan and Deliverables throughout the project are:

1. Continue operation production of the 2˚ Tropical Pacific and 1˚ Tropical Indian Ocean FSU wind products.
2. Develop a multi-satellite (over water) wind product
3. Design a satellite-based flux product, based on (2)
4. Engage new users of (2) and (3)
5. Continue interaction with national and international satellite and in situ wind groups
6. Continue interaction with national and international flux groups

Description of research conducted during the reporting period and milestones accomplished and/or completed

Progress on these deliverables specifically target the *program deliverables related to sea surface temperature, surface currents (via wind observations), and the air-sea exchanges of heat, momentum, and freshwater.* The DAC strives to make high-quality fields of surface turbulent fluxes readily available to the research and operational marine climate community. We produced the Pacific and Indian Ocean FSU Winds products with 100% success in meeting our timeliness goal. Improved data returns from the

TOA/TRITON array almost certainly positively impacted the quality of the tropical Pacific Ocean product. The data-related problem in the Indian Ocean, associated with a lack of sampling in the northwestern Indian Ocean due to fears of piracy, has diminished resulting in more observations from this region. Our prior examination of this problem found an enormous impact on the accuracy of in situ-based products in this region (Smith, et al 2011), and we now see the sampling improving.

The FSU fluxes support a broad user community. Our web data portal currently shows ~170 registered users from 16 countries. Users are from academic institutions (57), governmental agencies (30), public/non-profit entities, and the military. Although we do not track the users applications, we know that many are using the FSU winds and fluxes to support tropical SST forecast models (e.g., LDEO model; http://rainbow.ldeo.columbia.edu/~dchen/forecast.html). Fisheries managers abroad (e.g., France's IRD) make use of all our wind products. Discussions with a major user at IRD indicated continued high value in the products.

Our satellite winds are currently undergoing a vast improvement. We have coupled a log-layer model with an Ekman layer model to a geostrophic winds model. Preliminary testing indicates that all the desired physics are represented in the new model, and that the model works globally. We have begun nearly completed comparison of this boundary-layer model with the University of Washington PBL model. This is a major milestone in the development of this product, indicating solving of the single greatest barrier to success. The satellite sensible and latent heat fluxes will continue to be in a development phase, pending implementation of the above model as a soft constraint in our objective analysis. We have made little progress in this integration with the code for our objective analysis of winds and fluxes because the time had to be spent updating the code for the in situ winds (the current code runs only on an old server that is beyond its expected life.

Description of significant research results, protocols developed, and research transitions

We have resolved several issues with the transfer of the FSU Winds products to a modern server. These products continue to be produced in a timely fashion.

We have had several major breakthroughs related to surface fluxes. Through guidance of a student that was supported through other sources we have checked surface stress parameterization in a three-way coupled ocean-wave-atmosphere model. We were able to address three very topical questions in ocean and atmosphere modeling as a bi-product of this study:

1) Does the (modeled) atmosphere respond to small spatial scale ocean surface variability (stratification, waves and currents)?
2) Does the ocean respond to these changes (if any) in the atmosphere?
3) Does resolution matter?

The answers to each of these questions is a strong 'yes,' at least for the modified coupled ROMS, SWAN and WRF system (Shi 2017).

We found that the consideration of currents in the calculation of surface stress was critical for coupling the ocean and atmosphere, and that related changes in the sea state had smaller impact. Considering sea state alone had a larger impact, but the pattern of stress appears to be unrealistic.

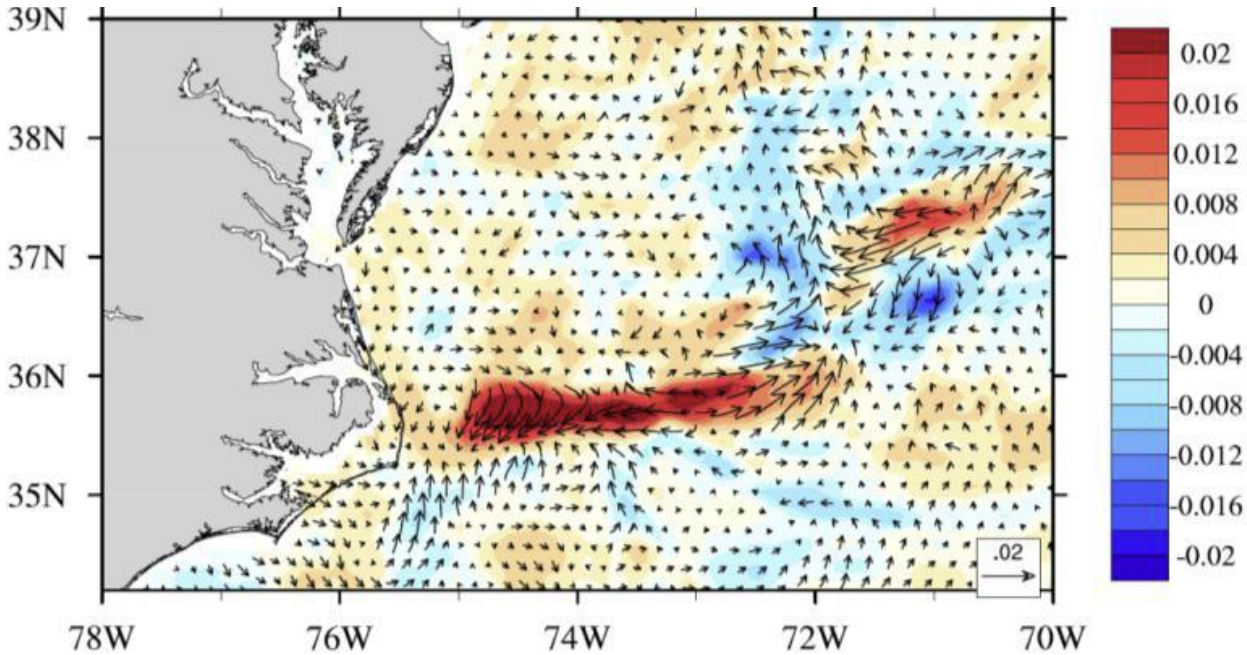


Fig. 1. Changes in stress due to including sea state and currents in the calculation of stress in a two-way coupled model. These changes are relatively small, but the gradients can be quite large where the gradient in the current is large.

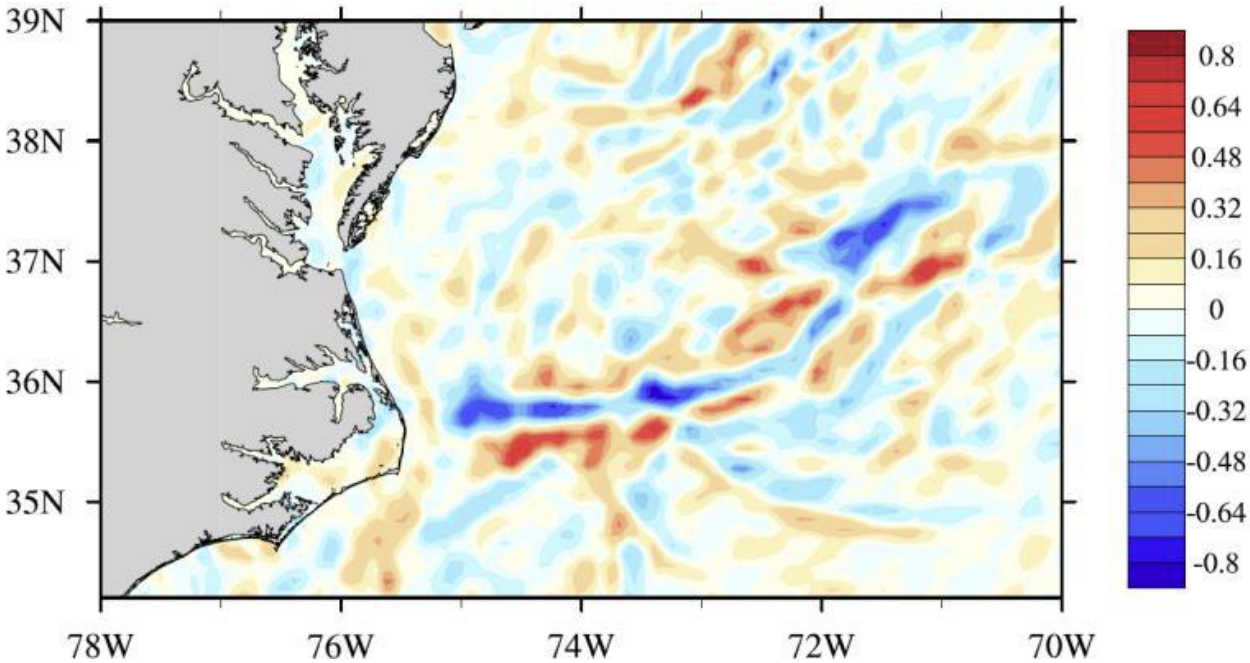


Fig. 2. The influence of currents, in a two-way coupled model, were needed to greatly strengthen the positive and negative curl seen on the sides of a major current, resulting in much stronger Ekman pumping (m/s).

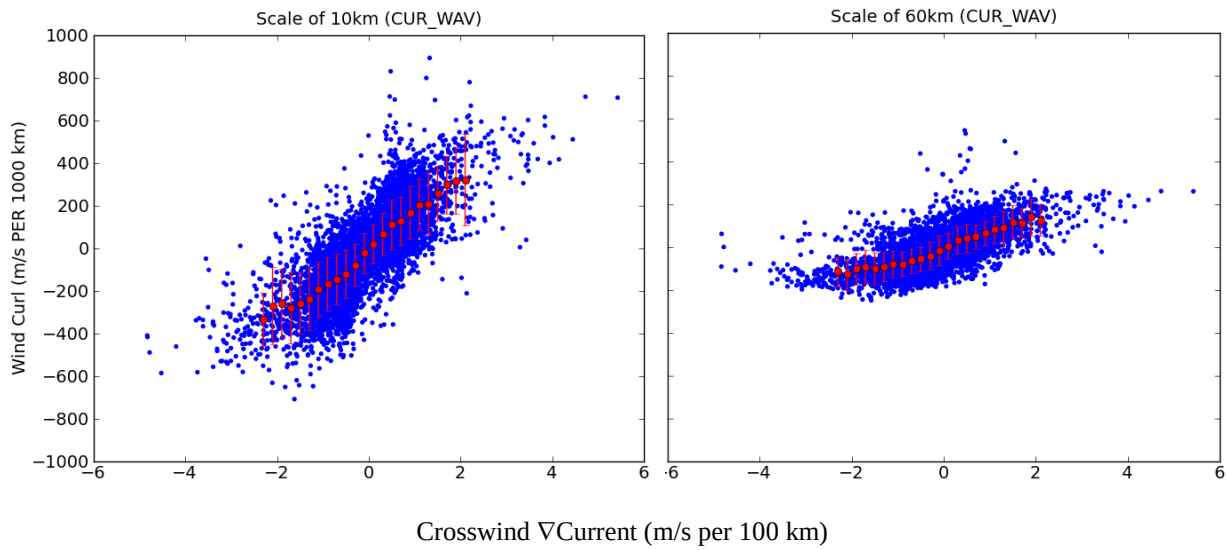


Fig. 3. The curl of the wind as a function of the crosswind gradient of the current. This is a very strong coupling compared to the dependence of the curl of winds on SST gradients. However, it is highly dependent on the scale over which the curl is calculated. The left image has curl calculated at a 10 km scale (typical of very high resolution regional models), while the right image is a 60km scale (better than for climate models).

The currents and upwelling cause changes in the surface stress through changes in wind shear and boundary-layer stratification. The changes in stress due to changes in stratification are similar and a little greater than the changes due to wind shear, but usually in the opposite direction: the changes in stress due to thermodynamics are important. These thermodynamics come about from changes in the mixed layer energy budget, with large changes to vertical transport, horizontal transport, and entrainment at the bottom of the mixed layer. These changes are closely tied to the changes in the curl of the stress, for which the atmospheric response plays important roles.

The atmospheric response includes an increase in the amount of water vapor in the water column and related changes in the radiative fluxes and surface turbulent heat fluxes. These changes can exceed 30 Wm^{-2} in a monthly average (only one month was examined in this study). Median magnitudes are shown in Fig. 4.

Discussions with colleagues at AOML have suggested ideas for attempting to validate the ocean portion of these findings. In the future, we will use comparisons to satellite data to examine some of the atmospheric findings (i.e., the curl of the stress).

These results show the great importance of two-way coupling between the ocean and the atmosphere and the importance of currents and wind stress curl in the physical processes causing this coupling. Observations will capture how two-way coupling changes the atmosphere and ocean when they have sufficient sampling and resolution to resolve sufficient detail. These findings emphasize the importance of including scales finer than 25 km in ocean forcing, and the construction of gridded products.

With another student we have begun examination of the 10-20 day mode of variability in the Indian Ocean. This mode of variability has been found to be very important in its association with monsoon rains over India. This is the first study to focus on surface winds and uses satellite-derived winds. Preliminary findings indicate that this mode of variability is much weaker during years with light monsoon rains than years with heavy monsoon rains.

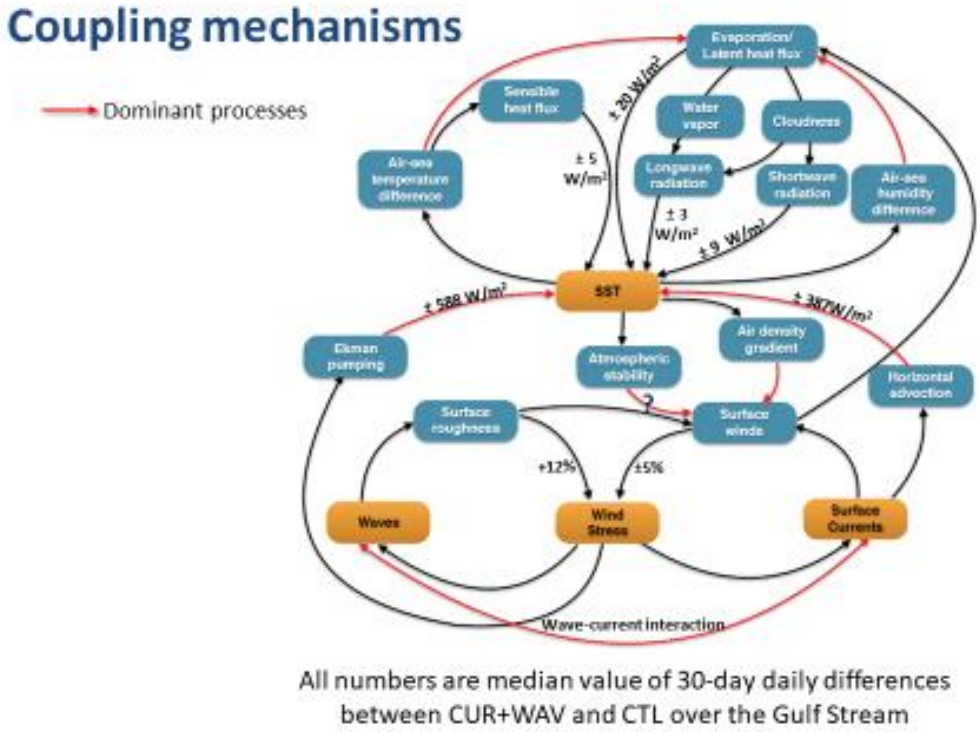


Fig. 4. Coupling mechanisms and changes between the coupled model with stress dependent on currents and sea state relative to the model with stress independent of currents and sea state. Note the substantial changes in surface fluxes including radiative fluxes.

Information on collaborators / partners (if applicable):

The coupled modeling results have been presented at several meetings and discussed with Rick Lumpkin and Molly Baringer at NOAA/AOML. Several approaches to validating the model results were discussed, as well as possible future activities.

Information on any outreach activities (if applicable)

1. We presented our findings on coupled ocean-wave-atmosphere modeling at several meetings and interacted with attendees.

2. Results were presented at a NOAA laboratory and discussed with NOAA researchers.

3. The PI Co-chaired or organized meetings and sessions on topics closely tied to the observing system.

4. The Co-PI is Co-Chair of the Ship Observation Team (SOT)

Work with students and schools

I have advised two graduate students: Qi Shi (Ph.D, 2018) and Heather Roman-Stork (MS, to be completed in 2018) on projects that are tied to surface winds and fluxes.

Publications and Reports

Publications by Principal Investigators

Published

Bentamy, A., Piollé, J. F., Grouazel, A., Paul, F., Azelmat, H., Mathieu, P. P., Schuchmann, K. V., Sathyendranah, S., King, H. E., Danielson, R., Esau, I., Johannessen, J., Gulev, S., Clayson, C. A., Pinker, R., Grodsky, S., Bourassa, M., Smith, S. R., Haines, K., Valdivieso, M., Merchant, C., Chapron, B., Anderson, A., Hollmann, R., & Simon, J., 2017: global oceans. *Remote Sensing of Environment*, **201**, 196-218. DOI: 10.1016/j.rse.2017.08.016

Shi, Q. 2017: Coupling ocean currents and waves with wind stress over the Gulf Stream. Ph.D. Dissertation, Florida State University

Technical reports

Bourassa, M.A. and Q. Shi, 2017: Wind, current, wave, and stress coupling in the boundary layer. Report submitted to the National Academies workshop on the future of boundary-layer observations.

References

Shi, Q. 2017: Coupling ocean currents and waves with wind stress over the Gulf Stream. Ph.D. Dissertation, Florida State University

Smith, R.S., **M.A. Bourassa**, and M. Long, 2011: Pirate attacks affect Indian Ocean climate research. *Eos*, **92**, 225-226.

NGI File # 17-NGI3-21

Project Title: Determination of Movement Patterns and Reproductive Status of Adult Smalltooth Sawfish

Project Lead (PI) name, affiliation, email address: R. Dean Grubbs, Ph.D., Florida State University Coastal and Marine Laboratory, dgrubbs@bio.fsu.edu

Co-Principal Investigator name, affiliation, email address: James Gelsleichter, Ph.D., University of North Florida, jim.gelsleichter@unf.edu

Project objectives and goals

The primary objectives of this project are:

1) investigate movements and migration of large juvenile and adult smalltooth sawfish (*Pristis pectinata*), particularly those captured in areas of elevated interaction with fisheries, using satellite and acoustic telemetry,
2) assess physiological stress in sawfish as a function of capture methods, and
3) use blood hormone cycling to determine reproductive timing and importance of aggregation sites to mating.

We seek specifically to answer the following research questions:

A) Are there spatial and temporal patterns to the distribution of adult smalltooth sawfish in the areas of interaction with commercial trawl and longline fisheries?
B) Do adult sawfish have affinities for specific habitats (e.g. depths, bottom types, current regimes) and is there fidelity to specific areas?
C) Could bycatch rates be mitigated by seasonally limiting access to specific areas and habitats?
D) What are the stress profiles of captured sawfish using different gears and how do they compare with other elasmobranchs?
E) What is the reproductive status of captured sawfish and are the areas of high fisheries interaction the sites of mating aggregations?
F) What are the long-term residency and migration patterns of adult smalltooth sawfish?

This is a continuation of a long-term project; each year of this project we seek to conduct up to 24 days of fishery-independent sampling to capture and tag adult smalltooth sawfish. However, actual days at sea are often limited by permitted captures of endangered sawfish and inclement weather. Due to the size of the animals (often over 400 cm in length and 300 kg in weight), relatively calm weather is necessary to handle and tag the animals while maintaining the safety of the sawfish and the researchers.

Sampling locations are based on known records of interactions with commercial shrimp and longline fisheries, recreational fisheries, or our research surveys. The shelf edge at water depths of 40-55 meters from offshore of Key West the Marquesas Keys is a known area of sawfish interactions with commercial longline and shrimp trial fisheries. Our data suggest this may be a year-round, but ephemeral aggregation site for adult smalltooth sawfish. In addition, Florida Bay is a known area of high interaction with charter fisheries. These are the two primary areas of sampling.

Methods

Bottom longlines consisting of nylon or 3.5 mm monofilament mainline and 50-100 gangions are deployed to capture sawfish. Gangions are terminated with non-offset, baited circle hooks (≥ 16/0) and longlines are anchored and marked with a buoy and/or highflier at each end. Soak times are typically one hour but do not exceed two hours. Once brought alongside the boat, each sawfish is restrained by placing a line around the rostrum and the caudal peduncle. Sex and length measurements are recorded. Fin clips are collected for population genetics studies and blood samples are collected to assess reproductive status

and physiological stress. Beginning in 2016, we have been permitted to surgically implant coded acoustic transmitters in sawfish. These transmitters are recorded by acoustic receivers for up to ten years. There are now large arrays of several hundred receivers along the East Coast of the U.S., in the Florida Keys and in the Gulf of Mexico thus providing the potential to gather long-term insights into the movements, migration timing, site fidelity and aggregation behavior of smalltooth sawfish. Transmitters are implanted by making a 15mm incision with a sterile scalpel, on the ventral surface of the sawfish into the peritoneum. The placement of the incision is off-center and just posterior to the liver. The transmitter is inserted into the peritoneum and the incision closed with three stitches using sterile Vicryl braided absorbable sutures with a CT-1 needle.

Description of research conducted during the reporting period and milestones accomplished and/or completed

After having one of our most productive periods during FY16, the current reporting period (01 July 2017 – 30 June 2018) was our least productive to date for field sampling but was analytically productive. Planned trips in August and October had to be canceled due to an injury to the PI and inclement weather prevented sampling during another trip. Only two research trips were completed (11 total days, 7 days at sea) were completed and 38 total fishery independent longline sets were made (Figure 1), all aboard an FSU research vessel (a 26' Calcutta). Only 1 sawfish (an adult male) were captured and tagged (Figure 1). The first trip to the Florida Keys was conducted in December 2017.Due to inclement weather, we were only able to sample three days, making 14 sets, primarily in Florida Bay. No sawfish were captured during this trip. The second trip was conducted in April 2018 in conjunction with the conclusion of the Smalltooth Sawfish Recovery Implementation Team meeting in Key Largo. We made 24 sets over four days and again, due to weather offshore sets were limited to two sets. The remaining sets were divided between Florida Bay, the Everglades National Park back-country from Shark River to Coot Bay, and lower Keys inlets between Big Pine and Sugarloaf Keys. We captured one adult male sawfish in the Newfound Harbor Channel on the last sets of this trip.

From an analytical standpoint, we made a lot of progress during this period. All samples collected to date have been analyzed for reproductive hormones allowing us a better picture of the reproductive periodicity and timing in smalltooth sawfish. Using a combination of blood hormones, morphology and new metabolomics methods, we now have a robust estimate of the size at maturity for male and female sawfish. FSU doctoral student Bianca Prohaska completed an analysis of the effects of capture depth and method on physiological stress in smalltooth sawfish as well as a comparison between stress profiles of juvenile sawfish captured in an anthropogenically altered nursery (Charlotte Harbor) and a relatively pristine nursery (Everglades National Park). FSU Master's student Jasmin Graham began analyzing the passive acoustic tracking data collected from all internally tagged sawfish to date.

Description of significant research results, protocols developed, and research transitions

Using NGI funds and previous funds from the NOAA Section 6 Program, we have completed 476 demersal longline sets during the last seven years in the Middle to Lower Florida Keys, off the Marquesas Keys and Dry Tortugas, and between Ten Thousand Islands National Wildlife Refuge and Florida Bay (Figure 1). We captured 58 adult or large juvenile smalltooth sawfish on longlines and an additional 9 sawfish on rod and reel. Of the 58 captured on longline, 24 of these sawfish were captured in relatively deep water (40-70 meters) on the edge of the continental shelf in the middle to lower Florida Keys and 28 were caught in the shallow waters of Florida Bay. Six were caught in shallow water on the Atlantic side of the Florida Keys.

Over the past two years, we have tagged 19 large sawfish internally with acoustic transmitters with 10-year battery lives. These tags can be detected by the hundreds of receivers distributed along the Atlantic and Gulf coasts of Florida and up the East Coast as part of the i-TAG, ACT and FACT receiver arrays as well as by receivers distributed throughout the Bahamas if Florida-tagged sawfish leave the U.S. and cross the Straits of Florida into Bahamian waters. To date, detections from 12 of these large sawfish have been reported to us on more than 170 receivers from off Sarasota, Florida in the Gulf of Mexico to Georgia.in the Atlantic (Figure 2). The preliminary results from this study were presented in March 2018 at

the Bahamas Natural History Conference in Nassau, Bahamas and in June 2018 3rd quadrennial meeting of Sharks International in Jaoa Pessoa, Brazil.

We completed the analyses comparing the effects of capture method, capture depth, and habitat quality on physiological stress in sawfish. We found that sawfish expressed very low capture stress compared to most elasmobranchs, suggesting they are relatively resilient to capture. Our findings suggested the gillnet capture exerted higher stress than longline or rod and reel capture. Capture depth had no effect on physiological stress. Most interesting, we found that sawfish in the highly altered Peace and Caloosahatchee rivers expressed significantly higher metabolic stress than in the relatively pristine nurseries in Everglades National Park suggesting that habitat fragmentation and pollution in the primary nurseries may cause chronic stress in this endangered species (Figure 3). These results were published in the Journal Endangered Species Research (Prohaska et al. 2018).

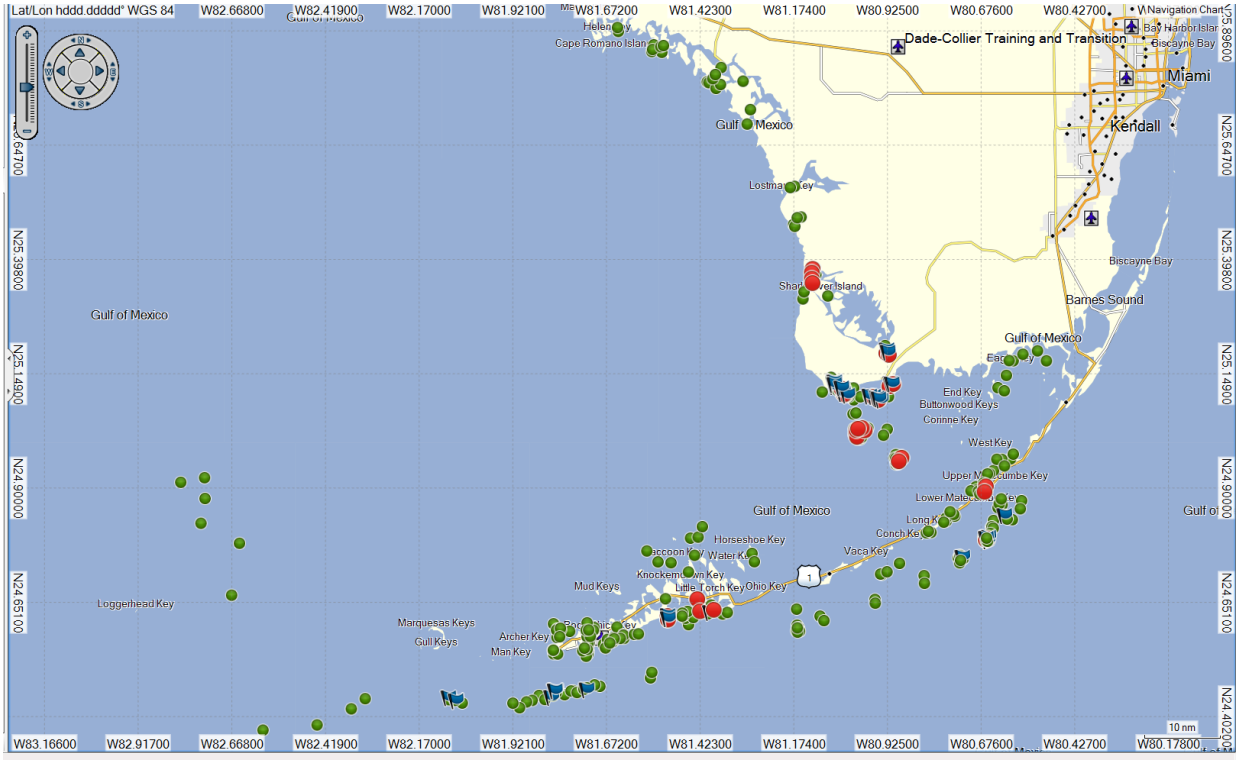


Figure 1: Distribution of fishery-independent longline stations samples from 2011 - 2018 (N=476)
Red circles = stations during this reporting period Flags = sawfish capture locations

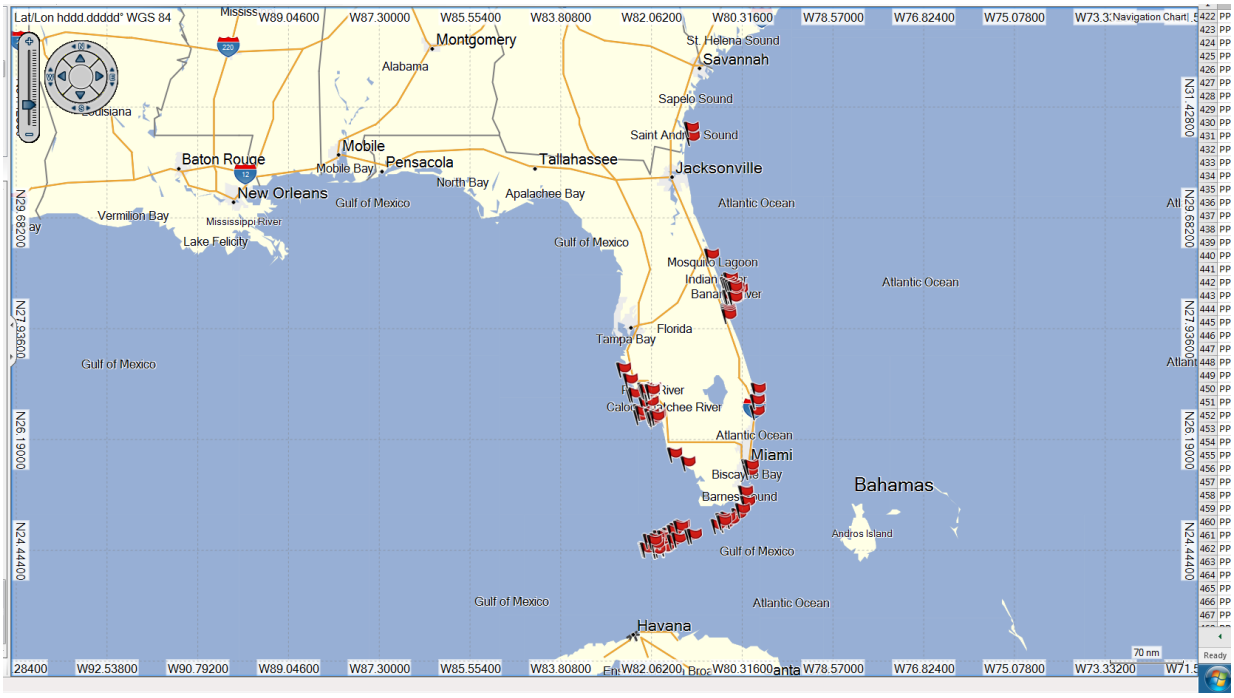


Figure 2: Distribution of VR2W receivers with adult sawfish detections 2016-2018

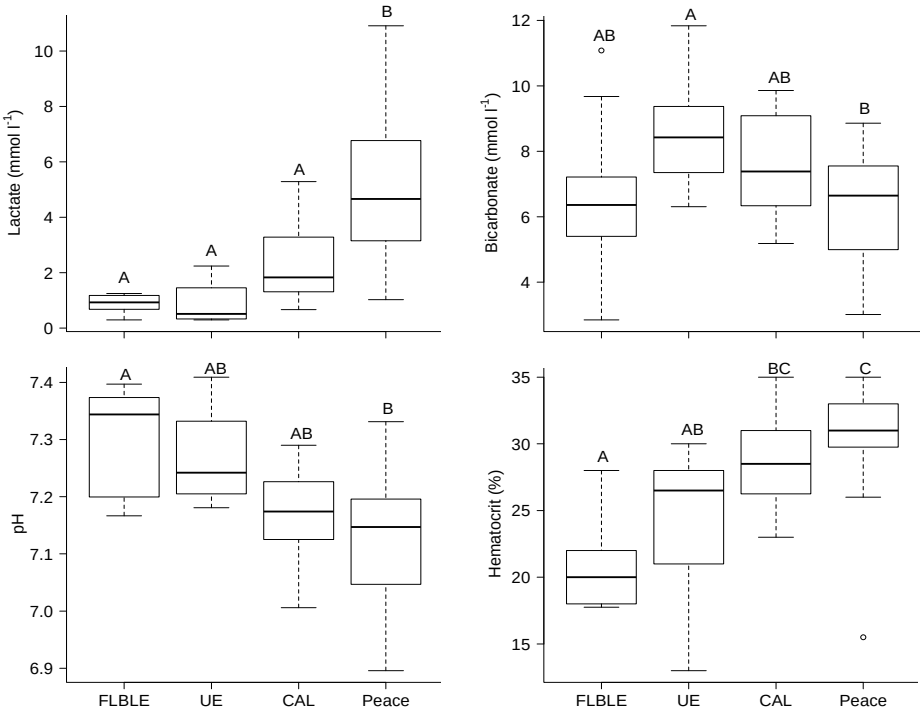


Figure 3: Copied from Prohaska et al. (2018). Boxplots of (A) lactate concentration (mmol l−1), (B) bicarbonate concentration (mmol l−1), (C) pH, and (D) hematocrit (%) in young of the year smalltooth sawfish Pristis pectinata captured in the more pristine Florida Bay and lower Everglades (FLBLE) and upper Everglades (UE), and in the anthropogenically influenced Caloosahatchee River (CAL), and the Peace River (Peace). Plot B includes juveniles. Different letters indicate significant pairwise differences.

Information on collaborators / partners

f. Dr. John Carlson, Adam Brame - NOAA Southeast Fisheries Science Center and Office of Protected Resources
g. November 2009
h. No monetary support through NGI
i. Yes, acoustic transmitters and receivers
j. Our colleague from NOAA Fisheries supplies acoustic transmitters that we deploy and contributes to the receiver array in Florida Bay
    a. Dr. Gregg Poulakis – Florida Fish and Wildlife Conservation Commission
    b. November 2009
    c. No current monetary support
    d. No
    e. Our colleagues from FWC are conducting stable isotope analyses using samples we collected. They were also our collaborators on work previously funded through the NOAA Section 6 program

Information on any outreach activities (if applicable)

Our NGI supported research was highlighted in numerous national documentaries:

Discovery Channel: Shark Week, "Alien Sharks: Stranger Fins." It will be highlighted again during Shark Week 2018.

Our discovery of potential sawfish mating ground in 2017 continue to receive media coverage through various outlets during this period: *Save Our Seas Magazine, Shark Advocates International, Earth Touch News, Nautical Mile Magazine, Orlando Sun Sentinel, Entertainment Weekly, Florida Guides Association, The Mullet Wrapper, Roaring Earth, Boredom Therapy.*

I gave 10 presentations to public schools, the general public, and university groups that highlighted NGI supported research on smalltooth sawfish. A selection is listed below:

St. Lawrence University. Research presentation to on deep-sea shark and endangered sawfish research at FSU to students visiting FSUCML from New York. 15 January 2018

Pre-Veterinary Club at FSU. Research presentation to ~100 club members on endangered sawfish research at FSU. 11 October 2017

Fulbright Scholars Program. Research presentation to Fulbright Scholars from the University of Florida and Florida State University. FSUCML. 20 October 2017

St. John Paul II Catholic High School, Tallahassee, FL. Research on endangered smalltooth sawfish in Florida and the Bahamas. 30 November 2017. Lecture to 30 high school students

I presented our work at the First Annual Florida Marine Science Symposium in October 2017, the IUCN Shark Specialist Group's sawfish strategy workshop in November 2017 and to the Smalltooth Sawfish Recovery Implementation Team in April 2018.

I published an article for *Save Our Seas Magazine*, which is distributed worldwide, on progress towards recovering endangered smalltooth sawfish in the U.S. and the Bahamas. The article highlighted the work on this project.

NGI FILE #17-NGI3-22

Project Title: Hypoxia National Office Technical Assistance, Observations, Monitoring, and Coordination

Project Lead (PI) name, affiliation, email address: Steve Ashby, Mississippi State University, sashby@ngi.msstate.edu

NOAA sponsor and NOAA office of primary technical contact: Alan Lewitus, NOS

Project objectives and goals

- Advance the science underpinning management of the large annual hypoxic zone ("dead zone") in the northern Gulf of Mexico.
- Provide a forum for strengthening communication between physical, biological, and socioeconomic modelers of the Gulf of Mexico hypoxia and the Mississippi River diversions, and the users and stakeholders.
- Validate and refine key fisheries management and habitat conservation needs associated with ecosystem effects of hypoxia and large-scale river diversions in the Gulf of Mexico;
- Assess adaptive management needs for advancing ecosystem modeling of hypoxia and diversion effects on habitats and living resources in the northern Gulf of Mexico.

Description of research conducted during the reporting period and milestones accomplished and/or completed

Technical Assistance and Coordination
NGI provided technical assistance to support scientific and research efforts conducted by the Hypoxia National Office related to hypoxia forecasting and modeling, social and economic impacts, and impacts on marine resources. Regional working groups continued to inventory and coordinate ongoing monitoring related to hypoxia in the respective regions.

Observations and Monitoring
NGI provided support for observations and monitoring in hypoxic regions of the Gulf of Mexico in support of NOAA's goals associated with the Gulf of Mexico Hypoxia Task Force and NOAA's Ecological Forecasting Roadmap (EFR) and specifically the EFR-Hypoxia pilot for operationalization. A cruise was conducted by LUMCON in July 2017 to acquire oceanographic and biological data in the hypoxic zone. Objectives of this cruise were to:

- Collect data and samples from established stations;
- Collect hydrographic profiles of temperature, salinity, dissolved oxygen, fluorescence (chl a), and turbidity using a SeaBird 911 plus CTD unit with 5-L Niskins;
- Underway flow-through system for near surface temperature, salinity, in vivo fluorescence, and percent light transmission with GPS and meteorological information - MIDAS
- Collect dissolved nutrients and bottle oxygen samples for chemical analysis;
- Collect samples for phytoplankton biomass estimates and classification;

Three deterministic models developed through NGOMEX and currently in prototype testing through the IOOS COMT program for transition to operations will use data from the cruise to characterize the dynamics of the dead zone from spring through late summer.

- Justic and Wang's (2009) 3-D coupled hydrodynamics (FVCOM-LATEX)-water quality model;
- Hetland and DiMarco's (2012) 3D dynamically coupled (ROMS hydrodynamic model);
- Fennel et al.'s (2012) 3D dynamically coupled (biogeochemical model).

The findings were presented to the Gulf Hypoxia Task Force at their 2017 public meeting.

Hypoxia research coordination workshop: Three workshops were conducted in lieu of an Annual Hypoxia workshop. Presentations from these workshop will be posted on the NGI website once the transition from the NOAA website is complete.

1. Joint NGOMEX Modeling Grants and Hypoxia Task Force representatives – Multi-dimensional modeling results were presented and discussions were held about the current HTF target for reduction in the size of the "dead zone".
2. CHAMP Monitoring Work Group - The *7th Annual NOAA/NGI Workshop* was held in January at the MSU Science and Technology Center at the Stennis Space Center. In addition to technical presentations, attendees revised the CHAMP monitoring matrix (Tables 2 and 3 from *6th Annual NOAA/NGI Workshop* proceedings paper) by incorporating additional monitoring requirements met by the monitoring workgroups, updating the remaining programmatic gaps, and identifying priorities in filling these based on management needs. An addendum to the proceedings paper is in preparation.
3. CHAMP Fisheries Work Group – Considerable efforts to coordinate with the other PI's funded through NGOMEX were made including participation in a workshop held in May at the MSU Science and Technology Center at the Stennis Space Center. Discussions primarily focused on streamlining the potential products so that modeling outcomes can be more easily compared among the three efforts. To a lesser degree model parameterization is being coordinated so that things like spatial resolution and time steps are comparable, but not to the extent that models could not be differentiated. Inroads were primarily with federal assessment biologists and Integrated Ecosystem Assessment group members to continue to work on including model outcomes at federal assessments. Discussions on integrating into state run assessment processes, integration with the shrimp stock assessment group in Galveston, and improving interactions with managers are ongoing. The group will meet again at the American Fishery Society Meeting in September to continue coordination across projects.

Description of significant research results, protocols developed, and research transitions

The annual cruise of the hypoxia area off of the coast of Louisiana was conducted in July of 2017. A summary of the cruise and findings is included as an appendix.

Near real-time data were posted to the web site (http://www.gulfhypoxia.net) along with graphic representation of the data.

Summary of CHAMP Work Group activities:

Autonomous Vehicles Work Group
This group has successfully deployed Slocum gliders, Liquid Robotics Wave gliders, and C-Worker ASVs. Current activities include the identification of group members, providing information to NOAA/NCCOS, and identifying the most promising vehicles such as Teledyne Webb Research Slocum Gliders, Liquid Robotics Wave Rider (SV3), and ASV Global C-Worker series. Other vehicle considerations include Kongsberg: Coastal Glider, Spray, and MOST Autonaut.

A Glider Implementation Plan is scheduled for development in July of 2018. The group is engaged in the Texas OneGulf Center of Excellence 2016-2018 Field Campaign, the Galveston to FGBNMS Transect, and Private/Public Partnership with Liquid Robotics and Texas A&M University. Additional activities include participation in the Stones Array (PPP Shell/Fugro/USM/TAMU).
Resources include GCOOS GANDALF glider data, Stones Mooring, and the NAS Loop Current Report.

TAMU Mission Summary - 34 missions, 800+ days, 15000 km traveled, 20 Coastal missions (< 200 m), 14 Deep missions (> 1000 m).

Hypoxia Task Force Work Group

- Nutrient Loading Monitoring Support discussion with the USGS
- Hypoxia Annual Cruise Support were discussed
  - Modeling commitment for FY19 was discussed
  - Cruise commitment until FY19 was discussed

- Discharge Monitoring discussions were conducted with the USGS.
- Updates to the HTF on CHAMP activities were provided.
- Updates to CHAMP members on relevant HTF activities.
- Development of a SOP for Hypoxia Cruise was initiated.

Fisheries Work Group
A workshop with the NGOMEX funded hydrodynamic and water quality modelers was held in Silver Spring in September of 2017. Participants also included EPA and USGS representatives associated with the Hypoxia Task Force. The Fisheries Work Group conducted a workshop in May 2018 at the MSU Science and Technology Center, Stennis Space Center that included work group members and invited scientists conducting monitoring in the Mississippi Sound and ecological modeling in the Gulf of Mexico.

Oil&Gas/Ocean Acidification Work Group
A buoy asset with a dissolved oxygen sensor near the surface was relocated from the Mississippi Bight to the hypoxic zone in Louisiana. The location chosen is near the LUMCON water quality station and LSU WAVCIS station CSI-06 (W90º29', N28º52').

Louisiana Monitoring Work Group
Developed a proposal to address the urgent need to establish a monitoring transect extending from Barataria Pass to the inner shelf. Awarded a $50K Gulf of Mexico Alliance Grant that funds a portion of the monitoring transect. Working to fund the full transect monitoring proposal ($300K yr/15 years) Submitted a project idea *Water Quality Offshore Monitoring Transect* to the Natural Resource Damage Assessment Open Ocean call for project ideas (5/15/2017, LCMW subgroup)

Mississippi/Alabama Hypoxia Monitoring Work Group
Met in August and included representatives from the Louisiana Coastal Protection and Restoration Authority and the Lake Ponchartrain Basin Foundation (LPBF). Three independent water quality monitoring efforts related to hypoxia in the Mississippi Bight were identified and discussed. Studies conducted by the LPBF, the University of Southern Mississippi, and the Dauphin Island Sea Laboratory have observed hypoxia throughout the Mississippi Bight. A proposal to the Gulf of Mexico Alliance to consolidate the independent data sets, conduct a gap analysis, and identify a more regional monitoring strategy was not selected for funding. The working group is planning another meeting to be held in the summer of 2018.

RESTORE Act Work Group
Current and Proposed Activities.
- Participate directly in RESTORE Council Monitoring and Assessment Program (CMAP) to identify and create leveraging opportunities

CMAP status
1. Initial funding for Phase I in place
2. Facilitating monitoring coordination across Gulf restoration programs and development of minimum monitoring components
3. Funding GOMA to facilitate creation of Gulf Monitoring Community of Practice in 2018
4. Funding MS-AL SG to hold User workshops in 2018
5. WQ and Habitat Long-term Monitoring Inventory (underway)
6. Gap Analysis (in process)
7. Establishment of Regional Monitoring CoP and network of existing programs
8. Establishment of Monitoring Coordination Committee to coordinate and leverage restoration program and other funding for monitoring

- Determine funded research that is relevant to CHAMP.
- Identify pending Gulf restoration activities with significant and relevant monitoring components (e.g., LA Mid-Barataria Sediment Diversion, project monitoring, modeling, and adaptive management framework)

Texas Work Group
This group has engaged with the AUV group and deployed Slocum gliders, collaborated with the Texas RESTORE Act Center of Excellence, provided rapid response to Hurricane Harvey (via NSF funding, 5 awards to TAMU), and initiated quantification of Slocum glider ability to reach near bottom waters. Additional group members were identified. NOAA CSCOR: Glider Implementation Plan (July 2018). Additional planned or ongoing activities include participation in the Texas OneGulf Center of Excellence 2018 Field Campaign: Padre Island to Sabine, Repeat Transects: Galveston to FGBNMS, TAMU: Observing the Ocean REU, June cruise: RV Pelican, RV Manta SCS dataset.

Information on collaborators / partners

a. Name of collaborating organization: The Steering Committee members for the *6th Annual NOAA/NGI Hypoxia Research Coordination Workshop* were all collaborators on this project. The membership of the committee is: Steve Ashby (Northern Gulf Institute), Alan Lewitus (NOAA NCCOS), Dave Scheurer (NOAA NCCOS), Steve Giordano (NOAA OHC), Trevor Meckley (NOAA NCCOS), David Hilmer (NOAA NCCOS), Rick Greene (EPA Gulf Breeze Laboratory), Troy Pierce (EPA Gulf of Mexico Program), Nancy Rabalais (LUMCON), Steve DiMarco (TAMU), Barbara Kirkpatrick (GCOOS), Stephan Howden (USM), and Rick Raynie (LACPRA)
   Gulf of Mexico Alliance
   IOOS and GCOOS
   LUMCON, Louisiana State University, Texas A&M University, Dalhousie University, the University of Southern Mississippi, and the University of South Florida
   Lake Ponchartrain Basin Foundation
   Louisiana Office of Coastal Protection and Restoration
   Mississippi Department of Marine Resources
b. Date collaborating established: July 2009
c. Does partner provide monetary support to project? Amount of support? None Reported
d. Does partner provide non-monetary (in-kind) support? Yes
e. Short description of collaboration/partnership relationship: Workshop co-sponsor

Information on any outreach activities

Trevor Meckley participated in the Gulf of Mexico Alliance All Hands Meeting in June of 2018 and, specifically, with the Water Resources Priority Issues Team where he presented information on the Hypoxia National Office Activities including a summary of CHAMP.

Appendix
RESULTS OF 2017 HYPOXIA SHELFWIDE CRUISE EFFORTS

Louisiana Universities Marine Consortium
for
Northern Gulf Institute Cooperative Agreement

Statement of Issues

The persistence of seasonal hypoxia, or a "dead zone," in the northern Gulf of Mexico represents a significant national-level water quality problem. In 2001, a federal inter-agency Mississippi River-/Gulf of Mexico Watershed Nutrient Task Force set a goal to reduce the 5-year running average areal extent of this hypoxic zone to less than 5,000 km^2 by the year 2015 (Mississippi River/ Gulf of Mexico Watershed Nutrient Task Force, 2001). The Task Force recently affirmed this goal in a 2008 report. While the environmental goal remains the same, the Task Force expanded the date goal to the year 2035 in anticipation of improved nutrient management in the watershed. An interim goal of 20% reduction in nitrogen inputs to the Mississippi River by the year 2025 is anticipated to help reach the eventual environmental goal 5,000 km^2 of by the year 2035.

Careful monitoring of water quality changes in the northern Gulf of Mexico are critical to documenting changes in the hypoxic zone with regard to nutrient loading. It is also critical that this type of monitoring be conducted longer-term to take into account physical conditions that might alter the measured area of bottom-water hypoxia. A consistent, uniform data collection is necessary for maintenance of a long-term database.

Description of Cruise

The 2017 shelfwide survey of bottom-water hypoxia was conducted on July 24 – July 30, 2017, consistent with cruises that were conducted onboard the *R/V Pelican* from 1985 to 2015 to document the size. Along with this basic number, there was collection of ancillary parameters and determination of process rates to better understand the physical and biological underpinnings of hypoxia in the northern Gulf of Mexico.

Hydrographic profiles will be collected using the ship's SeaBird 911+ CTD unit equipped with pressure sensor, altimeter, redundant pumped temperature, conductivity and dissolved oxygen sensors, % transmissometer, PAR and in vivo fluorometer. A secondary YSI 6820 was deployed to reach within 0.5 m of the bottom and 0.5 m within the surface layer.

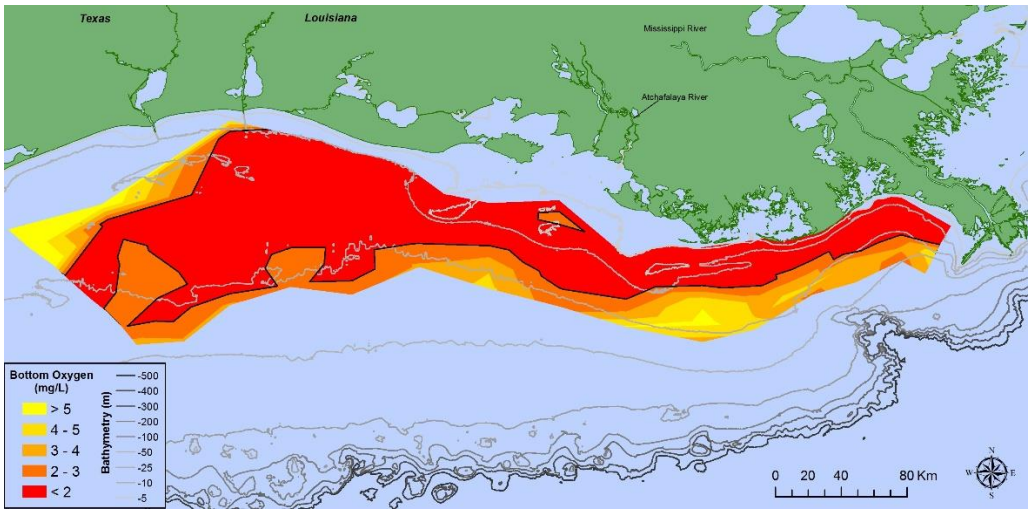
Flow-though and acoustic data current profiler (ADCP) data collection systems coupled with integrated data for GPS navigational, meteorological (wind speed and direction, barometric pressure, air temperature, relative humidity and photosynthetically active radiation (PAR)), and sea surface hydrographic (temperature, conductivity, % transmission, fluorescence) was used in this effort. A flow-through seawater system was used for incubation chambers and underway pCO_2 measurements.

Winkler titration data are used to validate oxygen levels and PortaSal to validate salinity levels. Phytoplankton community biomass will be determined using fluorometry with an AU Turner Designs fluorometer. Nutrients (nitrate, ammonium, phosphate and silicate) will be determined on unfiltered samples (consistent with data from 1985) with a Lachat nutrient analyzer. The inorganic and organic contribution to the total suspended sediments is determined using pre- and post-ashed glass fiber filters.

The LUMCON Vessel Operations salinometer has been used to cross-check salinities from the SeaBird and the YSI and to correct data as necessary. The LUMCON salinometer has not worked properly since June 2015, and data for the 2015, 2016, and 2017 hypoxia cruises have not yet been cross-checked. This has delayed final data QA/QC and submission to NOAA/NCEI. Only 2015 data are delinquent at this time. The Rabalais Hypoxia Lab in investigating a precise but economical salinometer for determination of salinity samples.

Results from 2017 Hypoxia Shelfwide Cruise

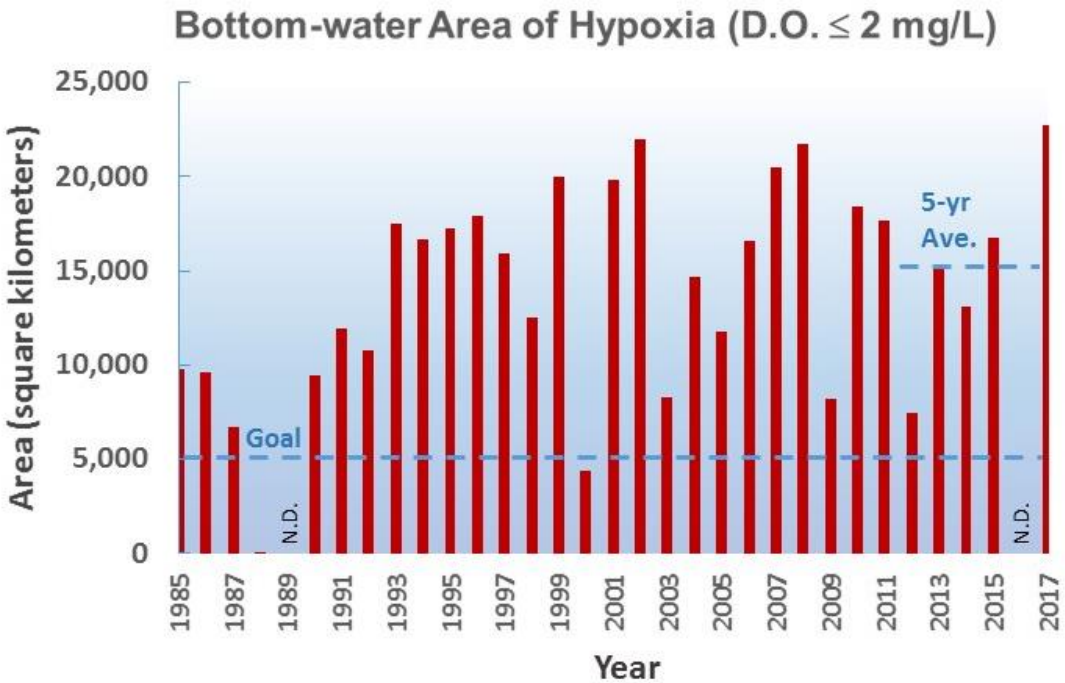
The 2017 area of low oxygen, commonly known as the 'Dead Zone,' measured 22,720 square kilometers (= 8,776 square miles) is the largest size measured to date since the standardized mapping cruises began in July 1985. July 24 – July 30, 2017, the dates of this year's cruise, mark the **31st** cruise measuring the area of hypoxia (low oxygen) in the northern Gulf of Mexico. Based on the May nitrogen load from the Mississippi River, the area was predicted by LSU/LUMCON to be 26,131 km^2 (10,089 mi^2) of the bottom of the continental shelf off Louisiana and Texas. The size is the largest yet and is 4.5 times the Mississippi River Nutrient/Hypoxia Task Force environmental goal of 5,000 square kilometers (1,900 square miles). Mississippi River discharge, well above average in May with high nitrate concentrations, provided a high nitrate load, the best predictor of the summer size of bottom-water hypoxia.



Distribution of bottom-water dissolved oxygen, July 24 – July 30, 2017. Black line denotes 2 mg l^{-1}. Data source: N. N. Rabalais, Louisiana State University & Louisiana Universities Marine Consortium; R. E. Turner, Louisiana State University. Funding: National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science.

The average size for the last five years, including this year, is 15,032 square kilometers (= 5,543 square miles). The 31-year average (less 1989 and 2016) is 14,037 square kilometers (5,543 square miles). This year's 'Dead Zone' is the size of New Jersey.

Please note that the entire area was not mapped because of insufficient days on the ship. There was more hypoxia to the west, but we did not have time to map it. The size would have been larger. Quality Control/Quality Assurance standards for processing the data may change the overall estimate and other environmental parameters.



Historic size of hypoxia from 1985 to 2017. There are no data (N.D.) for 1989 and 2016. The value for 1988 is 42 square kilometers and barely visible on the scale.

A notable feature of this year's distribution of low oxygen is the mostly continuous band of extremely low oxygen concentrations alongshore at the nearshore edge of the zone. Values there were very often less than 0.5 milligrams per liter and close to 0 milligrams per liter (anoxia). The definition of hypoxia is 2 milligrams per liter. The low oxygen waters also reached well up into the water column, at least on the eastern area of the map.

Low oxygen areas are sometimes called 'Dead Zones' because of the absence of commercial quantities of shrimp and fish in the bottom layer. The number of Dead Zones throughout the world has been increasing in the last several decades and currently totals over 500. The Dead Zone off the Louisiana coast is the second largest human-caused coastal hypoxic area in the global ocean and stretches from the mouth of the Mississippi River into Texas waters and less often, but increasingly more frequent, east of the Mississippi River.

There is a series of coupled cause-and-effect relationships linking the amount of water emptying into the Gulf of Mexico and water quality in the Mississippi River to hypoxia. The fresher, warmer water in the upper layer is separated from the saltier, colder water in the lower layer, resulting in a barrier to the normal diffusion of oxygen from the surface to the bottom. The excess nutrients delivered by the river stimulate high phytoplankton biomass offshore, which fuels the coastal food web but also contributes to high carbon loading to the bottom layer. The decomposition of this carbon by bacteria in the bottom layer leads to the low oxygen that is not resupplied from the surface waters.

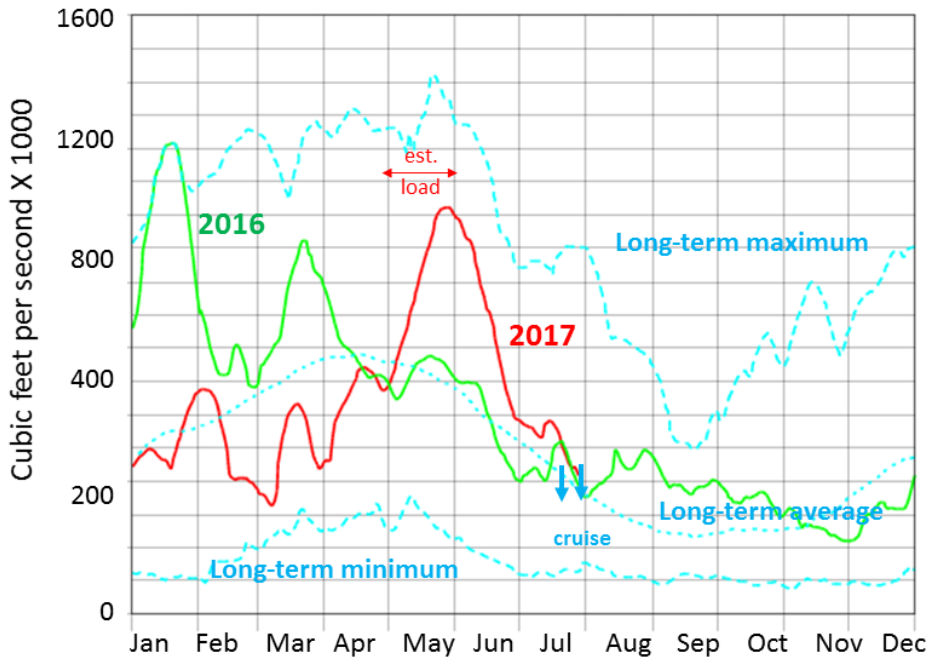
The amount of nutrient loading from the river increased considerably in the 1960s as a result of more intense agricultural activity in the watershed. The primary driver of the increased nutrient loading is agricultural land use, which is strongly influenced by farm policy. The nitrogen load has stabilized somewhat in the last two decades. Additionally, the nitrate portion of the total nitrogen load is increasing. This is important, because the nitrate-N concentration and load is proportional to the phytoplankton

produced and the subsequent bottom-water hypoxia. Reducing the size of the hypoxic area requires, therefore, changes in land use practices. Pilot projects and recent developments demonstrate that this can be done for crops with benefits for regional and local water quality, farm communities, soil health and erosion reduction, and without compromising yields or profit.

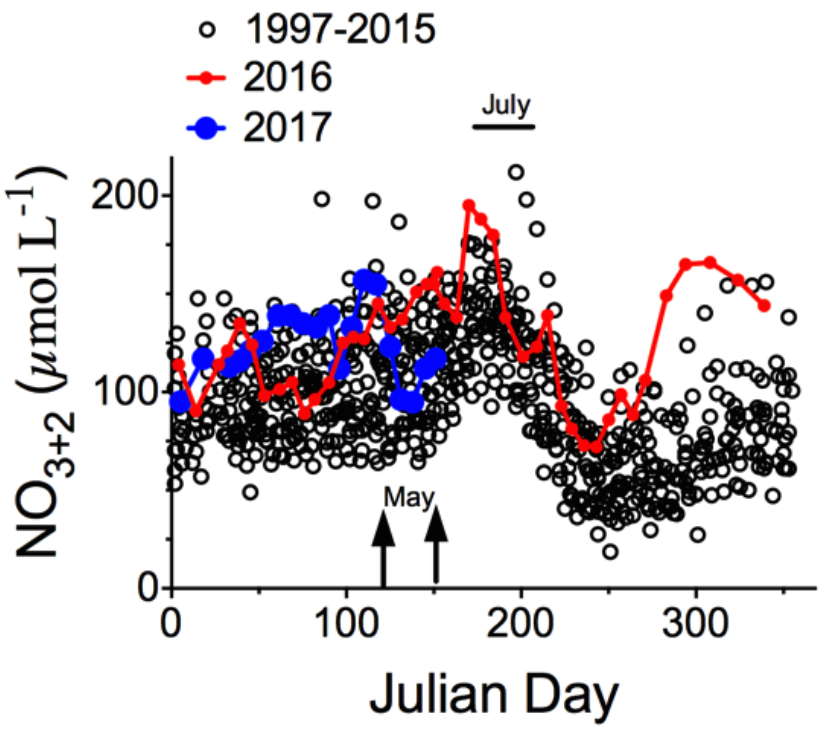
The long-term pattern in the hypoxic zone size shows that there is a greater sensitivity to nutrient loading that is carried over from one year to the next. These 'legacy' effects can be explained as the result of incremental changes in organic matter accumulated in the sediments one year, and metabolized in later years, by changes in the nitrogen form, or long-term climate change.

2017 Conditions

The Mississippi River discharge and its associated nutrient load is the single factor that explains most of the variability in the summer size of low oxygen. The May river discharge was well above average compared to the long-term average since 1935. The May river discharge was well above average for the month, nitrate concentrations were average, although near the long-term maxima for January through April. The figure below illustrates with the pointer on the left, the timing of the nitrate load when the prediction was made for the mid-summer cruise (double blue arrows).

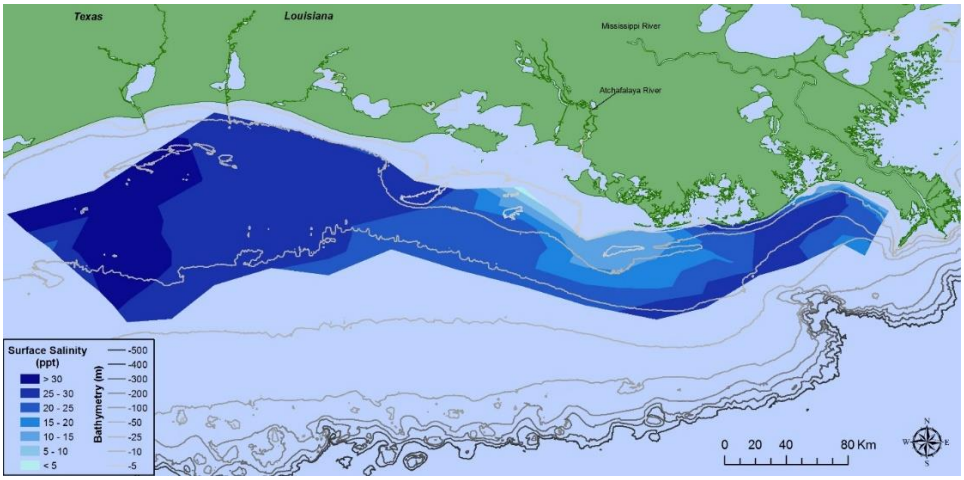


Flow of the Mississippi River at Tarbert Landing LA since 1935 with discharge for 2017 in red, compared to long-term conditions (http://www2.mvn.usace.army.mil/eng/edhd/tar.gif).



The concentration of nitrite+nitrate (NO_{2+3}) at Baton Rouge, Louisiana, from 1997 through May 30, 2017. The data for2016 and 2017 are shown separately. Source: R. Eugene Turner, LSU Department of Oceanography and Coastal Sciences. Funding: NOAA National Centers for Coastal Ocean Science.

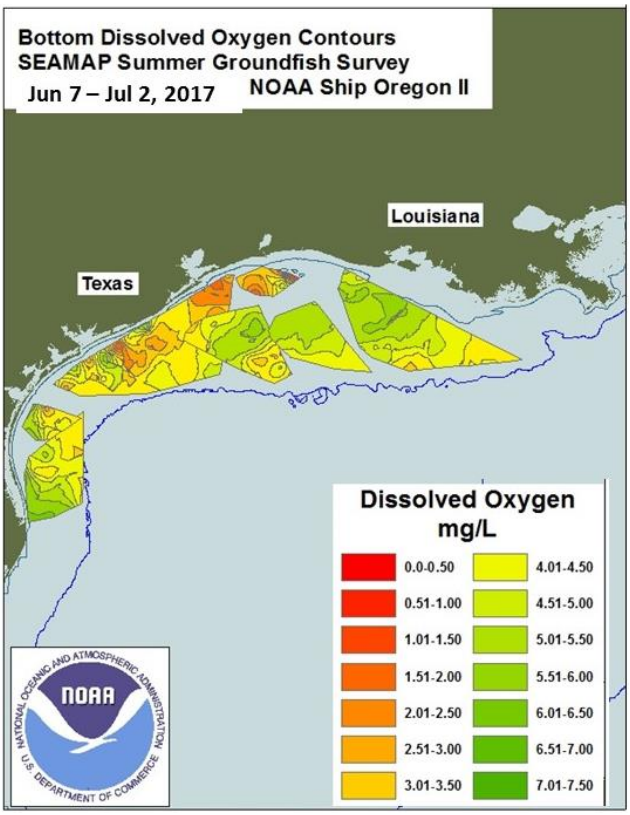
Conditions favorable for the formation and maintenance of hypoxia, water column stratification and nutrient-enhanced algal growth, continued well up to the time of the cruise and are still present over much of the study area. The high river flow in May and June was retained on the shelf, at least through the mapping of hypoxia. Salinities > 30 were rare. The amount of Mississippi and Atchafalaya fresh water can be seen in the figure below.



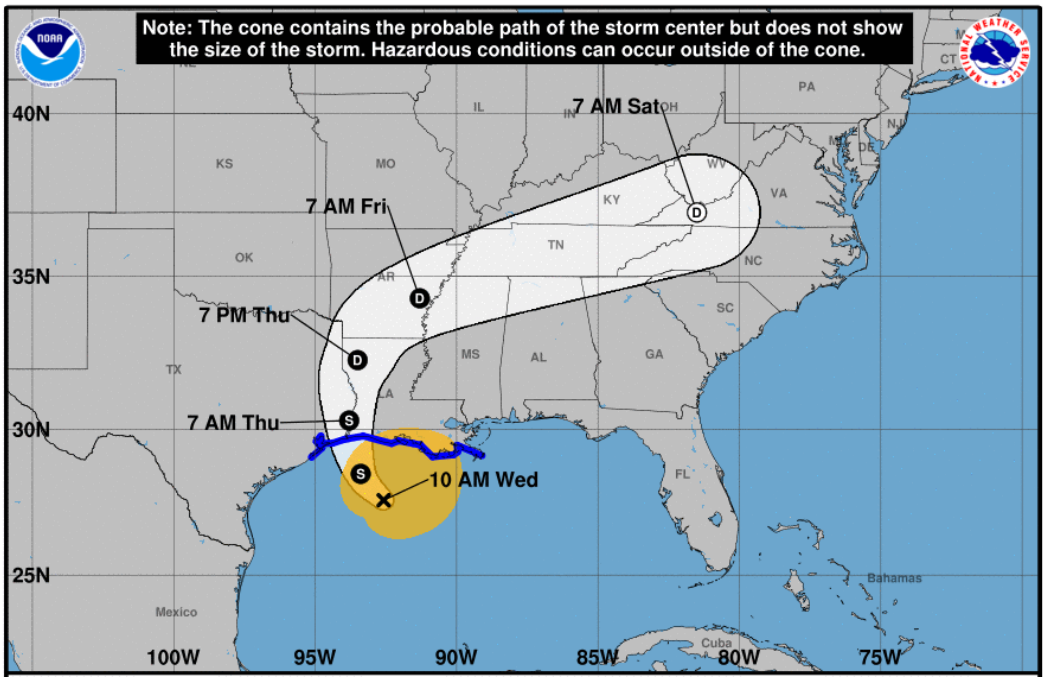
Distribution of the surface salinity along the Louisiana shelf, July 24 – July 29, 2017.

Progression of 2017 Hypoxia

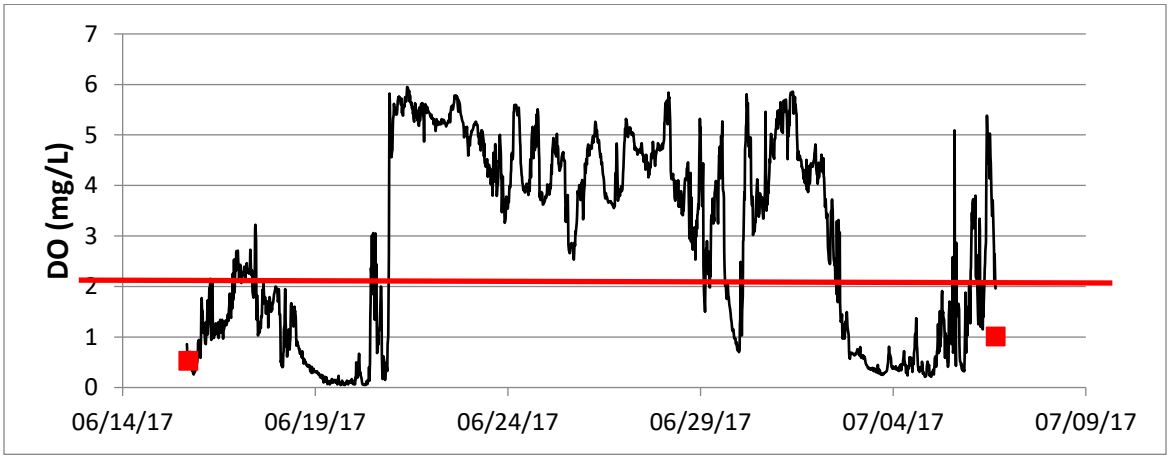
The National Marine Fisheries Service groundfish surveys on the NOAA vessel Oregon II (SEAMAP cruises) was the first systematic mapping of the summer. The areas off Texas and Louisiana were occupied from June 7 – July 2, 2017. Low oxygen occurred off Galveston Bay and Lake Sabine (the Texas-Louisiana border) before Tropical Storm Cindy crossed the coastline at that location on June 22. Waters that were stratified and supported low oxygen conditions below the surface layer were most likely disrupted, and the water column was not restratified by the time the remainder of the survey was conducted off Louisiana. The disruption of hypoxic bottom-waters was recorded off Terrebonne Bay, 200 km west of the Mississippi River delta, following the passage of the storm center. The low oxygen on the bottom there was well below 2 milligrams per liter for a month and a half before the passage of the storm.



Bottom-water oxygen concentrations from SEAMAP groundfish surveys (map modified to show Texas and Louisiana). Source: https://service.ncddc.noaa.gov/rdn/www/media/hypoxia/maps/2017-hypoxia-contours.jpg



Tropical Storm Cindy likely path of storm center on June 21, 2017.

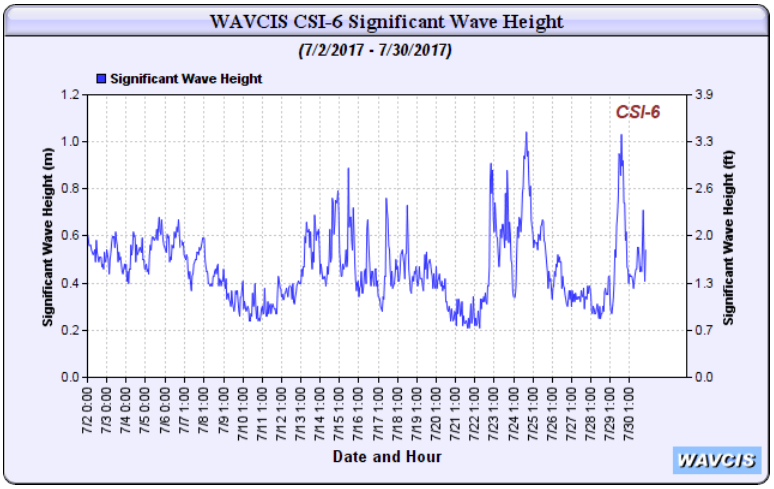


Bottom-water dissolved oxygen in 20-m depth off Terrebonne Bay before and after Tropical Storm Cindy (unpublished data of Nancy Rabalais, LSU/LUMCON).

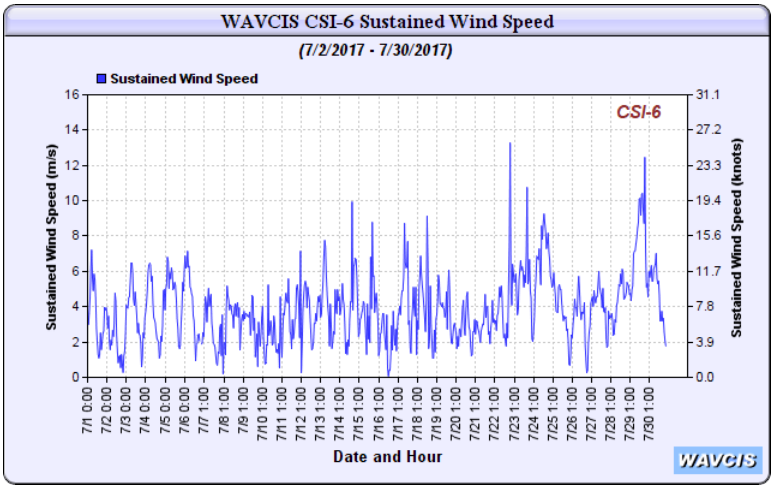
The area of hypoxia on the Louisiana shelf adjacent to the Mississippi River is the focus of an NSF collaborative Ocean Acidification project, pH Dynamics and Interactive Effects of Multiple Processes in a River-Dominated Eutrophic Coastal Ocean, is led by Wei-Jun Cai (University of Delaware) and Nancy Rabalais as co-PIs. Cai was mapping oxygen and CO_2 conditions the week and a before the LSU/LUMCON cruise. The low oxygen on their cruise from July 7-21 showed a discontinuous distribution of hypoxia on the southeastern Louisiana shelf and a larger low oxygen area west of the Atchafalaya River. They did not occupy all the same stations as the Rabalais et al. cruise did, and others that Rabalais did not occupy. Cai et al. did not go farther west than Lake Calcasieu, transect K of Rabalais et al., nor did they go as far east as the Rabalais et al. cruise (i.e., transect A′). The Cai et al. cruise did not send a second, smaller CTD unit to within 0.5 m of the seabed to capture readings from near-bottom waters. The estimated area of bottom-water oxygen concentrations less than or equal to 2 milligrams per liter for the area mapped by Cai et al. was 13,600 km^2. The large and rapid seasonal decrease in pH of nGOM bottom waters and its link to eutrophication, respiration and hypoxia under the Mississippi River

plume provides an ideal natural laboratory to study the interactions between OA and biogeochemical processes.

For much of the two weeks prior to the shelfwide mapping, the winds were predominantly from the west and southwest, and pushed the water from the Atchafalaya River to the east of its delta. These conditions would also help push less saline waters on the western edge to the east. A more stratified (layered) water column occurred in the center of the study area and supported more low oxygen. Winds were mostly calm for that period as well, and allowed for the strengthening of the stratification and support of low oxygen conditions across the broader area.



Data from http://www.wavcis.lsu.edu station CSI-6, where oxygen meters are deployed (Rabalais et al. station C6C).



Data from http://www.wavcis.lsu.edu station CSI-6, where oxygen meters are deployed (Rabalais et al. station C6C).

The multiple inputs of data available to explain the changing distribution and size of the hypoxic water mass are compelling. Hypoxia is a recurring environmental problem in Louisiana (and becoming more so in Texas and Mississippi) offshore waters. Long-term research and observations are the best ways to test and calibrate ecosystem models, to recognize the dynamic nature of our changing environment(s), and to improve the basis for sound management decisions.

The annual measurement of the hypoxic area also provides a critical scientific record of the trend of hypoxia in the Gulf to determine whether efforts to reduce nutrient loading upstream in the Mississippi River Basin are yielding results. Maintaining such a valuable ecological dataset can be difficult. However,

without these continued observations and related research and modeling, the ability to predict changes in the ecosystem resulting from nutrient mitigation efforts in the Mississippi River watershed will be stymied.

Data Management

Near real-time data were posted to www.gulfhypoxia.net along with graphics of the hypoxic zone. Adjustments were applied as necessary to correct dissolved oxygen, salinity, density, and percent oxygen saturations. The CTD data were post-processed according to the SeaBird manual, and outliers and suspect data identified. Dr. Leslie Smith, Your Ocean Consulting, processed the data for the last several years and, along with Wendy Morrison, RA for Rabalais, identified many improvements in the post-processing. Smith was responsible for the preparation and submission of data, including metadata, generated under this project to the National Centers for Environmental Information (NCEI). Data are due no later than two years of collection and will undergo quality control and assurance.

Additional Hypoxia Season 2017 Activities

Bottom-water continuous oxygen data were collected from May through October 2017 in collaboration with Rabalais' collaboration on an NSF-funded Ocean Acidification with Wei-Jun Cai, University of Delaware. These data were provided to modeling teams led by Fennel and Justić. The entirety of the 2017 summer's data could not be generated in time for modeling efforts due during the fall. The more complicated post-processing of the CTD SeaBird data is still underway, along with quality control/quality assurance for those data, nutrients, chlorophyll, and other parameters for submission to NOAA NCEI. The comparisons of the SeaBird CTD and the YSI 6820 were close to each other and the Winklers, but there was a consistent offset from the 1:1 relationship. The data were corrected, but this is not final until the full QA/QC is applied to all data.

Peer-reviewed Papers

Turner, R.E. and N.N. Rabalais. 2018. The Gulf of Mexico in The World Seas. C. Shepard ed., (in press)

Rabalais, N.N. 2018. Coastal Hypoxia: What, When, Where, Why. The Marine Biologist Magazine, Marine Biological Association of the U.K., Plymouth, England.

Rabalais, N.N. 2018. Ocean Deoxygenation from Eutrophication (Human Nutrient Inputs). In D. Laffoley and J.M. Baxter eds., Ocean deoxygenation: everyone's problem: Causes, impacts, consequences and solutions. International Union for Conservation of Nature and Natural Resources, IUCN, Gland Switzerland, xxx pp. (in review)

Rabalais, N.N. 2018. Estuarine and coastal benthos. In D. Laffoley and J.M. Baxter eds., Ocean deoxygenation: everyone's problem: Causes, impacts, consequences and solutions. International Union for Conservation of Nature and Natural Resources, IUCN, Gland Switzerland, xxx pp. (in review)

Yasuhara, M., N.N. Rabalais, D.J. Conley, D. Gutiérrez Aguilar. 2018. Paleo-records of histories of deoxygeneration and its ecosystem impact. In D. Laffoley and J.M. Baxter eds., Ocean deoxygenation: everyone's problem: Causes, impacts, consequences and solutions. International Union for Conservation of Nature and Natural Resources, IUCN, Gland Switzerland, xxx pp. (in review)

Price, Andrea M., Melissa M. Baustian, R. Eugene Turner, Nancy N. Rabalais, and Gail L. Chmura. 2017. Dinoflagellate cysts track eutrophication in the northern Gulf of Mexico. Estuaries and Coasts ttps://doi.org/10.1007/s12237-017-0351-x

Thrash, J. C., K. W. Seitz, B. J. Baker, B. Temperton, L. E. Gillies, N. N. Rabalais, B. Henrissat and O. U. Mason. 2017. Metabolic roles of uncultivated bacterioplankton lineages in the northern Gulf of Mexico "Dead Zone." mBio https://doi.org/10.1128/MBIO.01017-17

Turner, R.E., N.N. Rabalais, D. Justić. 2017. Summer bottom-water temperature trends northern Gulf of Mexico continental shelf, 1985 to 2015. PLOS ONE https://doi.org/10.1371/journal.pone.0184350.

Denise Breitburg, Lisa A. Levin, Andreas Oschlies, Marilaure Grégoire, Francisco P. Chavez, Daniel J. Conley, Véronique Garçon, Denis Gilbert, Dimitri Gutiérrez, Kirsten Isensee, Gil S. Jacinto, Karin E. Limburg, Ivonne Montes, S. W. A. Naqvi, Grant C. Pitcher, Nancy N. Rabalais, Michael R. Roman, Kenneth A. Rose, Brad A. Seibel, Maciej Telszewski, Moriaki Yasuhara, Jing Zhang (2018). Declining

oxygen in the global ocean and coastal waters. *Science*. 359 (46), eaam7240. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: http://dx.doi. org/10.1126/ science.aam7240

Nancy N. Rabalais, Leslie M. Smith, R. Eugene Turner (2018). The Deepwater Horizon oil spill and Gulf of Mexico shelf hypoxia. *Continental Shelf Research*. 152 (NA), 98. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: https://doi.org/10.1016/j.csr.2017.11.007

Price, Andrea M., Melissa M. Baustian, R. Eugene Turner, Nancy N. Rabalais, and Gail L. Chmura. 2017. Dinoflagellate cysts track eutrophication in the northern Gulf of Mexico. Estuaries and Coasts ttps://doi.org/10.1007/s12237-017-0351-x

Thrash, J. C., K. W. Seitz, B. J. Baker, B. Temperton, L. E. Gillies, N. N. Rabalais, B. Henrissat and O. U. Mason. 2017. Metabolic roles of uncultivated bacterioplankton lineages in the northern Gulf of Mexico "Dead Zone." mBio https://doi.org/10.1128/MBIO.01017-17

Turner, R.E., N.N. Rabalais, D. Justić. 2017. Summer bottom-water temperature trends northern Gulf of Mexico continental shelf, 1985 to 2015. PLOS ONE https://doi.org/10.1371/journal.pone.0184350.

Invited Presentations

Rabalais, N.N., The Dead Zone: Will Shrimp and Corn Chowder Survive? Ronald Lecture Series in Environmental Conservation with an Emphasis in Water Sustainability; including a forum/lunch for ISU women scientists, and forum with women undergraduate students, Iowa State University, March 2018.

Rabalais, N.N. How Does Nitrogen from the Mid-West of the U.S. Cause 'Dead Zones' in the Northern Gulf of Mexico? Dept of Biology, University of Regina. January 2018.

Rabalais, Nancy N. TEDWomen Talk. The Dead Zone of the Gulf of Mexico. Placed on the web April 18, 2018; recorded Nov, 2017. https://www.ted.com/talks/nancy_rabalais_the_dead_zone_of_the_gulf_of_mexico

Rabalais, N. N., Gulf of Mexico: Dealing with Change in a Marginal Sea. Invited presentation in Addressing Environmental Challenges Through Research Infrastructures and Cooperative Networks with an Emphasis on Marine and Coastal Regions. American Geophysical Union, New Orleans, LA. 12 Dec 2017.

Rabalais, N.N., W.-J. Cai, C. Rabouille, K. Fennel, D. Justić, informal workshop at The Ocean Sciences Meeting, Portland, OR, Nov 2017 to compare 2017 summer data.

Rabalais, N.N., Beyond Science to Policy, Oschner Lifelong Learning Institute at Louisiana State University, Oct 2017.

Nancy Rabalais and Denis Gilbert both submitted potential sessions for the 4th Climate Change Symposium, The Effects of Climate Change on the World's Oceans, for June 2018. The sessions were combined. Coordination of speakers began in 2017, and activities will proceed through Sep 2018, time of conference.

Media and Other Requests for Information

Press coverage of the 2017 hypoxia season was extensive and posted at http://www.gulfhypoxia.net along with information from the 2017 hypoxia season work by LUMCON.

1-14-17
Paul Capel, USGS, Integrated Watershed Studies, Team Leader, National Water Quality Assessment Program, request for 2015 map and shape files for a USGS report on transport and behavior of agricultural chemicals throughout the hydrologic system

1-14-17
Adam J. Kuban, Assistant Professor, Ball State University
Met with his student-documentary team and provided information. Notification of completion and showing of a full (24:53) documentary — Downstream: Connecting Indiana to the Gulf of Mexico — at this link via YouTube: https://www.youtube.com/watch?v=l125AxuZ2N8&t=284s.
Final Product: http://www.scijourner.org/2017/04/07/infographic-dead-zones/

1-24-17
William E. Kelly, Co Editor Engineering for Sustainable Communities, permission for use of 2015 map in a book manuscript tentatively entitled “Engineering for Sustainable Communities.”

1-31-17
Sharon Levy levyscan@sbcglobal.net, interview for work on a book under contract for Oxford University Press. The focus is on the links between eutrophication and wetlands loss, and on strategies to limit nutrient pollution especially from ag land.

3-12-17
Meagan S. Mauter, Ph.D., Associate Professor, Civil & Environmental Engineering, Engineering & Public Policy, Carnegie Mellon University, I am a faculty member in Engineering and Public Policy at Carnegie Mellon and have followed your work at the intersection of science and policy for some time. I will be down in NOLA for the APS conference next week, as well as traveling with a colleague from my days at the Kennedy School to his camp in Cocodrie Tuesday night, 3/14. Meeting took place.

3-13-17
Molly Olmstead, interview for Slate magazine, I’m writing because I’m doing a story about jubilees (and other hypoxia events) and how they might change with loosened environmental regulations, as well as climate change. I wanted to make sure I didn’t write this post without trying to talk to you to get your thoughts on the future of hypoxia in the Gulf Coast. Did the interview.

3-28-17
Jerri G. Smitko, Smitko Law, Houma, LA 70361, invitation to participate and I did for on March 18th our friends from Wisconsin to witness firsthand the Louisiana seafood industry and continue our dialogue to prevent fertilizer run-off and combat the dead zone in the Gulf. Attended.

4-1-17
Katie Lodes, Science Teacher and Earth Angels moderator, St. Joseph’s Academy, St. Louis, MO 63131 I’m the science teacher from St. Louis, MO who you have been kind enough to correspond with over the years (and with my students as well). Currently, I have a student who is making an infographic on dead zones specifically the Gulf Dead Zone. She is trying to publish her work with the SciJourn group out of the University of Colorado. Continued to work with this teacher.

4-1-2017, Pro bono work for the DesMoines Water Works lawsuit against Buena Vista, Calhoun and Sac counties over nitrate pollution of the Raccoon River.

4-14-17
Mercedes Esperanza Fernández García <mercedesesperanzafg@gmail.com> My name is Mercedes Fernandez. I am an eighteen years old Mexican student from Mexico City. I am contacting many different nutritionists and environmental activists (among others) from many places around the world, asking them for their professional opinion about beginning a vegetarian or a vegan diet. Responded with information and publications about diet and nutrient loads, not as a dietitian.

5-1-17
Alex Wismer alex.wismer@optomenusa.com, I'm excited to hear that you're interested in joining us for an episode of our Nat Geo Wild show. As I mentioned, we're mainly exploring a cluster of human/shark encounters that occurred in 2006 in Oregon, but we are also interested in specifically featuring the cluster of encounters that occurred off of the Texas coast in 2004. Please let me know which days you are available from May 19 - May 25. NNR: this went nowhere

5-14-17
Lynn Grooms / Southern Wisconsin Reporter, Madison, WI 53713
Email interview into a magazine report.

5-18-17
Marianne V Moore mmoore@wellesley.edu, My question stems from a manuscript I'm co-writing with Russian scientific colleagues. In it, we argue that the recent coastal degradation occurring in Lake Baikal is due to eutrophication. Because of the many similarities between L. Baikal and the ocean …., Email response

5-22-17
Irina Zhorov izhorov@whyy.org, environmental reporter with a science show called The Pulse, out of Philadelphia's NPR station, WHYY. We're working on an episode dedicated to water, focused on the Mississippi basin. We'll trace issues in the basin from the headwaters of the Mississippi to the mouth of the river, covering agricultural and urban storm water runoff, conservation issues, etc. I want to end the show with a story about the Gulf's annual dead zone. Interviewed in person in Cocodrie.
http://www.newsworks.org/index.php/thepulse/item/107332-traveling-down-the-modern-mississippi

6-1-17
Lynn Grooms/Agri-View, Farmers from Iowa County's Farmer-Led Watershed Protection Group enter the Louisiana Universities Marine Consortium center to learn more about how nutrient runoff from farmlands impacts the Gulf of Mexico. Interviewed for Agriview article published

6-11-17
Lynn Grooms LGrooms@madison.com, Renewable Fuels Association's analysis of the hypoxia zone in the Gulf of Mexico. Fact check for article on ethanol.

6-12-17
Ricardo J. Salvador, Director and Senior Scientist, Food & Environment Program, Union of Concerned Scientists, Washington, DC 20006, We've got some work scheduled for this summer whose release date will be contingent on your annual update on the hypoxic zone. I'm writing in advance to confirm your schedule for this, as I remembered reading last year that there'd been a problem with funding for the full measurement? Did I imagine that? In any case, if that was an issue I hope it has been resolved (and if we can help with support via advocacy here in D.C., do let me know of course.) As always (it can't be said enough), many thanks for your leadership and commitment to this critical work. Interviewed for blog http://blog.ucsusa.org/karen-perry-stillerman/this-summers-gulf-dead-zone-could-be-bigger-than-connecticut-and-trumps-budget-cuts-would-make-it-worse

6-21-17
Matt Smith, seeker.com, interview for https://www.seeker.com/earth/conservation/the-gulf-of-mexicos-dead-zone-could-nearly-double-in-size-this-year

6-21-17
Mark Schlefstein, nola.com, Interview for 2017 dead zone predictions

6-21-17
Lucia von Reusner lucia@waxmanstrategies.com, Local grassroots and report outreach strategy for US meat pollution campaign, I was forwarded the prediction your lab just put out from Gulf Restoration Network. Mighty Earth is preparing to launch a campaign aim at pushing the meat industry to prevent fertilizer pollution from U.S. feed crops (i.e. corn and soy), and our report will be focused on how meat producers upstream are driving pollution problems downstream. The projected Dead Zone could be a great reporter angle, and Gulf Restoration Network mentioned that your team does a scientific boat trip to measure the Zone every year that could be interesting to invite reporters on. Discussed but declined to be a named member of the organization. Always supply data and maps as requested.

6-22-17
The Advocate, Baton Rouge, "A Dead Zone May Be Shaken Up.' Interviewed.

8-2-17
Janet McConnaughey, Associated Press Unwanted Record: Biggest Ever Dead Zone in Gulf of Mexico

There's an unwanted record in the Gulf of Mexico: This year's "dead zone," where there's too little oxygen to support marine life, is the biggest ever measured. Interviewed

8-2-17
The American Press, Influence of the 'dead zone' in gulf. Interviewed,

8-6-17
Times-Picayune, Gulf of Mexico dead zone is going in the wrong direction: Editorial, Our work heavily cited.

8-3-17
Ruairí Arrieta-Kenna@ruairiakruairi@vox.com, The biggest ever "dead zone" in the Gulf of Mexico is the size of New Jersey, The man-made problem is an environmental disaster and an economic threat. www.vox.com. Interviewed.

8-6-17
ADVOCATE, Baton Rouge, LA, Our Views: Setting a 'dead zone' record in Gulf, Editorial

8-7-17
Interview, live radio, WRKF 89.3, Baton Rouge, Louisiana Talk, with Jim Engster about hypoxia cruise results.

8-7-17
Interview - Prof. Rabalais with Tim Smedley, UK-based author writing a popular science book, to be published by Bloomsbury, telling the story of the fight against air pollution.

8-7-17
Satish Gupta gupta002@umn.edu, Request for data on the extent of hypoxic area in the Gulf of Mexico, Per my request to Dr. Scavia, I was wondering if the data on variation in hypoxic area that appeared in Scavia et al. recent paper in PNAS is available to researchers? I shall appreciate hearing from you on this request. To: Satish, My data are not the same as Obenour's paper, but within 1%. I do not have Obenour's modeled estimates. Mine are on the web site, www.gulfhypoxia.net but I include an xls for your use.

8-8-17
Alex Minton, Assistant Producer, Icon Films, Bristol, BS15SP, www.iconfilms.co.uk, Planet Earth series on Wild Rivers, Interviewed and worked on logistics. Coming back 3 weeks in September.

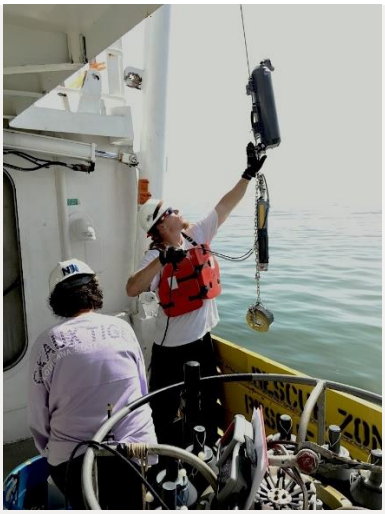
8-8-17
Ramos, Annie Rose (NBCUniversal) <AnnieRose.Ramos@nbcuni.com, Today Show
Took a lot of time, a cruise and provision of underwater video. They did not air because CBS morning news beat them. Initial on site interview and trip offshore.

8-14-17
Tennery Norton tennery.norton@byu.edu, Interview Request from BYUradio, I'm the producer of *Top of Mind with Julie Rose* on BYUradio. Interviewed. On line at
http://www.byuradio.org/episode/bfe3eee9-381c-4999-8725-7be695620a19?playhead=&autoplay=true

8-14-17
Mary Hartmett, Sioux City, IA, interview 8-11-17 for KWIT, the NPR affiliate in Sioux City
Aug 11, radio interview

8-14-17
LSU Press Office, Gulf of Mexico Dead Zone in Need of Bold New Approaches

08/02/2017
LSU Press Office



Scientists Nancy Rabalais [note “Geaux Tigers” t-shirt] and Matt Kupnick deploy an oxygen meter to measure oxygen concentrations within 1 foot of the seabed in the Gulf of Mexico. Rabalais has led the team measuring oxygen concentration in the bottom waters at more than 100 stations on 32 research cruises since 1985.
Photo Credit: R. Eugene Turner, LSU

8-16-17
CBS went live with Hypoxia story this morning
Here is the link to the broadcast:
http://www.cbs.com/shows/cbs_this_morning/video/wRLAnk69WpJaKWwXqKd8Ngk7FjeonlZV/-largest-dead-zone-recorded-in-u-s-threatens-marine-life/
Prime time in the morning, good piece. Took A LOT of work to coordinate.

8-22-17
Kevin Pina, kevinpina@yahoo.com. The show is “Flash Point” on Pacifica Radio. Would like to interview you about this year's unprecedented "Dead Zone" in the gulf. Done.

8-25-17
Linda M. Breazeale, Senior Extension Associate|Agricultural Communications, Mississippi State University Extension Service, requested use of 2017 map. Sent better jpg.
https://gulfhypoxia.net/research/shelfwide-cruise/?y=2017&p=oxy_maps

8-31-17
Flesher, John, Associated Press, environmental reporter: we’ve spoken before about the Gulf of Mexico dead zone and related issues. I’m now working on a story about the potential effects of the Harvey floodwaters – which eventually will end up in Galveston Bay and the Gulf itself. Could you spare a few minutes today to discuss potential ecological impacts? I’m wondering particularly about the nutrients that will wash into the Gulf, especially given the already huge size of the dead zone this year. Another question is how shellfish beds will be affected. Returned call and interview questions

9-5-17
Daniel Trotta @ thomsonreutere.com, Correspondent, U.S. General News, I am a reporter for Reuters who would like to interview you tomorrow (Tuesday) regarding Hurricane Harvey’s environmental impact on the Gulf. All the runoff from the storm can’t be good for the health of the Gulf. Might it exacerbate the Dead Zone, for example? Interviewed.

9-15-17
Michael L. Cain, Department of Biology, Bowdoin College, Brunswick, Maine, Hypoxia in Gulf/textbook request, I am a coauthor of the two Campbell textbooks for biology majors, BIOLOGY (11th edition) and

Biology in Focus (2nd edition). I'm now working on the next edition of *Focus* and plan to add a new figure on the Gulf of Mexico "dead zone." Related questions and request for image. Done.

9-21-17
Wiedeking.L@zdf.de, Dead Zone in the Mexican Gulf, Lara Wiedeking, I am a producer for ZDF German Television (www.zdf.de), we are a public broadcaster like the BBC or PBS and among Europe's largest TV channels. We are interested in doing a story about the expanding dead zone in the Gulf of Mexico. It would be a background piece, 5 to 6 minutes, about the situation in the Gulf of Mexico and the dangers resulting from it for the ecosystem. On a CBS newscast you were talking to a reporter on a boat, examining the water and the bad quality. I was wondering, if you still take your boat oat to test the water, and if you would be interested in working with us on this story? We would go out on the boat, show your work, do an interview. This did not happen, too late in the season, to be realistic to happen.

9-22-17
Mindy Cooper mindycooper@msn.com, Interview Request from Environmental Monitor, Good afternoon. I'm a writer with the Environmental Monitor, a trade publication backed by Fondriest Environmental. We write articles about notable environmental monitoring projects, as well as the professionals and equipment involved. I would like to write a piece about your work monitoring the dead zone in the Gulf of Mexico. Would you be interested in answering some questions about your work? If so, when is a good time for you? This was done.

10-4-17
Sara Sneath, nola.com, What does it look like to dive in the Gulf dead zone? This diver took video
Updated on October 4, 2017 at 12:29 PM

LSU marine scientist Nancy Rabalais is seen in the video shot by LSU assistant professor Cameron Thrash.

10-24-17
Television France: http://www.francetvinfo.fr/monde/usa/golfe-du-mexique-un-paradis-empoisonne_2432269.html, Also a lot of logistical work.

11-17-17
Ed Brotak
I am writing an article for *Southern Boating* magazine about the Gulf of Mexico "Dead Zone". I've checked out several NOAA sites and LUMCON's. I only have 800+ words to cover everything, but I have a good idea of what I want to present. We will need some high res images to go with the text. I saw your name with the July 2017 dead zone depiction map. Would this be available? Any other ideas on images would be greatly appreciated, too. Sent some images.
3-23-18 THE ADVOCATE

NGI FILE #17-NGI3-23

Project Title: Examination and Validation of Reconnaissance Field Program Data in Multiple HWRF Frameworks

Project Lead (PI) name, affiliation, email address: Pat Fitzpatrick, Mississippi State University, fitz@gri.msstate.edu

Project objective and goals

The overarching goal is to perform validation and case study analyses of NOAA HWRF products and experimental products such as HWRF-HYCOM, HEDAS, and basin-scale HWRF. We also leverage tropical cyclone-tornado research from a previously funded AOML grant into a paper.

Description of research conducted during the reporting period and milestones accomplished and/or completed

- We validated the current HRD operational HWRF products for the previous two Atlantic hurricane seasons in collaboration with Miami NOAA AOML HRD staff and National Hurricane Center staff. A multi-metric validation technique has been developed which blends absolute error; bias; 7 types of outlier metrics; model efficiency; Pearson correlation; Kendall's tau; reliability index; multiplicative gross error; and root mean squared differences. Each metric is ranked, followed by total rank averaging, and sorted to assess HWRF forecasts against. A) 17 track forecast products; B) 11 intensity forecast products; c) 4 R34 forecast products
- Examination of HWRF-HYCOM sensitivity experiments for Hurricane Edouard's intensification (provided by EMC). We examined the sensitivity of operational HWRF to eight sea surface temperature (SST) configurations in a neutral shear environment (8 m/s<shear<14m/s). This is achieved using a control run for Hurricane Edouard (2014) with the GFS SST, then rerun with SST configurations from NCODA for 2014; RTOFS for 2014; GDEM climatology; and NCODA for 2010-2013. This work also overlapped the Ocean Model Impact Tiger Team (OMITT) intiative.
- While examining the HWRF-HYCOM datasets, we discovered HWRF's current formulation for the Kurihara vortex filter was not working properly. A Von Neumann analysis of the Kurihara filter was performed, and an improved Kurihara scheme was developed.
- Wind structure assessments and four-quadrant empirical scheme algorithm development have begun, and include NOAA CIRA scientists in addition to HRD and EMC scientists. These results will be reported next year.
- Hurricane Nate rapidly weakened before landfall, and as part of the OMITT mission, we are examining the oceanic continental shelf evolution near the Mississippi coast. This work leverages other ocean model funded research (CONCORDE), and include atmospheric forcing components, including forcing from Hurricane Nate, and the remnants of Hurricane Patricia in recently published work. This ocean physics examination will also be supplemented by ocean temperature and salinity data from the USGS-MDMR, and ocean currents from the CenGOOS CODAR SeaSondse High-Frequency Radar network.

Finally, in a previously funded travel grant, Frank Mark encouraged research proposals on tornadoes and inner-core convection during tropical cyclone landfall. These proposals were not funded, but unique historical documentation was assembled which was published in a BAMS peer-reviewed paper of Dr. William Gray's legacy. Fitzpatrick was also a co-chair in organizing a Bill Gray memorial session at the recent 33rd Conference on Hurricanes and Tropical Meteorology.

Description of significant research results, protocols developed, and research transitions

Validation research results are summarized below:

- Track forecasts were evaluated in terms of forecast track distance error (a measure of translation speed error); track angle error; along- and cross-track errors; and distance error from forecasted location (NHC method, dubbed DFL). Generally, the consensus products provided the best skill (some of which include HWRF). In terms of early models, HWFI only trailed ECMWF for track angles and DFL. However, HWFI lagged the ECMWF, Canadian, and UKMET models for translation speed error. Also noteworthy was that the basin-scale HWRF outperformed the late version of HWRF.
- Intensity forecasts were evaluated against consensus, model, and empirical schemes. Generally, the consensus products provided the best skill (some of which include HWRF). However, for the 2nd year in a row, HWFI's skill exceeded all statistical products. Moreover, HWFI out-performed all other models.
- Structure forecasts were evaluated against operational HWRF, HWFI, and NHC official using the Radius of 34 (R34) knot winds. HWRF R34 predictions exceeded NHC's R34 prediction accuracy for the first time in 2017.

<u>Hurricane Edouard sensitivity analysis results are summarized below:</u>

- In all runs, the TC develops then approaches a steady-state. Intensity responses over the warmer and wider SST pools result in moderate-to-rapid intensification. Statistical assessments were performed for the 8 runs SST, sensible heat flux, latent heat flux, Convective Available Potential Energy (CAPE), surface relative humidity, and surface dewpoint temperature are determined at the radius of maximum winds (R_{max}) in compass 30-deg directions, and averaged. Filtered wind shear and precipitable water are determined at the 100-, 200-, 300-, 400-, and 500-km radii in 90-deg compass directions, and averaged using the 20 points. Wind shear was computed as the vectorial wind difference between 200- and 850-mb pressure levels.
- Linear correlation results showed V_{max} is correlated to SST with a variance explained of 59-61%, but higher correlations exist for the fluxes with a variance explained of 72-80%. However, the intensification cycle (defined as ΔV_{max} over a 24-h period) is mostly linearly correlated to CAPE with 49% explained variance. Generally, other correlations were either low for V_{max}, low for ΔV_{max}, or highly correlated with CAPE or sensible heat flux (multicollinearity relationships). Moreover, when a sigmoidal correlation relationship is computed for sensible heat flux versus V_{max}, r=0.94 and the variance explained is 88%. Hence, for a favorable environmental environment in this HWRF environment of 8 cases, the TC slowly develops as it approaches the warm pool with a correspondence to heat flux, intensifies in response to a "CAPE boost" as it begins moving over SST of 27.5-28.5°C with an intensity change linearly proportional to CAPE, then approaches steady-state as CAPE is reduced partially due to the developing warm-core aloft.

<u>Kurihara filter analysis results are summarized below:</u>

- while performing the Edouard sensitivity work, we encountered problems removing its large vortex (required for shear calculations) using the Kurihrara filter. The traditional 2-3-4-2-5-6-7-2-8-9-2 Kurihara filter failed, but was remedied by expanding to a 2-3-4-2-5-6-7-2-8-9-2-10-11-2-12-13-2-3-2 filter. A response function analysis of both filters shows the new scheme is more suitable for higher-resolution models, as Kurihara originally tuned his scheme for a coarse model to remove ten-degree features. An interesting necessity is the need for an intermittent 2Δx pass or the scheme becomes unstable — a property not discussed in Kurihara's original paper. It's been noted that more passes are required for the higher-resolution models, and additional modifications to remove 3-5Δx noise may be required. Ultimately, as model resolution continues to improve, the original Kurihara scheme will become ineffective, and we will explore the necessary steps to remedy this problem. Of equal concern is that this Kurihara scheme is a component of the HWRF data assimilation as the vortex is relocated.

Publications and conference summaries

- Five peer-review journals published, one in press.
- Ten presentations
- Two papers
- NOAA scientists were co-authors or leads in half

Collaborators/partners

- Interactions with NOAA NCEP scientists Jili Dong and Hyun-Sook Kim regarding operational HWRF sensitivity experiments to warm pool configurations (5 presentations this fiscal year)
- Dr. Chris Landsea of NOAA's National Hurricane Center was a co-author on a published paper
- The validation work involved collaborations NOAA AOML HRD scientists Frank Marks, Sim Aberson, and Ghassan Alaka; NOAA NHC forecaster John Cangialosi (1 presentation this year)
- Research on Kurihara filter involving collaborations with NOAA AOML HRD scientists Frank Marks, Sundararaman Gopalakrishnan, and Hua Chen; and NOAA EMC scientist Henry Winterbottom (2 presentations this year)
- Wind forcing/storm surge research with NOAA CIRA scientist John Knaff (1 poster)

Outreach activities

- Interactions with NOAA scientists, Wood Holes, NRL, and University of Miami on The Ocean Model Impact Tiger Team (OMITT).
- Participation in AOML HRD monthly science meetings
- Attended and presented at the Tropical Cyclone Operations and Research Forum (TCORF), March 13-15, 2018, in Miami, FL.
- Attended and co-author of presentation at 2017 Hurricane Forecast Improvement Program Annual Review Meeting, Nov. 7-9, 2017, in Miami, FL.
- Attended "Building a Weather-Ready Nation by Transitioning Academic Research into Operations Workshop" 10/31/17-11/2/17 in Washington, DC; led one of the break-out sessions
- Dr. Chris Landsea of NOAA's National Hurricane Center was a co-author on a published paper
- Fitzpatrick was one of the session chairs honoring Dr. Bill Gray at the AMS 33rd Conference on Hurricanes and Tropical Meteorology. We coordinated 11 invited speakers with a regular and evening session along with an open microphone session. Fitzpatrick was one of the speakers. Several speakers and another session chair were from NOAA.
- Member of the Scientific and Technological Activities Commission (STAC) Committee on the Coastal Environment (CE) for the American Meteorological Society. Its primary duty is to organize the Symposium on the Coastal Environment held at AMS meetings. We also review applicants for the Reichelderfer Award, judge student presentations, and act as session chairs.
- Fitzpatrick was an invited guest to a private sector conference ("On The Mark Hurricane Symposium") and gave two presentations on state-of-the-art hurricane observation technology and storm surge
- Member of National Hurricane Conference Hurricane History Committee
- Reviewer for *Oceanography; Journal of Waterway, Port, Coastal, and Ocean Engineering;* and *Bulletin of the American Meteorological Society* papers
- Interviews regarding hurricanes for *Mississippi Today; Physics World;* and *WGSO radio*

Economic activities

Not applicable. But Fitzpatrick has industry collaborators, and potential exists for transitioning the work to the commercial realm.

NGI FILE #17-NGI3-24:

Project Title: AOML-NGI South Florida Water Quality Analyses

Project Lead (PI) name, affiliation, email address: Steve Ashby, NGI, sashby@ngi.msstate.edu

Co-Principal Investigator name, affiliation, email address: Anna Linhoss, Mississippi State University, alinhoss@abe.msstate.edu, Nicole Millette, Mississippi State University, nicole.millette@noaa.gov

NOAA sponsor and NOAA office of primary technical contact: Molly Baringer, AOML and Chris Kelble, AOML

Project objectives and goals

The initial focus of this project is to analyze the temporal and spatial distributions of water quality parameters (particularly nutrients and chlorophyll a) in south Florida coastal systems. NOAA/AOML and its partners have over 20-years of water quality measurements in south Florida coastal and marine waters along with about 20-years of canal loading data for various canals in south Florida.
While focusing on the potential sources of nutrients to south Florida coastal waters, this analysis should develop hypotheses that can be tested with process studies during year 2 of the project. These process studies can be undertaken as added studies that will augment the existing field program in south Florida (www.aoml.noaa.gov/sfp). The process studies should focus on enhancing our understanding of water quality dynamics by addressing key gaps in our knowledge regarding nutrient cycling or sources or emerging issues of concern. These emerging issues of concern could entail investigating potential sources for nutrients from shoreline activities with a high potential to cause disturbance to Biscayne Bay (e.g. Turkey Point Power Plant, South Dade Landfill, wastewater treatment facilities, etc.).

Specific objectives for the first year of the study were:

1) Finalize a combined Quality controlled and Quality Assured data set for water quality in south Florida Coastal Waters from NOAA/AOML and partner's datasets
2) Develop a manuscript investigating temporal dynamics in water quality in south Florida focusing upon long-term trends and hypothetical causes for observed trends
3) Develop proposed process studies to investigate key gaps in our knowledge of south Florida water quality dynamics

Description of research conducted during the reporting period and milestones accomplished and/or completed

Data from the aforementioned studies were compiled into a single database, reviewed for quality control, and statistically analyzed to evaluate trends, spatial and temporal patterns, and anomalies.
One manuscript was prepared and accepted for the Bulletin of Marine Science (Millette, et al., Shift in Baseline Chlorophyll *a* Concentration Following a Three-Year *Synechococcus* Bloom in South Eastern Florida). Results from this study were presented by Dr. Millette at the 2017 Coastal and Estuarine Research Federation Conference. A second manuscript entitled "Using Spatial Variability in the Rate of Change of Chlorophyll *a* to Identify Primary Sources of Nutrients into a Subtropical Oligotrophic Estuary", was submitted to Estuaries and Coasts (ESCO) and is being revised to address reviewers' comments. A third manuscript is being prepared to describe the statistical methods employed to assess the data.

Recommendations for additional process studies include:

- Incorporate accurate estimations of phytoplankton carbon biomass and C:chl *a* ratios into the water quality analysis simulation program (WASP model)
- Conduct assessments of primary production using net ecosystem metabolism (NEM) as a way to measure the impact of eutrophication on the system
- Conduct measurements of zooplankton grazing rates on phytoplankton

- Conduct nutrient addition experiments to measure how phytoplankton community daily growth shifts with the addition of different nutrients and nutrient uptake experiments to measure the rate at which the phytoplankton community takes up different nutrient species.

These recommendations are currently being vetted with the entire team and NOAA/AOML partners.

A summary of activities document was prepared by Dr. Millette and provided to NGI and AOML. The document includes a summary of key findings, details of the databases used in the analyses and metadata describing the data files, and recommendations for additional process studies.

Emphasis on land use activities and watershed sources of nutrients was also identified as an additional need.

Description of significant research results, protocols developed, and research transitions

Key findings: (See Figures 1-4)
Biscayne Bay does not currently show many symptoms of severe, wide spread eutrophication, but we were able to identify specific canals that are likely the major source of nutrients causing the most severe localized degradation of water quality. The high rates of increase at the mouth of these canals suggest that nutrients from them are responsible for changes in chlorophyll *a* and provide an indication of nutrient sources for resource managers to target. The relatively uniform increase in PO_4^{3-} concentrations throughout all of Biscayne Bay and low, but significant increases in chlorophyll *a* at most offshore stations suggests that the entire Bay is susceptible to what is occurring at nearshore stations. If chlorophyll *a* concentrations continue to increase, then we will likely start to observe more damaging effects of eutrophication on Biscayne Bay's ecosystem such as the loss of SAV and periods of hypoxia. The present lack of these more serious effects of eutrophication suggests that the current eutrophication of Biscayne Bay could still be reversed if appropriate actions are taken to reduce the nutrient loading from land into the Bay.

Our analysis of long-term trends of various factors at individual stations provided a detailed look at where water quality is degrading at the fastest rate and what is driving the decline in water quality. It is clear, within Biscayne Bay, that chlorophyll *a* and phosphate concentrations are increasing while inorganic nitrogen concentrations are mostly stable. With a regional analysis we still would have rightly concluded that chlorophyll *a* and phosphate concentrations are increasing in Biscayne Bay, but with the individual station approach we are able to understand how the severity of the decline in water quality in NBB compared to the rest of the Bay and identify specific canals to target for aggressive management in CBB and SBB. This demonstrates how useful this nuanced approach is for studying water quality and creating management lands in Biscayne Bay, and potentially other systems.

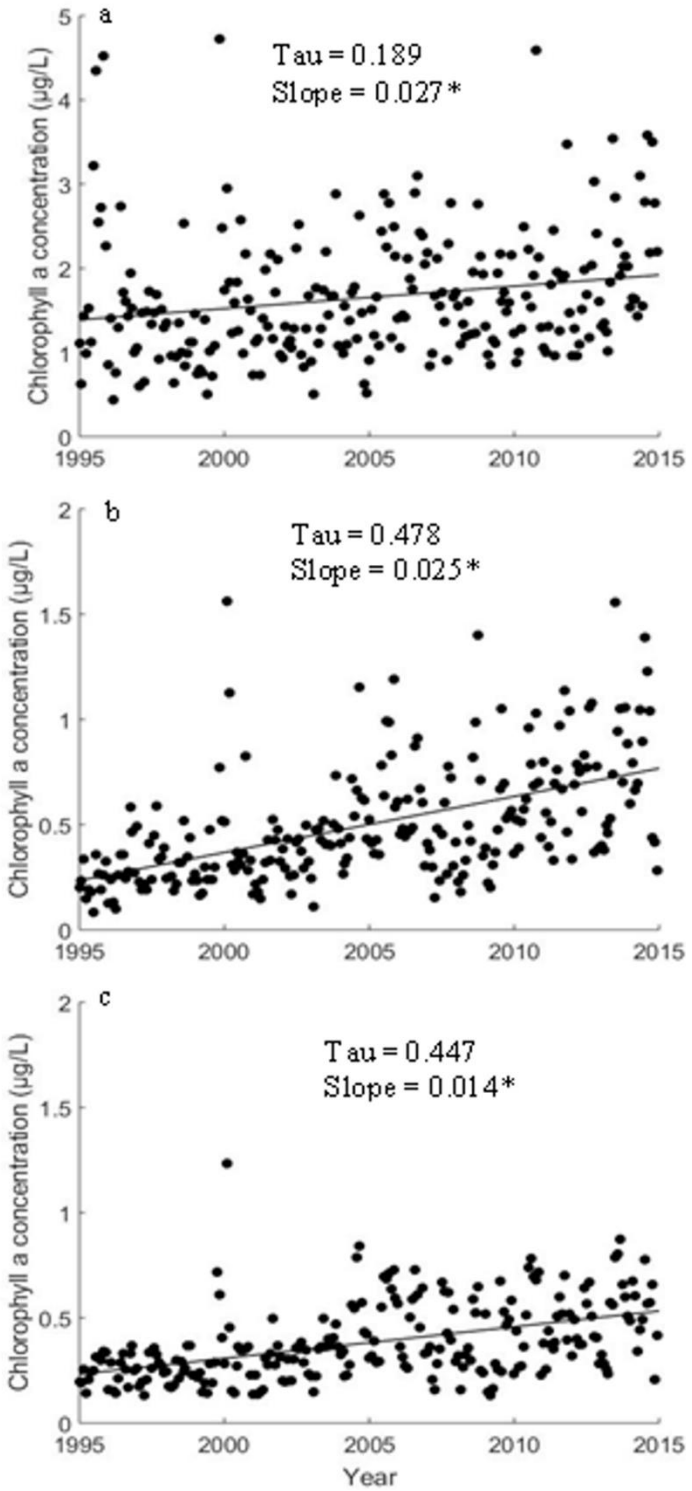


Figure 1. The chlorophyll *a* (µg L^{-1}) concentrations in (a) NBB, (b) CBB, and (c) SBB from 1996 to 2014 in NBB and 1995 to 2014 in CBB and SBB. *Refers to a significant multiple regression (P>0.05).

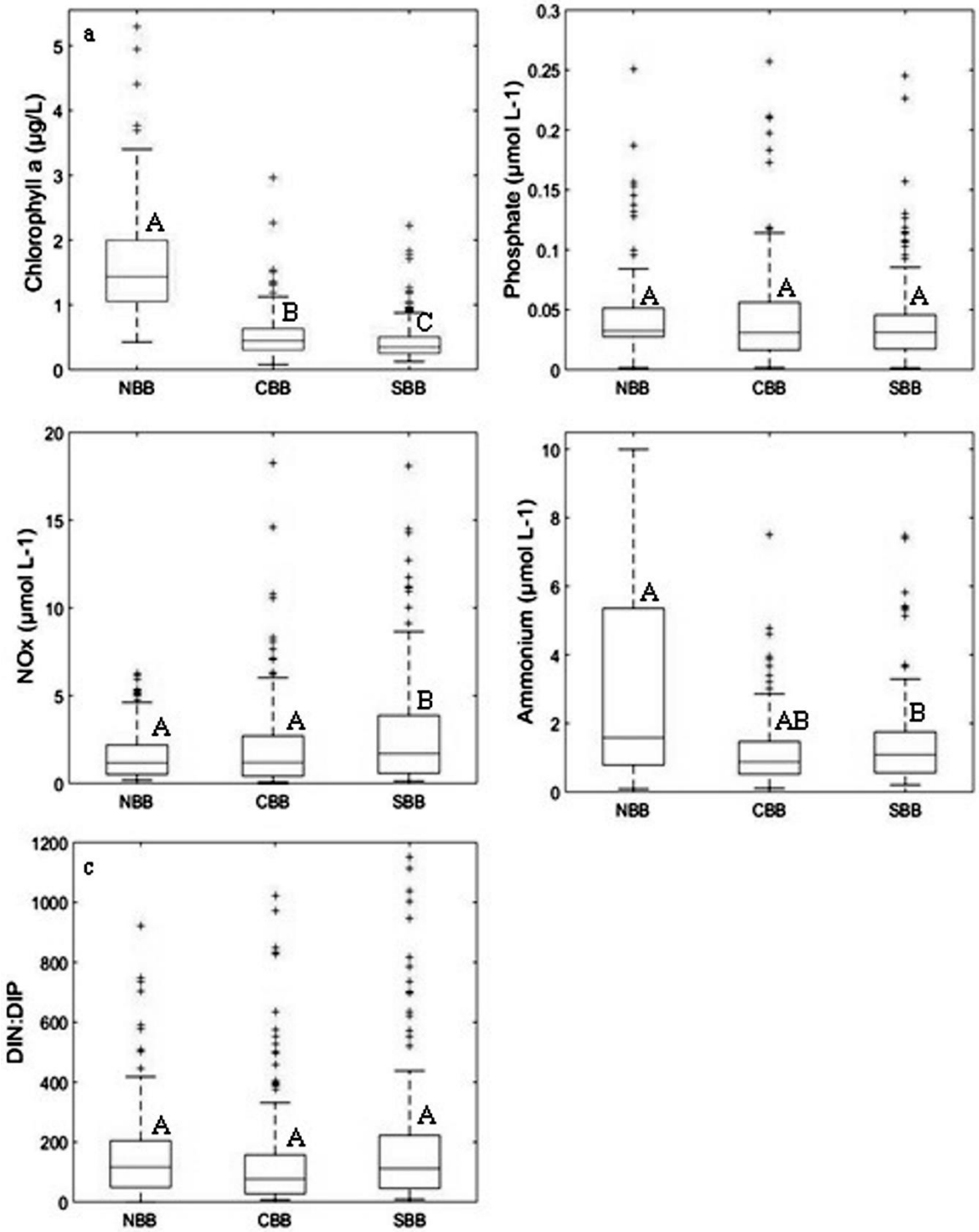


Figure 2. Box and whisker plots showing the mean, quartiles and range of (Chlorophyll a concentrations (µg L^{-1}), NOx (µmol L^{-1}), Phosphate (µmol L^{-1}), Ammonium (µmol L^{-1}), and NO_x:PO_4^{3-} in the three distinct regions of Biscayne Bay: north Biscayne Bay (NBB), central Biscayne Bay (CBB), and south Biscayne Bay (SBB). One-factor ANOVA tests were run for each factor to compare the different regions. The letters represent when regions are significantly different ($P<0.05$) from each other for that parameter.

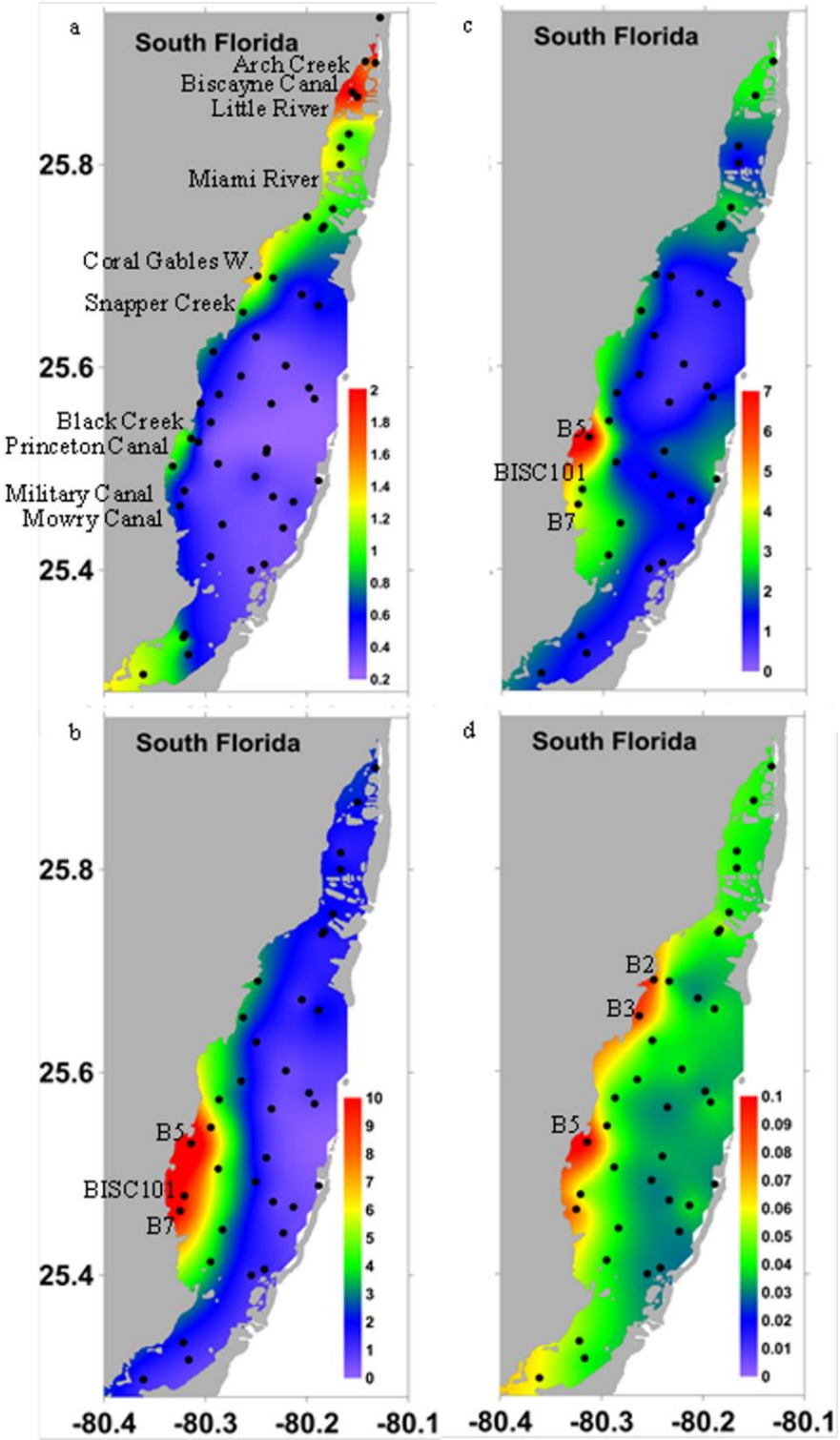


Figure 3. The average concentration of (a) chlorophyll a (µg L^{-1}), (b) NO_x (µmol L^{-1}), (c) PO_4^{3-} (µmol L^{-1}), and (d) ammonium (µmol L^{-1}) concentrations at individual stations throughout Biscayne Bay. Specific stations mentioned in the results and discussion of the publication in revision are labeled on the maps.

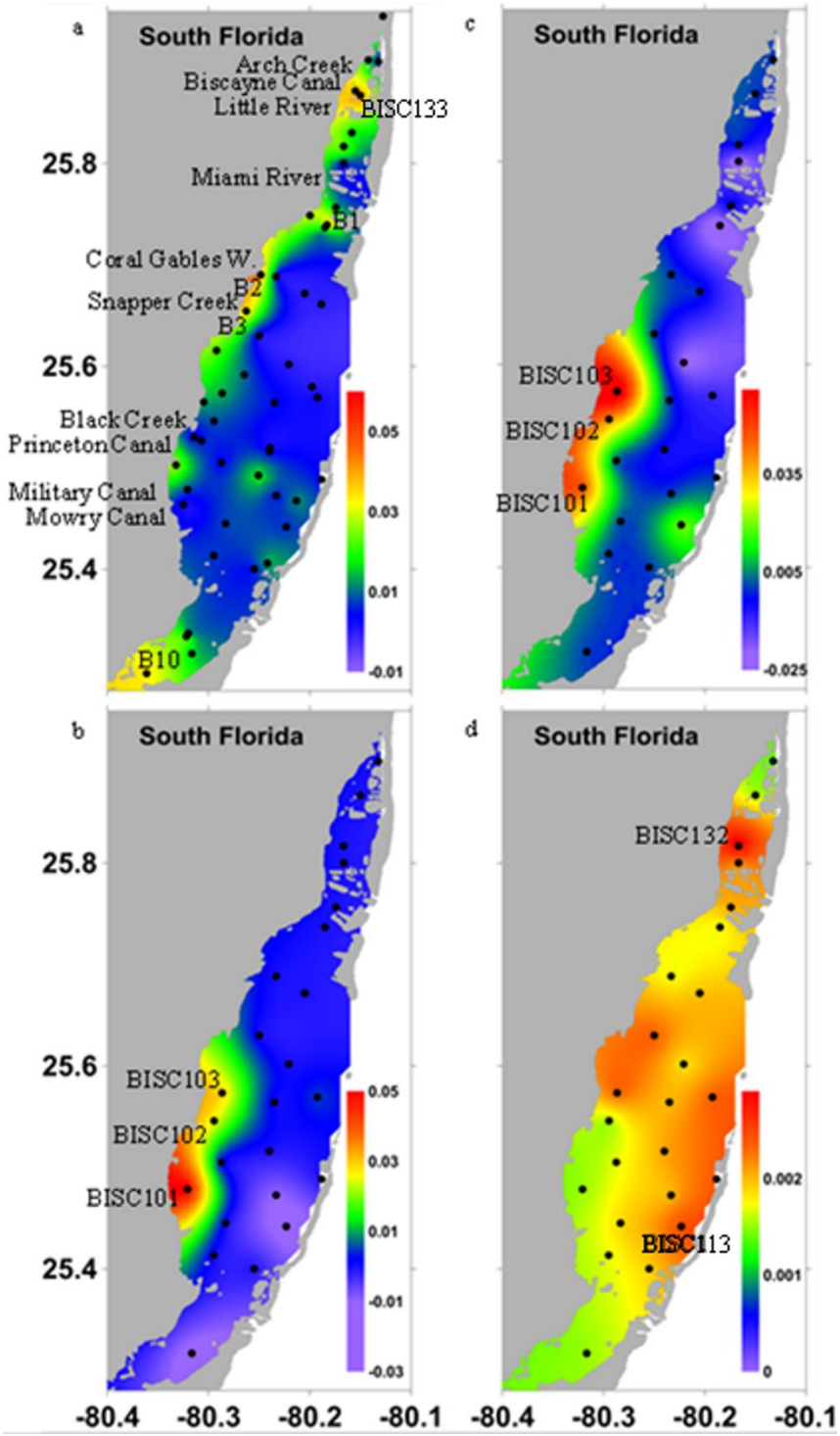


Figure 4. The annual rate of change in (a) chlorophyll a (µg L^{-1} y^{-1}), (b) NO_x (µmol L^{-1} y^{-1}), (c) PO_4^{3-} (µmol L^{-1} y^{-1}), and (d) ammonium (µmol L^{-1}) concentrations at individual stations throughout Biscayne Bay. Specific stations mentioned in the results of the publication in revision are labeled on the maps.

Information on collaborators/partners

Name of collaborating organization – NOAA Biscayne Bay Habitat Focus Area, NOAA/AOML
Date collaborating established – 6/1/2016
Does partner provide monetary support to project? No Amount of support? None
Does partner provide non-monetary (in-kind) support? Yes, technical input/review, technical input to studies, use of study results to improve management of Biscayne Bay nutrient loading
Short description of collaboration/partnership relationship –
The Biscayne Bay Habitat Focus Area (BB-HFA) has as one of its primary objectives halting the increase in eutrophication of Biscayne Bay. This study helps to determine where Biscayne Bay is showing signs of eutrophication to prioritize where BB-HFA should focus on working with partners to reduce nutrient loading.

Information on any outreach activities

Results to date will be presented the results to the Biscayne Bay Regional Restoration Coordination Team in June 2018.

NGI File# 17-NGI3-25

Project Title: Calibration and validation of Ocean Products on NOAA VIIRS for Monitoring Oceans

Project Lead (PI) name, affiliation, email address: Prof. Robert Arnone, University Southern Mississippi, Robert.Arnone@usm.edu

Co-Principal Investigators name, affiliation, email address: Bill Gibson, Louisiana State University, bgibson@lsu.edu and Sherwin Ladner, Naval Research Laboratory, Sherwin.Ladner@nrlssc.navy.mil

Project objectives and goals

This proposed activity is to establish the on-orbit calibration and validation of satellite ocean products for the VIIRS (Visible Infrared Imaging Radiometer Suite) on NOAA's Suomi National Polar–orbiting Preparatory Project (SNPP) satellite. Additional VIIRS sensors will be used aboard the follow-on NOAA satellite missions, therefore it is important to determine calibration and validation procedures for the sensor which can be applied to future missions such as J1 scheduled to be launched in 2018, J2, J3, etc). The project is coordinating with NOAA, NASA, Universities, and Navy scientists and has demonstrated the capability for VIIRS ocean products to reach maturity within the JPSS program. As a member of NOAA's national JPSS calibration and validation team for the United States, we coordinate with many team members for calibration of ocean satellite products.

The project goal is to improve and evaluate ocean color products through enhanced calibration and validation efforts. Ocean color products include the water leaving radiance (nLW and RRS), chlorophyll, and bio-optical properties. Improving ocean products will significantly enhance the capability to monitor coastal and open waters for both near real-time operational and scientific products. Monitoring the VIIRS calibration for stability and consistency is required to establish a long term climate trend of the ocean's properties. The VIIRS NOAA's environmental satellites fulfill a critical national requirement for monitoring ocean properties in supporting operations (CoastWatch) and science research.

NOAA Center for Satellite Applications and Research (STAR) is processing VIIRS ocean products using MSL12 for ocean color products. The project goals for ocean color are to collect accurate insitu data to be used for validation and calibration of the VIIRS sensor and to evaluate the long term trends of the sensor calibration for MSL12 processing software. Improved accuracy of the insitu data is attained by evaluating and improving measurement and processing protocols. Improvements in the insitu accuracy and variability of insitu optics are required for enhanced calibration.

The project goal is to support the NOAA STAR and JPSS programs to track the stability of the VIIRS sensor and satellite products and support the JPSS program. The VIIRS calval team will thoroughly investigate the sensor characterization as well as the processing software used to derive ocean products.

Description of research conducted during the reporting period and milestones accomplished

The project has major research areas which include:

A) Maintaining WavCis platform for insitu ocean color validation
B) VIIRS Matchup of IOP absorption with cruises continuous underway (flowthrough) surface data both 2016 Bonnie Carrie and cal val cruise
C) Hyperpro, ASD and Spectral Evolution comparison
D) Preparation for the Okeanos calval cruise
E) Okeanos Ocean Color calval cruise participation and coordination
F) Participation in NOAA's VIIRS calval telecons and annual review meeting
G) Summary

A. Maintaining WavCIS – Coastal Calibration Site:

The WAVCIS site (CSI 6) is located SW of Grand Island Louisiana and is equipped with an AERONET Sea Prism instrument and is part of an international network for ocean color calibration and validation (see http://aeronet.gsfc.nasa.gov/new_web/ocean_color.html). There currently are four Sea Prism sites in coastal United States waters. The WavCIS Sea Prism site is reporting daily spectral water leaving radiance (nlw) and aerosol optical depth every 30 minutes during daylight hours. The platform is visited periodically and the Sea Prism sensor is monitored for high quality data and consistent communication and calibration. WavCIS sends daily data to the NASA AERONET network that provides daily real-time Sea Prism data to scientists. The WavCIS site has been providing an excellent highly accurate data stream for the ocean color community for the last 6 years. The NOAA JPSS team has shown the matchups of VIIRS satellite to be quite good at WavCIS site compared to the other sites on the east and west coast of US. The Stennis team is using the WavCIS to maintain consistent and reliable data for monitoring the satellite and algorithm performance in coastal (green) waters. The WavCIS data goes through a level 0 to 1 to 2 processing at NASA. The WavCIS data was identified as good data and has reached the highest level 2, for data prior to Sept 2016.

WavCIS has been operating successfully and providing daily data to NOAA for VIIRS calval this reporting period. WavCIS site has had AERONET SN 638 operating since August 2017 this year, and is planning to change to SN610 in June/July 2018. WavCIS has been visited several times this year to repair and update the system to sustain operations. Communications failed last summer 2017 due to passage of Tropical Storm Cindy that made landfall at Texas/Louisiana border. The Satellite antenna was turned 30 degrees to the southwest and sleeves were added that allowed the antenna clamp to properly tighten around the pole and not slip under high wind conditions. No data was lost as it was stored on the computer and transferred successfully to NASA with the site fully up to date. The AERONET SN 610 failed at the end of July and the robotic arm was repaired on August 17th. SN 610 was removed and SN 638 installed and fully operational and working with no more error codes being set. The new Sea Prism view has changed due to the removal of the life capsules from the platform and has an increased view for improved data collection in the afternoon yielding more measurements. The changes have been forwarded to NASA (Zibordi) to identify and quality control additional late afternoon data. SN 610 was sent to Goddard for repairs and calibration. The filter wheel assembly was replaced and new calibration done. SN 610 is ready for reinstall in June/July 2018. A problem occurred May 20th when communications was lost with the site. The satellite communications system was operational. A site visit on May 31st found that the computer was shutting down due to over-heating of the processor. The problem was found to be two-fold, the blower wheel was full of styrofoam chips from the box insulation falling off and being sucked into the blower wheel and the other problem was the external water-cooling radiators were nearly blocked with dirt and lint. Both were cleaned up. The original computer was test run at a temperatures of near 100 degrees at the FSG Shop and is now serviceable. The communications problem between the computer and the Sea Prism was thought to be fixed, as NASA stated to me that they appeared to be getting data. However, the following day, that was not the case. Several things were tried remotely but were not successful. Also, NASA let me know that the AOD readings for SN 638 are higher than normal and they suspect some sort of debris in the collector tubes. So, SN 638 will be changed out a bit early. In order to troubleshoot the communications problem, the platform requires scaffolding to be set up next to the Sea Prism. The platform should have the scaffolding in place for a trip that is scheduled for the week of June 18th. On that trip, SN 638 will be changed out and SN 610 will be installed. The communications cable will also be tested to insure that it is working properly. The original computer will also be re-installed as well. We will also verify with NASA that it is working and transferring data prior to departing. SN 638 will be sent to NASA for Calibration in July/Aug 2018.

The AERONET nlw data has been compared to the NOAA MSL12 for the last year. Results are shown in Figure 1. The NOAA MSL12 VIIRS products (nlw) has been doing well in comparisons with the WavCIS site.

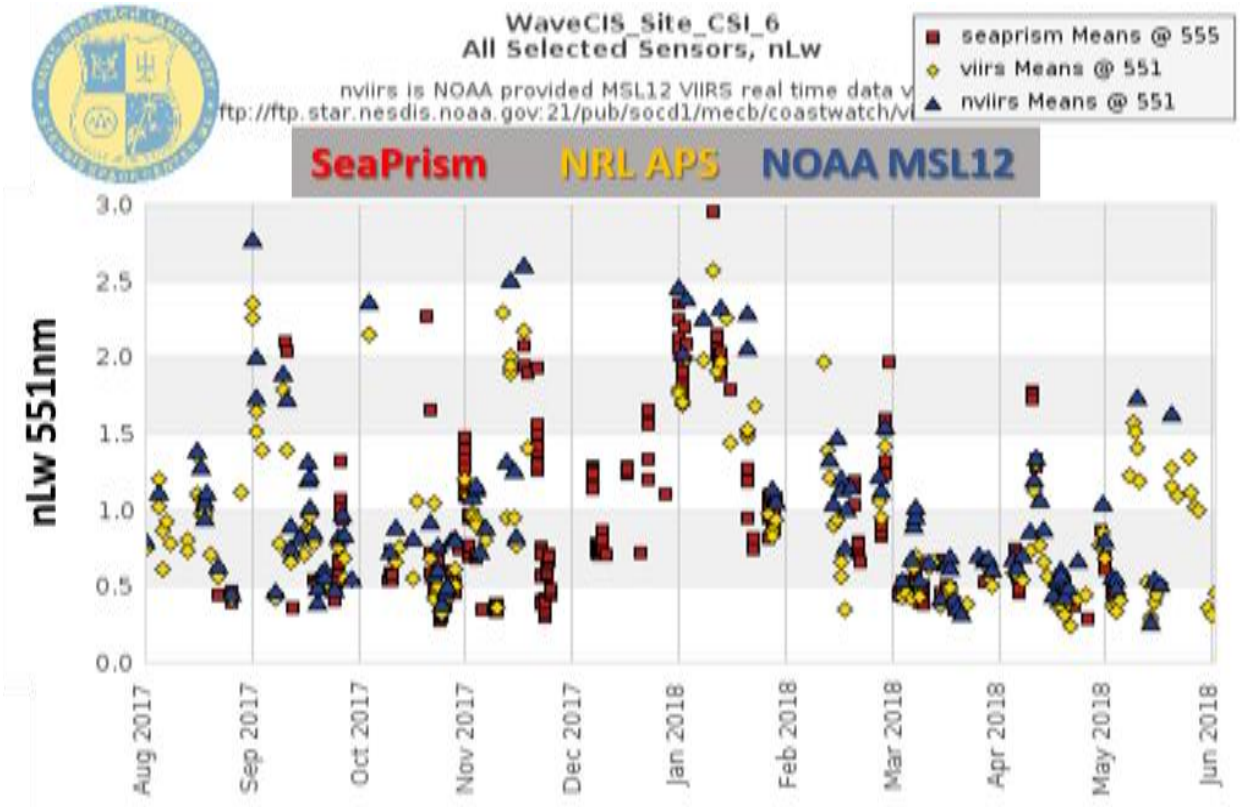


Figure 1. VIIRS / WavCIS time series from August 2017 to June 2018 has been continuous. The nLw@551nm time series of SeaPrism(red) 339 samples at multiple times per day, NRL APS(yellow) 188 samples and NOAA MSL12(blue) 120 samples.

Milestone completed

The WavCIS platform provided a continuous supply of daily data to NOAA, NASA AERONET and the calval team. The Sea Prism on WavCIS was removed and sent to NASA for calibration. WavCIS Sea Prism SN 638 and SN 610 is calibrated annually and the data set remained consistent and continuous. The WavCIS dataset is being used to track the stability and trends in the VIIRS calibration and determine the accuracy of the VIIRS satellite properties for calibration and validation.

<u>B) VIIRS Matchup of IOP absorption with cruise continuous underway (flowthrough) surface data.</u>

Bonnie Carrie Cruise:
Data from the Mississippi River Bonnie Carrie spillway opening in January – February 2016 was compared with VIIRS Inherent Optical Properties (IOP) for February 10th-12th in Mississippi shelf waters. The spillway opening affected Louisiana and Mississippi coastal waters with elevated water absorption (Color Dissolved Organic Matter - CDOM). VIIRS ocean color IOP Quasi-Analytical Algorithm (QAA) products were used to determine the locations affected by increased absorption from the spillway intrusion. VIIRS ocean color anomalies from IOP absorption 443 and STAR's chlorophyll identified the changes in water quality following spillway opening.

The ship flowthrough IOP data was collected with a SeaBird/WetLabs ACS absorption and beam attenuation sensor which was processed using Rudiger Rottger (RR) 2013 scatter correction method to determine the spectral IOP absorption at 443, 550 and 670 nm. These products were quality controlled and compared with VIIRS IOP QAA total absorption coefficients from STAR MSL12 and Navy Automated Processing System (APS) .

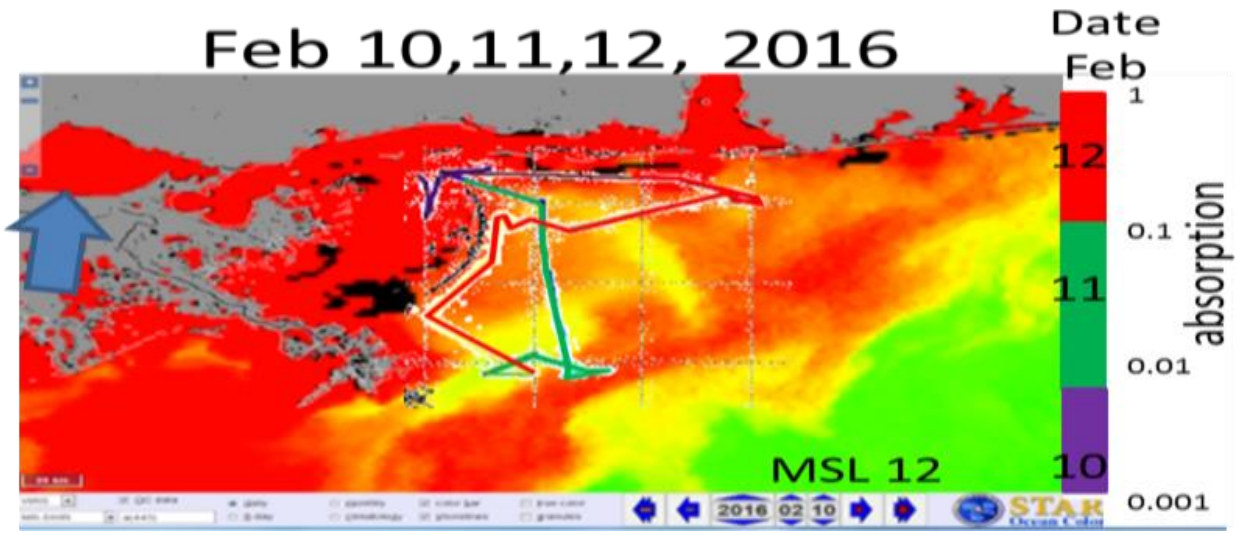


Figure 2. VIIRS total absorption @443nm for February 10th. Cruise track for February 10th-12th in the MS shelf. The Bonnie Carrie spillway opening is located at the arrow. The VIIRS data was cloud free on all 3 days during this cruise.

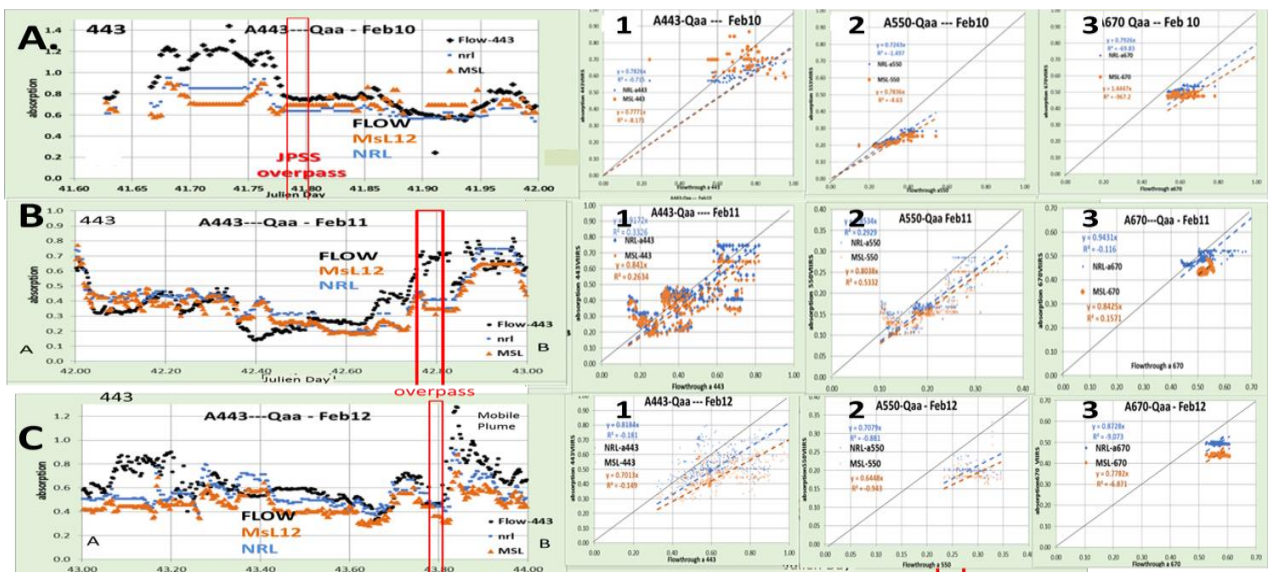


Figure 3. Matchup between VIIRS and flowthrough cruise track for IOP absorption at 443nm - A) Feb10th, B) Feb 11th, C) Feb 12th. First column (A, B, C,) is along track (Julian date) VIIRS NRL (blue), MSL12 (orange) and flowthrough (black) absorption at 443nm. The red lines are time of JPSS overpass (+-30minutes). Second column is IOP absorption and flowthrough scatter plot at 443nm for (1A) Feb 10th, (1B) Feb 11th and (1C) Feb 12th. Third column is IOP absorption and flowthrough scatter plot at 550nm dates 2A, 2B, 2C . Fourth column is IOP absorption and flowthrough scatter plot at 670nm for dates 3A, 3B, 3C.

The matchups above (Figure 3) show there are high spatial variability of IOP absorption 443 along the cruise track (A,B,C). The trends of the matchup are similar between the flowthrough and VIIRS data. The times of the VIIRS overpass within 30 minutes (red line for each day) show similar matchup in 3A, 3C and different in 3B suggesting the high spatial variability in these water masses.

The correlation of flowthrough and VIIRS matchup is highly variable in figure 3 (1, 2, and 3) for the IOP in 443, 550 and 670 indicating that both spatial and temporal change (flowthrough over entire day and static satellite) can cause uncertainty. The results suggest that in these highly turbid coastal waters, the uncertainty can be significant and require addition methods to determine VIIRS product correlation and uncertainty. The uncertainty from vertical IOP profile needs to the checked. Flowthrough IOP data is from ~ 10feet water depth. In turbid coastal waters this may be different from surface waters (<3feet). The satellite is sensing the first optical depth which is shallow in turbid waters. The vertical optical depth of the IOP may be required to improve the matchup using the flowthrough data in coastal waters. The comparison for the flowthrough data with satellite products requires that the flowthrough data is representative of IOP in the first optical depth. In coastal water a shallow optical depth can be above the depth of the flowthrough data which can be the reason for poor satellite insitu matchup. Protocols can be establishing in coastal waters to address using data in the first optical depth.

The effects of the Mississippi River Bonnie Carrie spill way opening and intrusion to coastal waters was shown to be observed in VIIRS dynamic anomaly properties of absorption (443nm) and chlorophyll. The VIIRS products identified the locations of spillway waters as they propagated over shelf waters. Results show applications of VIIRS color data for monitoring this event for several months following the spillway opening.

CAL VAL Cruise -2016-

In addition, a similar matchup comparison study was done during the October 2016 NOAA VIIRS calibration and validation cruise to access the spatial/subpixel uncertainty in validating SNPP VIIRS 750m resolution IOPs in the U.S. East Coast (Charleston, S.C) coastal waters/region using highly temporal and spatial underway shipboard flowthrough measurements. The NOAA calibration and validation team consist of scientists, students and technicians from NOAA, NRL, NASA, USM, OSU, USF, CUNY and UMASS. High temporal and spatial resolution IOPs was compared with SNPP VIIRS ocean color IOPs absorption and beam attenuation properties. SNPP VIIRS IOP products were derived using the Quasi-Analytical Algorithm (QAA). In addition to comparing underway measurements of total absorption and beam attenuation with SNPP VIIRS, the spatial/subpixel uncertainty was evaluated using numerous high (1000+) spatial resolution underway ship samples inside a VIIRS 750m pixel.
The ship underway flowthrough IOP data was collected with a SeaBird/WetLabs ACS absorption and beam attenuation sensor and processed using Rudiger Rottger (RR) 2013 scatter correction method to determine the hyperspectral IOP absorption and beam attenuation which is standard protocol. These products were quality controlled and used to 1) compare with the VIIRS IOP QAA total absorption and beam attenuation coefficients from the NOAA STAR MSL12 and NRL/Navy Automated Processing System (APS) and 2) assess the spatial uncertainty inside a VIIRS 750m pixel for validation in coastal and offshore waters. Results are shown in and described below Figure 4. Spatial and subpixel characterization and uncertainty in validation of SNPP VIIRS IOPs derived from the QAA algorithm in highly variable water masses. SNPP VIIRS IOP matchups were executed using hyperspectral IOPs (absorption and beam attenuation) collected from a shipboard underway flowthrough system.

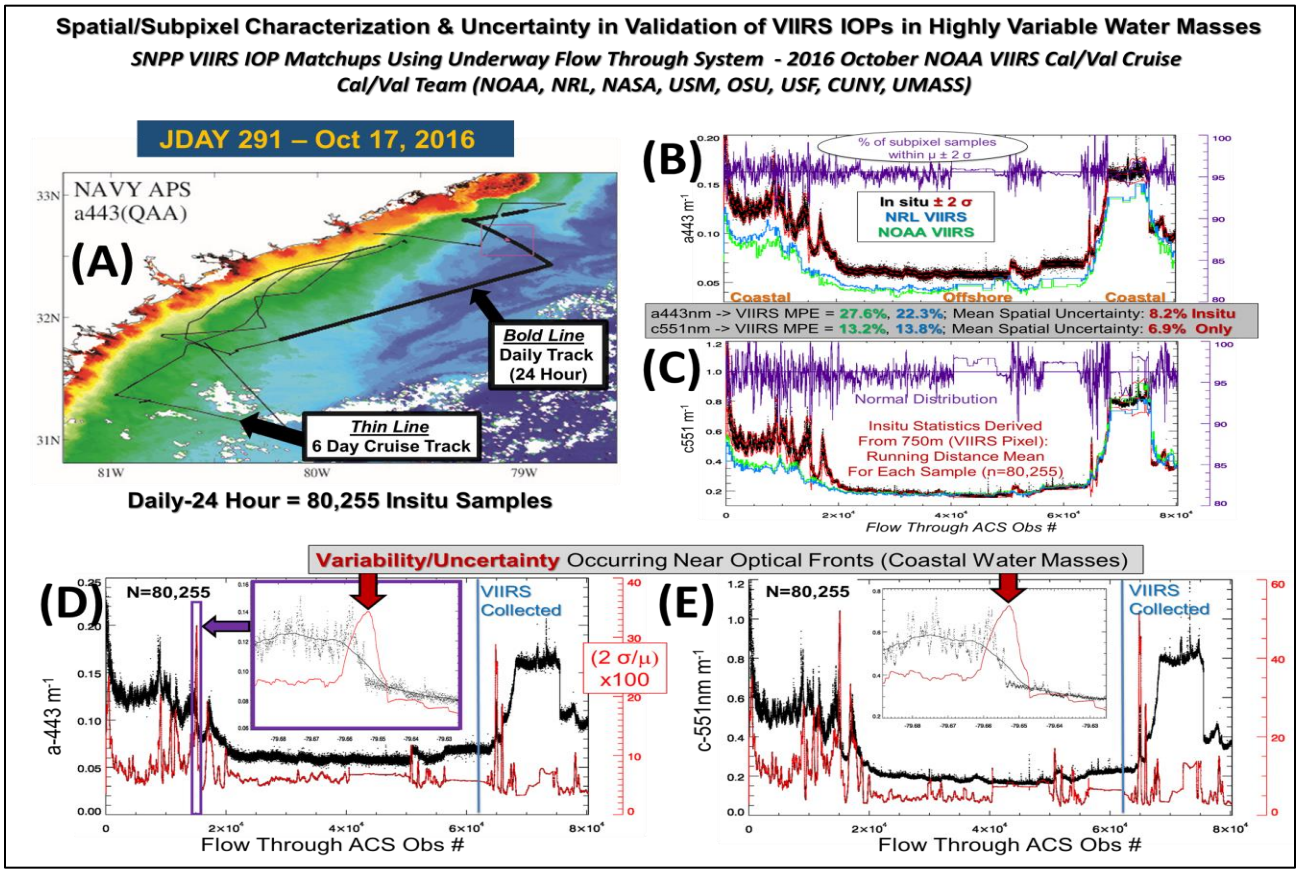


Figure 4. October 2016 NOAA VIIRS calibration and validation cruise. (A) Navy SNPP VIIRS total absorption @ 443nm image for October 17, 2016 showing 6 day cruise track (thin black line) and the 24 hour daily track (bold black line) collected the day of the image collection. Note the high variability in the coastal and offshore waters. Blue pixels represent clearer and Red represents more turbid water masses. For the 24 hour period on October 17th 80,255 underway hyperspectral IOP samples were taken. (B/C) Time series plot showing total absorption (plot B) @443nm and beam attenuation c@551nm (plot C) (y-axis) and flowthrough observations (80,255) from hour 1 to 24 for October 17, 2016. Purple line represents the % of subpixel samples within mean plus and minus 2 standard deviations (σ) and labeled on 2y-axis showing the distribution in this case is normal (at least 90% of data within 2 standard deviations). The shipboard underway samples of a443nm (B) and c551nm (C) are represented in black with the plus and minus 2 standard deviations (σ) are the red dashed lines. The NRL VIIRS extracted values along the 24 cruise track is blue line and NOAA MSL12 is the green line. Note for both plots B (a443nm) and C (c551nm) more variability and uncertainty occurs in the coastal waters and near optical fronts. Plots D and E illustrate the calculated uncertainty (insitu only) over the 24 period for each of the 80,255 samples of a443nm (D) and c551nm (E) using a running distance (750m pixel size) mean for each sample. Uncertainty (red line) was calculated by 2(σ/μ) / 100 in percentage. The black line represents the insitu iop property as in plots B & C. Note the spikes in uncertainty in coastal waters and near fronts. For this particular uncertainty evaluation it was determined that the average uncertainty for the flowthrough samples over the 24 period is 8.2% for a443nm and 6.9% for c551nm. The Mean Percent Error was calculated for the 24 hour matchups between insitu IOPs and VIIRS (NRL and NOAA) and results in MPE equal to 8.2% 27.6% for NOAA VIIRS a443nm, 13.2% for NOAA VIIRS c551nm, 22.3% for NRL a443nm and 13.8% for NRL c551nm. Most of the errors occur early in the day in the coastal area whereas the satellite is a snapshot at a particular time in this case 1838 GMT with possible coastal advection taking place between the time insitu was collected and satellite image was taken.

C) ASD and Spectral Evolution comparison

Testing and collection and processing protocol for two different instruments measuring ocean color was performed for cal val sensing. These two above water hyperspectral RRS sensors (ASD and Spectral

Evolution) for calibration and validation were compared for the same Alabama coastal location on the Gulf Shores State Pier at 3 different times (Figure 5). Methods of processing these sensor data, show that the 2 sensors give similar results when both sensors use the Mobley 2015 □(□) angular irradiance correction for processing. Protocols for the ASD and Spectral Evolution above water sensors have been updated to account for the angular □(0) correction.

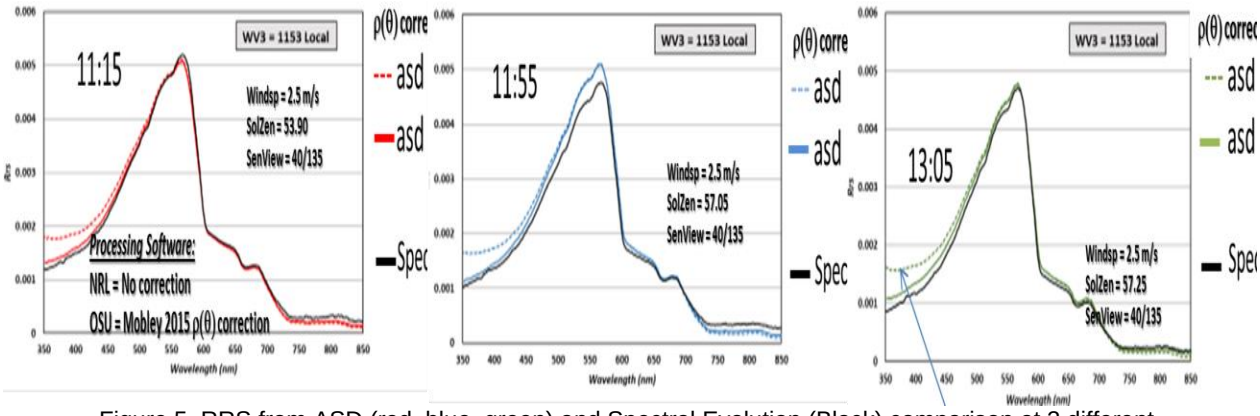


Figure 5. RRS from ASD (red, blue, green) and Spectral Evolution (Black) comparison at 3 different solar angles (time) in the same waters. Similar ASD (red, blue, green) and spectral evolution RRS was obtained using the Mobley 2015 □(0) correction (solid lines). ASD processed without using Mobley 2015 □(0) correction (dotted red, blue and green lines) . The arrow shows the higher RRS in the blue spectra by not using the □(0) correction.

D) Preparation for the Key West Okeanos calval cruise

The FY18 NOAA calval cruise was planned for May 9 through May 18, 2018. Real time satellite VIIRS ocean color and SST products and ocean model (physical) products will be used on the cruise to determine ocean conditions during the cruise for adaptive sampling. An example of recent chlorophyll products and the cruise track shows the area of coverage reaching the Loop current, and coastal water regions. The R/V Okeanos Explorer ship was visited prior to the cruise in Pascagoula, Mississippi to determine how instruments would be deployed and mounted. This included determining the location and setup of the instruments in the 1) Wet lab (flowthrough and water sample filtration) 2) dry lab for computers, 3) above waters measurements on the bow and 4) hyperpro profiles and floaters on the stern.

The initial planned/predicted cruise track to optimize calval data collection and matchups with satellite data in shallow and deep waters was determined. Permission to go to the Bahamas was denied and the cruise track was amended. Days when VIIRS (SNPP and NOAA-20/J1) will have diurnal passes were also identified. During the cruise there was 4 satellite overpassing per day including: MODIS (PM orbit), SNPP (PM orbit), NOAA-20/J1 (PM orbit) and Sentinel-3A OLCI (AM orbit). Also, SNPP and NOAA-20/JP1 will have two overpassed on May 9, 12, 14, 15, 17 and 20 yielding 5 satellite overpasses from 15:30 to 19:30 GMT. (11:30 to 15:00 EST).

Four possible locations for combined shallow and deep water stations on May 13 in the **Dry Tortugas** were identified and planned (Figure 6). The variability (Standard Deviation - SD) of chlorophyll in the Dry Tortugas assisted in identifying areas where the RRS is more spatially and temporal stable in the May - June time period. These optically shallow areas are not chlorophyll but represent regions where the bottom reflectance is more non changing and stable. The areas of lower CHL SD can be used to identify where possible stations can be used for to identify temporally stable bottom reflectance areas to be used for validation and possibly calibration of the satellite RRS in a reef region. Data can be collected at both the deep water station with the Okeanos Ship and the shallow water with the small boat (i.e. Dingy) at the same time to determine the validation of the satellite RRS is optically shallow and optically deep waters for the same VIIRS overpass.

Shallow stations were selected where there is low (blue) (Figure 6C) chlorophyll variability (SD) over a 2 month period in optically shallow waters. These areas represent homogenous bottom reflectance which can be used for stable RRS for the calval cruise. VIIRS calibration can be tested in both the shallow and deep waters on May 13 using the Okeanos for simultaneous measurements with VIIRS matchups for future calibration site for optical shallow waters.

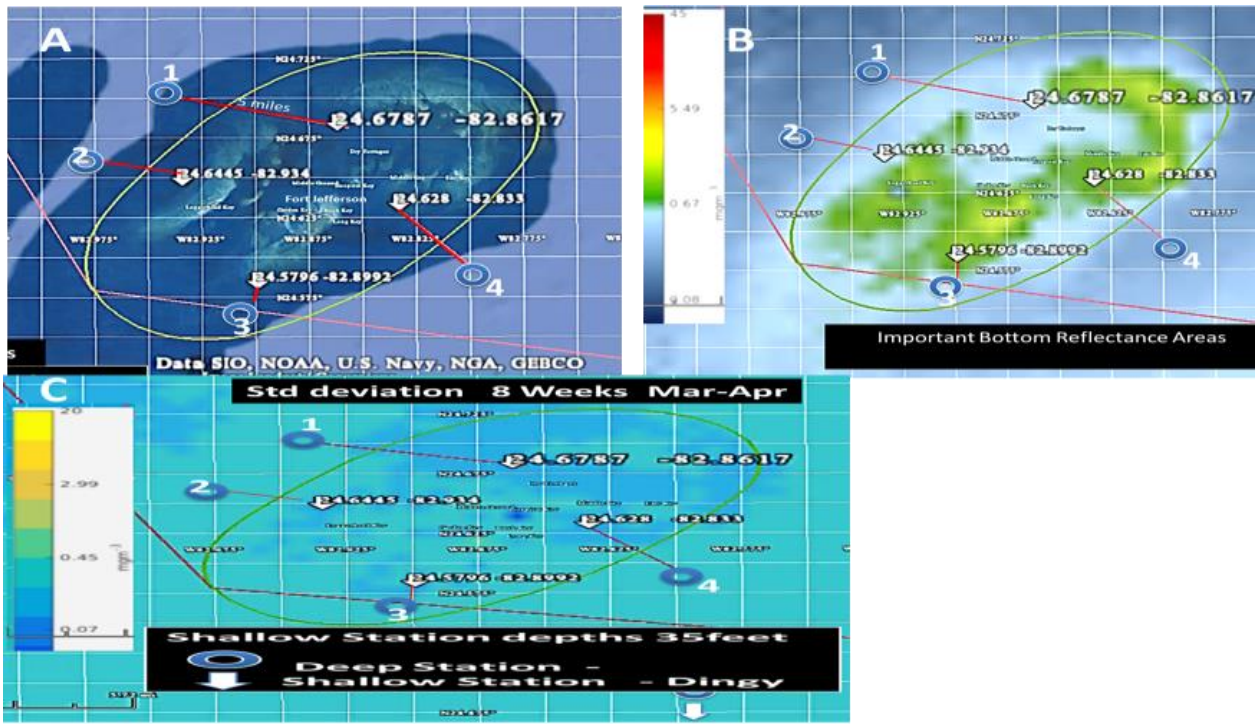


Figure 6. Dry Tortugas A. Bathymetry, B. Mean Chlorophyll C. Chlorophyll Standard Deviation (SD) over 8 weeks (May-June 2017). Potential/planned stations 1,2,3,4 represent areas which have low spatial and temporal variability and uncertainty from bottom reflectance. Locations can represent stable areas of ocean color that can be verified by ship measurements. These uniform color areas can support satellite calibration.

E. Okeanos Ocean Color calval cruise participation and coordination

The Stennis team (USM, LSU, and NRL) participated in the Okeanos cruise departing from Key West, FL to North Central Gulf of Mexico to Jacksonville, FL on May 7 - 18 2018. A major focus of the VIIRS calval effort is to determine the inner-sensor uncertainty and differences in insitu measurements (collection and processing protocols) of the nLw and RRS (Remote Sensing Reflectance) which are used for VIIRS calibration and validation. Our goal was to determine the variability/uncertainty between several insitu sensors measurements and how to improve the methods/protocols used in data collection and processing so that the VIIRS products can be better validated. Stennis participation on the VIIRS calval cruise included: coordination with NOAA for adaptive daily planning of the cruise track and sampling locations in coastal and offshore waters of the Gulf of Mexico and Gulf Stream which included optimizing stations based on current and predicted cloud cover and sea state. The Stennis team provided the cruise team with real time ocean conditions of satellite optical and SST products and ocean model physical nowcast and forecast properties of currents, salinity, etc. for selection of stations using Google Earth from the Ocean Weather Lab (OWX) (https://www.usm.edu/marine/research-owx). Stations were selected in Anticyclonic eddies and ocean frontal regions (Figure 7).

The Stennis calval team collected ocean color measurements at 24 stations. Measurements included: 1) water leaving radiance (nLw) with two (NRL, USM) floating Satlantic's Hyperpros, 2) flowthrough underway Inherent Optical Properties (IOPs) instruments using two Absorption and Beam Attenuation

meters (ACS) in parallel for hyperspectral measurements of water absorption (a) and beam attenuation (c), 3) above water ASD and Spectral Evolution and NIST blue plaque for calibration and 4) Secchi depth. The cruise track and stations are shown in Fig 6. Stations were selected based on cloud cover and the ocean conditions. The cruise began out of Key West at Station 1 and headed to north Gulf of Mexico on May 11 at stations 2,3,4, 5 , May 12 =Stations 6,7,8,9 , May 13 =Stations 10,11,12,13 (at the BP Oil Spill) , May 14 =Stations 14,15,16, May 15 = Station 17,18 , May 16= Stations 19,20,21,22, May 17= Stations 23, 24 Stations were not done in the Dry Tortugas. There were cloud free VIIRS data (@17 out of the 24 stations) at most of the stations. Data analyses of insitu and satellite is presently underway. Calibration of the Hypersas sensors is underway by the NOAA STAR team to provide standards for the insitu data sensors. A summary of the data collected by the cruise participants is underway which outlines the time, location of the sensors

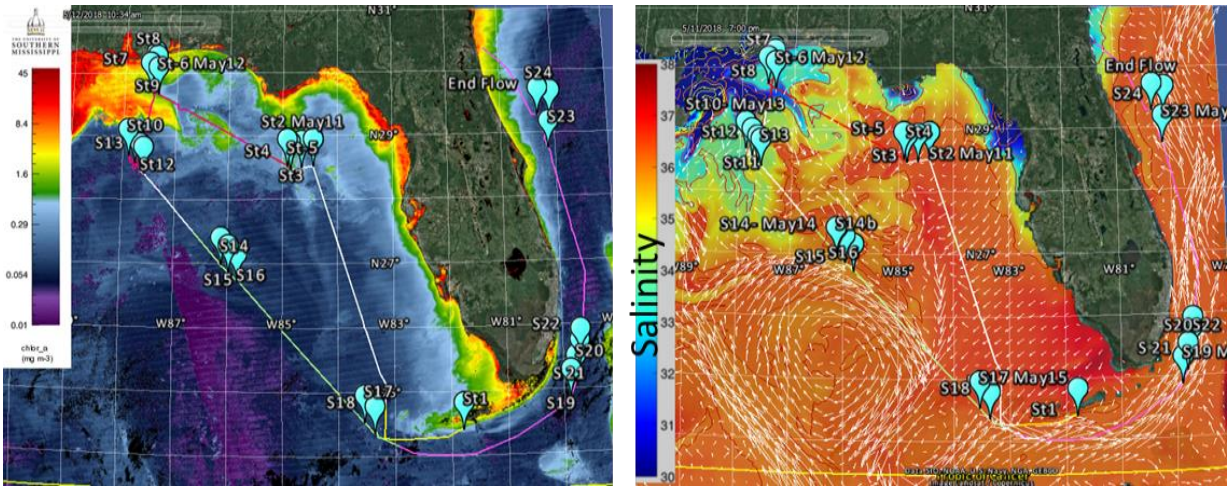


Figure 7. Okeanos Explorer cruise track and 24 stations from May 9- May 18. A) VIIRS Chlorophyll May 12 and B) NCOM Model Salinity Currents (OWX_ https://www.usm.edu/marine/research-owx)

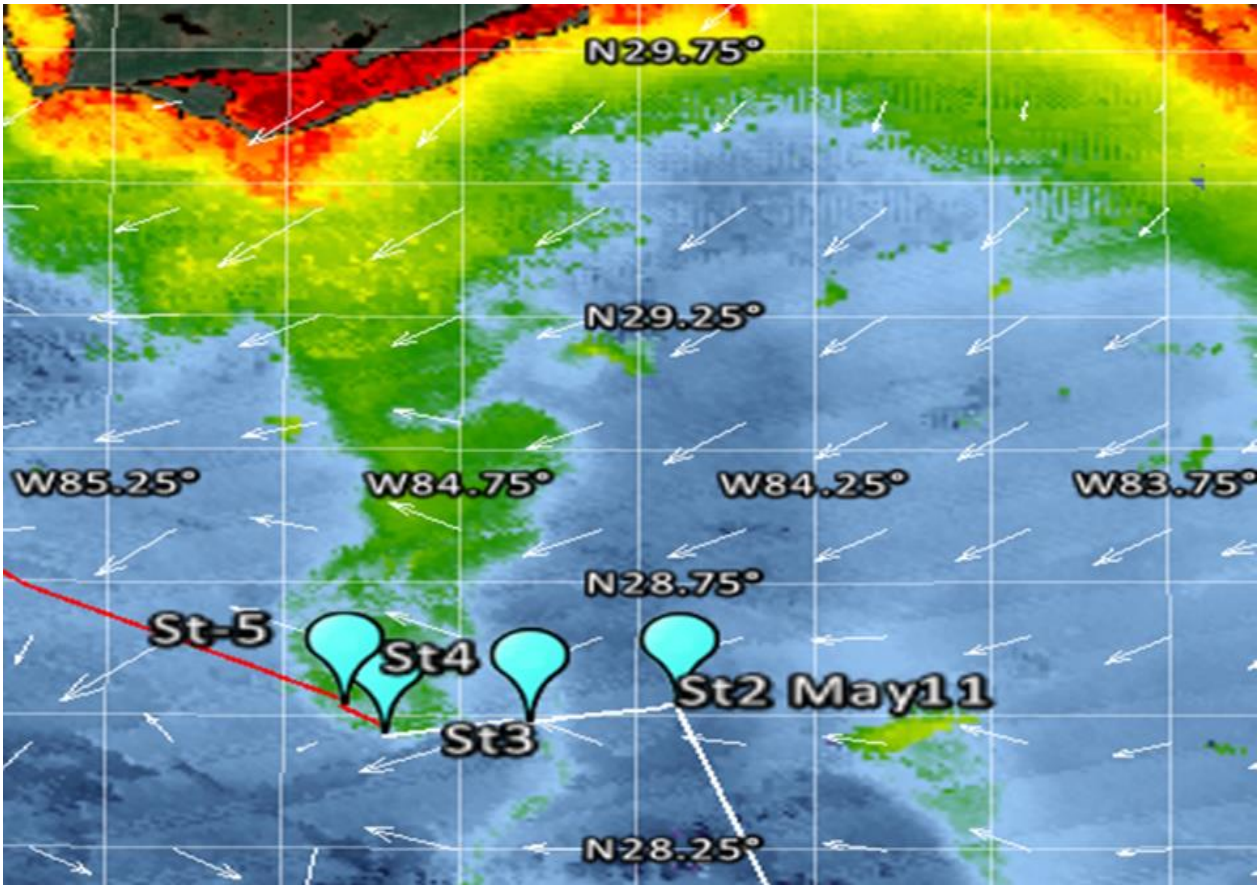


Fig 8. May 11, 2018 – Stations 2,3,4,5 were collected across a chlorophyll frontal area. Stations were done from at 0830 to 16:00 local time. Location South of Apalachicola Florida.

Ocean Color insitu sensors:

1) *Hyperpro:* The floating Hyperpro is a hyperspectral profiling radiometer that simultaneously measures above-water downwelling irradiance (E_s, E_d) and in-water upwelling radiance (L_u) on a tethered floating buoy platform and downwelling *Es* onboard the ship fixed to an elevated pole. The Hyperpro is used to measure the normalized water laving radiance (*nLw*), from which spectral remote sensing reflectance (RRS) is calculated, and used for validation and calibration of the VIIRS *nLw*. Both floating Hyperpros were calibrated at the NOAA facility which also calibrated the other team's instruments. The Stennis team utilized 2 floating Hyperpros (USM and NRL) on the cruise and collected measurements at 22 stations. These instruments were used with a molded floatation collar, allowing the observation of temporal variability of in-water surface measurements, at a fixed depth, just beneath the sea surface. The downwelling E_d sensor uses a cosine collector and is approximately 30 cm above the water surface. The upwelling (L_u) radiance sensor is mounted approximately 30 cm below the water surface. The ship mounted *Es* sensor also uses a cosine collector and was mounted on the 01 deck affixed to a pole which was elevated above the ships superstructure while on station. *Es* from the ship mounted sensor was combined with *Lu* from floating Hyperpro for computation of *Rrs*.

The Floating HyperPro, equipped with a floatation collar, was deployed near the starboard and port quarters). The instrument was allowed to float out a sufficient distance from the boat (20 to 30 m). This ensured there was no contamination from vessel-generated bubbles and ship shadowing or any other

potential disturbances. Once the instrument was a sufficient distance from the vessel, data was recorded for 10 minutes. Post processing of this dataset from level 1 to level 4 was done using Satlantic's Prosoft v8.1.4 with set protocols.

2) ACS (IOP): The flowthrough system provides an extensive Inherent Optical Properties (IOP) data set at very high spatial resolution demonstrating the large variety of the water masses and ocean processes that were identified along the cruise track (Figure 2). The flowthrough IOP products of total hyperspectral absorption and beam attenuation for the spectral VIIRS channels will be used to validate the VIIRS IOP products derived using the Quasi-Analytical Algorithm (QAA) for spectral absorption and backscattering. Matchups between ship collected and VIIRS derived IOPs will provide validation and uncertainty in different water masses including US coastal and shelf waters. Additionally, the high spatial resolution of the flowthrough can be used to validate the spatial variability within the VIIRS 750m pixel by defining the mean and variability of IOP measurements within the VIIRS pixel (as seen in Figures 3 and 4).

IOPs were measured continuously on the cruise while on station and underway using two WetLabs absorption and beam attenuation (*ac*) instruments connected to the ship's flow-through system. The two instruments will be used to determine the uncertainty within a VIIRS pixel and validate VIIRS IOPs derived using the QAA algorithm. These measurements address cruise objectives to: (A) characterize the spatial variability of water's optical properties (a,b->bb,c) along the cruise track and how the variability impacts the uncertainty of in situ measurements at each station. (B) determine the water total and dissolved absorption (*at*, *ag*) properties at specific wavelengths and validate the IOP measurements derived from the VIIRS ocean color satellite. (C) define coastal/shelf frontal boundaries using thermal, biological and optical properties. The ACS instruments were calibrated 7 times: once prior to the cruise and five times during the cruise and once after cruise. Post-processing of the acs will follow the "WET Labs, 2011" protocols.

3) Above water measurement of the RRS **–** The ASD (Analytical FieldSpec™ Spectro radiometers) instrument determined the ocean color without being in the water. A group of above water spectrometer instruments from different institutions collected data jointly at 22 stations during the cruise. The Above Water Group (AWG) totaling 8 instruments included 3 ASD instruments (NRL, NOAA, USF), 2 GER (CUNY, NOAA) and 3 Spectral Evolution instruments (OSU, NRL, UMASS). The procedures and analyses are underway as to the protocols and testing procedures. Several grey and white cards were used for testing and evaluation.

4) *NIST Blue Tile: AWG- Above Water Group* - To assess the differences among instruments at determining R_{rs}, the relative reflectance of a standard 16.5 cm square blue glass tile developed by NIST was measured by the ASD, GER and Spectral Evolution instruments. The groups all used similar measurement protocols (number of files collected, number of dark currents, angles, etc) to measure the relative reflectance of the target, using the tile in place of the surface water measurement. The blue tile measurements for the different instruments used the same gray and white plaques (NOAA) and will be processed using the NRL and OSU processing software for comparisons and inter-sensor uncertainty. Details of the protocols and NIST comparisons are underway.

F. Participation in NOAA's VIIRS Calibration and Validation telecons and 2017 annual meeting

The NGI ocean color calval team at Stennis participated in bi-monthly NOAA JPSS calval team telecons which are hosted by NOAA STAR. Every 2 weeks, we collaboratively reviewed and discussed collective results of work with other team members. The NOAA JPSS STAR calval ocean color team represent approximately 28 scientists from 10 universities, agencies and organization throughout the nation and are major leaders in satellite ocean color. Every 2 months, the NGI (Stennis team) presented our accomplishments and specific status and results to the calval team. The six presentations per year consisted of a 30 – 40 minute presentation/update to the entire team of approximately 15- 30 slides of progress and accomplishments. This was followed by a summary write up to the JPSS STAR program office of the ocean color calval status. Our 6 presentations and write-ups are available each year if required.

The Stennis NGI calval team participated in the annual NOAA STAR meeting in August 2017. The Stennis team gave an annual review presentation using VIIRS ocean color satellite data. Located at: STAR Home > Meetings > STAR JPSS Annual Science Team Meeting - 14-18 August 2017 – Agenda

Presentations

1. Robert Arnone, "*Evaluation of VIIRS Ocean Color Products and Development of Enhanced Ocean Products and Applications"* NOAA Annual Meeting 2017 https://www.star.nesdis.noaa.gov/star/meeting_2017JPSSAnnual_agenda.php#tab1

Posters Presented

1. *VIIRS Ocean Anomaly,* Robert Arnone, NOAA Annual Meeting, 2017 https://www.star.nesdis.noaa.gov/star/meeting_2017JPSSAnnual_agenda.php#tab1
2. *VIIRS Ocean Anomalies and Hotspots in the Gulf of Mexico,* Robert Arnone, NOOA Annual Meeting, 2017 https://www.star.nesdis.noaa.gov/star/meeting_2017JPSSAnnual_agenda.php#tab1
3. *Preliminary Evaluation of Suomi NPP VIIRS Inherent Optical Properties During The 2016 NOAA Cal/Val Cruise* Sherwin Ladner NOAA Annual Meeting 2017 https://www.star.nesdis.noaa.gov/star/meeting_2017JPSSAnnual_agenda.php#tab1
4. *Consistency and Continuity of Navy Operational Satellite Ocean Color Products* - Richard Crout NOAA Annual Meeting 2017 https://www.star.nesdis.noaa.gov/star/meeting_2017JPSSAnnual_agenda.php#tab1

G. Summary

The WavCis platform has been updated to sensor SN638 and is operating. Updates to a new calibrated sensor is planned for summer (June 2018). Matchup of VIIRS inherent optical properties (IOP) with cruise flowthrough data in the Mississippi shelf waters was performed for the Bonnie Carrier cruise for Feb 2016. Additional matchup of VIIRS ocean color products and spatial IOP uncertainty analysis was done off the coast of Charleston, SC using underway IOP flowthrough measurements collected during the NOAA VIIRS calval cruise in October 2016. Results improvied coastal validation using flowthrough data knowing the optical depth in coastal waters.

The Stennis calval team participated in the Okeanos Explorer calval cruise departing Key West May 2018 in the North Central Gulf of Mexico, and East Florida coast to Jacksonville, FL. Insitu data collected included ocean color optical data with multiple instruments for VIIRS calval. The cruise went well and 24 stations were collected for matchup with satellite products. Analysis of data is starting with the NOAA team cruise members.

The calval team participated in semi-annual presentations and progress report activity with NOAA STAR.

The major milestones that we achieved this year are listed.

1. WavCIS data was maintained for daily deliverable data to NASA and NOAA for VIIRS calibration.
2. Attended the annual JPSS calval meeting in August of 2015, 2016 and 2017 presenting 3 presentations and 12 posters of Stennis calval accomplishments.
3. Planned, coordinated and participated in the calval Key West cruise 2017 and the collection of insitu data.
4. Delivered the processed insitu data from the cruises in Fiscal Year 2017 to the STAR calval group.
5. Presented 6 telecons to the calval team and 6 detailed progress reports per year to NOAA.
6. Publications (SPIE) on Satellite and model dynamic anomalies that recognized events and seasonal trends in the Mississippi Shelf water.

Description of significant research results, protocols developed, and research transitions

1. Collection and processing protocols were developed for above water optical instruments.
2. Calval cruise results of protocols and all data from the ocean color cruises were transitioned to NOAA and put into published cruise reports with a DOI#
3. The NOAA MSL12 VIIRS ocean color products was shown to be similar and an improvement to NASA's products.
4. The WavCIS platform is transitioning daily data to NASA and NOAA for calibration and validation of the Ocean Color on VIIRS satellite. This data is being used for developing high quality VIIRS products.
5. VIIRS data products were used to determine Seasonal trends of biophysical ocean properties and anomalies across the Mississippi Shelf in a SPIE 2018. The seasonal cycle in surface biological, optical and physical properties across the river dominated Mississippi (MS) Shelf changed during years 2015 to 2017 at different locations across the shelf. VIIRS satellite and ocean model products were used to monitor cycles for different properties of both the nowcast and anomalous water properties. MS Shelf water properties vary spatially between offshore waters and coastal MS Sound waters, as well as temporally throughout the year. Ten selected regions spanning east to west from the MS Sound to the shelf break characterized the cross shelf seasonal fluctuations in satellite-derived chlorophyll-a, backscattering, euphotic depth, sea surface temperature, and modeled salinity currents. The seasonal relationships between physical and bio-optical properties were determined for different regions across the shelf and the seasonal eastward movement of the MS river plume across the shelf was identified in June. Yearly MS Sound seasonal cycles of coastal bio-physical properties are different from the shelf regions' offshore seasonal cycles and indicate a time-lag between the bio-optical responses to the physical properties. Bio-optical and physical results on the shelf indicated seasonal movements of the MS River plume locations. Results show the seasonal bio-physical response of the shelf waters which can be used to address and understand the timing of data collection and how ocean events are influenced by the natural seasonal cycle interactions between biological and physical properties. The seasonal cycle study will enable the ability to monitor the shelf water quality and to identify non-typical conditions and the impact of an event on the cycle. Correlations between the monthly seasonal cycle of bio-optical and physical properties such as salinity, ocean color, chlorophyll-a and particle scattering were not consistent over the shelf. Seasonal cycles of salinity and chlorophyll-a show improved correlation if chlorophyll-a is delayed one month from the salinity at offshore locations on the shelf. Results of the seasonal trends support how data collected at a single image location on the shelf during a certain month can be different from other seasons. The seasonal cycle of the dynamic anomaly properties (DAP) of bio-physical properties were determined to show how seasonal abnormal changes and trends at locations across the shelf can provide a method for seasonal adaptive sampling. The yearly differences in monthly cycles from 2015 to 2017 at shelf locations, identified elevated chlorophyll-a in several months of 2016 and yearly temperature differences in multiple areas. The seasonal cycle of Euphotic depth, solar UV light penetration, showed a maximum peak (deeper Euphotic depth) at certain shelf locations during the months of September and October and minimal penetration in Aug of 2015, 2016, 2017. This information could be useful to understand months for maximum oil UV degradation in case of an oil spill.
6. VIIRS Spatial /Subpixel uncertainty - An evaluation was done during the October 2016 NOAA VIIRS calibration and validation cruise to access the spatial/subpixel uncertainty in validating SNPP VIIRS 750m resolution IOPs in the U.S. East Coast (Charleston, S.C) coastal waters/region using highly temporal and spatial underway shipboard flowthrough measurements. High temporal and spatial resolution IOPs was compared with SNPP VIIRS ocean color IOPs absorption and beam attenuation properties. SNPP VIIRS IOP products were derived using the Quasi-Analytical Algorithm (QAA). In addition to comparing underway measurements of total absorption and beam attenuation with SNPP VIIRS, the spatial/subpixel uncertainty was evaluated using numerous high (@80,000 samples per day – 24 hour period) spatial resolution underway ship samples inside a VIIRS 750m pixel.

Information on collaborators / partners

Collaborating organizations
There were many collaborators and projects with USM on this project. These include: NOAA-STAR Center for Satellite Applications and Research, NASA, Goddard, Naval Research Laboratory, Louisiana State University, City College of New York, NIST, University of Southern Florida, UMB- University of Mass Boston, University of Miami, Oregon State University, Columbian University (LAMONT), Joint Research Council (Italy). Collaborated with GOMRI and the USM CONCORDE project. Additional collaborations include the NOAA National Marine Fishers Service with collaboration in the NOAA restore program. Collaborating with the NOAA calval team members was part of the bi-weekly weekly telecons and NOAA calval cruises.

Partners
GOMRI –CONCORD and NOAA Restore program.Navy NRL and LSU partners on the Stennis team.

Description of collaboration/partnership relationship
There are several collaborators that are involved in the NOAA VIIRS calval effort. By working together, we are developing the US national standards for the satellite ocean color calibration. These include protocols in instrumentation and validation methods. Collaboration with GOMRI using VIIRS ocean color products in USM's Ocean Weather Laboratory (OWX) in the Gulf of Mexico. The OWX products are used for adaptive sampling for gliders, ships, and sample collection. Collaboration was performed with the NOAA RESTORE Act Science Program for identifying Ocean Hotspots. The project includes using VIIRS products to define a data base and anomalies of ocean conditions in the Gulf of Mexico. VIIRS products will be used to identify the potential hotspots for fisheries. Collaboration with Navy includes NRL's calval projects for the automated processing system (APS) for the VIIRS and cruises of opportunity.

Outreach activities

General Description
VIIRS ocean color data is used in the Ocean Weather Laboratory (OWX) at USM https://www.usm.edu/marine/research-owx. Daily ocean satellite and circulation model products are visually displayed and animated with insitu observations from ships, glider and mooring etc. The VIIRS ocean color products provide a daily validation for the circulation models and better understanding the ship and glider observations. The products from the Ocean Weather Lab are used for adaptive sampling and are presented to students and teachers to show the daily changing ocean conditions in the Gulf of Mexico. The USM Ocean Weather Labs (OWX) hosted several telecons to describe the daily nowcast and anomalies and different environmental conditions from both the satellite ocean color and SST and ocean circulation models. This included training of several NOAA groups on data access and how to use the different products using Google Earth which are generated by the OWX. Daily ocean conditions were sent to several ships in near-real-time for identifying how the ocean conditions can influence the fisheries and biomass.

The cal val Cruise reports are available on the NOAA STAR web site with the details and protocols for cal val of VIIRS products - https://www.star.nesdis.noaa.gov/sod/mecb/color/other_pub.php

The OWX is collaborating with NOAA fisheries (R/V Nancy Foster, R/V Oregon II) ships in the Gulf of Mexico. The OWX is coordinating with the NOAA Restore program with identifying dynamic anomalies in the Gulf of Mexico. The OWX is collaborating with the NOAA Flower Garden Banks in using VIIRS satellite products for determining hotspots affecting the Flower Garden Banks. Participated in telecons to demonstrate how VIIRS satellites can be used to identify abnormal conditions that occurred during the bleaching event in the Flower Garden Banks. There was interest in using the OWX products as a forecast of events in the Gulf of Mexico. USM OWX- https://www.usm.edu/marine/research-owx

VIIRS satellite products were put into NOAA- National Centers for Environmental Information (NCEI)– Sent DAP data and publicly available. Products include weekly, means, standard deviation and anomalies for the Gulf of Mexico. VIIRS Publicly Available USM VIIRS_DAP.data ERDAP= :

https://ecowatch.ncddc.noaa.gov/erddap/griddap/USM_VIIRS_DAP.html and KML: https://ecowatch.ncddc.noaa.gov/thredds/catalog/usm_dap_kmz/catalog.html

Economic development activities

Support from NOAA Restore and GOMRI for identifying HOTSPOTS in the Gulf of Mexico which is ending.

Advanced economic activity is required to improve satellite and ocean sensing and monitoring. We are looking to improve our economic development.

Project Accomplishments

Measurements used for VIIRS calibration and validation of ocean color products were collected for several cruises, including major NOAA cruises. The cruises provide an international collaboration for establishing protocols for instruments and methods for collection and processing of ocean color radiance measurements for satellite ocean color. The NOAA calval cruises are setting the standards for the ocean color community for emerging satellites.

The WavCIS platform was maintained with a continuous data stream for NOAA, NASA, and the ocean color community and provided continuous calibration data sets in the Northern Gulf of Mexico for validation of ocean color products for the NOAA VIIRS sensor.

Publications, Presentations, Posters

Project results are in the 13 publications. List of the 39 publication, presentation and posters are in the enclosed list (excel file). These include:

1 - Paper at Journal of Geophysical Research March 2016 on Diurnal Ocean Color (Published)
8 - Papers at SPIE – Ocean Sensing and Defense – Baltimore, April 2016, Anaheim April 2017, Orlando April 2018 (Published Papers in Proceedings)
1 - Paper Earth Sciences (Published)
1 - NOAA- NESDIS report (Published)
1 - Paper Elsevier Journal (Published)
1 - AGU Ocean Sciences Meeting Portland, OR February 2018 (Poster)
6 - AGU Ocean Sciences Meeting New Orleans, LA February 2016 (Posters and presentations)
4 - JPSS VIIRS Annual Meeting College Park, MD August 2016 (Posters and presentations)
7 - GOMRI Oil Conference New Orleans February 2017 (Posters and presentations)
1 - GOMRI Oil Conference Tampa, FL January 2016 (Presentation)
2 - ASLO and IOCCG (Presentations)
1 - EOS Article (Published)
1 - FLOWER GARDEN BANKS Symposium (Presentations)
4 - Presentations and posters at 2017 NOAA – Annual Cal Val Meeting
39 - Total

The papers demonstrate the ability of VIIRS ocean color data to be used for ocean monitoring of biological–optical properties. The VIIRS calibration is important for determining changes in ocean properties. The accomplishments are the VIIRS ocean color data provides a capability to determine the spatial and seasonal changes in ocean waters for the biological chlorophyll, euphotic depth and absorption etc. These properties can be used to the determine impacts on oil degradations during certain months. Accomplishments show that in situ data matchup of the spatial and temporal changes in ocean color from VIIRS data is real and the uncertainty can be related to in insitu sensors data collection methods. An accomplishment includes determining protocols to make accurate insitu ocean optics data which is required for VIIRS cal val . The project demonstrated that accurate protocols for insitu collection and processing can validate the VIIRS Matchups for the above water remote sensing spectral reflectance and the insitu RRS and the Inherent optical properties.

NGI File #: 17-NGI3-26

Project Title: U.S. Research Vessel Surface Meteorology Data Assembly Center - *Home of the SAMOS Initiative*

Project Lead (PI) name, affiliation, email address: Mr. Shawn R. Smith, Center for Ocean-Atmospheric Prediction Studies, Florida State University, smith@coaps.fsu.edu

Co-Principal Investigator name, affiliation, email address: Dr. Mark A. Bourassa, Center for Ocean-Atmospheric Prediction Studies Florida State University, bourassa@coaps.fsu.edu

Project objectives and goals

The central activity of the U.S. Research Vessel Surface Meteorology Data Assembly Center (DAC) at the Florida State University (FSU) is the implementation of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative (http://samos.coaps.fsu.edu/). The SAMOS initiative focuses on improving the quality of and access to surface marine meteorological and oceanographic data collected in situ by automated instrumentation on research vessels. To date in the reporting period (7/1/17-6/30/18) 30 research vessels routinely transmitted daily emails containing one-minute averaged meteorology and surface oceanographic data to the DAC. Broadband satellite communication facilitates this daily transfer at ~0000 UTC. A preliminary version of the data is available in near-real time (within five minutes of email receipt) via the SAMOS web pages (http://samos.coaps.fsu.edu/data.shtml). The preliminary data are placed in a common data format, are augmented with vessel- and instrument-specific metadata (e.g., instrument height, type, units), and undergo automated quality control (QC). Visual inspection and further scientific QC result in intermediate and research-quality products that are nominally distributed on the SAMOS web site with a 10-day delay from the original data collection date. All data and metadata are version controlled and tracked using structured query language (SQL) databases. These data are distributed free of charge and proprietary holds and archived at the National Centers for Environmental Information (NCEI)-Maryland on a monthly basis.

Data collection by research vessels contributing to SAMOS represent a significant investment by the American taxpayer. Archival of complete and well documented SAMOS dataset at NCEI ensures these data are preserved for future generations of scientists, policy makers, and the public. The DAC activities focus primarily on *NOAA's Climate Mission* and *Technology and Mission Support* goals by providing high-quality weather and near-surface ocean data to validate complementary satellite observations; global analyses of the ocean-atmosphere exchange of heat, moisture, and momentum; and computer model-derived analyses of climate, weather, and ocean parameters. The data distributed by the DAC address the *Climate Observation Division deliverables* related to *sea surface temperature*, *surface currents* (via the wind), and *air-sea exchanges of heat, momentum, and fresh water*.

Description of significant research results, protocols developed, and research transitions

Primary Achievements

Accomplishments in the reporting period centered around the core mission to collect, quality-evaluate, distribute, and archive one-minute sampling interval underway meteorological and oceanographic data via the SAMOS initiative. Deliverables[1] include the following:

1. Continue daily monitoring and automated quality control of data received from NOAA vessels contributing to the SAMOS DAC.
2. Continue routine research-quality visual evaluation of meteorological data for all NOAA vessels contributing to the SAMOS DAC.

[1] Not all deliverables listed have been completed in the reporting period as a result of differences between OOMD FY funding cycles and performance periods for activities funded under the Northern Gulf of Mexico Cooperative Institute.

3. Distribute all quality-controlled SAMOS observations via web, ftp, and THREDDS services and ensure routine archival at NCEI.
4. Continue to update SAMOS instrumental metadata for all recruited vessels supported by NOAA.
5. Limited engagement of new user communities via meetings, publications, and electronic communications.
6. Continue collaborations with U.S. and international (limited) partners and throughout the marine climate community
7. Write formal data management plan and update documentation on SAMOS data processing and quality control.

The primary achievement in FY 2017 is the continuation the SAMOS initiative, founded by OOMD in 2005, which collects, evaluates, distributes, and archives underway meteorological and near surface ocean observations from research ships. The total number of vessels routinely transmitting meteorology and surface oceanographic data to the SAMOS DAC remained stable in the past year with a slight increase in the number of days of data received and processed in FY17. Two new vessels were recruited in FY17 (*Investigator* in collaboration with Australian Bureau of Meteorology and *Sally Ride* under complimentary NSF support). The *Healy*, *Pelican*, and *Thomas G. Thompson* were operational in FY17, but did not transmit data because of technical problems or long-term shipyard periods.

Our lead analyst, Jeremy Rolph, continues to conduct daily (not 24/7) visual inspections of all SAMOS observations [deliverable 1]. This inspection, a quick-look, does not allow for adding/altering quality control flags on the data, but ensures the data received from the vessel are free of major sensor failures or other problems that would require notification of the vessel at sea. These at-sea notifications are highly desired by the vessel operators and onboard technicians and are the core benefit to the vessel operator. Prompt problem notification results in a quick resolution of sampling issues and adds value to the public investment in expensive shipboard observing systems by ensuring the highest quality data are available to research and operational users. In addition, operator feedback often results in updates to sensor metadata [Deliverable 4] when problems are the result of the need to change instrumentation on the vessel or simply because a change was made and the SAMOS DAC was not notified.

Kristen Briggs completed visual QC for all recruited NOAA vessels [deliverable 2 under OOMD funding] and the RV *Falkor* (SOI funding). Visual QC allows the analyst to review, add, or modify data quality flags on the merged files. Visual data QC identifies a number of problems (e.g., stack exhaust contamination of temperature/humidity sensors, water flow problems in scientific sea water system, diurnal ship heating errors) that are difficult to capture reliably with automated QC. The result is data from ships only receiving automated QC likely have erroneous data reaching data users without being marked/flagged as problematic. Ms. Briggs again was lead author of an annual report (Briggs et al. 2018) that summarizes the data quality for all vessels contributing data for the calendar year 2017. The report has been distributed to all operators of SAMOS vessels and posted to the SAMOS web site.

All SAMOS data are distributed via web, ftp, and THREDDS services and Ms. Briggs submits all the original and processed data/documentation to NCEI for archival on a monthly basis [Deliverable 3] according to our data management plan (see section 4). In FY17 we began basic tracking of data downloads from the SAMOS web site and there have been 444 unique download requests that resulted in delivery of over 463K data files (~77 GB of data). NCEI also provides us with download logs, but to date we have not had the resources to mine those statistics.

Members of the DAC team engaged the marine climate and wider user community [Deliverables 5 and 6] via presentations at meetings and Mr. Smith's ongoing involvement with the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Ship Observation Team (SOT) and the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). For JCOMM, Mr. Smith has been elected the vice-chairperson for SOT and was acting chair from February - October 2017. Through this position, Mr. Smith has served the community by coordinating SOT activities and documentation in support of the Observation Coordination Group and for the JCOMM-5 meeting in October 2017. He also serves on the SOT task teams focused on the Marine Climate Data System (TT-MCDS) and Instrument Standards (TT-IS) and leads the task team on high-resolution marine meteorology (TT-HR) from

Voluntary Observing Ships. Mr. Smith is also a contributing member of the ICOADS International Steering Committee.

Scientific Advances and Significance

The collection, quality control, distribution, and archival of SAMOS observations support a diverse research and operational user community. The observations include several parameters that are either essential climate or ocean variables (Figure 1) and unlike the standard marine weather reports collected and transmitted to support operational marine weather forecasting, SAMOS observations are often collected in remote ocean regions where there is limited sampling to constrain the range of expected weather and surface ocean conditions. The uniqueness of these observations makes them ideal for marine climate and ocean process studies and evaluating numerical models and satellite products. Examples include creating estimates of the heat, moisture, momentum, and radiation fluxes at the air-sea interface, improving our understanding of the biases and uncertainties in global air-sea fluxes, benchmarking new satellite and model products, and providing high quality observations to support modeling activities (e.g., reanalysis) and global climate programs. SAMOS directly measures winds and *sea surface temperatures* which can be used to evaluate satellite ocean vector wind products (and derived *surface currents*) and SST products that are subsequently used to model the circulation and temperature structure of the ocean (e.g., *ocean heat content and transport*).

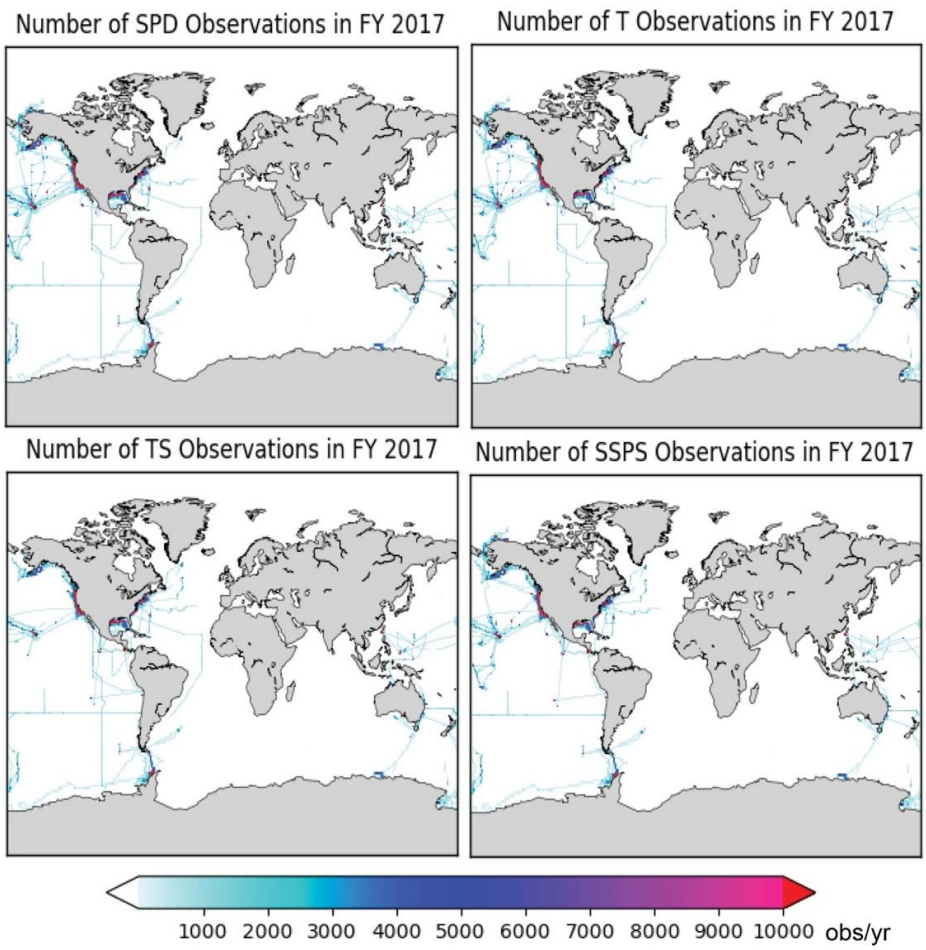


Figure 1: Maps showing the density of 1-minute observations reported by SAMOS vessels in FY17 (1 Oct 2016- 30 Sept. 2017) for wind speed (SPD), air temperature (T), sea temperature (TS), and near-surface salinity (SSPS). Observations are counted in 1˚ latitude by 1˚ longitude bins and color coded according to the color bar.

SAMOS observations, specifically the along ship track SAMOS air-sea flux product (https://rda.ucar.edu/datasets/ds260.4/), have been used by Darren Jackson (NOAA ESRL/CIRES) to develop a multi-satellite air temperature and specific humidity product (under NASA NEWS funding). The SAMOS data were used to tune the satellite retrieval algorithms during the product development cycle. These improved satellite retrievals can be applied to develop *improved estimates of air-sea exchanges of heat, momentum, and freshwater* and further be incorporated into numerical weather prediction and climate models that are used by NOAA for forecasting and decision making for the general public.

SAMOS observations are also being used to advance the technology used by scientists to conduct their research. In February 2017, a team that included FSU, the National Center for Atmospheric Research, and NASA's Jet Propulsion Laboratory demonstrated a prototype web service and user interface that supports user-customizable satellite-to-in situ data matching. The Distributed Oceanographic Match-Up Service (DOMS; https://mdc.coaps.fsu.edu/doms), funded by NASA AIST, take a unique approach to allow users to select geospatial and temporal bounds for a select set of variables (SST, SSS, and winds) and receive back a subset of collocated satellite-to-in situ data pairs. SAMOS is providing one of the foundational in-situ datasets that users can select using DOMS. The project has been extended by NASA and DOMS will be integrated into a new cloud-based ocean data analysis tool, known as OceanWorks, being developed by JPL.

In summary, the SAMOS project within the U.S. research vessel DAC at FSU provides the foundational high-quality meteorological and near-surface oceanographic data to support an expanding research and operational user community, which in turn is addressing many questions of primary interest to COD and NOAA. Additionally, archiving all quality-evaluated SAMOS data at NCEI ensures that data collected at taxpayer expense by U.S. research vessels are complete, accurate, and accessible for future generations of scientists, policy makers, and the public.

Milestones Accomplished and/or Completed

The DAC received and processed 5230 ship days of SAMOS observations in FY17. Of these, 4902 days were submitted to NCEI (we do not archive data from Australia or New Zealand per our agreement with IMOS), falling a bit short of the target metric of 5100 days to be submitted for archival in 2017. For the NOAA fleet, we received and processed data for 71% of the days NOAA vessels were at sea, which is short of our FY17 target of 82%. This may be biases a bit low because NOAA ship schedules are finalized near the end of the calendar year, so the baseline number of days at sea for the NOAA fleet may be overestimated. We continue to work with NOAA's Office of Marine and Aviation Operations (OMAO) to improve the quantity of data flowing from the NOAA ships to SAMOS. FSU produced the one technical report planned in our FY17 metrics and also completed the SAMOS data management plan. We identified 4 refereed publications that used or referenced SAMOS data in the past year, meeting our metric of 3 publications for FY17.

Outreach and Education

In the past year, the DAC has expanded its social media presence via new Facebook and Twitter feeds associated with the Marine Data Center at COAPS. The MDC was formed to provide unified vision for the marine data services conducted at COAPS and includes the RV DAC, satellite data services, the FSU winds, and other marine data products. To support public outreach activities, we developed a fact sheet (December 2016) entitled "Making use of a sea of data". The fact sheet outlines the role SAMOS observations play in supporting satellite product validation and, in turn, numerical weather forecasting. The fact sheet was disseminated at the COAPS Open House (February 2018) and FSU day at the Florida Capitol (March 2018).

We continue to train the next generation of marine and data scientists. In FY17, three undergraduate students (Ian Terry, William McCall Parker, and Jonathan Reynes) studying computer science and/or informatics have worked part time for the DAC aiding our lead programmer to maintain and update our data delivery web pages and services. Adam Stallard, a graduate student in Computer Science, was the lead developer on a NASA-funded project that integrated the SAMOS observations into a prototype

satellite-to-in situ data matching web service. He also developed some new metrics and databases for the SAMOS observations. In the area of professional development, Kris Suchdeve conducted a “How to SAMOS in SCS” training webex for in-service marine technicians in December 2017 (Newport, OR) and Jeremy Rolph did in-person training for NOAA technicians (Newport Beach, VA, Dec. 2017).

Data and Publication Sharing

The core mission of the DAC is data stewardship. This includes ensuring all data, reports, and documentation are readily available and SAMOS data and metadata are submitted to a national archive for long-term preservation [Deliverable 3]. To meet the requirements of PARR and NOAA guidelines, a data management plan for the SAMOS initiative [Deliverable 7] was published online in December 2016 (http://samos.coaps.fsu.edu/html/docs/SAMOS_DMP_for_NOAA_14Dec2016_v04.pdf).

All near real-time (preliminary, 5-min delay from receipt) and delayed-mode (intermediate or research, 10-day delay from receipt) SAMOS data are available via web (http://samos.coaps.fsu.edu/, under “Data Access”), ftp (samos.coaps.fsu.edu, anonymous access, cd /samos_pub/data/), and THREDDS (http://coaps.fsu.edu/thredds.php) services. The most recent data can be identified by selecting “preliminary” data at http://samos.coaps.fsu.edu/html/data_availability.php, and are typically available within a few minutes of 0000 UTC. We routinely test our web services and respond rapidly to failures of the system. In addition to data access, the SAMOS web site includes our mission statement, data policy, and acknowledgements under the “About” tab on the SAMOS home page. The web site also provides access to recruitment materials for vessels, a subscription service for operators to access monthly data reports, desired SAMOS parameters and accuracy requirements, best practice guides, and training materials. SAMOS publications and technical reports supported by COD are available at http://samos.coaps.fsu.edu/html/publications.php and acknowledgements are included in each document.

SAMOS data are not distributed via the Global Telecommunication System. The DAC has an ongoing collaboration with the managers of the U.S. Voluntary Observing Ship scheme at the National Data Buoy Center (NDBC) to assess the quality of data records transmitted via the GTS from the same vessels that contribute to SAMOS. The majority of the U.S. research vessels contributing to SAMOS provide irregular 1-, 3-, or 6-hourly reports to the GTS via other National Weather Service- (NWS) supported programs (e.g., AMVER SEAS). The PI notes that our major user community continues not to require SAMOS data to be delivered via GTS. Our current web, ftp, and THREDDS systems meet their needs.

SAMOS data are archived at the National Centers for Environmental Information (NCEI) - Maryland on a monthly schedule using automated submission protocols. To ensure integrity, each archival set includes files that contain the original, preliminary, and research-quality data and metadata (e.g., file naming and format descriptions); a file manifest; and a message-digest algorithm 5 (MD5) checksum for each file. In FY17 we developed and added a document describing the data quality control and file versioning system into every SAMOA archive package submitted to NCEI [Deliverable 7]. SAMOS data accessed from NCEI are linked to a collection level DOI via the landing page: http://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:COAPS-SAMOS. As of 25 October 2017, a granule search using keywords “SAMOS” and “COAPS” from the landing page located 4085 monthly SAMOS ship archive sets at NODC. Periodically, the PI downloads SAMOS data from NODC to ensure system integrity.

Collaborators

FSU has an ongoing collaboration with NOAA partners at OMAO to improve communication of best practices for meteorological and flow water system observations on the NOAA fleet. We also collaborate to provide feedback to operators and OMAO headquarters to support decision making for the fleet. Our primary collaborators are John Katebini and Patrick Murphy at OMAO. In addition, we collaborate with Chris Paver at NCEI to ensure timely archival of all SAMOS datasets. In the funding period, NCEI and OMAO did not provide any direct support for this activity, but they do provide in-kind support (travel and salaries) for their personnel to work with the SAMOS program.

NGI File # 17-NGI3-27

Project Title: Modeling Climate Impacts on Fish Larvae Mortality in the Gulf of Mexico

Project Lead (PI) name, affiliation, email address: Steven Morey, Florida State University, smorey@fsu.edu

Co-Principal Investigator name, affiliation, email address: Eric Chassignet, Florida State University, echassignet@fsu.edu

Project objectives and goals

The goal of this project is to develop a modeling framework that can be applied to many regions and species and to provide knowledge relevant for fisheries management. This biophysical ocean modeling research will increase our understanding of the interaction between physical and ecological processes in the Gulf of Mexico (GoM), specifically understanding the impacts of climate variability on mortality of larvae of several coastal pelagic fishes. This will be achieved by accomplishing the following objectives: (1) Develop a regional coupled physical/ecosystem model for the Gulf of Mexico; (2) Develop and apply a method of estimating food limiting conditions for fish larvae from measured or modeled zooplankton concentrations; (3) Conduct simulations for past and present climate conditions to understand the variability of food-limiting conditions and the impact on fish larvae mortality. This project primarily supports a Ph.D. student (Taylor Shropshire) and this work is being conducted as part of his Ph.D. dissertation research.

Description of research conducted during the reporting period and milestones accomplished and/or completed

Biophysical Model Development

The NEMURO (North Pacific Ecosystem Model for Understanding Regional Oceanography; Kishi et al., 2007) has been adapted to simulate the marine biogeochemistry of the Gulf of Mexico. NEMURO is an 11-component biogeochemical model that is particularly well designed for this project because it distinguishes small, large, and predatory zooplankton, facilitating the estimation of realistic spatio-temporal variability in prey for larval fish. This biogeochemical model has been coupled with the Massachusetts Institute of Technology General Circulation Model (MITgcm), which is used to perform simulations in an offline fashion (physical fields are prescribed instead of computed during the simulation). Input to the simulations include: three-dimensional velocity, temperature, and salinity fields from a preexisting HYCOM simulation and daily surface Climate Forecast System Reanalysis (CFSR). Under this project the biophysical model has been developed and preliminarily validated using zooplankton data from SEAMAP, World Ocean Database (nutrient data), and satellite-derived sea-surface chlorophyll from Sea-Viewing Wide Field-of-View Sensor (SeaWIFS)).

Food Limitation Methodology

A methodology to compute food limitation conditions was developed following review of the literature and interaction with NOAA/SEFSC to determine parameters needed to estimate food requirements and feeding mechanisms. Although strong ontogenetic variation exists between costal-pelagic species as individuals become older, the intrinsic physiological characteristics that determine food availability and food requirement for their respective larvae have well documented ranges for the first ~3 weeks of life. Most previous studies discussing food limitation of fish larvae have focused on laboratory experiments aimed at quantifying total food acquisition and the parameters that determine acquisition (e.g., sensory radius, swimming speed, capture success) or analyzing the relationships between gut contents and health of wild larvae. In both approaches the thresholds for food limitation have been estimated for individual larvae, however, to our knowledge the spatial and temporally varying food availability for fish larvae in the Gulf of Mexico has not been estimated and characterized. Furthermore the range of metabolic requirements has yet to be compared with actual zooplankton fields observed in the ocean. In this study we developed a Food Limitation Index (FLI) as a way to quantitatively compare food availability and food requirement experienced by fish larvae in the field (see method for computing the FLI below).

The methodology for computing food limitation conditions is as follows: Using the validated zooplankton fields output by the coupled biophysical model, food availability (g C d^{-1}) can be estimated as:

$$F_{avail}(\phi, r, \nu, Z, C_s, T) = \phi \pi r^2 \,.\, \nu \,.\, \frac{1\, m^3}{1x10^9\, mm^3} \,.\, Z \,.\, \frac{C}{N} \,.\, \frac{1\, mol}{1000\, mmol} \,.\, \frac{12.0107\, g\, C}{mol\, C} \,.\, C_s \,.\, T$$

Food requirement (g C d^{-1}) can be estimated as:

$$F_{req}(\mu, \frac{W}{L}, gge) = \mu \,.\, \frac{W}{L} \,.\, \frac{C}{DW} \,.\, \frac{1}{gge}$$

Comparing food availability and food requirement will reveal regions and periods where fish larvae are susceptible to starvation. This susceptibility is quantified through a food limitation index (FLI):

$$FLI = \frac{F_{avail}}{F_{req}} \qquad \begin{cases} FLI \geq 1 & Not\ Food\ Limited \\ FLI < 1 & Food\ Limited \end{cases}$$

Table 1. Parameters used to calculate the food limitation index.

Parameter	Abbrev	Value/Range	Units	Sources
Growth Rate	μ	0.2 – 1.5	mm d^{-1}	7, 8, 12, 17, 24, 34, 36, 39, 40
Swimming Speed	v	1.0 – 3.0 * BL	mm s^{-1}	3, 14, 15, 21
Sensory Radius	r	0.2 – 1.0 * BL	mm	4, 14, 29
Gross Growth Efficiency	gge	0.2 – 0.4	%	10, 13, 16
Carbon to Dry Weight Ratio	C/DW	0.35 – 0.45	non-dim.	25, 26, 38
Carbon to Nitrogen Ratio	C/N	106/16	non-dim.	28
Perceived Cross-Sectional Area	Φ	2/3	non-dim.	21
Zooplankton Concentration	Z	model output	mmol N m^3	
Feeding Duration	T	12 – 15h *3600	seconds	4
Body Length	BL	published *f(age)*	mm	e.g., 12
Capture Success	C_s	published *f(age)*	%	e.g., 4, 14, 29
Weight to Length Ratio	W/L	published *f(BL)*	non-dim	e.g., 12, 27

Based on this methodology, a larva with reasonable physiological characteristics (6 mm, 11-day old, 0.5 mm d^{-1}) and subject to average zooplankton concentrations in the open GoM from SEAMAP survey data has an FLI varying within a range of values near 1.0 indicating that food limited and non-limited conditions can occur in the GoM (Figure 2 and 3), which is what we would expect to find in the ocean.

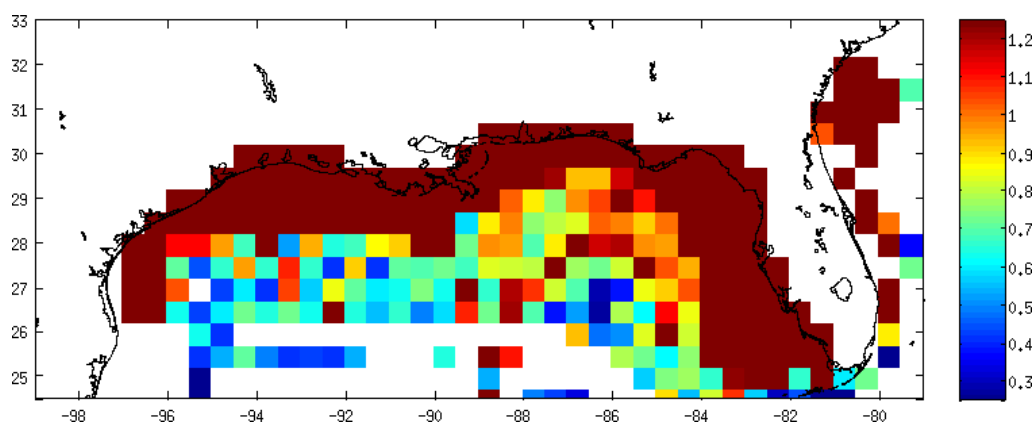


Figure 2. FLI calculated from temporally and spatially averaged SEAMAP for all available data (1982 – 2015).

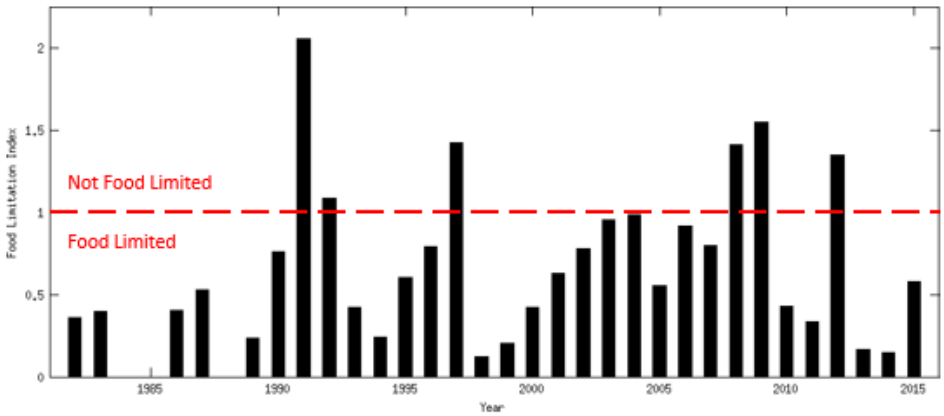


Figure 3. FLI calculated from temporally and spatially averaged SEAMAP in the month of May at 27° N -87° E for all years available (1982 – 2015).

Initiated Collaborations

The model developed in this study is already being used in two multi-institutional research initiatives. The first is CISIOMIO project…

The second collaboration is a project funded by NASA aimed at estimated zooplankton from space using this biogeochemical model as one of the methods of generating algorithms between chl and sst to estimate zooplankton

Description of significant research results, protocols developed, and research transitions

Results from the biophysical model developed in this project are novel in that to our knowledge no lower trophic level ecosystem modelling studies have validated against a multi-decadal zooplankton dataset for two reasons 1.) zooplankton concentrations have not been quantified past isolated sampling events in most regions and 2.) biogeochemical models are often designed with only one or sometimes two zooplankton state variables which does not resolve the important micro, meso, and macro zooplankton size classes that are sampled separately in field making model data comparisons not possible. Most biogeochemical models are designed to emphasize the phytoplankton dynamics because traditionally model tests focus on validating against satellite derived chlorophyll. In this project we show that NEMURO can be successfully tuned to simulate realistic average zooplankton fields. Figure 4 shows SEAMAP observations of combined meso (200 um – 2 mm) and macro (2 mm – 20 mm) zooplankton (size classes of larval fish prey) vs modeled meso and macro zooplankton.

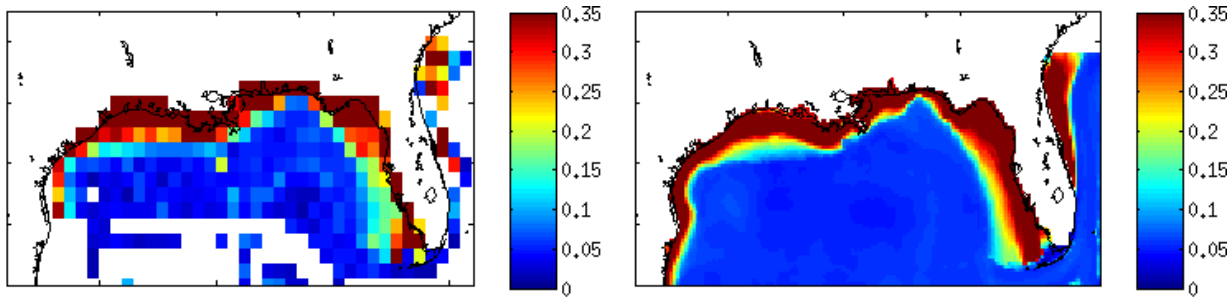


Figure 4. Mean meso- and macro-zooplankton concentration from SEAMAP observations (left) and the coupled physical-biogeochemical model (right).

Collaborators / partners

Dr. Sang-Ki Lee (NOAA-AOML) and Dr. Mandy Karnauskas (NOAA-SEFSC) are collaborating with this project. They are providing guidance to the graduate student (T. Shropshire) on refinement of the research project objectives, including selection of key study species, development of hypotheses, and

design of numerical experiments to test the hypotheses. Mr. Shropshire spent two months during the summer of 2017 in residence at the NOAA labs in Miami collaborating with these and other scientists.

Outreach Activities

Personnel supported during the entire duration of this project participated in the COAPS and FSU Coastal and Marine Laboratory open houses, presenting results from their research and other educational material to thousands of attendees from the community.

Publications

None during this reporting period.

Presentations

Shropshire, T., M. Stukel, E. Chassignet, S. Morey, and M. Karnauskas (2017). Estimates of food limitation experienced by coastal-pelagic fish larvae in the Gulf of Mexico. 2017 Advances in Marine Ecosystem Modeling Research Conference, Plymouth, U.K.

NGI File # 17-NGI3-28

Project Title: Predicting the impact of anthropogenic climate change on physical and biogeochemical processes in the northern Gulf of Mexico - Part 3

Project Lead (PI) name, affiliation, email address: Frank Hernandez, University of Southern Mississippi, frank.hernandez@usm.edu

Co-Principal Investigators name, affiliation, email address: Sang-Ki Lee, Atlantic Oceanographic and Meteorological Laboratory, NOAA, sang-ki.lee@noaa.gov and John Lamkin, Southeast Fisheries Science Center, NOAA, john.lamkin@noaa.gov

Project objectives and goals

The main objective of this project is to provide a range of realistic scenarios of future environmental changes in the northern Gulf of Mexico (GoM - including the shelf region) for the research community and fisheries resource managers.

Description of research

To examine seasonal and interannual patterns in the carbon-system variables across the GoM, we add a new 'carbon system' module into the ocean-biogeochemical model. This module contains two prognostic variables, dissolved inorganic carbon (DIC) and total alkalinity (TA), which are derived from model formulations by Fennel et al. (2008) and Laurent et al. (2017). Model DIC is consumed during phytoplankton growth and produced during organic matter remineralization and zooplankton excretion, while model alkalinity increases due to NO_3 uptake and remineralization, and decreases due to NH_4 uptake and nitrification. Air-sea CO_2 exchange is calculated using the Wanninkhof (2014) formulation. The full set of carbon-system variables (such as pH, CO_2, pressure, and aragonite saturation) is derived from DIC and TA monthly outputs using the matlab CO2SYS code (Lewis and Wallace, 1998).

Milestones accomplished

1. Submission of the article "Impact of ENSO on Salinity, Plankton Biomass, and Coastal Current in the Northern Gulf of Mexico" for revision in Geophysical Research Letters (currently under review).

2. Implementation of carbon-system module in the ocean-biogeochemical model to study patterns in ocean acidification.

Description of significant research results

We use the outputs of our ocean-biogeochemical model, as well as satellite data and in situ observations, to evaluate the impact of ENSO in the northern Gulf of Mexico. We find that the first Empirical Orthogonal Function mode of salinity (plankton biomass) is positively (negatively) and significantly correlated to the Nino 3.4 index during December-May. To visualize the spatial variability in salinity and plankton biomass related to ENSO, we derived El Nino composites for SSA, SPA, and SZA during winter (December-February) and spring (March-May) (Fig. 1). The derived patterns for the two seasons show low salinity conditions and enhanced plankton biomass prevailing across most of the northern Gulf of Mexico shelf. During winter, the largest El Nino absolute anomalies are found mainly shoreward of the 25-m isobath, and west of the 88°W. Westward advection of the Mississippi-Atchafalaya and other rivers plumes, due to the prevailing westward alongshore circulation over the northern Gulf of Mexico shelf, explains the largest anomalies west of 88°W. This alongshore circulation pattern is strengthened during El Nino winters. Because zooplankton growth responds to phytoplankton growth, the largest accumulation rates of zooplankton biomass occur downstream of the phytoplankton biomass maximum, thus producing the greatest zooplankton anomalies over the northwestern shelf. During spring, the mean surface current

anomalies are mainly southeastward on the Louisiana-Texas shelf, therefore the salinity and plankton anomalies tend to extend further offshore than during winter. The greatest absolute anomaly values are found in the central northern Gulf of Mexico, with the zooplankton maximum located offshore of the phytoplankton maximum. We also estimated the mean SSA, SPA, and SZA composites for La Nina winter and La Nina spring (not shown). The derived La Nina composites patterns are not significant in most of the northern Gulf of Mexico shelf, reflecting an asymmetry between El Nino and La Nina discharge patterns. Still, La Nina composites display the opposite patterns to El Nino composites during winter, but with about half of the El Nino anomaly magnitude.

Zhang et al. [2014] showed that the winter alongshore flow in the northern Gulf of Mexico shelf closely follows the thermal-wind relationship, with the cross-shore density gradient mainly driven by the cross-shore gradient in salinity. This is visualized in the climatological patterns of model salinity and model alongshore current in a vertical cross-shore section on the Louisiana-Texas shelf (Fig. 2a). As shown in Figure 2a, salinity displays almost vertically oriented isohalines, ranging from ~28 nearshore to >36 in the outer shelf (bottom depth >150 m), and the maximum alongshore currents (~10 cm s^{-1} at surface) co-occurs with the strongest salinity gradient. The salinity drop by ~2 psu in the nearshore (due to increasing river runoff) could explain the strengthened westward alongshore current during El Nino winters (Fig. 2b-c), as the circulation pattern in this season is usually near geostrophic balance [Zhang et al., 2014]. To evaluate the degree to which the flow anomalies during El Nino winters respond to disturbances in the geostrophic balance, we derived geostrophic currents from the thermal wind equation using the model density field (Fig. 2d). The comparison reveals similar structure and amplitude of the anomalies for the model current and the current derived from the thermal wind balance, with the maximum anomalies (~4 cm s^{-1}) located nearshore and over the outer shelf (~130 km offshore). This result makes evident the link between the Louisiana-Texas circulation anomalies and salinity-driven changes in density during El Nino winters.

Model derived time series of DIC (as well as sea surface CO_2 pressure and pH) show the expected long-term trend due to anthropogenic CO_2 increase (Fig. 3). Interannual anomalies in the simulated sea surface pressure of CO_2 (pCO_2) mainly responded to SST changes in the oceanic region, and DIC changes in the northern shelf (Fig. 4). DIC changes can be linked to variability in biological production, the latter driven by fluctuations in river runoff. Simulated gradient in DIC, pCO_2, and CO_2 fluxes near the Mississippi delta are consistent with Huang et al. (2015) observations, reflecting the influence of DIC and nutrients from the Mississippi river and the associated enhanced biological productivity.

Information on collaborators / partners (if applicable):
N/A

Information on any outreach activities
N/A

Publications and Presentations

<u>Submitted article:</u>
Gomez, F. A., S.-K. Lee, F. J. Hernandez, L. M. Chiaverano, F. E. Muller-Karger, Y. Liu, and J. T. Lamkin: Impact of ENSO on Salinity, Plankton Biomass, and Coastal Current in the Northern Gulf of Mexico. Submitted to Geophysical Research Letters (under review).

<u>Posters:</u>
Gomez, F. A., S.K. Lee, F. J. Hernandez, L. M. Chiaverano, F. E. Muller-Karger, Y. Liu, and J.T. Lamkin. Impact of ENSO on Salinity, Plankton Biomass, and Coastal Current in the Northern Gulf of Mexico: Ocean Sciences Meeting, February 2018, Portland, OR.

<u>Webinar:</u>
"Seasonal to interannual patterns of alkalinity and DIC in the Gulf of Mexico derived from an ocean-biogeochemical model" Presented by F. Gomez in the Gulf of Mexico Coastal Acidification Network (GCAN) Webinar Series, May 29th, 2018.

References

Fennel, K., J. Wilkin, M. Previdi, and R. Najjar (2008), Denitrification effects on air-sea CO 2 flux in the coastal ocean: Simulations for the northwest North Atlantic, Geophys. Res. Lett., 35, L24608, doi:10.1029/2008GL036147.

Laurent, A., K. Fennel, W.-J. Cai, W.-J. Huang, L. Barbero, and R. Wanninkhof (2017), Eutrophication-induced acidification of coastal waters in the northern Gulf of Mexico: Insights into origin and processes from a coupled physical-biogeochemical model, Geophys. Res. Lett., 44, 946–956, doi:10.1002/2016GL071881.

Lewis, E., and D. W. R. Wallace (1998), Program Developed for CO2 System Calculations. ORNL/CDIAC-105. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee.

Zhang, Z., Hetland, R., & Zhang, X. (2014), Wind-modulated buoyancy circulation over the Texas-Louisiana shelf. Journal of Geophysical Research C: Oceans, 119(9), 5705–5723, doi.org/10.1002/2013JC009763.

NGI File #: 17-NGI3-29

Project Title: SHOUT4Rivers

Project Lead (PI) name, affiliation, email address: Robert Moorhead, Mississippi State University, rjm@gri.msstate.edu

Co-Principal Investigator: name(s), affiliation, email address: Jamie Dyer, Mississippi State University, JDyer@geosci.msstate.edu

Project objectives and goals

The goal is to perform a cost and feasibility analysis of exploiting unmanned aerial systems (UAS) to address key priorities given by the NWS river forecast centers (RFC), as well as a data impact study. The requirements to be addressed are:

- Rapid response during and after a catastrophic flooding event to track *changes in river channel* structure and morphology and debris.
- Detailed information on *levee breaches* and any inundation in near real time (location, width, depth)
- Rapid response *photos* to document extent of inundation to verify flash flooding, flood inundation maps, and enable production of flood maps for more locations

The concept is a field experiment: develop a rapid response UAS team to collect data for a set of high impact weather events (e.g., floods) to determine the cost and feasibility of UAS exploitation, as well as the data impact. The events to be addressed would be in and determined by the NWS Southern Region, which includes the Southeast RFC, the Lower Mississippi RFC, and the West Gulf RFC. For situational awareness during high-impact events, the high-res on-demand UAS imagery, as well as satellite imagery when available, is absolutely invaluable when the RFCs and Weather Forecast Offices (WFOs) can obtain it. In cases where cloud cover prohibits the availability of surface imagery from satellites, UAS imagery becomes critical as it is the only real-time source of information. The capability to have pre, current, and post storm imagery is something the RFCs need to find a way to obtain, as this has implications for post-storm disaster declarations and for insuring forecast models take into account any channel modifications resulting from the flood event.

Description of research conducted during the reporting period and milestones accomplished and/or completed

Two areas were selected for UAS missions in response to flooding due to heavy regional precipitation the week of March 4, 2018:

- Big Sunflower River near Sunflower, Mississippi
  - Peak on Mar. 6, estimated drop by 1.5’ on Mar. 7
- Coldwater River near Marks, Mississippi
  - Remain near crest entire week
  - Selected as primary study area

We encountered several UAS challenges in executing the mission:

- Cold front moved through area on Mar. 5, leading to extensive cloud cover and poor flight conditions
- Weather conditions included nighttime lows in the mid-30s and relatively high winds on Mar. 7 (5-15 mph with gusts to 20 mph)

However, we were able to collect UAS imagery:

- Detailed spatial imagery of area around Marks, Mississippi showing inundated areas.
- Data can/will be used for assessment of surface water storage areas, impact assessment, and influence of structures on river level.

Since the imagery is high resolution (~ 2cm per pixel), the final image mosaic files are large (~14 GB) and thus not easily transferable from the field to the RFC. This made us realize the need to be able to create a coarse mosaic in the field and send to the RFC ASAP. From that, we can select critical/important locations for detailed spatial analysis in cooperation with NWS RFC personnel. We can then extract images and send to the RFC for further analysis.

Below is a low-resolution representation of a mosaic of the flooding in and around Marks, Mississippi on March 6-7, 2018. The mosaic contains data from one 40-minute flight with an Altavian F7200 and four 20-minute flights with a DJI Phantom 4 Pro. One would want to use the fixed-wing (the F7200) to map large areas and the multi-rotor Phantom when / if you needed to "zoom in" to particular areas or lacked a suitable landing area for the fixed wing UAV. This demonstrates our ability to fuse data from different UAV platforms.

The UAS imagery shows inundated areas along the river banks, the extent of the inundation near critical features such as bridge embankments, power lines, etc., and debris in the floodplain that is a navigation hazard.

Description of significant research results, protocols developed, and research transitions

We identified the need to get an initial picture to the RFC as soon as possible, for maximum impact.

Information on collaborators / partners (if applicable)

a. Name of collaborating organization: NWS/LMRFC
b. Date collaborating established: on-going
c. Does partner provide monetary support to project? Amount of support? No
d. Does partner provide non-monetary (in-kind) support? Yes
e. Short description of collaboration/partnership relationship: The LMRFC advises us about the ideal
f. tradeoff between higher resolution and smaller data volumes: During high-impact events, they inform us about specific locations where imagery is needed to improve their situational awareness. We discuss how to best address their goal of decreasing loss of life and property by providing more timely and relevant data using UAS resources.

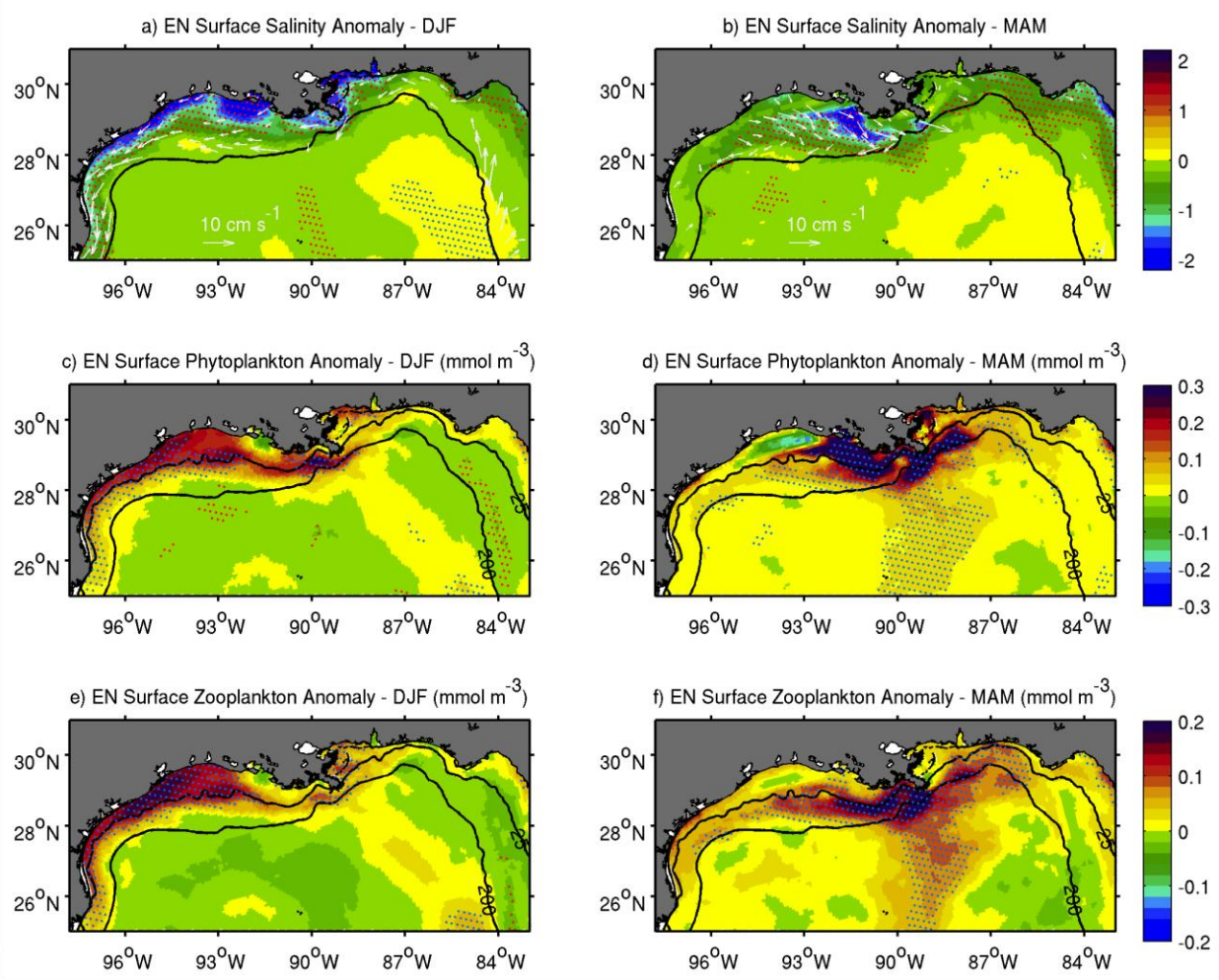


Figure 1. Mean El Nino composite for a, b) surface salinity anomaly c, d) surface phytoplankton anomaly, and e, f) surface zooplankton anomaly during winter (DJF, left panels) and spring (MAM, right panels). Plankton concentration is in terms of mmol of nitrogen m^{-3}. Red (blue) dots indicate significant negative (positive) anomalies at the 90% confidence level. Vectors in panels a, b depict surface shelf current anomalies (only significant values at the 90% level). Black contours depict the 25 and 200 m isobaths.

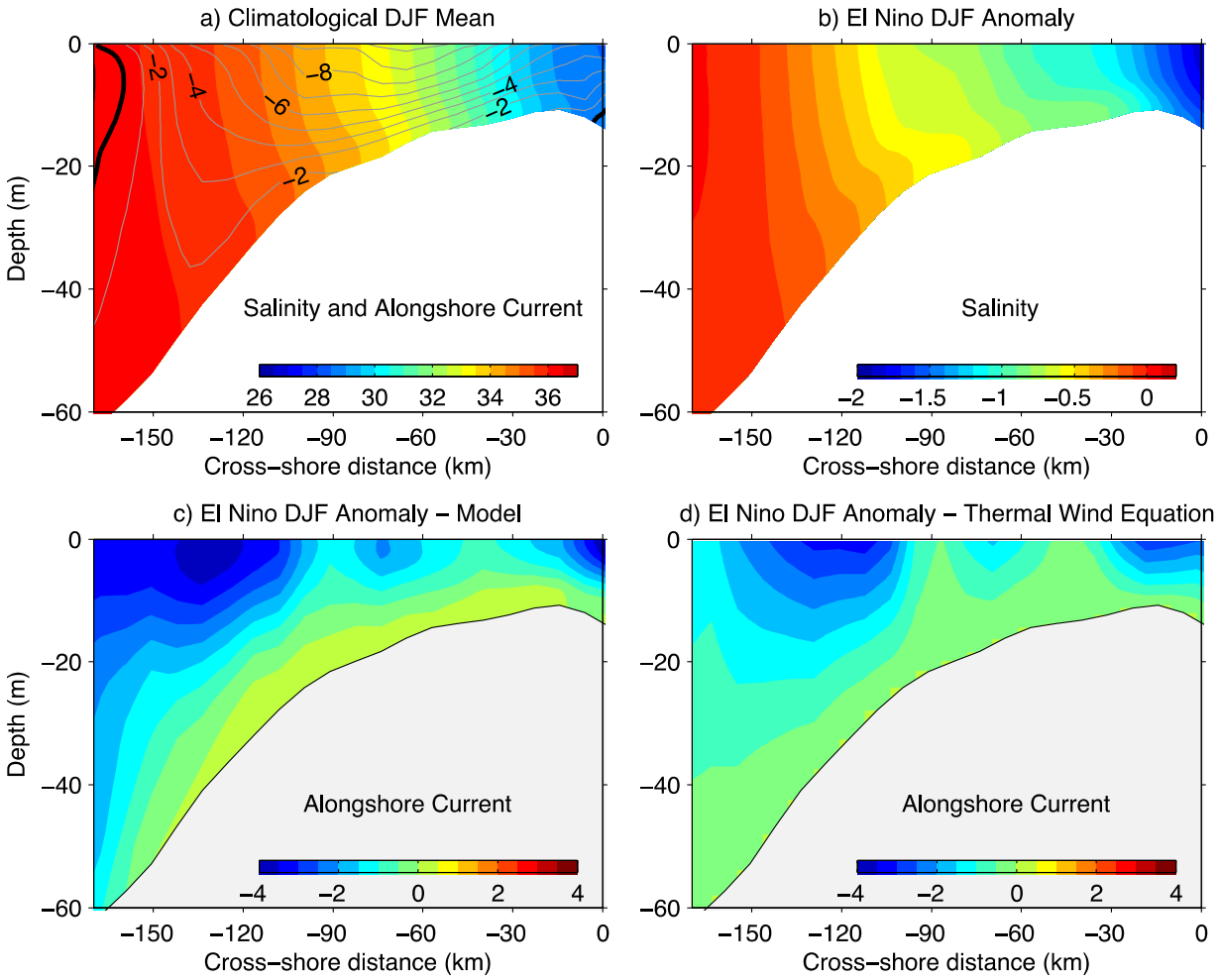


Figure 2. Winter (DJF) vertical patterns for a cross-section on the LATEX shelf: a) Model climatological mean for salinity (color) and alongshore current (contours; cm s^{-1}). Down-coast (up-coast) circulation is in thin gray (black) contours. 0 cm s^{-1} is depicted as thick black contour. b-c) El Nino mean anomaly for model salinity (b) and alongshore current (c); d) El Nino alongshore current anomaly derived from the model density field using the thermal-wind equation (assuming zero velocity at the bottom).

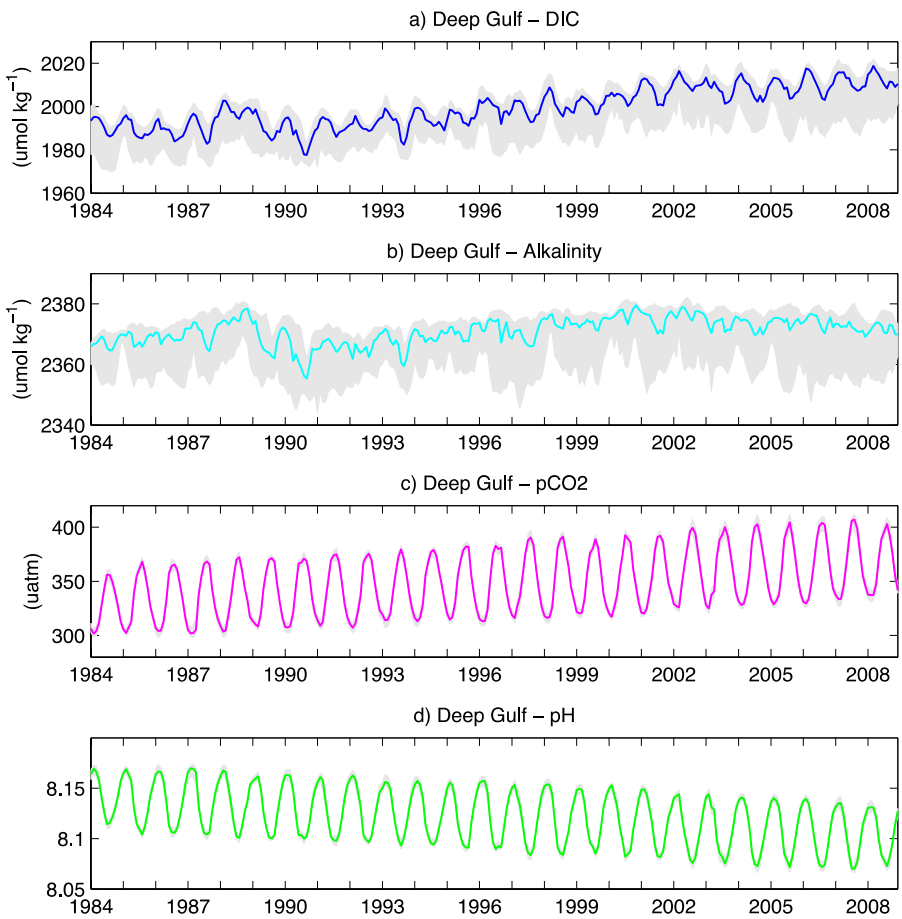


Figure 3. Monthly time series of model surface a) DIC, b) alkalinity, c) pCO2, and d) pH in the deep Gulf. The estimated linear trends for DIC, pCO2, and pH are 1.01 umol kg^{-1}, 1.67 uatm, and -0.0016 units per year, respectively. Gray areas indicate the variable interquartile ranges.

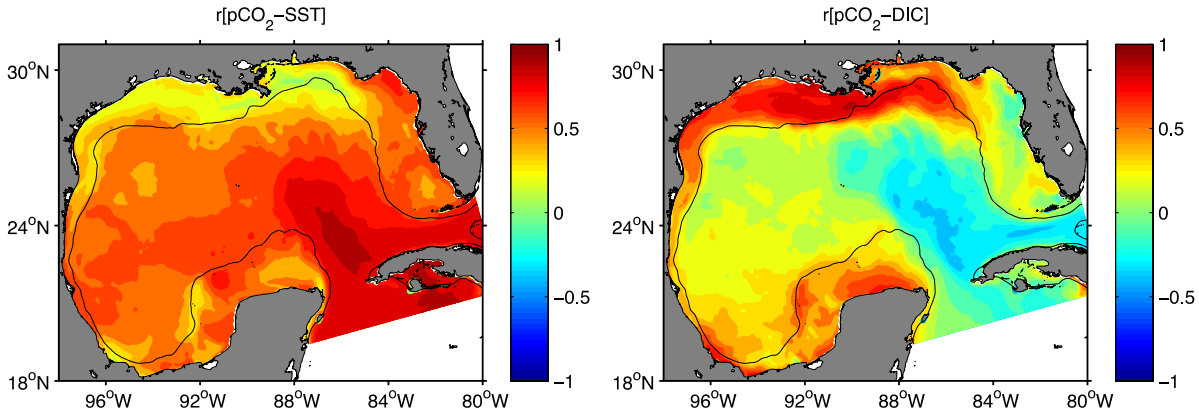


Figure 4. Correlation between sea surface CO_2 pressure (pCO_2) anomaly and a) SST, and b) dissolved inorganic carbon.

NGI File # 17-NGI-30

Project Title: HPC Support for OAR

Project Lead (PI) name, affiliation, email address: William B. (Trey) Breckenridge III, Mississippi State University, trey@hpc.msstate.edu

Project objectives and goals

The Introduction to NOAA's Office of Oceanic and Atmospheric Research's (OAR) Strategic Plan states that OAR "creates improved understanding and predictions of tornadoes, hurricanes, climate variability, changes in the ozone layer, El Nino/La Nina events, ocean acidification, fisheries, productivity, ocean currents, deep sea thermal vents, and coastal ecosystem health." It goes on to state that OAR "specializes in improving these capabilities, and improving our understanding of the Earth system" and "conducts R&D that increases our knowledge of climate, weather, oceans and coasts."

NOAA depends on high performance computing to meet many aspects of its mission. At the Senior Research Council meeting in September 2016, the NOAA OAR AA listed high performance computing among his top 3 issues, noting that a clear need for more dedicated research high performance computing capacity was need for OAR to fulfill its mission.

The Mississippi State University-led Northern Gulf Institute (NGI), a NOAA Cooperative Institute, has a rich history of supporting NOAA research activities. NGI has partnered with every line office within NOAA, delivering high quality research output and supporting broad research activities. Furthermore, MSU has long been a leader in high performance computing, supporting research and operational needs for numerous federal agencies for several decades. Coupling this HPC expertise with the existing research relationship with NOAA, this award supports the acquisition of high performance computing resources located at MSU in an effort to build HPC capacity in support of NOAA research and development activities. This computing resource will provide HPC capacity to enable science requiring larger, more complex, and more detailed environmental models, while advancing the historical and on-going relation between NGI scientists and personnel in NOAA Labs and other Cooperative institutes.

Description of research conducted during the reporting period and milestones accomplished and/or completed

Building upon the numerous successful research activities between NOAA and the Northern Gulf institute, this award funds the establishment a high performance computing capability at MSU. The scope of work for the award consists of the acquisition, installation, support and operation of a high performance computing resource and all required supporting infrastructure. The period of performance for the project is four (4) years. Activities conducted during the reporting period, which coincides with the first 9 months of the award period, primarily involved facility modifications for support of the new system and initiation of procurement of the HPC system.

Facilities modification-related tasks initiated or completed during the reporting period include the selection of an engineering firm, Corbett Legge & Associates PLLC, to design the electrical and mechanical infrastructure additions/modifications necessary for the system, as well as oversee the installation and implementation of the electrical/mechanical infrastructure to their design standards. The Corbett-Legge contract was executed in late September 2017. During October 2017, facility reviews and project needs were evaluated, and bid documents developed. The advertisement for contractor services began in November 2017, with McLain Plumbing & Electric Service Inc being selected as the contractor for the infrastructure modifications/installation after the required advertisement period. A contract with McLain was executed in early January 2018. Modifications to existing mechanical systems involved the decommissioning and relocating of HVAC components located in the mechanical yard. During the next few months, a new HVAC chiller was placed in the mechanical yard, water piping from the chiller to the data center installed (not completed inside the data center, though), a building electrical service

transformer was replaced with a larger unit, and electrical connections made to the chiller. As of the end of the reporting period, the chiller start-up has not yet occurred, but is expected within the next month. Electrical connections from the switch-gear to the new computing equipment will occur when the computing equipment arrives.

Numerous conversations have been held with NOAA personnel regarding hardware configurations for the new computing system. The primary discussions involved whether the purchase of a tightly-coupled supercomputer (e.g. a Cray-style system) or a traditional cluster would best meet the needs of NOAA; it was decided that a traditional cluster would be best. A broad system design and specifications were developed, including how many of each type of nodes are needed (e.g. large-memory compute, login, data transfer, system management), the required amount of memory per nodes, amount of storage, etc. A request-for-proposals was released in May 2018, timed such that the delivery of the system components would correlate with completion of the facilities modifications. In June 2018, the RFP responses were opened, reviewed and scored by a review panel. The Mississippi State University Department of Procurement and Contracts compiled the panel review scores, selected the winning vendor and solution, and submitted the procurement request to the State of Mississippi's Public Procurement Review Board (PPRB) for final approval to execute a procurement. A response from the PPRB is expected in July.

In late June 2018, a team of senior MSU personnel traveled to NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, NJ to meet with NOAA HPC personnel to formulate and discuss system operation details. Much of the early portion of the meeting revolved around current NOAA processes and workflows, and how the MSU system would be utilized by NOAA researchers. These discussions resulted in basic plans for areas including account management, user support, and software needs and management, and security plans.

Fiscal expenses for the project have been minimal during the reporting period, primarily due to the fact that the system procurement hasn't been executed. Expenses incurred include personnel time for senior staff members to oversee the facility infrastructure modifications, the development of system specifications and RFP documentation, and initial design and implementation of software stacks to be deployed on the system. Additional staff positions, to be funded from the project, have been advertised, but no new staff yet hired.

Description of significant research results, protocols developed, and research transitions

Design and installation of facilities infrastructure to support the HPC system; Study of NOAA workflows and the initial development of operational plans to support them; Design and implementation of base software stacks to be deployed on the system.

Information on collaborators/partners

Met with NOAA CIO Zach Goldstein and NOAA HPC collaborator Frank Indiviglio at SC18 conference in November 2018. In March 2018, MSU hosted Goldstein and Indiviglio for their first visit to MSU to see MSU facilities and discuss MSU HPC operations, including our strategies for broad adoption of HPC across research disciplines as well as the cyber security implementation process at MSU. In May 2018, met with Indiviglio at Cray User Group conference to discuss project status and plans. MSU senior staff visited GFDL in June 2018 to discuss operations and project status.

Information on any outreach activities

The existence of the award and initial plans have been shared with NOAA OAR personnel and with visitors to MSU. MSU has promoted the award and how the system will be utilized to support NOAA and NGI research activities.

Publications and Presentation (list these on the MS Excel template provided): None

NGI File # 17-NGI-31

Project Title: VORTEX-SE 2018 Field Campaign Activities: High-CAPE, Low-Shear Emphasis

Project Lead (PI) name, affiliation, email address: Kevin Knupp (PI), University of Alabama in Huntsville, kevin.knupp@uah.edu

Co-Principal Investigator name, affiliation, email address: Ryan Wade, University of Alabama in Huntsville, rwade@nsstc.uah.edu

Project objectives and goals

The general goal of this project is to (a) acquire field observations over northern Alabama, and (b) complete preliminary analyses of the data collected as part of VORTEX-SE activities for potential severe weather events between 11/1/2017 and 6/1/2018. An important component of this activity included evaluation (risk reduction) of observational strategies for a future *LowCAPE* experiment, which had a primary goal of documenting the characteristics of cool season tornado events, with a particular focus on quasi-linear convective systems (QLCSs).

This ongoing project includes the following specific goals:

1) Collection, initial analysis, and quality control of data acquired over northern AL during the November 2017 to May 2018 time frame.
    a. Acquire data sets *within* a *meso-β-scale network* using the following facilities:
        i. An outer meso-β-scale network triangle of three IMET sounding systems, deployed in a triangular network with spacing of ~100 km.
        ii. A meso-γ-scale network of three profilers with 30-40 km spacing, located within the meso-β-scale sounding network defined in (i). Each site will include a boundary layer profiler (MIPS, RaDAPS, or MoDLS) and a *Windsond* sounding system, provided that all systems are functional.
        iii. A dual Doppler analysis domain within the region defined by (ii) will resolve small/sub meso-γ-scale flows, both within the ABL, and within QLCSs and cellular deep convection.
    b. Data collected will provide a foundation and context for more detailed planning of a future *LowCAPE* experiment, including cool-season severe weather events that occur primarily in the form of QLCS's. The dual Doppler data will both supplement and provide validation for the P-3 aircraft Doppler radar velocity retrievals. Therefore, sampling of the evolving mesoscale environment and internal structure of QLCS's represents important components of the measurement activities.
2) Data collected and initial data analyses will support the development of hypotheses associated with a future *LowCAPE* experiment, including cool-season severe weather events that occur primarily in the form of QLCS's. After this proposal was accepted for funding, the scientific focus of the VORTEX-SE program was broadened to document mesoscale variability at the meso-α and meso-β scales. The network configurations for the primary IOPs during the March-April 2018 time frame will partially satisfy this requirement.
3) Analysis of data collected during previous VORTEX-SE spring field campaigns in 2016 and 2017 will continue under this support.

Description of research conducted during the reporting period and milestones accomplished and/or completed

Primary research components include the following:

- Analyses of data collected during a tornado outbreak on 30 November 2016. This tornado outbreak event produced a violent tornado (with fatalities) over Sand Mountain. The mesocyclone, bounded

weak echo region, and rear flank downdraft of one supercell storm was well sampled by the MIPS instruments, located at the default UAH site.

- Completion of an initial study examining horizontal shearing instability (HIS) within QLCSs.
- Completion of characterization of Sc clouds during cool season tornado events.
- Acquisition of data sets during the November 2017 to May 2018 time frame. Table 1 provides a summary of the priority cases. Some preliminary analysis and radar data editing have been completed.

Table 1. Summary of the priority IOPs during the 2017-2018 severe storm season.

Date	***Facilities***	***Event synopsis***
18 Nov 2017	ARMOR, MAX, CLAMPS, MIPS & MoDLS at SWIRLL	QLCS intensified and evolved as it moved into the N AL domain. Several mesoscale vortices formed, and 16 tornadoes were documented. Five tornadogenesis events occurred within the SE dual Doppler lobe (18 km, MAX to ARMOR). Two pre-storm soundings were acquired from the SWIRLL, good profiler data sets from the CLAMPS (Belle Mina) and MIPS (UAH) are available. Very good data set.
19 Mar 2018	ARMOR, MAX, SR2, SR3, P-3, CLAMPS, MIPS & MoDLS at SWIRLL	High shear case with mesoscale variability in CAPE and SRH, associated with a boundary across the domain. One supercell evolved over the stable air mass near the AL-TN border, and produced an EF2+ tornado with a 66 km long track. Supercells to the south tapped higher-valued θ_e air and produced shorter live tornadoes and very large hail. Excellent data set.
3 Apr 2018	ARMOR, MAX, SR2, SR3, P-3, CLAMPS, MIPS & MoDLS at SWIRLL	Atypical tornadic QLCS that persisted within an environment with a much higher than average LCL height of ~2 km AGL. Multiple tornado damage paths were documented across N AL, with several tornadoes passing into, or forming within, the ARMOR-MAX-SR3 radar network. (The MIPS, located at Sheffield, AL, sustained considerable damage from a lightning strike.) Very good data set.

Milestones accomplished

During this initial one-year project, the following deliverables will have been completed (project start was 9/1/2017):

a) QC'd sounding data, including quick-look images.
b) QC'd profiler data, including quick-look images.
c) QC'd radar data (ARMOR and MAX), including quick-look images.
d) Sample single Doppler and dual Doppler analyses.
e) Preliminary hypotheses regarding the propagation characteristics, internal structure and dynamical behavior, and development of mesovortices within HSLC QLCSs.

Description of significant research results, protocols developed, and research transitions

Research results

Completion of a case study of the 1 March 2016 isolated tornado in central Alabama

On 1 March 2016, an EF-2 tornado formed south of Birmingham, Alabama within a boundary layer environment that was heterogeneous in space and unsteady in time. It is often assumed that a sounding close in time (~30 min) and distance (~30 km) from the storm location is considered to be an excellent proximity sounding, but in this case the actual sounding, and the SPC mesoanalysis, significantly underestimated both CAPE and wind shear. Tornadogenesis occurred near a weak, but frontogenetical,

thermal boundary, where antecedent light showers had also increased dewpoint values. A local maximum in surface dewpoint (and instability), and a local maximum in low-level wind shear (storm-relative helicity), both existed near this boundary. As a pre-existing QLCS moved into this region of higher CAPE air, part of it became supercellular, and tornadogenesis occurred near the center of a local maximum in surface dewpoint (and θ_e) shortly thereafter. Details of this case are published in Coleman et al. (2018).

Tornadogenesis produced within cool-season QLCSs via horizontal shearing instability

The main goal of this component was to condense and refine a M.S. thesis (Conrad 2017), which was completed in December 2017. Dual Doppler observations (using ARMOR and KHTX) of two cool season QLCSs were analyzed to determine the role that *Horizontal Shearing Instability* (HSI) plays in formation of mesovortices that may spawn tornadoes. One QLCS occurred on 4 Jan 2015 and produced a tornado. The second QLCS occurred on 28 Nov 2016 and did not produce any mesovortices. Storm characteristics such as the wind speed, wind shift angle, and the contraction of the wind shift associated with the QLCS were investigated at the lowest level of the dual Doppler analysis (~800 m AGL). Rayleigh and Fjrtoft stability criteria, which are required for HSI, were satisfied for the 4 Jan 2015 QLCS, but not for the 28 Nov 2016 QLCS. Dual polarization signatures, such as Z_{DR} columns and Z_{DR} arcs and/or K_{DP} foot separation were examined as potential indicators to favored locations for mesovortexgenesis. Z_{DR} columns were observed in locations favorable to mesovortexgenesis while Z_{DR} arc and K_{DP} foot separation showed some correlation with the mesovortexgenesis location. A manuscript documenting these findings will be submitted to Monthly Weather Review by mid July 2018.

Analysis of stratocumulus clouds associated with cool-season tornado events.

This component, also a M.S. thesis topic (Lisauckis 2018), was completed in June 2018.
Stratocumulus clouds, hypothesized to control boundary layer processes during cold season tornado events, were investigated. Lower atmospheric profiles of wind, low clouds (e.g., cloud base height, cloud fraction), water vapor, and boundary layer cloud depth near tornadogenesis events were analyzed over northern Alabama and nearby areas of the Southeastern U.S. Based on a sample size of 50 events (29 supercell and 21 QLCS) the stratocumulus cloud fraction for QLCS's was 97%, and 83% for supercells. Stratocumulus clouds first occurred an average of 200 min (QLCSs) and 90 min (supercell) prior to tornadogenesis. The mean LCL height for all QLCS cases was 660 m for QLCS, and 650 m for supercell cases. The MIPS microwave profiling radiometer and ceilometer provided an estimate of sub cloud layer stability, using the observed cloud base height (ceilometer) and MPR infrared and *in situ* surface temperature, for cases where the liquid water path was sufficiently high for the cloud to act (and emit) as a black body. The sub cloud boundary layer was found to be statically stable, with lapse rates typically in the range 6-8 K per km, roughly 70% the dry adiabatic lapse rate. This finding is corroborated by the surface layer stability derived from *in situ* temperature measurements at 10 and 0.5 m AGL, which show an average temperature difference of about 0.2 K. These findings are contrary to the typical cloud-topped mixed layers, which exhibit a dry adiabatic temperature profile. Thus, large bulk shear magnitudes of 14 and 18 m/s can be maintained within the respective 0-0.5 km and 0-1.0 km layers due to the suppression of turbulent mixing (buoyant generation term in the TKE equation is negative, and therefore suppresses turbulence). These findings will be summarized in a manuscript to be submitted to a journal (TBD) in the near future.

Analysis of effects of complex terrain on tornado evolution

This study (Tony Lyza, Ph.D. candidate) evaluates an apparent maximum in tornado activity noted across northeastern Alabama, across a significant system of plateaus adjacent to the Tennessee River valley. These plateaus, Sand Mountain and Lookout Mountain, along with the narrow, shallow Wills Valley that separates them, span and area of ~5000 km^2, and were impacted by at least 79 tornadoes within the period 1992-2016, including 4 violent (EF4-EF5) tornadoes. A particular pattern is noted in tornadogenesis across this region, where nearly half of the tornadoes that formed atop the Sand Mountain plateau in the 25-year dataset formed within approximately 20% of the land area closest to the northwestern plateau edge. This exploratory study investigates storm behavior and possible physical

explanations for why tornado activity may be enhanced across the plateaus of northeastern Alabama and why the northwestern edge of the Sand Mountain plateau in particular may serve as a favored region for tornadogenesis. Sample cases of rapid parent storm evolution and tornado development have been analyzed. Long-term surface observation datasets and Rapid Update Cycle (RUC)/Rapid Refresh (RAP) model output were used to inform physical hypotheses for enhanced tornado potential. Physical hypotheses explored include changes in lifted condensation level (LCL) height and subsequent downdraft buoyancy characteristics, and acceleration of low-level flow over the plateaus and associated effects on low-level wind shear, convergence, and vorticity generation.

Potential impact of surface roughness on initiation of weak tornadoes. This study is included here because of its relevance to VORTEX-SE project objectives. The participation by Knupp and Coleman was supported by the project funds. This investigation examined spatial relationships and patterns between horizontal variations in land surface roughness and locations of tornadogenesis for weak (EF0-EF1) tornadoes. Surface roughness was estimated using parameterizations from the Noah land surface model, based on MODIS 500 m and Landsat 30 m data. Spatial variations in the parameterized roughness length were assessed using GIS-based grid and quadrant pattern analyses to quantify observed variation of land surface features surrounding tornadogenesis locations across a range of spatial scales. This analysis determined that tornadogenesis locations are favored in areas where higher roughness length is located on the left side relative to the surface-level flow direction, consistent with the conceptual model advanced by Coleman and Knupp (2011).

Modeling and observations study of a severe nocturnal QLCS

The Weather Forecasting Model (WRF) was used to study boundary layer evolution of a nocturnal QLCS that moved through northern Alabama domain on 9-10 March 2017. Two comprehensive profiling systems, the UAH Mobile Integrated Profiling System (MIPS) and the NSSL Collaborative Lower Atmospheric Mobile Profiling System (CLAMPS), separated by 59 km, were utilized to evaluate the simulated boundary layer evolution during this time. The spatial setup of the WRF simulations consisted of 4 domains with a horizontal grid spacing the ranged from 12 km (outer grid), 444 m within the innermost grid. Three data sets were utilized for initial conditions: the ERA-Interim, GFS (0.5°) and NAM reanalysis. Start times included 0000 UTC and 1200 UTC on 9 March. In total, 15 simulations were conducted with varying parameterizations for the boundary layer / surface layer (local, non-local and hybrid) and microphysics (single and double moment). Results showed that the QLCS timing was near the observed location in all simulations, but the structure varied with initialization type and time. The boundary layer depth was underestimated in all simulations due to a negative bias in the 2-meter temperatures in all simulations. The 0-1 km SRH was overestimated in 14 of the15 of the simulations, but all simulations captured the increase in the 0-1 km SRH as the QLCS approached northern Alabama. Root Mean Square errors were calculated for various parameters to quantify the performance of each simulation. The Asymmetric Convective Model 2 (ACM2) boundary layer parameterization scheme produced results that most closely represented the observed evolution in low-level winds and 0-1 km SRH. This work was a thesis topic for an M.S. student, David Haliczer, who is now condensing and refining the thesis to a journal manuscript.

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Conrad, D.M., 2017: Doppler Radar Observations Of Horizontal Shearing Instability In Quasi-Linear Convective Systems. M.S. Thesis, University Of Alabama In Huntsville, 68 pp.

Lisauckis, C.A., 2018: Cold-Season Severe QLCS Events over North AL: Climatology, Cloud, and Boundary Layer Characteristics. M.S. Thesis, University of Alabama in Huntsville, 51 pp.

Information on collaborators / partners (if applicable): none

Information on any outreach activities (if applicable): none

Include details on any economic development activities: none

Publications

Note: The following is a combined reference/ list for 191001-363513-4A and 191001-363513-4B

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1. Conrad, D.M., 2017: Doppler Radar Observations Of Horizontal Shearing Instability In Quasi-Linear Convective Systems. M.S. Thesis, University Of Alabama In Huntsville, 68 pp.
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7. Coleman, T.A., A. W. Lyza, K. Knupp, K. B. Laws, and W. Wyatt, 2018: A significant tornado in a Heterogeneous environment during VORTEX-SE. 29th Conference on Weather Analysis and Forecasting, Amer. Meteor. Soc., 3-8 June 2018, Denver, CO, oral presentation.

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10. Conrad, D.M., and K. R. Knupp, 2018: Doppler Radar Observations of a Tornadic Mesovortex in the 04 January 2015 Quasi-Linear Convective System. 29th Conference on Weather Analysis and Forecasting, Amer. Meteor. Soc., 3-8 June 2018, Denver, CO, oral presentation.
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NGI File # 17-NGI3-32

Project Title: Further Refinements to Stepped-Frequency Microwave Radiometer Surface Wind Measurements in Hurricanes

Project Lead (PI) name, affiliation, email address: Mark Bourassa, COAPS Florida State University, Bourassa@coaps.fsu.edu

NOAA sponsor and NOAA office of primary technical contact: Frank Marks, NOAA/AOML/HRD

Project objectives and goals

Surface wind speed observations from Stepped-Frequency Microwave Radiometers (SFMR) are a primary tool for aircraft reconnaissance-based estimates of hurricane intensity and size, both of which are critical for forecasting coastal wind and water impacts from land-falling storms. The SFMR algorithm is sensitive to sea surface temperature (SST), ambient air temperature, emission from rain, roll angle, and pitch angle among other variables. Further understanding of the physical relationships of emissivity measured by the SFMR with these variables can lead to improvements of the SFMR wind speed retrievals. Another factor that impacts the SFMR algorithm is the quality of the dropsonde-based estimates of surface winds, which are the comparison data used in tuning the SFMR. The calculation of the dropsonde WL150 wind speed adjustment to a 10-m surface wind speed was tuned to observations in eyewalls, and appears to be very good for these conditions; however, the accuracy has not been examined outside of eyewalls for the SFMR. Improvements to the dropsonde surface wind speed calculation would very likely also improve the SFMR wind speed retrievals.

The goals of this project are:

- Obtain additional measurements from NOAA hurricane reconnaissance flights as necessary;
- Extend SFMR software algorithms to correct for the items discussed above;
- Develop a new SFMR data product revision to be made available to the research community and follow HRD's data management plan;
- Transition software revisions for real-time operational use by NOAA aircraft.
- Build and strengthen collaboration on high wind speed calibration with national and international communities.

Description of research conducted during the reporting period and milestones accomplished and/or completed

SFMR wind-induced emissivities have been compared to the modeled wind-induced emissivity in the current version of the SFMR algorithm to identify any rain-related errors. While the majority of the SFMR data is collected in tropical cyclones, there have been field campaigns during the winter over the northern Atlantic Ocean that have also collected SFMR data. This winter data has been analyzed to identify any issues that may be present in the algorithm related to the drastically different air temperature and SSTs encountered during the winter missions. Finally, the dropsonde WL150 calculation has been reviewed to identify any sources of error in the SFMR algorithm that may be related to tuning it to the dropsonde WL150 surface adjusted wind speeds.

Description of significant research results, protocols developed, and research transitions

Figure 1 displays SFMR wind-induced emissivity measurements versus dropsonde surface wind speed colored by rain rate. If the algorithm was completely removing the emissivity of the rain, we would expect all of the data to fall on the modeled wind-induced emissivity line. However, this is not the case. In general, the SFMR data collected in higher rain rates fall above the model line and the lower rain rate data fall near or below the model line. While much work has been completed to improve the rain emissivity calculation in the algorithm, it is apparent that there is still room for improvement.

Figure 2 displays a comparison of SFMR retrieved wind speeds versus collocated dropsonde surface adjusted WL150 wind speeds for data collected during ocean winter winds missions. This data should cluster around the 1:1 line; however, there is a clear bias present. The SFMR retrieved wind speeds are consistently higher than the dropsonde surface wind speeds indicating that the current SFMR algorithm is not appropriate for use in these conditions. Some possible sources of error in the SFMR algorithm that may be responsible for this are the calibration coefficients, which are tuned to tropical air temperatures, and the effects of cooler SSTs on whitewater generation.

Finally, one of the key aspects to the SFMR algorithm is the source of truth for the surface wind speed. The current dropsonde WL150 wind speed adjustment to 10-m was developed using eyewall dropsonde profiles. Figure 3 shows some example eyewall profiles from several hurricanes that were presented in Franklin et al. (2003). This figure shows that there can be quite a large amount of variation in the eyewall profiles between hurricanes. Also, the majority of the SFMR data is collected outside of the hurricane eyewall and this potential source of error has not been investigated during previous SFMR algorithm update studies.

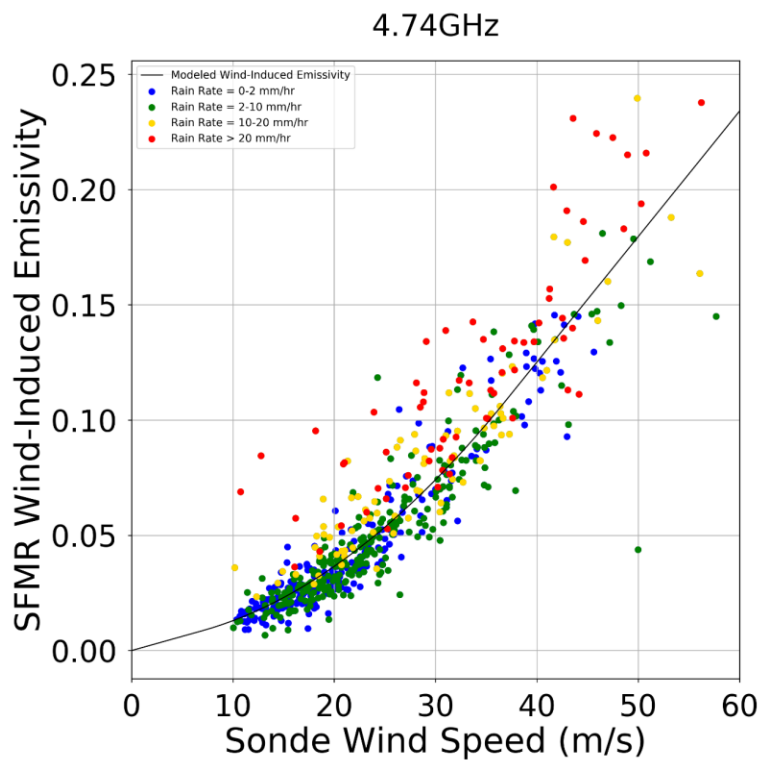

Figure 1: 4.74 GHz SFMR wind-induced emissivity versus dropsonde surface wind speeds. Colors denote the rain rate at the collocation and the black line is the current wind-induced emissivity model function.

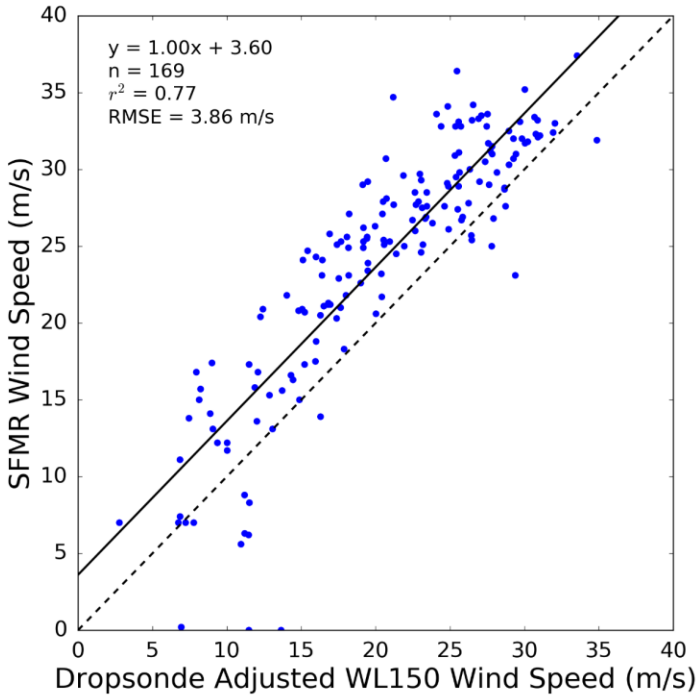

Figure 2: SFMR wind speed versus dropsonde surface adjusted wind speed for data collected during winter winds missions. The black dashed line is the 1:1 line and the solid black line is the best fit line. The statistics for the best fit line are displayed in the upper left corner of the plot.

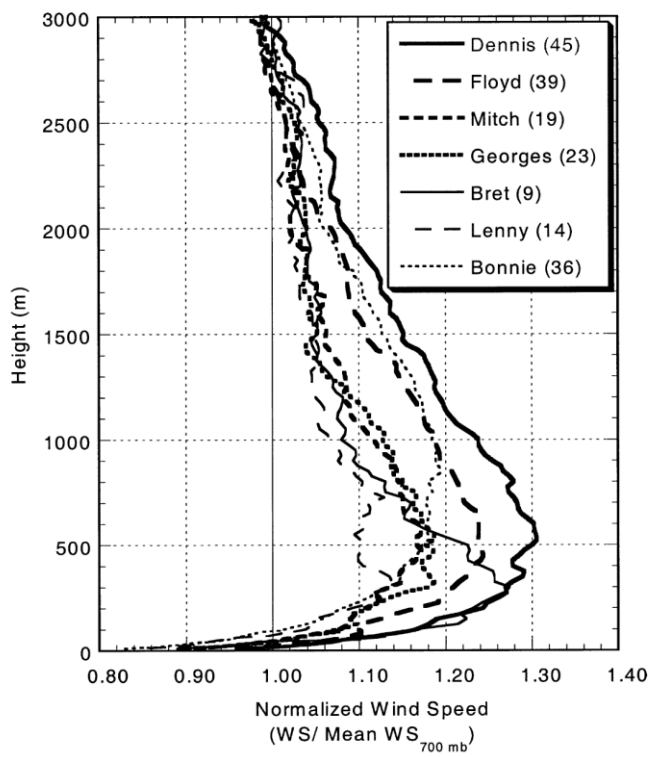

Figure 3: Fig. 11 from Franklin et al. (2003) depicting the mean eyewall dropsonde wind speed profiles for several different hurricanes listed in the table in the upper right corner of the plot. The winds are expressed as a percentage of the 700 mb wind speed.

Information on collaborators / partners (if applicable):
Name of collaborating organization: NOAA/AOML/HRD
Date collaborating established: February 2013
Does partner provide monetary support to project? Amount of support? No
Does partner provide non-monetary (in-kind) support? Yes
Short description of collaboration/partnership relationship: Mentor postdoctoral fellow; collect data

Information on any outreach activities (if applicable): None reported

Related NOAA Strategic Goal: Weather-Ready Nation

Related NOAA Enterprise Objectives: Science and Technology

NGI File # 17-NGI3-33

Project Title: Bioinformatics to Aid Ecosystem Understanding, Research Transition, and Development of a Next-Gen Workforce

Project Lead (PI) name, affiliation, email address: Shiao Wang, University of Southern Mississippi, shiao.wang@usm.edu

Project objectives and goals

Despite the many emerging applications of 'omics for marine science and commerce, our ability to supply bioinformatics expertise has not kept pace with the generation of sequence data. This has created a data backlog that hinders transition of data collected into actionable information. The primary goal of this project is to address this gap by analyzing ’omics datasets that address numerous aspects of the NOAA mission, developing bioinformatics workflows for transition to project applications, developing bioinformatics capacity through training and community resources, and working with international partners to develop the next generation of ’omics monitoring standards.

Dr. Luke Thompson, a recognized expert in the analysis of microbial communities, is the chief scientist on the project addressing the following specific objectives:

1. Develop and assess multi-omics bioinformatics workflows for transition to ’omics projects.

2. Apply workflows to characterize microbial communities in the Gulf of Mexico, the California Current, the Great Lakes, other aquatic environments, and the global microbiomes of Earth.

3. Provide training and community resources to develop NOAA’s bioinformatics expertise.

4. Engage with academic and governmental bodies from the U.S., Europe, and beyond to develop and promote metadata and data standards critical for inter-operability and environmental contextualization of ’omics data streams.

Description of research conducted during the reporting period and milestones accomplished and/or completed

During the past year, Dr. Thompson has developed workflows for analysis of marker gene (amplicon sequencing) data from a variety of marker genes, from bacteria to fish. Additionally, multi-omic analysis methods are being developed, for example, to simultaneously analyze metagenomic (whole-DNA) and metabolomic (whole-metabolite) data from the same set of samples. These workflows have been compared to other workflows in two separate cross-comparison benchmarking studies. Our workflows have been used in a range of studies, from the open ocean to mammal guts to a massive set of environmental microbiomes (as described in the results summary, below). In the coming year, these workflows will be implemented in our work on, metagenetics, metagenomics, environmental DNA (eDNA) in the California Current and Great Lakes. Dr. Thompson is also providing his bioinformatics and marine microbiology expertise to analyze and publish two older datasets from the Gulf of Mexico. One contains data from the Gulf of Mexico water column prior to the Deepwater Horizon spill and will help determine to what degree hydrocarbon-degrading microbes were present before the spill. The other dataset comes from the microbiome of a rare deep-sea polychaete invertebrate, the methane ice worm, which possesses unique abilities for hydrocarbon utilization and other metabolic processes.

Description of significant research results, protocols developed, and research transitions

The results of Dr. Thompson’s research on marine and terrestrial microbial communities have yielded several publications over the past year. Dr. Thompson was the lead author of a *Nature* paper (Thompson et al., 2017, DOI: 10.1038/nature24621) on the Earth Microbiome Project. This massive survey of microbiomes from across Earth revealed some of the basic principles driving microbial community structure on our planet. This study also created a database of microbial samples and sequences and a

framework for investigating further patterns, which will benefit our efforts to understand aquatic systems important in NOAA's mission. For example, the Ocean Sampling Day project, which Drs. Thompson, Goodwin, and Wang are involved with, has benefitted from the 'microbial trading cards' and source-tracking approach used in the Earth Microbiome Project.

Two additional studies of marine microbes have benefited from Dr. Thompson's bioinformatics expertise, both involving whole DNA sequencing, or "shotgun metagenomics", of microbial communities. One study examined the differential aerosolization of bacteria and viruses in sea spray, which was recently published in *Nature Communications* (Michaud et al., 2018, DOI: 10.1038/s41467-018-04409-z). The results show that certain bacterial taxa are better aerosolized, and viruses in general are less well aerosolized. This helps us identify taxa relevant to atmospheric processes and a framework to further elucidate aerosolization mechanisms influencing microbial and viral transport pathways. A study of Red Sea metagenomes has provided insight to the taxa responsible for nitrogen metabolism in the ocean. This study, published in *FEMS Microbiol Ecol* (Kharbush et al., 2018, DOI: 10.1093/femsec/fiy063), helps shed light on the producers of a major marine biomarker: hopanoid producers are taxonomically affiliated with the major marine nitrite oxidizers, *Nitrospinae* and *Nitrospirae*. These results suggest that the relationship between hopanoid production and nitrite oxidation is conserved across varying biogeochemical conditions in dark ocean microbial ecosystems.

Dr. Thompson's work has also touched on the gut bacteria of animals, a research area of growing interest. He analyzed a dataset of gut microbiomes from voles inside and outside of the Chernobyl Exclusion Zone to help understand the effects of radiation on the mammal gut microbiome. This study, published in *The ISME Journal* (Lavrienko et al., 2018, in press), is the first to quantify how the gut microbiome of wild animals is affected by exposure to environmental pollutants. Dr. Thompson was also a co-author on a massive crowd-sourced human gut microbiome project, the American Gut Project, published in *mSystems* (McDonald et al., 2018, DOI: 10.1128/mSystems.00031-18), and a study of whether phylogeny or diet better predicts the gut microbiome in primates, published in *The ISME Journal* (Amato et al., 2018, in press).

Information on collaborators / partners

a. Name of collaborating organization: NOAA AMOL

b. Date collaborating established: September 1, 2013

c. Does partner provide monetary support to project? Indirectly. Support is provided through a NOAA cooperative agreement to NGI.

d. Does partner provide non-monetary (in-kind) support? Yes, NOAA partners helped with research prioritization and design.

e. Short description of collaboration/partnership relationship: Regular contact by telephone and email to discuss projects and allocation of time/effort by research personnel. We also discuss outreach activities and new training opportunities.

We have a number of collaborators both nationally and internationally. For example, Rob Knight at UC San Diego is a world-renowned microbiome scientist and our main collaborator on the Earth Microbiome Project. Andy Allen at the J. Craig Venter Institute is our main collaborator on the California Current microbiome project (NCOG). Collaborators on eDNA projects include scientists at the Monterey Bay Aquarium Research Institute, NOAA's Southwest Fisheries Science Center (SWFSC), and researchers that are part of the Marine Biodiversity Observing Network (MBON). We continue to work with groups in Europe on Ocean Sampling Day and Global 'Omics Observatories.

Information on any outreach activities

Dr. Thompson has been involved in multiple teaching activities over the past year, which have enabled him to transfer bioinformatics and computational skills to the next generation of scientists. He developed an online data science course called Python For Data Analysis, which is hosted on GitHub

(https://github.com/cuttlefishh/python-for-data-analysis) and YouTube (https://www.youtube.com/channel/UCVZrIrWtcvTzYlrNx7RcDyg), having over 440 subscribers.

Dr. Thompson co-taught two short courses on bioinformatics analysis:

a. SIO Transcriptomics Workshop, Scripps Institution of Oceanography, October 2017

b. Advanced Bioinformatics for Metagenomics and Population Genomics, University of Oulu, Finland, March 2018

Dr. Thompson participated in two workshops on bioinformatics:

a. TDWG 2017: Biodiversity Information Standards, Ottawa, Canada, October 2017 – He co-chaired a session called "Towards robust interoperability in multi-omic approaches to biodiversity monitoring". This meeting laid the foundation for the 'Omic Biomonitoring Workshop held in February 2018 (below).

b. 'Omic Biomonitoring Workshop, Max-Planck-Institute for Marine Microbiology, Bremen, Germany, February 2018 – This was the first workshop in a series dedicated to enhancing the interoperability and coordination of long-term observatories with 'omic capabilities. The objective of these workshops is to facilitate the creation of a well-integrated, global network of 'omic observatories delivering coherent insight into ecosystem health and functioning. As an international task force, we are creating a strongly collaborative consortium sharing data, methods, calibration standards, and vision. Collectively we seek to interface with national and international biomonitoring frameworks as well as standards communities to shape a more coherent and sustainable future for 'omic observation.

Publications and Presentations

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NGI File # 17-NGI3-34

Project Title: Bayesian Merging of GLM Data With Ground-Based Networks

Project Lead (PI) name, affiliation, email address: Phillip Bitzer, University of Alabama in Huntsville, bitzerp@uah.edu

Co-Principal Investigator name, affiliation, email address: Christopher Schultz, NASA-Marshall, christopher.j.schukltz@nasa.gov

Project objectives and goals

The overall goal of the project is create a product that merges GLM data with ground based observations in a Bayesian manner to produce 1) a merged data set and 2) a new product that calculates the ratio of intracloud flashes to cloud to ground flashes.

Description of research conducted during the reporting period and milestones accomplished and/or completed

There were four main milestones in year 1 outlined in the proposed work, detailed below.

1. Set up the framework for Bayesian analysis using GLM checkout data and/or historical LIS data and ground-based lightning locating systems (LLSs).
This milestone has been successfully reached. A code base that ingests GLM and various ground based systems has been developed. Further, the code base matches GLM flashes to their ground based counterparts.

2. Produce initial estimates of GLM detection efficiency relative the various LLSs.
There have been numerous issues with the processing algorithm of GLM data implemented by the ground team. Because of this, this milestone has not been achieved. However, the PI is part of the GLM Instrument Team and has processed selected raw level 0 GLM data with a proper processing algorithm. Two specific detection efficiency estimates show GLM detects 51% of GLD360 strokes, similar performance to that of the Lightning Imaging Sensor. Further, we GLM to LMA flash data. These results are summarized in Table 1. The bigger a flash (as determined by the convex hull of LMA sources), the more likely GLM detects it. For all but the very smallest flashes, GLM detects >70%. Once a flash reaches the size of a GLM pixel (roughly 8km x 8 km), GLM detects 94% of flashes.

Table 1. GLM detection efficiency as a function of LMA flash size.

Min LMA Area	Num LMA Flash	Num GLM Flash	DE
0 km^2	37 699	24 993	0.663
5 km^2	32 912	23 768	0.722
10 km^2	27 236	21 110	0.775
20 km^2	19 698	16 524	0.839
64 km^2	9 023	8 483	0.940

3. Begin development of the merged data product for AWIPS2 specifically for OPC/NHS and forecast offices.
We have worked with an AWIPS2 Transition Team member to produce a data product that would be suitable for display in AWIPS2. Currently, the merged product is formatted similarly to current ingests of lightning data. Work continues in this area.

4. Calculate initial grids of Z-ratio and begin working on how to best represent the data for operational use.

Initial grids of Z-ratio have been calculated. We are currently working with the AWIPS2 Transition Team to explore how to best represent this data. Figure 1 shows an initial representation of the data. Early work determined that Z-ratio (number of intracloud flashes/number of cloud to ground flashes) was a poor value to use. Instead, we have decided to use cloud flash fraction (number of intracloud flashes/total number of flashes). One obvious benefit is that for areas with all intracloud flashes, the cloud flash fraction is 1 (instead of infinity for the Z-ratio). Areas in Figure 1 in which the cloud flash fraction is high are colored red, providing immediate feedback to the forecaster of these types of events.

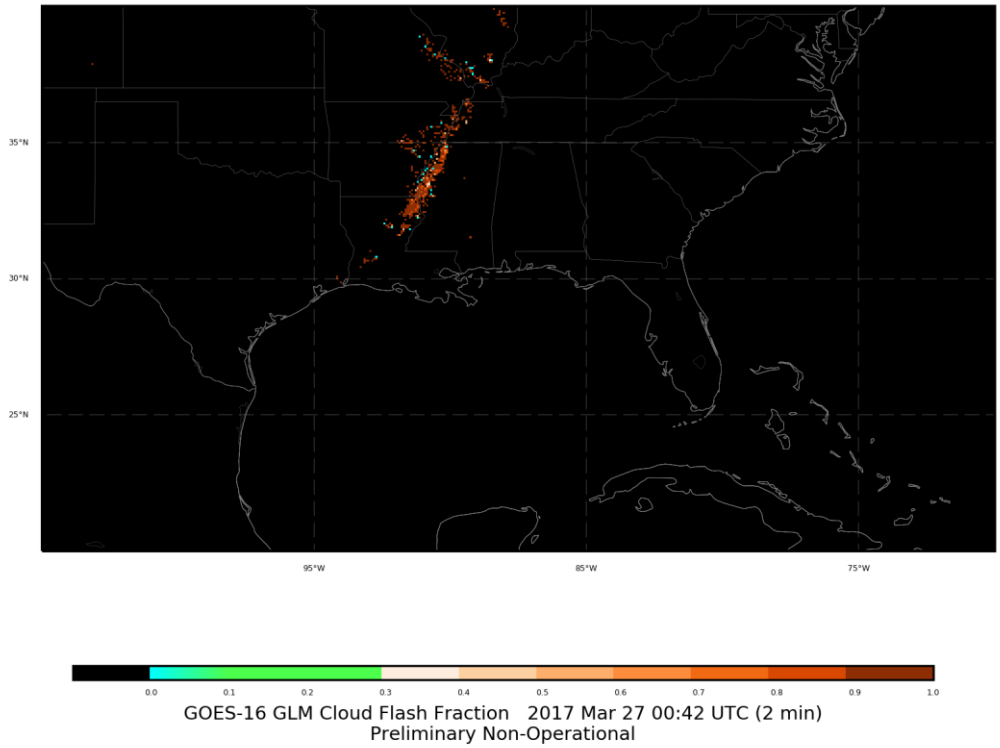


Figure 2. Example image for AWIPS2 for cloud flash fraction (Z ratio).

Description of significant research results, protocols developed, and research transitions

Some results related to the proposed work were presented at the 2017 American Geophysical Union Fall Meeting. This work studied lightning activity in Hurricane Harvey.

In this work, we looked at lightning activity in the eyewall and rain bands. We analyzed both stroke level data and flash level data. To do so, we merged GLM data with Earth Networks (ENTLN) data. Figure 2 shows the time series of lightning data relative to wind speed observations. Eyewall lightning increases dramatically and time of initial intensification, while rain band lightning peaks much later, after reaching hurricane status.

We also looked cloud flash fraction for the same time period (Figure 3). No trend is immediately evident for this event. However, there are some interesting notes. The cloud flash fraction in the rain band increase prior to intensification, and remains elevated. After hurricane status, the cloud flash fraction is high in the eyewall. Further events are being studied to see if similar trends emerge.

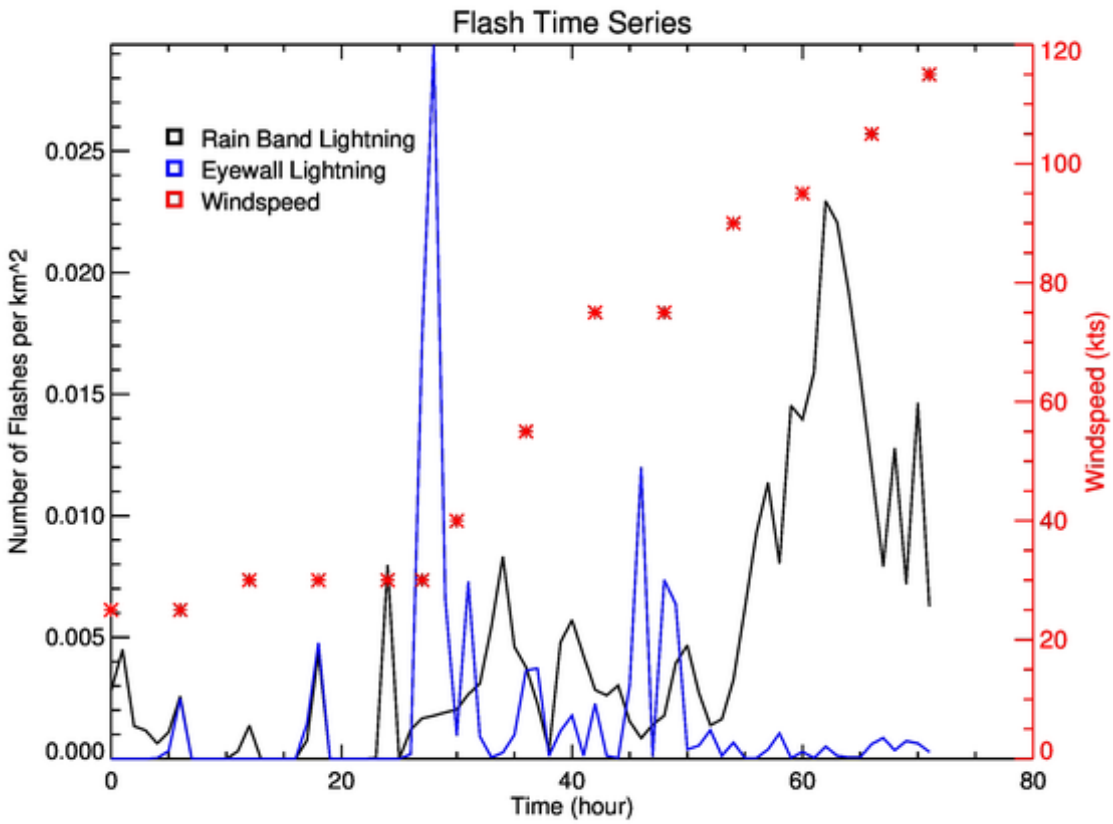


Figure 3. Time series of lightning activity and wind speed of Hurrican Harvey for 2017/08/23-2017/08/26.

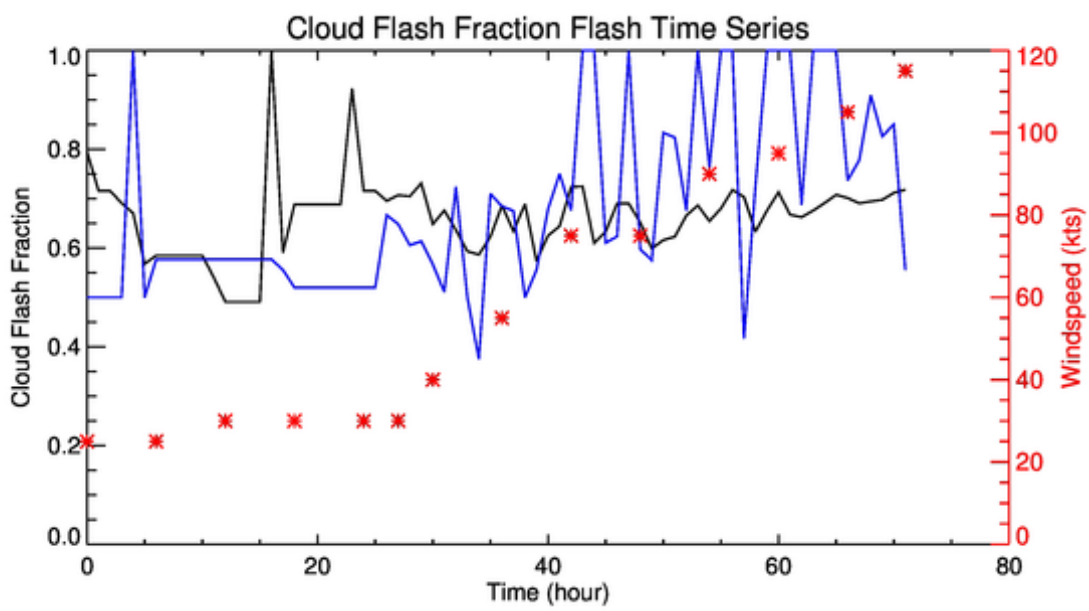


Figure 4. Cloud flash fraction for Hurricane Harvey. Spans same time period as Figure 2.

Information on collaborators / partners (if applicable)

Matt Smith, NASA Sport, AWIPS2 Transition Team

Information on any outreach activities (if applicable): N/A

Include details on any economic development activities: N/A

Publications and Presentations

Ringhausen, J. and Bitzer, P. *An In Depth Look at Lightning Trends in Hurricane Harvey using Satellite and Ground-Based Measurements.* Presented at 2017 AGU Annual Meeting.

NGI FILE #17-NGI3-35

Project Title: Enhanced Coastal Data Development and Information Services: Coastal Ecosystem Data Assembly Center

Project Lead (PI) name, affiliation, email address: Steve Ashby, NGI, sashby@ngi.msstate.edu

Co-Principal Investigator: names, affiliation, email address: Fred Zeile, Mississippi State University, fredz@ngi.msstate.edu

Project objectives and goals

In conjunction with NCEI-MS, the Northern Gulf Institute (NGI) is developing a *Coastal Ecosystem Data Assembly Center* (CEDAC) to: (1) provide information services to gather and assess stakeholder requirements; (2) develop and steward the long term coastal data record; (3) enhance the understanding of historical trends, anomalies, and the frequency of event occurrences; and (4) investigate, develop and transition innovative data stewardship solutions to enhance NOAA's data management, visualization, and dissemination capabilities.

Specific tasks to be included:

Task 1. Information Services: The scope of the effort will include: (1) Developing and enhancing Gulf of Mexico partnerships and expertise among the institutes of higher learning, industry and government agencies at Stennis Space Center and along the Gulf Coast; (2) Development of innovative and professional quality interactive, written, and graphics materials; (3) Ongoing evaluation of CCOG information products for market applicability and to inform production sustainment activities; (4) Support to conference activities as required; (5) Integration of CCOG metrics and activities with NCEI Communications, Outreach, Engagement, and Social Media activities and reports.

Task 2. Scientific Data Stewardship**:** The scope of the effort will include (1) ongoing collation of the coastal data management requirements to ensure data are identified and appropriately prioritized for archival; (2) scientific oversight of data preparation for archival and for the data ingest into the archive; (3) implementation of data standards and metadata guidelines; (4) refining data discovery and access points at NCEI to meet scientific community requirements.

Task 3. Scientific Data Monitoring, Assessment and Analysis: The scope of the effort will include: (1) providing domain specific support to scientific stewardship activities including quality control and documentation review; (2) developing techniques to synthesize and visualize data; (3) implementing techniques to integrate disparate data into unified spatial and temporal collections for product generation; (4) creating value-added foundational products (e.g. monitoring time series, satellite and ocean climatologies, etc.) for integration into NCEI products (e.g. World Ocean Database, Gulf of Mexico Data Atlas, etc.); (5) developing Reference Environmental Data Records (REDR authoritative records); (6) Participate in professional activities including active participation in professional organizations, publication in professional journals and attendance at professional conferences.

Task 4. Established and Emerging Technology Solutions: The scope of this research will address needs such as: (1) the gaps in data management capabilities resulting from the development of new environmental data sensors and platforms; (2) the increased complexities of multi-dimensional and non-traditional data sets that are outside the stewardship solutions currently offered by NOAA.

Task 5. Project Management: Conduct technical management oversight to ensure that high quality deliverables that result from all five proposed activities are provided to the NWS on schedule and in accordance with project requirements.

- Assist in development of project milestones in accordance with NCEI Annual Operating Plan guidelines and timelines

- Written quarterly report on status of tasks, milestones, and deliverables
- Regular meetings to discuss status of tasks, milestones, and deliverables. Discussions focused on technical, management, financial, and requirement issues, especially if assumptions, dependencies, and constraints have been affected

Description of research conducted during the reporting period and milestones accomplished and/or completed

The activities briefly highlighted in the tasks below were conducted in support of the newly initiated Coastal Ecosystem Data Assembly Center (CEDAC)

Task 1. Information Services:
Handout materials, one-pagers, and posters were updated for a NASA Open House Event and NCEI meetings in Boulder. Design of an Extended Continental Shelf report template was initiated. Several infographics were prepared for the National Climate Assessment Report. A graphic element was created for the Deep Sea Coral program. The Gulf of Mexico RESTORE Council Yearly Report was made 508 compliant. Coordination with the NCEI Storymap team resulted in two new Storymaps (Tsunami Marigram Preservation and History of Bathymetry).

Attended Gulf-wide Seagrass Monitoring and Needs Assessment Workshop (3-5 October, 2017, Gulf Breeze, FL) to source content and data for the Gulf of Mexico Data Atlas and identify opportunities for collaboration.

Support to CCOG included preparation of 2 project plans.
Gulf of Mexico Data Atlas New Plates Project Plan.
Gulf of Mexico Data Atlas Modernization Project Plan.

Participation on Gulf of Mexico Alliance Priority Issues Teams included attendance at meetings and participation in scheduled conference calls. This included interactions with other institutions of higher learning, non-governmental organizations, and public and private sectors. Presentations and participation in meetings and conferences were also conducted with the Mississippi Enterprise for Technology and the Marine Technology Society.

Task 2. Scientific Data Stewardship
Participated at the NOAA Water Center Showcase (Tuscaloosa, AL) to promote NCEI data and products.

Several team members attended the NOAA's EDM (Environmental Data Management) workshop, which covered topics such as cloud computing and data visualization.

Set up and continue to maintain a Confluence site for the Coastal and Marine Ecosystem Classification Standard (CMECS) Implementation Group (IG), released to public on 21 March, 2018.

Task 3. Scientific Data Monitoring, Assessment and Analysis:
Participated at the RESTORE Council Monitoring and Assessment Program (CMPA)/GOMA Gulf of Mexico Habitat Monitoring and Mapping User Workshop and Mapping Summit.

Researchers participated in an Animal Telemetry Network workshop and developed products for the Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS), and Sharing Science Effectively workshops for the Gulf of Mexico Oil Spill and Ecosystem Science Conference (GOMOSES). An example is the review of data packages and provision of feedback guidance to GRIIDC on RFP-1 (Research Funded Projects) datasets being archived with NCEI.

Task 4. Established and Emerging Technology Solutions:
Research was conducted in collaboration with USGS to implement a geonetwork instance on their servers to help manage and create metadata for the gulf restoration project.

Task 5. Project Management:
Regular meetings were conducted during the reporting period to evaluate progress on milestones and coordinate research activities.
Quarterly reports describing activities were provided to the NOAA/NCEI PM.

Description of significant research results, protocols developed, and research transitions

Built and released the Marigrams story map (via NCEI social media).

Built and released the History of Bathymetry story map (at the Ocean Sciences meeting in Portland, then on NCEI social media) .

Five GRIIDC data packages were submitted and archived in Send2NCEI. Additional data packages were submitted or are under review for archiving in Send2NCEI.

Several python scripts were developed to automate metadata creation for a BEDI project.

Information on collaborators/partners

Name of collaborating organization – Gulf of Mexico Research Initiative data management team
Date collaborating established – 2012
Does partner provide monetary support to project? No Amount of support?
Does partner provide non-monetary (in-kind) support? Yes
Short description of collaboration/partnership relationship – Data from the Gulf of Mexico Research Initiative is managed by GRIIDC and then sent to NCEI for archiving

Information on any outreach activities

Presentation on the NCEI Prototype Arctic Data Viewer at the 2017 Esri Ocean GIS Forum.
NGI/NCEI conducted a NOAA activity for the 2018 Celebrate the Gulf booth in Pass Christian, Mississippi that included children sampling the ocean (large tub of rice with plastic marine organisms) with two different size trawls (strainers with different mesh sizes), recording their results, and making graphs for comparisons. Over 150 children participated and parents were very complimentary about the activity.

Poster on Improving the Accuracy of Benthic Habitat Maps in the Gulf of Mexico: Integration of BOEM High-Resolution Bathymetry and Geophysical Data with a CMECS-Classified Geomorphic Features Basemap. GEOhab 2018 Annual Meeting

Scientists conducted active interactions with researchers from the Bureau of Ocean Energy Management and demonstrations for Navy leaders located at the Stennis Space Center.

NGI File # 17-NGI3-36

Project Title: Regional Geospatial Modeling

Project Lead (PI) name, affiliation, email address: Dr. Scott A. Samson, Geosystems Research Institute, ssamson@gri.msstate.edu

Project Objectives and Goals

The Regional Geospatial Modeling Grant was developed to promote geospatial technology to the public through: workforce training in geographic information systems (GIS) for government employees of Mississippi as well the general public; develop web-based geospatial tools for public access; and the creation of new geospatial data for public consumption.

Description of research conducted during the reporting period and milestones accomplished and/or completed

- Interactive Sea Level Model: Lidar data collected in 2015 for the 3 coastal counties of Mississippi were used to develop a 10-ft resolution DEM (digital earth model) as a base for assessing the impact of sea level rise on the road network. A road centerline dataset, developed in an earlier MDEM (Mississippi Digital Earth Model) award, was merged with the elevation raster cells to transfer elevation measures to segments of the road centerline dataset.

  The new road network dataset was used to develop a web-based, interactive model to assess the impact of sea level rise in 1-foot increments. Users may identify an origin and a destination on a basemap to evaluate the impact of sea level rise on traffic patterns as well as accessibility to points of critical infrastructure. An areal display of inundated landscape is displayed over basemaps (both aerial imagery and generalized landmark features).

  The *GeoCoast* sea level rise model may be accessed at http://geoproject.hpc.msstate.edu/Html5Viewer/index.html?viewer=GeoCoast.

  Status: completed

- A web-based GIS for the people of Mississippi: Instruction in the concepts and applications of geographic information systems (GIS) has a long learning curve to use the tools of GIS properly. The infrequent user of a GIS may find it difficult to recall the operation of desktop GIS software. For this reason, a web-based GIS has been developed with the general public in mind. Popular spatial datasets (e.g., census of population, economics) may be accessed with a collection of commonly used GIS tools.

  GeoDawg is a “HTML” web application with compatibility with all computer operating systems. Tools to create point, line, polygon and text overlays as well as linear and areal measurements on an assortment of basemaps are easy to use. The system is also designed to allow users to upload spatial datasets, such as “GPX” data associated with inexpensive GPS units. Users may also publish products may be exported through a variety of graphic format images, social media outlets or to ESRI’s ArcGIS Online.

  While the initial task for the development of *GeoDawg* has been met, enhancements to the application is ongoing.

  Status: completed

- The following tasks are on-going and will be completed before the termination of the award.

- A flood-risk model is under development for the Mississippi Gulf Coast area. Several scenarios focusing on rainfall events and surface conditions will be made available to the public in similar manner to *GeoDawg* and *GeoCoast*. The intent of this web-based application is to allow planners and developers in the coastal counties to assess the probable flooding risks based on the scenarios in development.

  Status: approximately 85 % completed

- An evaluation of the applicability of using UAS for oil spill detection in the Gulf of Mexico is currently underway. The focus of this task is to use an ultraviolet light source to "excite" hydrocarbons associated with oil deposits on the sea surface. Current remote sensing sensors used for oil spill detection deliver a high level of false positives in the identification of the areal extent of oil deposits. Ultraviolet-based remote sensors are in use over may European and Asian oil fields to monitor oil leaks around oil drilling platforms. Unfortunately, the cost of these systems are high and require a dedicated aircraft.

  A 400-watt ultraviolet light source used on ocean craft has been acquired and is currently under modification to reduce the weight of the light and battery support system. Due to FAA restrictions on weight and altitude levels for non-military UAS, the modified ultraviolet light system will be evaluated on a land-based platform to assess the potential for the system to be used on future UAS platforms.

  Status: approximately 70% completed

- A subcontract to the Mississippi Department of Environmental Quality covers 85% of the current award. The task associated with the subcontract is to develop 1:4800-scale surface hydrology databases for over 13,000 square miles of HUC-8 watersheds in southeastern and coastal Mississippi. Products are developed according to guidelines established by the U.S. Geological Survey for 1:4800 enhanced hydrologic mapping. Completed products are delivered to the U.S. Geological Survey.

  Status: approximately 80% completed

Outreach activities

In order for geospatial data products developed in Mississippi to be used by governmental and commercial entities, it is necessary to have a user community knowledgeable of the concepts and software systems associated with geographic information systems. The GEO (geospatial education and outreach) Project was developed 11 year ago to develop a professional GIS community across Mississippi. Since the inception of the GEO Project approximately 3,600 participants in over 365 2-day GIS workshops have been delivered across the state.

Content of workshops range from introduction to GIS to multi-user database systems, using commercial as well as "open source" software. The GEO Project employs 2 mobile classrooms to teach the workshops in a variety of facilities near the workshop participants.

During the period of this progress report (October 1, 2017 through June 30, 2018), 13 workshops were offered to 121 participants. A detailed listing of courses, dates, locations and number of participants is on the following page. All workshops are covered over 2 days (the last day of a workshop is displayed in the listing).

Course Name	Date		Location	Number of Participants
Introduction to ArcGIS Desktop	June 15, 2017		NASA Stennis Space Center	7
Intermediate QGIS	June 9, 2017		NASA Stennis Space Center	11
Introduction to ArcGIS for Desktop	May 17, 2017		Itawamba Community College	6
Introduction to QGIS	April 28, 2017		NASA Stennis Space Center	7
Introduction to ArcGIS Online	April 27, 2017		Holmes Community College	11
Introduction to ArcGIS Online	April 21, 2017		Itawamba Community College	12
Advanced QGIS	April 21, 2017		Holmes Community College	11
Advanced QGIS	April 18, 2017		NASA Stennis Space Center	10
Intermediate QGIS	April 12, 2017		Holmes Community College	7
Introduction to ArcGIS for Desktop	April 7, 2017		Holmes Community College	8
Intermediate QGIS	March 29, 2017		NASA Stennis Space Center	10
Parcel Mapping using ArcGIS for Desktop	March 9, 2017		NASA Stennis Space Center	5
Intermediate QGIS	March 8, 2017		Holmes Community College	9
Introduction to ArcGIS for Desktop	February 23, 2017		Holmes Community College	11
Introduction to ArcGIS for Desktop	February 16, 2017		NASA Stennis Space Center	12
Introduction to QGIS	February 9, 2017		Holmes Community College	11
Introduction to ArcGIS for Desktop	January 19, 2017		NASA Stennis Space Center	12
Advanced QGIS	December 9, 2016		Holmes Community College	8
Advanced QGIS	December 6, 2016		NASA Stennis Space Center	7
Introduction to ArcGIS for Desktop	December 2, 2016		Holmes Community College	12

Introduction to ArcGIS for Desktop	November 17, 2016		NASA Stennis Space Center	11
Intermediate QGIS	October 21, 2016		Holmes Community College	10
Introduction to ArcGIS for Desktop	October 19, 2016		Holmes Community College	12
Intermediate QGIS	October 18, 2016		NASA Stennis Space Center	9
Intermediate QGIS	July 22, 2016		Holmes Community College	12

NGI File # 17-NGI3-37

Project Title: University of Southern Mississippi Mapping Center

Project Lead (PI) name, affiliation, email address: Anand Hiroji, University of Southern Mississippi, aanand.hiroji@usm.edu

Project objectives and goals

The goal of this project is to establish an enduring mapping center to address research and development needs that advance the science and practice of hydrography and cartography. The research plan encompasses five thrusts (e.g. Sensors/Platforms, Positioning, Water Levels, Data Management, Data Portrayal) that capture the legislative visions of a mapping center. The first year's efforts were focused on LIDAR and positioning accuracy investigations and the second year is focused on assessing an Unmanned Surface vessel (ASV C-Worker 5) for use as a hydrographic research vessel

Tasks within the five thrust areas in year 1 focus on:

- Innovative Use of Lidar Data
  - Gulf of Mexico Shoreline Analysis
  - Great Lakes Lidar Data to Charts
  - Lidar vs MBES Object Detection
  - JALBTCX Great Lakes Database

- Precise Positioning
  - GPS Block IIF Third Frequency Algorithms
  - GPS-GLONASS-Galileo-Beidou Performance Synergies

- Precise Water Level Determination
  - V-Datum Validation and Expansion
  - Sea Level Rise/Land Subsidence
  - Bottom Mounted Tide Gauge Performance

- Integrated Ocean & Coastal Mapping
  - Enhance IOCM efforts

- Cartography and ECDIS
  - Educating the Next Generation Cartographer
  - Transition to S-100
  - Re-constitute ECDIS Lab

Description of research conducted during the reporting period and milestones accomplished and/or completed for Year 1 funding:

Innovative Use of Lidar Data – Lidar data for several significant sections of the Northern Gulf Coast shoreline have been retrieved and compared to shorelines depicted on existing charts. Great Lakes lidar data sets have been analyzed using the methodology previously developed by USM; however, the volume of lidar data for the great Lakes, compared to the coastal data sets previously used, are substantially larger and not optimum for the USM methodology. A new methodology is being adopted that manages the larger data sets more efficiently. Data density and object detection analysis was performed using coincident CZMIL lidar and U.S. Navy multi beam echo sounder data.

Precise Positioning - One graduate research assistant has prepared and submitted procurement documents for the necessary receivers to conduct the investigations into the enhancements that may be

realizable from innovative use of the third frequency transmitted from GPS Block IIF satellites and from the synergistic use of the four international constellations.

Precise Water Level Determination - One graduate research assistant checked the VDatum ellipsoid to tidal datum offsets at three locations. First he used existing ellipsoid water level data from the USM 3m buoy moored in the Mississippi Bight and performed a tidal datum transfer from NOAA gauge 8747437 to reference the tidal datums to the NAD83(2011) ellipsoid. He then compared the tidal datums to ellipsoid separations to thos same values derived from V-Datum. He and other team members then performed 3-day occupations of 2 USGS coastal water level gauges (201141089320300 and 301001089442600) with Trimble Net-RS GNSS receivers, and processed the data in GravNav for both PPP and Static positions using the CORS network. Through measurements of the antenna phase centers to gauge reference points the NAD83(2011) elevations of the two gauge zeros was determined. Using over 3 months of water level data, tidal datums transfers to each gauge was performed using the modified range ratio method and NOAA gauge 8747437 as the primary gauge. Over the past year the equipment for installing a permanent tide gauge in Gulfport, Mississippi and a roving temporary gauge setup was also procured. We also began discussions with Leidos and the Naval Oceanographic Office about deploying a HydroLevel Buoy in the western Mississippi Bight to evaluate separations between tidal datums and the ellipsoid offshore in that region.

Integrated Ocean & Coastal Mapping - Documents and activitiAes of the Interagency Working Group on IOCM were reviewed.

Cartography & ECDIS - IHO standards publications S-5 and S-8 were reviewed and compared to determine what new material is necessary for cartography Category A and B recognition.

Description of significant research results, protocols developed, and research transitions

Innovative Use of Lidar Data - The results of the analysis of data density and object detection was presented at the 18th Annual Airborne Coastal Mapping and Charting Workshop on 6 June 2017. A new protocol for assessing large quantities of lidar data and preparing those data for inclusion into the nautical chart update workflow is completed and the initial dataset is being prepared for submission.

Precise Positioning - This investigation is in its preliminary phase with no results to date.

Precise Water Level Determination - The USM 3m buoy is located offshore of the VDatum coverage area, but provides data that can be used to extend the VDatum coverage area. The GPS surveys and tidal datum transfers at the two USGS gauges have uncertainties of 8-9 cm, which are less than the published values (~17 cm) associated with transformations using V-Datum along the Mississippi Gulf Coast. Upcoming work will check VDatum in the larger region of interest, including for a contract survey for NOAA east of the Chandeleur Islands.

Integrated Ocean & Coastal Mapping - This investigation is in its preliminary phase with no results to date.

Cartography & ECDIS - This investigation is in its preliminary phase with no results to date.

Tasks within the five thrust areas in year 2 focus on:

- Procurement of Autonomous Surface Vessel
    - Establish requirements
    - Evaluate competing brands

- Integration of Survey Suite
    - Integrate existing equipment onto the ASV
    - Test and prove

- Development of Autonomous CONOPS
    - Evaluate variety of operational approaches
    - Develop launch and recovery programs
    - Evaluate adherence to COLRegs
    - Assess real time data telemetry

- Advancing the State of Technology
    - Determine where advancements in the state of technology are most likely
    - Engage industry partners to develop those advancements

- Autonomous Maritime Vessel Training and Assistance
    - Incorporate USV into existing UMS (Unmanned Maritime Systems) certificate program
    - Strengthen ties between UMS and Hydrographic programs

Research conducted during reporting period & milestones accomplished/completed - Yr 2

Procurement of Autonomous Surface Vessel –The ASV envisioned should be capable of extended operations (up to five days) at various states of autonomy and capable of employing a hydrographic survey suite to include multibeam echo sounder (MBES), inertial measuring unit, sound velocity profiler, data acquisition equipment, and appropriate navigation and communication equipment commensurate to the level of autonomy. A number of hydrography focused companies offering ASVs were evaluated and the ASV Global C-Worker 5 was selected based on capabilities as well as proven track record of performance. A purchase order was placed and the vehicle will be delivered in October of 2018

Integration of Survey Suite – USM's hydrographic program has amassed several multibeam sonar systems and these are integrated into the two manned surface vessels each summer as a student exercise. Although the C-Worker 5 USV that was ordered will not be available until October of 2018, the company graciously provided us with a temporary data acquisition equipment and the procurement of ancillary components, integrate the equipment onto the ASV for testing and CONOPS development

Development of Autonomous CONOPS – ASVs have the potential to increase the volume of hydrographic data collection per unit effort. However, without a fully developed Concept of Operations it is quite possible that an ASV will require the same amount of operator intervention as a conventional survey launch. The first step in establishing a CONOPS is to get familiar with what the vessel can and will do when given a survey pattern to complete and then carefully supervising its execution of this mission. During early May, the UMS class deployed the borrowed C-Worker 5 with Kongsberg MBES and SeaPath navigation for two days at sites adjacent to the Gulfport ship channel. The results were compared with surveys of the same sites using an AUV and also with data from a towed sidescan sonar. The ASV performed extremely well with excellent data telemetry and the next steps will be executed in the fall, including evaluation of autonomous collision avoidance, launch and recovery procedures, and operations in rough seas. Each level of autonomy places different requirements on the need for communication bandwidth, distance from base station, navigation, situational awareness, collision avoidance, and real-time data processing, so these will all be tested in turn.

Advancing the State of Technology – Based on the assessments performed, a determination of where advancements in the state of technology are most likely realizable will be assessed in parallel with other evaluation activities. ASV and other industry partners collaborate to develop those advancements, and, where feasible, integrate those advancements into the existing ASV.

Autonomous Maritime Vessel Training and Assistance – As mentioned above, the loaner ASV was and integral part of the UMS curriculum in the months of April and May 2018. Students helped to prepare, launch, navigate, and track the vessel and then, once the data were in hand, they helped assess its quality. Among the 27 students was an individual from NRT1 who will apply his knowledge to the operation of the Z-Boats and perhaps an ASV C-Worker in the future. These training activities will be repeated each time the class is offered, at least once each year, and in upper tiers of instruction once they are established.

NGI FILE #17-NGI3-38

Project Title: Enhanced Coastal Data Development and Information Services: Scientific Support for Partner Agencies Providing Enhanced Data, Products, and Services

Project Lead (PI) name, affiliation, email address: Steve Ashby, NGI, sashby@ngi.msstate.edu

Co-Principal Investigator: names, affiliation, email address: Fred Zeile, Mississippi State University, fredz@ngi.msstate.edu

NOAA sponsor and NOAA office of primary technical contact: Sharon Mesick, NCEI

Project objectives and goals

In conjunction with NCEI-MS, the Northern Gulf Institute (NGI) is providing research support to a cadre of partner-funded research and development activities to: (1) provide information services to gather and assess stakeholder requirements; (2) develop and steward the long term coastal data record; (3) enhance the understanding of historical trends, anomalies, and the frequency of event occurrences; and (4) investigate, develop, and transition innovative data stewardship solutions to enhance NOAA's data management, visualization, and dissemination capabilities.

Current partners include the NOAA National Centers for Coastal Ocean Science (NCCOS), the NOAA Office of Response and Restoration (OR&R), the NOAA Deep Sea Corals Research and Technology Program (DSCRTP), the NOAA Office of Ocean Exploration and Research (OER), and several members of the Gulf Coast Restoration efforts.

Specific tasks to be addressed include:

<u>Task 1. Scientific support to the National Centers for Coastal Ocean Science for enhanced data, products and services</u>: The scope of the effort will include: (1) Consultation services for NCCOS data management personnel to ensure the most current and innovative capabilities and techniques are available to NCCOS scientists and grant managers; (2) Data preservation services, ensuring that critical NCCOS data sets areefficiently documented, formatted, and stewarded through the archive process; (3) Development of innovative, enhanced data access schemes, implementing cutting edge technologies including new Web Mapping Services, ERSI REST web services, evolving ERDDAP (tabular) REST web services, and other appropriate technical breakthroughs; (4) Development of enhanced Data Discovery tools and techniques, including upgrades to the tailored NCCOS Geoportal application, NCCOS Web Accessible Folder (WAF) and WAF publishing.

<u>Task 2. Scientific support to the Office of Response and Restoration for enhanced data, products and services (NRDA support):</u> NOAA's Office of Response and Restoration (OR&R) is a center of expertise in preparing for, evaluating, and responding to threats to coastal environments, including oil and chemical spills, releases from hazardous waste sites, and marine debris. OR&R is the lead NOAA office managing data collected is support of the Deepwater Horizon (DWH) Response and Damage Assessment. NGI, NCEI, and OR&R scientists will collaborate closely to research, develop, and implement a Data Archive Plan for this data, including Environmental Response Management Application (ERMA) shape files, raw data collections on hard drives, and output from the Data Integration, Visualization, Exploration, and Reporting (DIVER) tool. The initial effort will focus on data used to support the Programmatic Damage Assessment and restoration Plan (PDARP) but will be readily adaptable to future data that fall under the Long Term Data Management (LTDM) needs to meet DWH Restoration efforts.

The scope of the effort will include: (1) Develop a Service Level Agreement between NOAA OR&R and NCEI for the management of DWH Response, Assessment, and Restoration environmental data; (2) Develop inventories and an Archive plan for existing DWH Incident Close-out data; (3) Conduct archive

appraisals of data collections by Resource Group inventory; (4) Develop, modify, and implement processes within NCEI to automate the archival of the LTDM DWH Incident Close-Out inventory.

Task 3. Scientific support to the Deep Sea Corals Research and Technology Program for enhanced data, products and services: The Deep Sea Coral Research and Technology Program (DSCRTP), managed by NOAA National Marine Fisheries, collates, analyzes, manages, maps, and maintains coral and sponge occurrence data, alongside predictive model outputs, and related physical/ biological datasets. DSCRTP-funded fieldwork is conducted on dedicated cruises, as well as by leveraging ship time from other programs doing similar work, especially NOAA's Ocean Exploration and Research Program. DSCRTP data analysis is conducted in close coordination with the National Centers for Coastal and Ocean Science. NGI and NCEI scientists will collaborate closely with DSCRTP scientists, providing expertise to research, design, develop and implement an innovative, comprehensive end-to-end data management system that supports planning, quality control, data documentation, discovery, access and long-term preservation of DSCRTP scientific data collections.

Task 4. Scientific support to the Ocean Exploration and Research Program for enhanced data, products and services: The NOAA Office of Ocean Exploration and Research (OER) is the only federal organization currently dedicated to exploring the unknown ocean. OER, working closely with partners, provides the coordination, funding, staff, tools, and expertise needed to develop exploration missions that deliver rigorous, systematic observations and documentation of biological, chemical, physical, geological, and archaeological aspects of the ocean. OER brings scientists to uncharted areas; to design, test, and implement new deep-sea technologies; and to bring the wonders of ocean exploration to everyone via telepresence enabled exploration. OER's data management system ensures that collected information arrives quickly – and accurately – to decision-makers and to the public. OER depends upon a team of scientists within NCEI to provide its data management, strategic planning, scientific development, and execution.

Task 5. Scientific support to the Gulf of Mexico Restoration Program for enhanced data, products and services: Gulf of Mexico Restoration provides the opportunity to assemble an unprecedented data collection in temporal and spatial scale and overall resolution. This data collection will provide baseline conditions and allow for objective analysis of the status of restoration efforts. NGI and NCEI scientists will work closely with other Gulf partners, such as the Restoration Council, USGS, the Gulf of Mexico Governors' Alliance (GOMA), the Gulf of Mexico Coastal Ocean Observing System (GCOOS), The Gulf of Mexico Research Initiative, and many others to ensure the data is effectively managed including implementation of standards-based metadata, data processing and quality control, and file organization and formatting; and by increasing access to collections through data analysis, discovery and access to scientific products and services.

The scope of the effort will include: (1) Develop an innovative, comprehensive framework for integrated data management to leverage existing information and protocols for use in science based decision making, analyses, prioritizing needs, and identifying gaps; (2) Provide scientific expertise and training to assist restoration project performers to develop and optimize effective data management processes and procedures, ensuring efficient end-to-end data stewardship; (3) Provide expertise in education, outreach, meeting facilitation and other activities supporting community engagement and responsiveness to constituent needs for improved understanding.

Task 6. Infrastructure Support for Research Activities: Data collected during sponsored missions passes through NCEI Mississippi where standard documentation is prepared and data is reformatted for submission to NCEI for long term preservation. A standard suite of products may be prepared for public dissemination as required. These data products are currently served from an NCEI ftp site, but this model is anticipated to evolve over time.

The scope of the effort will include: (1) Server development, operations and maintenance; (2) Develop specifications to purchase and operate a server and storage system to serve information products to the public via ftp and/or other generally accepted protocols. The server needs to provide high I/O bandwidth for user data access and sufficient storage to provide increased reliability; (3) Selected staff from the

NGI/NCEI team at NCEI Mississippi require the ability, directly or indirectly, to add folders for new cruises and to load information products as developed; (4) Exploration Command Center (ECC) Computing systems; (5) Upgrade the six ECC computers to new, modern technology to better support operational needs; (6) Operational IT support.

Task 7. Project Management: Conduct technical management oversight to ensure that high quality deliverables that result from all six proposed activities are provided on schedule and in accordance with project requirements. Assist in development of project milestones in accordance with NCEI Annual Operating Plan guidelines and timelines. Written quarterly report on status of tasks, milestones, and deliverables. Regular meetings to discuss status of tasks, milestones, and deliverables. Discussions focused on technical, management, financial, and requirement issues, especially if assumptions, dependencies, and constraints have been affected.

Description of research conducted during the reporting period and milestones accomplished and/or completed

Task 1. Scientific support to the National Centers for Coastal Ocean Science for enhanced data, products and services:
Eight NCCOS data packages were published during the reporting period. Data access and discovery were provided by maintaining a custom geoportal that NCEI developed specifically for NCCOS data. Quarterly reports were provided to NCCOS on this data management project.

Task 2. Scientific support to the Office of Response and Restoration for enhanced data, products and services (NRDA support):
Researchers completed the archive of Deepwater Horizon Close-out data. All packages and metadata have been transferred from NCEI Stennis to NCEI Asheville with a total volume of 118.3 TB consisting of 3 array transfers.

Task 3. Scientific support to the Deep Sea Corals Research and Technology Program for enhanced data, products and services:
Performed real-time video annotation of geological observations for the EX1803 ROV expeditions in the Gulf of Mexico for the DSCRTP (May, 2018). Research continued to create algorithms for analyses and syntheses of the DSCRTP Data. Researchers continued to check-in, store, archive, track DSC Cruise Data. Archiving continued for the DSC Database and an updated DSC Database was submitted to the Ocean Biogeographic Information System (OBIS). A dataset structure was created for the database and to assign all data to a Dataset. A total of 165 datasets were created with metadata for each dataset and direct links to download the data all contained in an online index. Initiated an effort under the NOAA Big Earth Data Initiative to develop a cloud based video annotation website.

Task 4. Scientific support to the Ocean Exploration and Research Program for enhanced data, products and services:
We designated a team leader to manage the NGI/NCEI OER project team and to coordinate with the NCEI/OER virtual team that includes researchers in Boulder, CO and Silver Spring MD. Some of the outcomes of this action include several coordinated interactions with the Okeanos Explorer expeditions, including several on ship scientists and scientists at the Exploration Command Center at the MSU Science and Technology Center at the Stennis Space Center. Some specific examples of research efforts include coordination and annotations for Okeanos Explorer expeditions, Sample Image Selection, and Sample Data Management. Processing all of the legacy Okeanos Explorer CTD data was completed. Researchers developed and provided training for the Okeanos Explorer dive annotations pilot project. Many of these research products were presented at the NCEI Environmental Data Management workshop in the Video Annotations Quality Descriptors presentation.

https://schd.ws/hosted_files/edmw2018/e3/4D1_Malik_VideoAnnotationQualityDescriptors.pdf

Task 5. Scientific support to the Gulf of Mexico Restoration Program for enhanced data, products and services:
Provided support to the NOAA RESTORE Act Science Program (NOAA RSP) as a Technical Monitor for an FFO 2015 project, "The Central Role of the Mississippi River and its Delta in the Oceanography and Ecology of the Gulf of Mexico Large Marine Ecosystem". Duties in this reporting period included attending a project working group meeting (9-10 January, 2018, New Orleans, LA), reviewing project updates and semiannual reports, and providing feedback to the RSP Program Associate Director.

Task 6. Infrastructure Support for Research Activities:
Researchers working on the Big Earth Data Initiative developed a Video Annotation Portal. The Big Earth Data Initiative grant to rescue historical video data on physical media and make it accessible was presented at the Environmental Data Management Workshop Conference hosted by NCEI in Silver Spring, MD.

Task 7. Project Management:
Regular meetings were conducted during the reporting period to evaluate progress on milestones and coordinate research activities.
Quarterly reports describing activities were provided to the NOAA/NCEI PM.
Discussions were held on assisting with the development of a science plan to ensure that a holistic approach incorporates all aspects of the focus areas in this grant.

Description of significant research results, protocols developed, and research transitions

Two NCCOS Map Services were created and one Map Service was updated in FY18 to date.

Deep Water horizon close-out data were submitted as two distinct groups; data stored on the original hard drives resulted in 69 archive packages, and data migrated into Data Integration, Visualization, Exploration and Reporting (DIVER) Tool resulted in 922 archive packages.

The National Database for Deep-Sea Corals and Sponges was updated with 25 new datasets during the reporting period.

The DSC Web Page Content was updated with activities including coding new pages and features and correcting any identified errors that occurred in any DSC Web Map and ERDDAP pages.

An interactive Story Map was developed for DSC Site Characterization Reports to highlight well studied deep-sea coral areas

Researchers participated on the Okeanos Explorer cruise EX1802 (an emerging technology cruise)

Information on collaborators/partners

Name of collaborating organizations – NOAA National Centers for Coastal Ocean Science (NCCOS), the NOAA Office of Response and Restoration (OR&R), the NOAA Deep Sea Corals Research and Technology Program (DSCRTP), the NOAA Office of Ocean Exploration and Research (OER), and several members of the Gulf Coast Restoration efforts.

Date collaborating established – Ongoing
Do partners provide monetary support to project? Yes Amount of support? Varies annually but approximately $1,000,000.00
Does partner provide non-monetary (in-kind) support? Yes
Short description of collaboration/partnership relationship – Virtual teams for data management, stewardship, research, and product development.

Information on any outreach activities

Researchers made presentations to Gulfport High School STEM students regarding the Okeanos Explorer activities and data.

A NGI/NCEI researcher presented a guest lectured at the University of Southern Mississippi regarding Marine Geographic Information Services.

Collaborative NGI/NCEI research was presented to a local high school for their STEM Academy Seminar Series.

Appendix A. Publication Documentation

Publications completed during the reporting period:

	Institute Lead Author	NOAA Lead Author	Other Lead Author
Peer-Reviewed	14	0	23
Non Peer-Reviewed	39	4	20

Appendix B. Employee Support

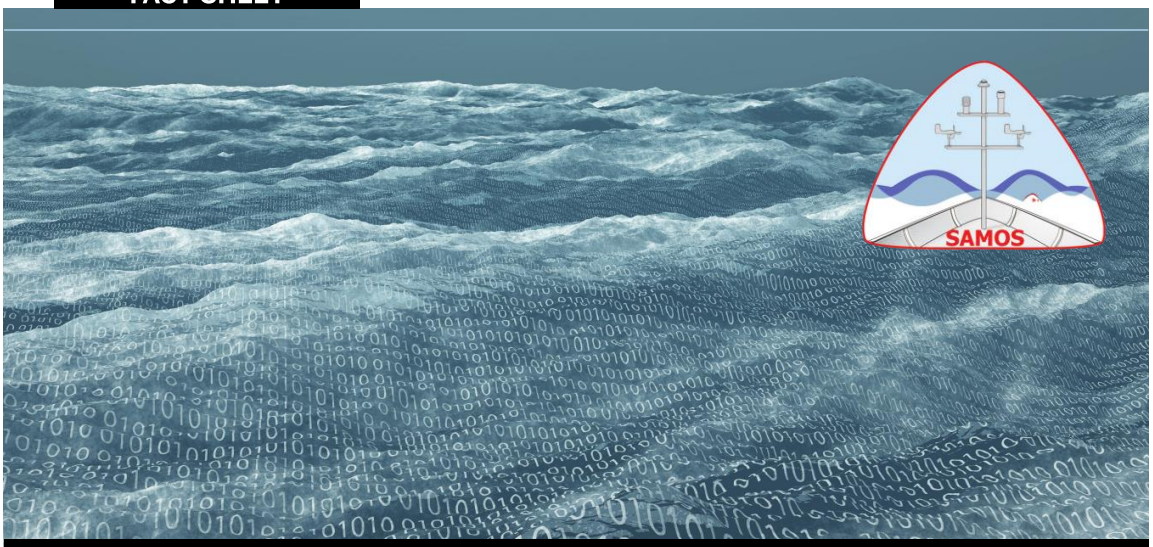
Personnel				
Total # of employees by job title & terminal degree that receive at least 50% support from the NGI NOAA CI funds, postdocs & visiting scientists				
Northern Gulf Institute Employee Support **July 1, 2017 - June 30, 2018** Personnel (all schools combined)				
Category	**Number**	**B.S.**	**M.S.**	**Ph.D.**
>= 50% Support				
Research Scientist	5	0	1	4
Visiting Scientist	0	0	0	0
Postdoctoral Fellow	2	0	0	2
Research Support Staff	22	12	9	1
Administrative	0	0	0	0
Total (>= 50% support)	**29**	**12**	**10**	**7**
Category	**Number**	**B.S.**	**M.S.**	**Ph.D.**
Employees w/ <50% support	32	6	14	12
Category	**Number**	**B.S.**	**M.S.**	**Ph.D.**
Undergraduate Students	4	4	0	0
Graduate Students	19	0	12	7
Category	**Number**	**Name of Lab**		
# of employees / students that are located at the Lab (include name of lab)	3	AOML		
# of employees / students that were hired by NOAA within the last year	0			

Appendix C. Other Agency Awards

Principal Investigator	Prime Sponsor	Project Title	Funding Amount
Mercer, Andrew	National Oceanic and Atmospheric Administration (NOAA)	Transition of Machine-Learning Based Intensification Forecasts to Operations	$100,186.00
Sherman-Morris, Kathleen	National Oceanic and Atmospheric Administration (NOAA)	Improving Accessibility and Comprehension of Tornado Warnings in the Southeast for the Deaf, Blind, and Deaf-Blind	$103,434.00
Fitzpatrick, Patrick	Gulf of Mexico Alliance	CONsortium for oil spill exposure pathways in COastal River-Dominated Ecosystems (CONCORDE)	$25,000.00
		Total	**$228,620.00**

Appendix D. Fact Sheet

FACT SHEET



Making use of a sea of data

While weather satellites orbit the earth monitoring the cloud systems, winds, ocean currents, and ocean-atmospheric energy flows, research vessels are at sea observing our oceans — measuring wind speed, ocean salinity, air and sea temperature, pressure, moisture, and rainfall. But what in the world do scientists do with all of these data? And how do they find what they need in the sea of information that has been collected over the years?

An important part of what researchers who study the Earth's ocean and atmosphere do is observe and measure factors such as temperature, wind speed-direction, and air pressure. The data they collect help answer questions about how earth systems work, including how and why weather events occur. Scientific data also reveal what areas require more study. **The work marine meteorologists and weather data curators do impacts everyone... even you!**

For instance, if you plan to go outside today, chances are you want to know what kind of weather to expect. Should you bring an umbrella, wear a light or heavy jacket, or maybe even consider staying in? Of course you'd want to know if there was any potential dangerous weather such as a hurricane or tornado to watch out for.

Weather prediction is an example of how ocean and atmopsheric science impacts our daily lives. Certainly agricultural decision-making depends upon accurate weather forecasts, not just to help farmers schedule their crop planting and harvesting, but also to forecast the spread of diseases that threaten their crops and can be carried on the wind. But those of us readying ourselves for school, work, or just running errands also rely on weather prediction in our day-to-day lives.

The science behind weather forecasting

Did you ever wonder what makes it possible to accurately predict the weather? Weather forecasting begins by observing phenomena that create weather events such as rainfall, storms, and temperatures. It requires an understanding of patterns observed because they offer some explanation for common phenomena and can therefore be used to predict future occurrences.

Early weather forecasters based their predictions on what they could see and measure themselves — rainfall, winds, temperature, and storm patterns — observing how these changed over time. Today, scientists also use satellites, marine towers, buoys, and ships equipped with sophisticated instruments to monitor and record these kinds of observations, making modern weather forecasting possible. In fact, accurate forecasting depends upon observations made both within the atmosphere and remotely from space-based satellites.

As a result of all these data collection techniques, there is an incredible amount of historical and current information available for scientists to analyze. However, scientists need to be able sort through this sea of information to address the questions they want to answer. Thanks to the Internet, that is now possible... no matter where the data comes from and who wants access.

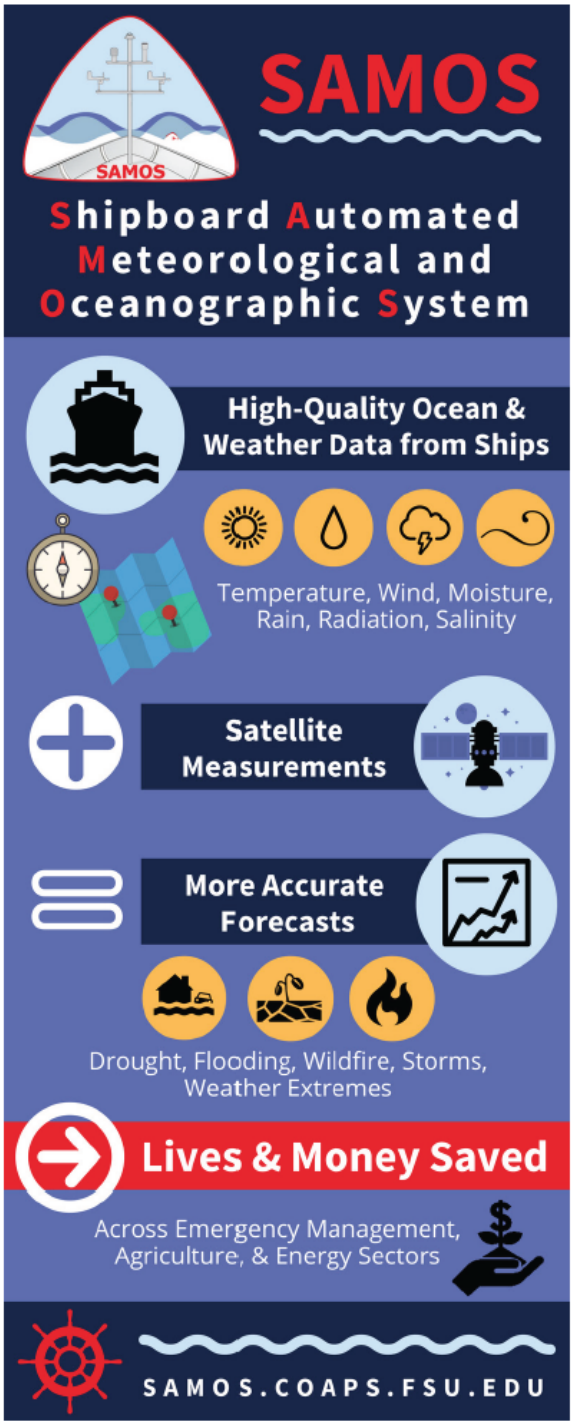
Gathering and sharing ship data

The Marine Data Center at FSU COAPS is home to a project that captures and shares the extensive and nearly continuous meteorological data collected by research vessels. This **Shipboard Automated Meteorological and Oceanographic System** (known as **SAMOS**) gets the meteorological data and other measurements collected by research vessels while they are at sea. But more importantly, SAMOS makes these data available to individual researchers, organizations, and weather forecast agencies that, in turn, use them to validate weather satellite data from the National Aeronautics and Space Administration (NASA). Validated data can be used to create and improve computer models and other tools employed in weather forecasting.

Data validation is critical

It is important to remember that scientists don't just want access to **a lot** of data... they need to know that data they are using in their research has been validated, meaning it has been checked for accuracy and inconsistencies. This is particularly true for observations made by satellites in space. That is done is by comparing the satellite data to the observational data collected by research vessels at sea.

The SAMOS system is an important part of our nation's weather forecasting capabilities — **allowing scientists to validate satellite observations with what ships at sea observe.**



The SAMOS initiative at Florida State University is base-funded by NOAA's Ocean Observing and Monitoring Program via the Northern Gulf Institute (Cooperative Agreement #NA11OAR4320199) and the National Science Foundation's Oceanographic Instrumentation and Technical Services Program (Grant #OCE-1447797). Since 2013, the Schmidt Ocean Institute has provided funding to complete SAMOS data processing for observations from the RV Falkor.

The Florida State University (FSU) Center for Ocean-Atmospheric Prediction Studies (COAPS) is internationally known for providing high quality, innovative data products. Our goal is to provide data products that are useful for both operational and research activities and climate applications. The COAPS Marine Data Center dispenses a wide range of these products focusing on the atmosphere-ocean interface. For more information visit www.coaps.fsu.edu