Principal Investigator Abstract Table of Contents

Marine Operations

North Carolina and South Carolina Moorings – University of North Carolina Wilmington

UNCW's Coastal Ocean Research and Monitoring Program: Optimization & Enhancement of Observing Elements in the Carolinas

***Principal Investigator**: Lynn Leonard, University of North Carolina Wilmington*

As part of the larger SECOORA coastal observing enterprise, and in partnership with the US Army Corps of Engineers (USACE) and UCSD Coastal Data Information Program (CDIP), UNCW's Coastal Ocean Research and Monitoring Program (CORMP) operates 7 real-time meteorological buoys and 7 real-time wave buoys in the coastal waters offshore of North and South Carolina. CORMP also supports three coastal stations that provide weather, water level and/or water quality observations as well as one non-real time instrumented frame that measures water column currents, water depth, and near bottom temperature and salinity.

CORMP implements QARTOD for real-time data QA/QC and uses an interactive QA/QC reporting tool, developed in partnership with Second Creek Consulting, to flag suspect or failed data. All data, including QARTOD flags, are archived on CORMP servers and provided to SECOORA. Real time data are made available as soon as they are received and processed and used by stakeholders such as USACE's Research and Development Center's Coastal and Hydraulics Laboratory, NOAA's National Weather Service, South Carolina Ports Authority, Wrightsville Beach Ocean Rescue, harbor pilots, fishing websites (e.g. saltwatercentral.com) and the public.

The data also support existing applications such as SECOORA's Marine Weather Portal as well as a Situational Awareness Tool (SAST) also supported by this award. By providing observations in the Carolinas portion of the SECOORA footprint, CORMP fills what would otherwise be large observational gaps in the region. The UNCW observing program supports SECOORA goals in the areas of Marine Operations; Coastal Hazards; and Living Marine Ecosystems.

Key goals for year 2 included: maintain operational status of all real-time assets with a target collection efficiency of at least 85%; maintain non-real time assets; create metadata for all new platforms and publish data in Research Workspace; maintain VEMCO acoustic receivers on four moorings for FACT Network, upgrade CHR60WAVE to a Sofar Spotter Gen 2 Smart Buoy; complete and begin testing of SAST prototype; and conduct stakeholder engagement.

While all year 2 goals were met, there were some challenges. This included failure of the Sofar Spotter Gen 2 system shortly after deployment, two power system failures at LEJ3, sensor failures on ILM2Wave and CAP2, and periodic communication issues. Noteworthy accomplishments included: the successful short-term deployment of a Sofar spotter buoy to support local fishing tournaments; co-hosting the MTS Buoy Workshop; and adding iframe code to cormp.org to allow users to easily embed CORMP station data on their own websites. CORMP prioritizes stakeholder engagement and is proud to report these efforts resulted in the receipt of a private gift used to establish a CORMP endowment at UNCW. Proceeds generated by this endowment will be used to support student internships and other outreach activities.

In year 3, CORMP will continue to support and enhance SECOORA's mooring array, refine the SAST tool, and increase awareness and effectiveness of the SECOORA RCOOS through partnerships and stakeholder engagement activities.

East Florida Moorings – University of North Carolina Wilmington

Filling the Gap: SECOORA Members Partnering to Affordably Increase Observations and Build Capacity Along the Florida East Coast

Principal Investigators: *Lynn Leonard[1], Chris LaClair[1], and Jordon Beckler[2]*
[1]University North Carolina Wilmington; [2] FAU Harbor Branch Oceanographic Institute

This project leverages two decades of operational experience, existing observing and data management infrastructure, established partnerships, and local logistical and science expertise to 1) enhance availability of meteorological, oceanographic, wave and ecosystem observations at two data poor locations on the Florida east coast; 2) support established stakeholder needs; and 3) provide real-time data that support SECOORA initiatives and products. The project directly addresses priorities and investment opportunities identified in SECOORA's Regional Coastal Ocean Observing System (RCOOS) Strategic Operational, while also establishing a buoy infrastructure that can later be physically leveraged for monitoring other core oceanographic variables. The effort comprises a new partnership between two SECOORA academic institutions (UNCW and FAU HBOI), whose combination of expertise and resources allows the team to realize significant cost-efficiencies, a private sector partner (2Creek Consulting) with an established record of data management service to SECOORA partners, the FACT Network, St. Lucie County and two NOAA National Weather Service offices (NWS Southern Region Office and NOAA NWS Melbourne, FL Forecast Office). This combination of technical expertise, regional knowledge, and stakeholder engagement ensures optimization and enhancement of SECOORA's observing system to inform three SECOORA focus areas: a) Coastal Hazards and Climate Variability; b) Marine Operations; and c) Ecosystems.

A key objective of this effort is to build two real-time meteorologic buoys that measure water temperature, salinity, air temperature, barometric pressure, and wind (speed, gust, and direction) and deploy them at two locations on the Florida east coast. One system will be located approximately 10nm east of Ponce de Leon Inlet, a location prioritized by the NWS Melbourne weather forecast office due to the paucity of real-time coastal ocean observations between Cape Canaveral and St. Augustine. A Sofar wave buoy that measures wave height, dominant wave period, mean wave direction, and water temperature also will be deployed at this location. The second system will be deployed approximately 5nm northeast of Fort Pierce Inlet and co-located next to an existing Coastal Data and Information Program waverider (NDBC 41114). Both buoys will be equipped with FACT Network acoustic receivers to track tagged fish.

Since receipt of funding in early 2023, the team has ordered components for the buoy systems, worked with SECOORA on required permitting, and started in-house fabrication of frames and instrument mounts. Diver surveys are scheduled (pending weather) and the FAU team will travel to UNCW in mid-May to begin buoy maintenance and operation training. Once deployed, the buoys will inform NWS products, support regional scale ecosystem and coastal vulnerability studies, inform operational decision-making by commercial interests, and enhance a growing archive of wave, climate, and oceanographic measurements to track temporal trends and evaluate event-specific impacts.

West Florida Shelf Moorings and Modeling – University of South Florida

Hurricane Ian: Coastal Ocean Observing and Modeling

Principal Investigators: *Yonggang Liu, Robert H. Weisberg, Jing Chen, Sebin John, Jay Law, Alexander Nickerson, Luis Sorinas, Siria Munoz, College of Marine Science, University of South Florida*

The University of South Florida, Ocean Circulation Lab maintains a coordinated program of coastal ocean observations and models, with observations consisting of instrumented moorings for surface meteorology and in-water sensors and models consisting of coastal ocean models that downscale from the deep ocean, across the continental shelf and into the estuaries. The objectives continue to be to describe and understand the circulation of the West Florida Continental Shelf (WFS) and the role that the circulation plays in shelf ecology and other matters of societal concern, such as HABs, fisheries, storm surges, SAROPS.

Hurricane Ian swept over the southern WFS while intensifying into a Category 4 hurricane before making landfall near Fort Myers Florida on September 28, 2022, causing catastrophic damage to

southwest Florida coastal regions. Ian passed over two surface buoys, one located near the Dry Tortugas (C22) and one located offshore of Fort Meyers (C13). Both stations recorded the initial approach of Ian in real time but ultimately lost data transmissions due to damaged antennas. In a remarkable example of a 'bend but don't break' design, both buoys were moved off of their positions significantly in response to strong winds and extreme waves but they did not break free. Both buoys recorded valuable time series of water column velocity, and C13 also collected meteorological data, throughout the entire Ian event.

By using the automated West Florida Coastal Ocean Model (WFCOM) and Tampa Bay Coastal Ocean Model (TBCOM) nowcast/forecast systems, the USF lab was able to successfully forecast the WFS coastal ocean response to Hurricane Ian three days in advance, thereby providing important information to federal, state and local agency along with the local community regarding extreme water level changes throughout the impacted region. Coastal areas south from the landfall location were subjected to damaging storm surge and waves, whereas regions to the north experienced a negative storm surge. Heavy rainfall and subsequent drainage from the land then caused a series of low salinity, turbid water plumes emanating from all the estuaries and inlets along the southwest Florida coast. As the low salinity plumes grew and evolved on the inner shelf, the coastal currents exhibited complex spatial patterns.

Other funding resources (e.g., NASEM, NOAA ECOHAB, NOAA COMIT, FDEP) have been heavily leveraged for our observing and modeling work. Note that some of those resources are lost (e.g., NASEM). Steady funding are required to sustain the critical SECOORA assets and to retain highly skilled and dedicated scientists that are difficult to recruit.

North Carolina High Frequency Radar – ECU Coastal Studies Institute and UNC Chapel Hill

North Carolina long-range high-frequency radar system

Principal Investigators: *H. Seim, University of North Carolina at Chapel Hill and M. Muglia, Coastal Studies Institute / East Carolina University*

During Year 2, the 4 NC long-range high-frequency radar (HFR) sites (CORE, OCRA, HATY and DUCK) have generally performed well. Among accomplishments were application for renewed FCC licenses and transition to and testing of operation in the lower ITU band. The transmit amplifier on the low-power unit at CORE failed (again) this winter, but we were fortunate to have a spare (repaired) amplifier and were able to swap it out, keeping downtime at the site under one month. With funding from NASA, in March 2023 we added a second transmit antenna to the HATY site, intended to increase its range coverage and provide more overlap with the footprint of the newly-launched Surface Water Ocean Topography (SWOT) satellite. Maximum coverage is now about 230 km at the site, a roughly 40 km increase. In March we also un-installed the DUCK site, which was originally installed in 2003, and re-installed it at Jennette's Pier, about 25 km closer to HATY, the next site to the south. The relocation of the site is hoped to provide more consistent overlap with HATY, as the 2 sites were farther apart than is now recommended. The DUCK site was also challenging because of the long metal pier which distorted the beam pattern; the hope is that the interference from Jennette's Pier is less severe. At the time of the abstract submission the new site (JENN) is still offline as we await establishing communications to the site. We plan to transition JENN to a twin transmitter in early May, to increase its range as well. The primary challenge faced in the last year is the performance of the newest NC HFR site, OCRA, on Ocracoke Island. Its signal has been noisy since installation in July 2021 and the resulting low signal to noise has meant limited range coverage. In late March 2023 the site was forced off by overheating, suggesting a failure of the air conditioner. We also have a GPS module to repair at the site. We haven't been able to afford the repairs immediately but hope to use the new HFR coming in April as a temporary replacement. A visit will take place as soon as logistics allow (the site can only be accessed by boat, similar to CORE). We are working hard to have all sites working as well as possible during the mid-April to mid-June 2023 time period when the SWOT satellite mission is in a special cal/val orbit, mapping sea surface height offshore of NC twice a day. During Year 3 we will evaluate if the twin transmit antenna setups at HATY and JENN can be sustained, as well as continuing to maximize uptime and coverage.

Additionally, we have been developing a Gulf Stream (GS) hindcast and nowcast that uses the radial currents from individual sites to examine GS variability going back to 2004, funded by NSF. We have also proposed to NSF to put an array of nested high frequency (13 MHz) sites in our current HFR coverage on the northern Outer Banks to study shelf exchange, combining additional surface current observations with those made by the Pioneer Array assets being relocated to the Outer Banks in Spring 2024.

South Carolina High Frequency Radar Network – University of South Carolina

University of South Carolina HF Radar Operation and Maintenance

Principal Investigators: *George Voulgaris, William (Jeff) Jefferson and Douglas Cahl, University of South Carolina*

The University of South Carolina continued the operation and maintenance of three WERA HFR systems that provide coverage over the coastal ocean area extending from Wilmington NC to Georgetown SC (Long Bay). The three stations are located in Georgetown, SC (GTN), Fort Caswell, NC (CSW) and at Myrtle Beach State Park, SC (MBSP). CSW and GTN were initially installed to operate at 8.3MHz; their operational frequency was changed in 2022 to the new oceanographic radar FCC-approved frequency of 5.26 MHz. The MBSP operates at 13.5 MHZ. Our operations revealed that the 5.26MHz frequency is more susceptible to noise and interference than the earlier frequency of 8.3MHz and this has led to some reduction in range.

All three stations have been maintained through routine and emergency repair visits ranging from 3-4 per year for CSW to over 12 for GTN. CSW has been the most reliable site and its down time is associated mostly with aging hardware. On the other hand, GTN has endured the most storm related damages over the last year, primarily due to the fact that the site is located in an area of sustained erosion that has removed the previously established dune line. The site is susceptible to damage under any spring/king tide, northeast storm, and/or hurricane; these conditions can easily overwash the array and cause enough damage to bring the site down. MBSP, the newer of the systems, was underperforming for an extended period due to tuning issues of the Rx antenna array and most recently because of issues with the computer controlling the system. Despite all these challenges over the last year we managed to remain operational for 92.52%, 87.19% and 84.12% of the time for CSW, GTN and MBSP, respectively.

We are planning to continue operations for year 3 and hope to increase the reliability of the system through a number of actions. CSW maintenance will include replacing old/fatigued infrastructure for the TX array, RX cables, communications hardware, and a major renovation of the trailer housing the system. For GTN the plan is to reposition the TX array to an area less susceptible to overwash.

In the area of data processing, we assessed the performance of three different algorithms for estimating surface ocean currents from two linear array HF radar systems (CSW and GTN)[1]. The delay-and-sum beamforming algorithm, commonly used with beamforming systems, was compared with two direction-finding algorithms: Multiple Signal Classification (MUSIC) and direction finding using beam-forming (Beamscan). The results indicated that under certain conditions, Beamscan and MUSIC can outperform the traditional beamforming method. This offers significant improvement when one or more antennas in the linear array fail or perform poorly (i.e., badly tuned, slightly damaged, etc.). The results and codes[2] were published and are available in the public domain.

We plan to use data from the same systems to study the effects Stokes' drift has on the phase speed of Bragg waves. Although currently the measurement method utilized by HF radars assumes negligible or no effect, we hypothesize that during stormy periods where significant wave energy is present in the ocean this is not the case. This is to be examined in the next period using traditional methods but also employing neural network methods too.

[1] Cahl, D., G. Voulgaris, and L. Leonard, 2023: A Comparison of Beamforming and Direction Finding Algorithms (Beamscan and MUSIC) on a Linear Array HF Radar in a Medium to Low Wave Energy Environment. J. Atmos. Oceanic Technol., 40, 191–218, https://doi.org/10.1175/JTECH-D-22-0005.1.

[2] Cahl, D. and G. Voulgaris, 2022: HFcur_BBM: A MATLAB package for calculating surface currents from HF radars using Beamforming, Beamscan (direction finding using beamforming) and MUSIC for a linear array (v0.0aa). Zenodo. https://doi.org/10.5281/zenodo.7231459

Georgia and Florida High Frequency Radar – Skidaway Institute of Oceanography

Georgia and Florida Radar Networks

Principal Investigators: *Catherine R. Edwards, Kris Maedke-Russell, James Bird, Karen Dreger, Dana Savidge, Skidaway Institute of Oceanography, University of Georgia*

Two shore-based surface current measuring WERA HF-radar systems have been installed on St. Catherine's and Jekyll Islands, along the coast of Georgia. Surface velocity measurements from these systems cover a shelf area extending approximately 100 miles alongshelf and 100 miles out to sea. A dense grid of measurements at ~3.5mile spacing are updated every half hour, and are used for model verification (R. He, NCSU), assist in glider navigation (C. Edwards, SkIO) and support continuing scientific analysis of shelf circulation and Gulf Stream variability. Both systems have required significant hands-on troubleshooting of multiple hardware failures due to the age of the instruments. In early summer 2022, massive wildfires sparked by lightning broke out on St. Catherine's Island, overcoming 3 weeks of firefighting efforts and ultimately resulting in the total loss of the trailer, power hook-up, and all components of the antenna arrays. UGA has approved the insurance claim for partial reimbursement, and efforts are underway to seek auxiliary funding to replace the system.

Over the past year, we have been working steadily on installation of a new pair of 13.5 MHz radars north of Cape Canaveral. The first system, at Canaveral National Seashore, was installed in December 2021, and has remained operational, but several of the coils repurposed from operations in North Carolina were unable to be tuned. The most favorable combination of equipment was chosen to maximize range and performance until the issues can be addressed in the long term. After a multi-year process due to the complexities of federal-federal agreements, COVID, and other unforeseen delays, the land use agreement for a radar site at Kennedy Space Center was finalized in early spring 2022 and planning is underway for installation to begin during summer 2022. However, significant erosion from Hurricane Ian and several sustained fall/winter storms required redesign of the array and amendment of the legal land use agreements. An April 2023 site visit, with assistance from USC technician J. Jefferson, the team worked with NASA to re-survey the new cable and antenna placement, coordinate with the site manager for mowing, and install electrical service to the NASA panels. IOOS HFR coordinator B. Zelenke has provided assistance coordinating the re-siting of the array. Regular coordination with NASA KSC site managers continues as the surveyed locations and allowances can be updated in the land use agreement. Installation is expected to begin in June 2023, pending scheduling and approval from KSC site manager partners.

FCC licenses for all four sites were issued in spring 2021, but construction permits for new installations stipulate that they must be operational within a year. Given the lengthy delays in the land use agreement process, a second year-long extension for the KSC site is now required. Other operational challenges include maintaining uptime with the ongoing issues troubleshooting and repairing aging systems and balancing the financial burden (time, hardware/repair costs, and travel) of operating aging equipment with a limited budget.

East Florida High Frequency Radar – Florida Institute of Technology

Treasure Shores and Hightower Beach Florida HFR

Principal Investigator: *Dr. Steven Lazarus, Florida Institute of Technology*

The Treasure Shores (TS) radar has been operational since February 2022 and the radar data (radials) have been flowing in near-real time to both Axiom (since July 2022) and HFRNet (since November 2022). The second radar install has just begun (as of April 14, 2023) – with the installation of both the transmit and receive antennas at Hightower Park in Satellite Beach, Florida. Although the installation was originally planned for November 2022, the PI did not receive a green light from the Florida Communities Trust (FCT) until April 11, 2023. In addition to the go ahead, FCT representative William McMahon has also indicated that, following the installation "…the city will prepare an appraisal (or other valuation method of the land use area impacted)". The PI has applied for and received an FCC license for the Hightower site in December 2022. A shed, which was just purchased, will be installed and the PI just receive a quote for the accompanying electric work – both of which are planned over the next couple weeks. The comms will be provided by the same Florida Tech Verizon account that was set-up for the radar at Treasure Shores.

There continues to be some unresolved issues with the receive antennas at Treasure Shores and we have been working with Helzel and the project engineer to solve these. Cabling issues have been ruled out by Helzel and a visit to the TS site in March to investigate some rodent damage did not, with the exception of the transmit cable, indicate that there was a need for replacement (some new cables were ordered). Assessment of the transmit antenna indicate that the power is on the order of 13 watts and recent site tests have cleared the rack electronics. At this point we believe the low power problem may be coil related – and Helzel has recommended that we swap cables at the antennas to trouble shoot this. The PI plans to run these tests during May.

South Florida High Frequency Radar Network – University of Miami RSMAS

South Florida High Frequency Radar Network

Principal Investigators: *L. K. (Nick) Shay, J. Martinez Pedraja and B. Jaimes de la Cruz, Department of Ocean Sciences, Rosenstiel School, University of Miami*

As part of the US IOOS/SECOORA priority Wellen Radar (WERA), we continue to operate and maintain to the extent possible high frequency (HF) radar sites at Crandon Park (CP), Virginia Key (VK), Dania Beach (DB) and North Key Largo (NKL). Hourly (subsampled to 2.2 km) data from these sites are sent to SECOORA and the IOOS National High Frequency Radar Network at Scripps Institution of Oceanography for integration, display and dissemination. These data are also on the UM's Rosenstiel School web site. Our targeted "up time" is 85% for these sites, however, there have challenges to maintain this up time given that we do have to comply with requests from the county, state and federal government to turn the radars off at certain times on a not-to-interfere basis. All four radar have been operational over the past year: CP 100%; DB 94%; NKL 82%; and VK 54%. Three of the four site are working well except for intermittent outages. For example, at NKL these are 21-23 January, 17, 27 July, 25-27 October and 3 November.

The VK site underperformance was due to two reasons. First a major king tide again occurred in November 2022 where the sea level was higher than Mean High Higher Water observed at the Rosenstiel School Pier. Note that tropical storm Nicole caused an increase in sea level (~ 2.37 feet above normal at the RSMAS pier on 10 November 2022) just prior to the King Tide event on 17 November. These sea level increases again caused damage to the transmit antennae (e.g., cables, pipes and antennas). That is, the optimal location of the Tx antennae is exposed to the increase in sea levels and damaging waves. The site was down the rest of 2022 due to repairs. However, a larger problem was identified by Operations Management Division of Water and Sewer Department who cancelled our operations until they could build a better platform for the power splitter and repair the power problems inside the beach hut. This included a new 480-volt transformer inside the structure. We are grateful to the operations folks for assisting us with improving electricity inside the structure. Clearly the VK site continues to be our challenge, yet it is the optimal site linking the northern and southern domains of our footprint.

Fiscal challenges remain with respect to our day-to-day HF radar operations given rising fuel and electricity costs, increases in the rent for the beach hut at Virginia Key, beach maintenance around the sites damaging equipment as well as cost-of-living salary increases for technical personnel.

West Florida High Frequency Radar Network – University of South Florida

West Florida High Frequency Radar (HFR) Network – University of South Florida
Maintaining West Florida High Frequency Radar Network
Principal Investigator: *Dr. Clifford R. Merz, University of South Florida, College of Marine Science (USF/CMS)*

The USF/COMPS/Ocean Circulation Group operates and maintains:

- Three (3) Funded SECOORA IOOS identified priority CODAR SeaSonde HFR sites (Naples, Venice and Redington Shores) along the West Florida Shelf (WFS).
    - The Naples site sustained significant damage during Hurricane Ian with a complete new site installation required once equipment is repaired/replaced and the housing facility repair is completed. Status: Site Non-Operational awaiting repairs delayed by supply chain disruptions and funding issues.
    - Venice site required a replacement A/C, localized storm damage equipment repair with site downtime, and a new TX antenna replacement. Status: Site Operational.
    - Redington Shores required an A/C system repair along with ageing equipment repair and downtime, and a new TX antenna replacement. Status: Operational.
- Two (2) Unfunded WERA HFR sites at Venice and Ft. DeSoto Park that provide higher resolution coverage within the larger CODAR WFS footprint near the entrance of Tampa Bay. These WERA systems are not identified as IOOS priority HFRs and are operated by USF without any direct SECOORA funding. Status: Sites Operational.
- Two (2) Unfunded Lower Florida Keys CODAR SeaSonde HFR sites at Marathon and Key West that were installed under a now expired NASEM-GRP award aimed at better understanding the Gulf of Mexico Loop Current outflow within the Florida Straits. Located at positions identified as gaps in the HFR BOP, these CODAR sites are operated by USF without any direct SECOORA funding. Status: Sites Operational.
- Real-time hourly HFR data are remote site pulled via scripting to a central processing station located at USF/CMS and provided to SECOORA, NOAA NDBC, and the IOOS National HFR CORDC Network (HFRNet) for integration, display and dissemination. Data plots displayed on the USF/CMS Coastal Ocean Monitoring and Prediction System (COMPS) (http://comps.marine.usf.edu) web site.
- PI performed as SECOORA's HFR Settings Coordinator; interfacing between the IOOS Surface Currents Program Manager and SECOORA member HFR operators regarding FCC ITU Band ULS licensing.
- Historically, USF CODAR HFR and WERA HFR systems have operated under an FCC experimental license at 4.900 MHz and 12.23 – 13.20 MHz, respectively. During this Period of Performance, all USF HFR system operation moved to the dedicated FCC HFR bands of 5.250-5.275 MHz and 13.450 – 13.550 MHz, respectively.
- Correspondence and on-site meetings with USCG and Eglin AFB personnel regarding Hurricane Ian beach sand erosion and facility building changes at the Venice USCG Auxiliary Station where the USF CODAR/WERA HFR systems are located.

Coastal Hazards and Climate Variability

Water Level Team – American Shore & Beach Preservation Association and Hohonu, Inc.

Water Level Network Team | Nicole Elko and Brian Glazer
Principal Investigators: *ASBPA (American Shore & Beach Preservation Association) and Hohonu, Inc.*

Year 2 Accomplishments

34 of 34 sensors installed in North and South Carolina and Florida (e.g., Figure 1) all surveyed to NAVD88 using RTK GPS, established local datum, reporting real-time water levels to SECOORA data portal and to Hohonu site relative to MLLW.

Co-developed installation plans, data needs, and flooding thresholds with 34 coastal communities who install sensors, serve as key partners, and utilize water level data for decision support; hosted quarterly partner meetings, both in-person and virtual.

Challenges

Controlling costs/resource investment – Sensors are relatively cheap and easy to build/replace, but other project elements require significant time/cost investments such as survey, data management, quality control, and partner engagement.

Year 3 Objectives

Maintain the established observing networks to provide 80-85% uptime of real-time water level data collection in North and South Carolina and Florida. Upgrade the hardware in all sensors in year 3 to replace legacy telemetry cell systems with LTE grade systems and standardize installation and sensor replacement procedures.

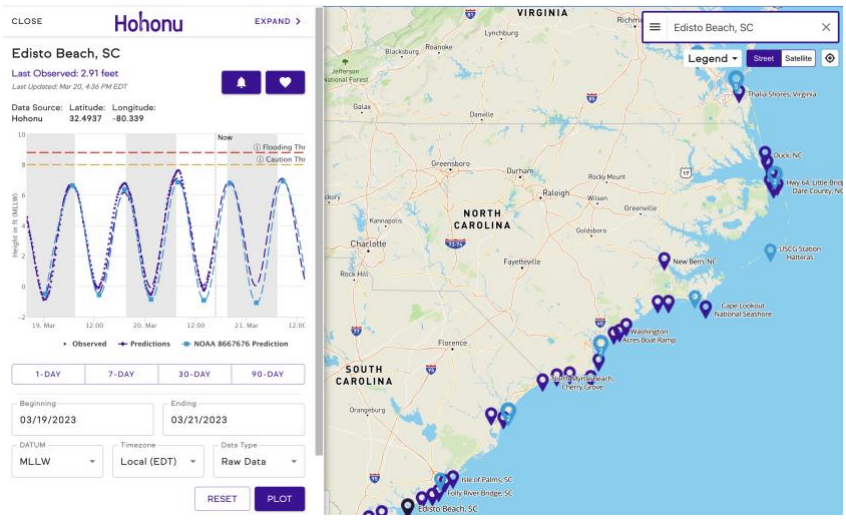

Figure 1*. Screengrab of real-time water level data dashboard from Edisto Beach, SC. Also including predictions (beta using AI), nearest NOAA predictions, and user-defined caution and flood thresholds, as well as a map of N. and S. Carolina sensors (purple pins) and NOAA stations (blue pins).*

Water Level Team Update – Florida International University

Integrated coastal flood observation network for citizen engagement and improved data, modeling and projections

Principal Investigators: *Tiffany Troxler, Rachel Stovall, Jayantha Obeysekera, Michael Sukop, Florida International University; Greg Dusek, NOAA/National Ocean Service; Amy Clement, University of Miami; Alex Nunez, Digitial E Consulting*

The overall goal of our proposed project is to develop a multi-sensor network of integrated coastal flood observation sites that combine approaches of crowd-sourced, citizen flood measurements, in-situ surface and shallow subsurface measurements of depth and salinity, video surveillance and drone surveillance, and coordinate with SECOORA partners to develop a regional scale enterprise. The information from the network is highly responsive to stakeholder challenges and societal needs, and fundamentally supports SECOORA's priorities for contributing to our improved understanding, management, and stewardship of valued coastal ocean resources. Value-added products and services include improved flood modeling and projections, flood warning systems with location specific thresholds, improving our understanding of land-ocean interaction, and how local frequency and duration of flooding affects infrastructure and ecosystem vulnerability to support decision-making. To this end, we are establishing real-time water and salinity gauges and at a subset of sites, integrated coastal flood observation stations in Florida, with each including extreme high tide citizen science flood reporting and drone flights, real-time water and salinity gauges, and web cams,

2) coordinating with SECOORA projects to extend integrated observation stations and data to other SECOORA locations; and 3) working to coordinate the transfer of citizen science flood reporting programming and tools to other interested communities. Over the next year, we plan to complete site installations, begin processing data from drone surveillance and web cam monitoring and test integration of data products from integrated coastal flood observations.

Water Level Team Update – Georgia Institute of Technology

Smart Sensor Networks for Coastal Flooding in Georgia
Principal Investigator: *Russell Clark, Georgia Institute of Technology*

The goal of this work is to partner with stakeholders, decision-makers, and residents to co-design and co-deploy a network of internet-enabled smart flooding sensors along the Georgia coast at the scales required for the decision-support tools of coastal communities.

Leveraging existing collaborations with a diverse stakeholder and outreach network in Georgia's coastal counties, this project will provide real-time high-resolution and high-frequency flood data that coastal communities can use to **(1)** plan for and respond to flood emergencies (e.g. flooding, hurricanes, storms) and **(2)** design resilience and adaptation strategies for the long-term effects of sea level rise and the projected increase in flooding. The data produced in this project will also be integrated in ongoing high-resolution modeling efforts to advance our understanding of coastal system dynamics and prediction capabilities at 10 meter spatial resolution.

The project team deployed three new water level monitoring stations in Camden County and two in Glynn county. The two in Glynn are deployed in conjunction with community partners to address flooding concerns in traditionally underserved communities.

In Chatham and Effingham counties, five additional water level monitors are installed to resolve inland drainage and low-lying areas. The project team also continued to maintain and support the previously deployed sensors from year 1.

In year 3, the team will deploy additional monitoring stations in Glynn, McIntosh, Liberty, and Bryan counties. The design and deployment of the sensor network involves close collaboration with existing City and County partners along Georgia's coast. Ultimately, our shared goal is to transfer the ownership and maintenance of these sensor network to the community at the end of the project. This will include plans for maintaining stations to established SECOORA SOPs for low cost monitoring stations.

The team continued to experience some issues with hardware availability due to supply chain disruptions of the last two years. This has been mostly addressed with alternative vendors.

Expanding the Southeast Water Level Project – Southeast US Sea Grants

Expanding Southeast Water Level Sensor Network
SECOORA has funding for all southeast Sea Grants to help identify community needs, particularly in underserved or disadvantaged communities, for water level sensors and products to access water level data. The following summaries describe what the other states are working on.

South Carolina Sea Grant Consortium: Expanding Southeast Water Level Sensor Network in the Pee Dee Watershed

Principal Investigators: *Susan Lovelace, Ph.D., Executive Director, S.C. Sea Grant Consortium And Katie Finegan, PE, S.C. Sea Grant Consortium and Coastal Carolina University*
Partner: *Jeffrey Steinmetz, Ph.D. Francis Marion University*
Staff: *Ke'Ziyah Williamson, S.C. Sea Grant Consortium in partnership with Francis Marion University*

The South Carolina Sea Grant Consortium (Consortium) contracted a Community Engaged Intern during the summer of 2022. Intern Ke'Ziyah Williamson, piloted a partnership with the Southeast Coastal Ocean Observing Regional Association (SECOORA) to make connections to install water level sensors with rural and low wealth communities located within the Pee Dee watershed. Williamson was able to connect with 5 communities with an expressed interest and need for water level sensors. There was not enough time during the summer internship to follow-up with those communities regarding installation and use of sensors. With the advent of funding from SECOORA to the Consortium to continue the work, Williamson was hired by the Consortium in the fall of 2022 as an engagement specialist to follow-through on the installment of at least 2-3 sensors in the communities that were identified in the summer of 2022. In addition to coordinating installment of sensors, Williamson was hired to assist the communities on the maintenance and use of the sensor data.

Since Williamson was hired by the Consortium in fall 2022, two additional communities have been identified with a need for local water level monitoring. February 2023 marked the installation of the first sensor in a community that was identified in the summer of 2022. The installment of this sensor in Marlboro County required extensive communication with the South Carolina Department of Transportation (SCDOT). Currently Williamson is working with Marlboro County's officials to establish a flooding threshold, as well as the best way for the community to access, download, and understand the data. In March 2023, The Post and Courier regional publications published an article about water level sensor discussions with Williamsburg County. https://www.postandcourier.com/kingstree/news/williamsburg-county-approves-grant-that-will-allow-it-to-monitor-water-conditions/article_e0d2b2f8-bdda-11ed-88c4-5780b91df353.html

It is planned for at least 2 more sensors to be installed before fall 2023.

Despite being challenging there has been some progress connecting with SCDOT District 5 where most of the work is taking place to hopefully allow for smoother communication in future installs. Installing on County or privately owned structures has been an easier process however developing a consistent process for working with SCDOT is important for future installations. For accessing and downloading the data from the website, Marlboro County has already provided feedback that data is more useful to them in feet instead of meters (as displayed on website). Establishing local flooding thresholds with communities will be a longer term process that will require collaboration so maintaining relationships will be key. The team has yet to experience a technical failure of a sensor but when this occurs will need to make sure it is resolved efficiently.

North Carolina Sea Grant (NCSG)

Principal Investigator: *Frank Lopez, Extension Director, North Carolina Sea Grant*

The North Carolina Sea Grant (NCSG) extension team, with its direct ties to state-level resilience initiatives and networks, is leading a prioritization/scoping of the potential water level sites and leading the engagement with selected communities. NCSG has started to review and collect data and information to develop a preliminary list of communities, including existing/planned stream gauge locations from various networks in coastal NC, lessons learned from ongoing NCSG resilience extension programming, and engaging stakeholders.

Georgia Sea Grant

Principal Investigator: *Jill Gambill, Coastal Community Resilience Specialist, Georgia Sea Grant*

Georgia Sea Grant is working with the Georgia Institute of Technology to develop a regional network of environmental sensors. The "Smart Sea Level Sensor Project" began in 2018 and was anchored on a partnership between Georgia Tech, the City of Savannah, and the Chatham County Emergency Management Agency. In recent years, the project has entailed an additional partnership with Harambee House, an environmental justice organization in Savannah. The project has installed more than 50 low-cost, internet-connected water level sensors in Chatham County that provide input to a dynamical model of coastal flooding and are used in curriculum modules designed for local middle and high schools. Georgia Sea Grant is communicating with several community partners in Brunswick, Glynn County, Sapelo Island and Camden County to determine sensor

placement and user needs. GA has slightly pivoted to assess the effectiveness of an existing sensor dashboard in Chatham County to make sure to gather strengths and opportunities to apply those lessons in the dashboards developed for other communities.

Florida Sea Grant

Principal Investigator: *Sherry Larkin, Director, Florida Sea Grant*

Florida Sea Grant is in the preliminary states of their project and are planning to hire a summer intern to work on the Florida panhandle to help with location identification and community engagement for installation of approximately 15 water level sensors on the panhandle. They are working in collaboration with scientists from Florida International University.

Glider Operations – Georgia Tech, Skidaway Institute of Oceanography, University of South Florida

SECOORA Glider Observatory

Principal Investigators: *Catherine R. Edwards, Karen Dreger, Frank McQuarrie, James Bird, Kris Maedke-Russell, Garrison Hefner, Drew Vincent, Ben Hefner, Skidaway Institute of Oceanography, University of Georgia*
Chad Lembke, Alex Silverman, Heather Broadbent, and Garrett Miller, College of Marine Science, University of South Florida
Harvey E. Seim, Tony Whipple, Lu Han, and Yubeen Jeong, University of North Carolina at Chapel Hill
Fumin Zhang, Ruochu Yang, and Mengxue Hou, Georgia Institute of Technology

The SECOORA regional glider observatory is a collective effort among the glider groups at SkIO, UNC, USF, and GT. Project PIs cooperate to support shelf-wide glider surveys through at least 4 glider deployments in the South Atlantic Bight (SAB), with joint deployments/recoveries, piloting, and data management, pooling resources to take advantage of complementary assets (instruments, personnel, and ship access).

In year 2, observatory partners conducted 4 observatory-funded missions in the SAB for a total of 94 glider-days, providing data visualization, logistics, deployment/recovery, piloting, and/or coordination support among the group. This tight coordination of resources and operations is facilitated by a glider coordinator who serves on SkIO and USF teams, as well as cross-training of lab personnel for glider preparation and piloting. In addition to these directly supported missions, the observatory provided data submission and observatory structural resources to one additional NSF-funded mission at Gray's Reef National Marine Sanctuary and one privately-funded mission for right whale monitoring off the Georgia coast. Two observatory missions were piloted with support from the Glider Environment Network Information System (GENIoS), which integrates smart piloting strategies into waypoint generation and monitoring for flight anomalies, and was ported from MATLAB to Python, with its first real-time operational test in March 2023. Post-deployment, data from deployments has been used to post-process CTD observations as a science product, integrating an independent model of glider flight to adjust for measurement dependence on variable vehicle speed.

Coordination of observatory operations, resources, and planning occurs through monthly all-hands calls, and a monthly "Tech Talk" series for deep dives into technical and/or scientific topics of interest; in 2022, 7 "Tech Talk" sessions were presented on technical (5) and scientific (2) aspects of glider operations. Four observatory personnel represented their institutions and the SECOORA glider observatory at the Underwater Glider User Group conference in Seattle, WA, presenting 4 posters, giving one talk, and leading a discussion group. Outreach events included a Girls Code Games camp, a week-long camp in which middle school girls designed, coded, and demonstrated games based on gliders and the science they enable.

The glider observatory has been awarded significant external funding to supplement baseline operations, including $675k to purchase a new glider and fund 3 deployments per year in the 2023

and 2024 seasons. Data from 2022 deployments during hurricane season were assimilated into Navy and NOAA models, including RTOFS, the operational ocean model used by NOAA coupled with meteorological models for tropical storm predictions. SkIO also supported deployment, piloting, and recovery of 4 Navy gliders made available through a Navy/NOAA partnership and OMAO funding. SkIO deployed and led recovery for a deep Navy glider that sampled for over 6 months in the Sargasso Sea before crossing the Gulf Stream for recovery with partner SC-DNR.

PI Edwards also participated in a continuing collaboration with NOAA AOML/PMEL scientists to coordinate gliders with 5 Saildrones during hurricane season, including 1 Saildrone in the South Atlantic Bight. Edwards assisted with design and implementation of the Saildrone sampling in the SAB and GoM, including coordination of Saildrones with gliders, multiple NDBC and CDIP buoys, and one NOAA OMAO cruise at GRNMS. This work received significant press, in part through media participation in a glider deployment next to Saildrone 1059 at Gray's Reef, and has thus far resulted in 2 publications (EOS, BAMS) and 13 presentations at national meetings (AMS Tropical, AMS annual meeting, Ocean Sciences, CLIVAR workshop). Efforts are underway for 2023 operations, which will include coordinated glider and saildrone sampling near the edge of the Gulf Stream, where air-sea interaction can be significant. A pending proposal led by G. Foltz would fund analysis of coordinated glider/Saildrone sampling ($120k).

Improving Hurricane Forecasting with Gliders – IOOS Regional Associations

Accelerate Improvements in Hurricane Intensity Forecasting Through Underwater Glider Field Campaigns

Principal Investigator: *Gerhard Kuska, MARACOOS*

Timely and accurate hurricane track and intensity forecasts are critical for coastal communities to prepare and evacuate or shelter in place to save lives and mitigate property damage. While track forecasts have improved over the last 30 years, intensity forecast improvements have lagged. Models require more accurate ocean and atmospheric initial conditions to improve intensity forecasts. This is primarily accomplished through a complementary suite of observing systems (e.g., satellites, aircraft, crewed and uncrewed surface vessels, buoys, profiling floats, and underwater gliders).

Gliders capture high resolution vertical profile data within the water column. This allows them to identify and characterize water masses associated with regional oceanographic features and map the distribution of ocean heat content, which has been linked to rapid Atlantic hurricane intensity changes. Accurate representation of these essential ocean features in ocean models is critical for improving storm intensity forecasts. A distributed network of partners (including Integrated Ocean Observing System (IOOS) Regional Associations, NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), the U.S. Navy, private industry and academic institutions) have demonstrated the use of 'hurricane gliders' to measure essential ocean features in hurricane-prone regions of the Caribbean Sea-Tropical Atlantic Ocean, Gulf of Mexico, the South Atlantic Bight, and Mid-Atlantic Bight. The glider data are submitted to the U.S. IOOS National Glider Data Assembly Center, where they are delivered through National Weather Service (NWS) pipelines for assimilation into operational NOAA models.

The goal of this project is to employ the multi-regional hurricane glider network to provide a dedicated ocean observing field campaign during the 2023-2025 hurricane seasons designed to improve NOAA NWS hurricane intensity forecasts. The network will comprise targeted and sustained glider deployments that collect temperature and salinity profiles needed to accurately represent ocean features in ocean-atmosphere coupled models used for hurricane intensity forecasts. Four IOOS Regional Associations, MARACOOS, SECOORA, CARICOOS, and GCOOS, will operate the hurricane glider network in close partnership with NOAA IOOS, AOML, Environmental Modeling Center (EMC), and other NOAA line offices, as well as the U.S. Navy, and academic institutions.

Southeast and Caribbean Disaster Resilience Partnership

Southeast and Caribbean Disaster Resilience Partnership (SCDRP)
Principal Investigator: *Heather P. McCarthy, Southeast and Caribbean Disaster Resilience Partnership*

The Southeast and Caribbean Disaster Resilience Partnership (SCDRP) is the primary network for professionals in emergency management, climate adaptation, and disaster preparedness, recovery, and resilience specifically in the U.S. Southeast (NC, SC, GA, and FL) and Caribbean. Organizationally, SCDRP is an affiliate program of SECOORA, led by an Advisory Board, and staffed by an Executive Director and a Program Coordinator.

Over the last year, SCDRP has experienced exceptional growth in the number of active, dues-paying members – rising from 37 in April 2022 to 142 members in April 2023! Similarly, the number of members plus participants (not dues-paying) grew exponentially to 544. SCDRP adopted a new membership model, conducted a successful Fall Membership Drive which doubled membership from 42 to 84, adopted formal Policies & Procedures for the Advisory Board, and held the first official election of new Advisory Board Members.

For the first time in three years, the Partnership was able to convene in-person, and registration for the SCDRP 2023 Annual Meeting in Miami, Florida reached maximum capacity at 120 registered attendees. The theme of the meeting was *"Responding to the Urgency: Working Together to Build Effective & Inclusive Resilience."* During the nine sessions, speakers and panelists addressed how to build effective resilience in our communities through a) unique partnerships across larger areas that share common vulnerabilities, b) inclusive, equitable, community-based solutions, and c) taking actions with immediacy and urgency. The 2023 Annual Meeting kicked off with inspirational keynote addresses from Mayor Levine-Cava of Miami-Dade County and Assistant Secretary-General Hart of the United Nations. The meeting was uniquely marked by the engagement of political and military dignitaries and special VIP speakers from the nations and territories of the Caribbean.

During the coming year, the newly expanded Advisory Board will update the *SCDRP Strategic Plan* with a revised vision, mission, core values, and 3-year strategic goals. The Development Committee will seek grant funding to advance solutions that address continuous and emerging regional resilience issues. The Governance Committee will revise the Policies & Procedures for the Advisory Board, and write new Policies & Procedures for Advisory Board Elections, Membership, and Committees. The Partnership Committee will pursue a broader diversity of members and scale-up resources and educational opportunities provided to members and communities. With time, SCDRP aims to become an autonomous, durable, and membership-supported organization to better serve our members, communities, and region.

Drones in the Coastal Zone - SECOORA

Support and expand the existing Drone in the Coastal Zone Community of Practice (DITCZ CoP)
Principal Investigator*: Abbey Wakely, SECOORA*

Uncrewed Aircraft Systems (UAS), or drones, are a rapidly growing component of research, assessment, and monitoring of coastal regions within the U.S. Southeast and the Caribbean. SECOORA, with SE National Estuarine Research Reserve System (NERRS), NOAA Southeast and Caribbean Regional Team (SECART), Duke University and the NOAA's National Centers for Coastal Ocean Science (NCCOS) Beaufort Lab, hosted the Drones in the Coastal Zone virtual workshop series in October 2020 (https://secoora.org/drones-in-the-coastal-zone-workshop/). This series covered aspects of drone technology including governmental policy and procedures, mission planning, data management, demonstrations on emerging drone technologies, and more. There were over 250 participants from NC, SC, GA, FL, and the Caribbean.

A Drones in the Coastal Zone CoP is being established to continue supporting the sharing of knowledge and best practices related to the use of drone technologies to support coastal research. The following tasks will be supported to better establish the CoP:

- Year 1: The SECOORA Communications Director will develop the Drones in the Coastal Zone CoP webpage with links to projects, resources, latest news, and past and future workshop materials. The webpage will be hosted on the SECOORA website.

- Year 1: SECOORA will work with Duke University and NOAA NCCOS Beaufort Lab to host a 2-day regional workshop that builds off the virtual workshop hosted in 2020. The workshop will advance the understanding of applications of drone data to key coastal and ocean management issues.

- Year 1 and Year 2: SECOORA will host a competition for winners to attend a 3-part UAS executive education course offered by the Nicholas School of the Environment at Duke University to build capacity in the region for implementing the technology and understanding the data. SECOORA, in collaboration with CariCOOS, will sponsor six candidates each year from the US Southeast and Caribbean region to attend. Each online course is six weeks in duration, and includes asynchronous video lectures, weekly 1.5-hour virtual synchronous sessions, projects and assessments, and inclusion into a growing online community of UAS researchers. After successful completion of all three courses, applicants will receive a certificate of completion.

Ecosystem: Water Quality & Living Marine Resources

Regional Surface Elevation Table (SET) Coordination – SECOORA

Regional SET Coordination

Principal Investigator: *Heather P. McCarthy, SECOORA*

Current and future coastal zone management decisions rely on consistent, comparable, and accessible scientific datasets assessing the impacts of sea level rise on coastal marshes. Wetland ecologists measure incremental changes in the elevation of coastal marshes over time using monitoring equipment known as Surface Elevation Tables (SETs). SET data help determine the extent to which marshes are a) retaining enough sediment to keep up with sea level rise, or b) transitioning to open water. Southeast coastal zone managers have expressed the need for additional SET monitoring stations across the region to increase data available on marsh resilience to sea level change. Throughout NC, SC, GA, and FL, SETs are installed and managed by researchers from NOAA National Estuarine Research Reserves, U.S. Geological Survey, U.S. Fish and Wildlife Service, National Park Service, The Nature Conservancy, academic institutions, and others. There is the need for integrated regional coordination on SET installation, standardized protocols, and an accessible SET data repository in the Southeast.

In February 2023, SECOORA embarked on a new initiative with the overarching goal of establishing a Southeast SET Community of Practice to address this regional ocean data sharing need. The Regional SET Coordinator (Heather McCarthy) is spearheading this initiative to bring together southeast SET practitioners and their research. The Regional SET Coordinator gave a presentation at the NC SET Community of Practice Workshop in Morehead City, NC on March 31, 2023, and initiated collaborations with the researchers and coastal zone managers in attendance.

The major goals during the first two years of SECOORA's initiative are:

1. Expand and enhance the regional inventory of SETs in NC, SC, GA, and FL.
2. Conduct a gap analysis in conjunction with experts in each state.
3. Formalize a Community of Practice (CoP) focused on sharing best practices and creating new knowledge around the data and its applications.
4. Host a 2-day Regional SET CoP Workshop to focus on data management and installation locations.

5. Coordinate with data management contractors to develop the framework for integration and viewing of standardized SET data for the region.
6. Oversee the installation of 16 new SETs in the region.
7. Work with regional SET experts and data management specialists to further develop a useful database of regional surface elevation information and trends.

A regional SET database is challenged by inconsistencies in research methods, metadata, vegetation types, confounding variables, and availability of unpublished data. The value of some data points is compromised if the SETs were part of experimental manipulations, or the SETs have been read for less than 3-5 years.

The FACT Network and DaVIT – The Fact Network

Let's get together: the FACT Network

Principal Investigator: *Joy Young, PhD*

The FACT Network is a collaboration dedicated to improving the conservation and management of aquatic animals by facilitating data management amongst researchers using acoustic telemetry, providing a community for scientists, and building stakeholder partnerships. Founded in 2008, it has grown to include much of the Southeast United States and parts of the US Caribbean, Bahamas, and eastern Gulf of Mexico. Participating researchers support over $4.7 million in telemetry assets currently in the water. Animals tagged with an acoustic tag are detected on mobile or stationary receivers. Detection data from the receivers are retrieved on a semi-annual basis. By sharing tag metadata and detections, researchers can effectively track their animals well beyond their individual array of receivers. Network members meet twice a year (virtually or in person) and contribute data (detections and tag and receiver metadata) via a password protected website. Data are processed in a cloud-based system called the FACT node. Data processed in the node are cross matched against data in all other compatible nodes, connecting the entire east coast of North America and parts of Central and South America. The connectedness lends itself to large-scale projects and discovery of novel movements. In year 2, accomplishments included a two-day in-person meeting, improvements to the FACT website, an active student sub-group, and growing the FACT node. The two-day meeting supported a workshop on scientific communication (i.e. learning how to write for a non-scientific audience) and a student-led workshop on range testing which evolved into a publication in progress. The FACT website added new pages that allow members to join FACT, learn how to submit data and download data form templates- streamlining the process of onboarding new members. In addition to the meeting workshop, the FACT student group sought out scientists and organized a webinar on data analysis. The FACT database is one of the largest in the world, with almost 10% of growth per year. The database currently houses over 240.5 million detections and 9,516 tags on 119 species. Challenges in year 2 included an under-staffed data team. FACT is ingesting and processing the same amount of data as other networks with multiple full-time people. To help distribute the work through time, we began requesting researchers submit data as they are collected, not just at submission deadlines. We also implemented monthly calls between the data team members. Year 3 objectives are to continue to grow the network, increase our Moorings of Opportunity and Receiver Loaner programs, support member-led initiatives, create data products, and represent FACT on national and global scales.

See what's tracking: the FACT DaViT

Principal Investigator: *Joy Young, PhD*

The FACT Data Visualization Tool (DaViT) is an exciting new tool to enhance research using animal observations and bridge the gap between the public and scientific communities. The interactive web map which displays animal movements by species is embedded in the FACT website, hosted by our regional IOOS association, SECOORA (https://secoora.org/fact/data-visualization-tool/). Designed with the guidance of stakeholders and the FACT community, it went live in summer 2022 with data from 32 tagging projects. Since then, it has grown to display data from 52 projects on 68 species. Year 2 objectives centered on improving the useability of the website and accuracy of the visualizations. We collaborated with the Atlantic Coast Telemetry network and Ocean Tracking Network (OTN) to create a comprehensive receiver map, which will be embedded into the FAQs

section, or as a toggle on the map. Language was updated to illustrate metrics are calculated within the receiver network, months were changed from numbers to words, and five new project pages were created that link out from the visualizations. Challenges included some delays due to staff turnover and researcher uncertainty on their authority to allow their information to be displayed. However, with the growing popularity of the DaViT we have seen improvements in participation. Year 3 objectives are to augment researchers' detection extracts with species level QC flags, adapt the DaVit to ingest detections based on QC flags, and change the algorithm used to calculate range and distribution to stay within the confines of the receiver networks. To help accomplish these objectives, FACT advertised a student opportunity through our social media sites. A graduate student was selected in early April and will begin work identifying machine readable sources for home range and maximum swim velocity. In collaboration with colleagues from OTN and the Integrated Marine Observing System in Australia, QC filters from a software package (Remora) will be adapted to include the student-created dataset. Progress has already been made adapting Remora including updating the code to ingest FACT-formatted data, adding customization of parameters, and testing the process. Because the DaViT is based on detection data ingested from a node, this tool may transplanted and used by any network using the same system. Thus, improvements to the FACT DaViT will benefit multiple other networks in different IOOS regions. We are energized by the success and usefulness of the DaViT- go check it out!

BioTracks – University of Miami

Towards a MBON-ATN acoustic telemetry data project to map and monitor marine biodiversity hotspots

***Principal Investigators**: Neil Hammerschlag[1,2] and Thiago B. A. Cout[2],*
[1]Atlantic Shark Expeditions Ltd., [2]Rosenstiel School of Marine, Atmospheric, and Earth Science, University of Miami

The overall goal of this project is to integrate historical and newly acquired acoustic animal tracking data into biodiversity monitoring, and ultimately generate data visualizations of marine biodiversity hotspots that will be useful for conservation and natural resource management. These multi-species hotspots will be analyzed with respect to essential ocean variables to identify the key environmental and biological drivers behind them. Current and projected hotspots and migration corridors will be overlayed with place-based management zones to highlight areas vulnerable to exploitation. This is focused on the Gulf of Mexico, Caribbean and Western North Atlantic. This collaborative A-BioTrack project, is a joint initiative of the Animal Telemetry Network (ATN) and of the Marine Biodiversity Observation Network (MBON). Over the past year, this project had two major accomplishments. First, we acquired data from 66 separate acoustic telemetry projects, comprising 51 principal investigators from 38 institutions (>100 people with co-PIs and collaborators). The data set acquired included 43 million acoustic detections from 3,509 unique receiver locations within the study area. Overall, 69 species were detected: teleost fishes (39), sharks (16), rays (8), turtles (4), sturgeons (2), mammals (1), crustaceans (1). Second, we began an integrated special distribution modeling approach of these data, using spatial occupancy models, integrating both acoustic tracking and OBIS data into our spatial analysis. We are currently in the processes of creating and mapping shared multi-species hot spots. Challenges included delays in receiving data from contributors and those not wishing to share. Within the next year, we aim to (1) finish spatial analysis and map shared multi-species hot spots from species distribution modeling of tracking locations and covarying remotely sensed variables; (2) overlay these aggregated biodiversity hotspots with place-based management zones to highlight and map areas protected from and vulnerable to exploitation; (3) create and disseminate map visualizations of these protected and vulnerable biodiversity hotspots; and (4) preparation of a peer-reviewed scientific paper for submission.

South Carolina Soundscape Observatory – University of South Carolina Beaufort

The Estuarine Soundscape Observatory Network in South Carolina (ESONS)

***Principal Investigators**: Eric W. Montie[1, 2] and Alyssa Marian[1], [1] Department of Natural Sciences, University of South Carolina Beaufort, SC, [2] Graduate Program in Marine Biology, College of Charleston, SC*

The Estuarine Soundscape Observatory Network in South Carolina (ESONS) monitors underwater sounds and noise using passive acoustic recorders in four estuaries including the May River (n=3 stations, 2013 - present), Port Royal Sound (n=2, 2019 - present), Charleston Harbor (n=3, 2017 - present), and North Inlet-Winyah Bay (NI-WB) NERRS (n=1, 2020 - present). Soundscape data are used to monitor animal behavior at multiple levels of biological complexity (i.e., from snapping shrimp to fish to marine mammals) and at time scales ranging from minutes to years. The soundscape approach allows the ability to 'eavesdrop' on key behaviors of marine animals that can change rapidly or gradually in response to environmental changes and human impacts, thus providing a measure of resilience or shifting baselines for economically important or protected species. Passive acoustic platforms provide sound files at a high temporal resolution of two minutes every hour. Acoustic records from this network assist in tracking soundscape endpoints: (1) received root mean square (rms) sound pressure levels (SPLs) over various bandwidths; (2) snapping shrimp acoustic behavior; (3) courtship sounds and spawning potential of soniferous fish; (4) vocalizations of marine mammals; and (5) anthropogenic noise detections.

During Year 2, we serviced all nine recorders. At one station in May River (i.e., 14M), we lost data from 8/4/22 – 9/28/22 due to hydrophone failure. We have entered soundscape endpoints and associated metadata from 2/20/2013 to 6/16/2021 into Research Workspace with some data/stations to 9/28/2022. Our biggest accomplishment is a publication in *PLOS ONE* on the Charleston Soundscape that was highlighted by their press team. Six passive acoustic recorders were deployed in the Charleston Harbor from December 2017 to June 2019 to determine biological patterns and human-associated influences on the soundscape. Despite anthropogenic noise, biological sound patterns were identified including snapping shrimp snaps, fish calling and chorusing, and bottlenose dolphin vocalizations. Biological response to anthropogenic activity varied among trophic levels, with decreased detection of fish calling when anthropogenic noise occurred and increased dolphin vocalizations in the presence of anthropogenic noise. Statistically, fine-scale, temporal patterns in biological sound were not clearly identified by SPLs, until files with anthropogenic noise presence were removed. These findings indicate that SPL patterns may be limited in their interpretation of biological activity for noisy regions and that the overall ecological, acoustic signature that we find in more pristine estuaries (like May River and Port Royal Sound) is lost in Charleston Harbor.

The biggest challenge in this project is manually reviewing acoustic files, which is labor intensive. We are working with Conservation Metrics on a proposal to apply machine learning to identify and quantify sound-producing organisms. During year 3, our objectives are to (i) continue servicing ESONS recorders, (ii) complete soundscape endpoints through 2023, (iii) incorporate data into Research Workspace, and (iv) understand bottlenose dolphin vocalizations and relationships to dolphin sightings and prey in Charleston Harbor.

Water Quality Decision Support Tools – University of South Carolina

Integrated Decision Support and Management Tools for Adaptive Public Health Practices: An Early Advisement and Reporting System for Recreational and Shellfish Harvesting Waters of the Southeast

***Principal Investigators**: D.E. Porter[1], D. Ramage[1], H. Kelsey[2], N. Miller[2], N. Nelson[3], A. Cook[4] and K. Claridge[4]*
University of South Carolina[1], University of Maryland Center for Environmental Science[2], North Carolina State University[3], Mote Marine Laboratory & Aquarium[4]

The overall goal of our five-year SECOORA project is to integrate, enhance, and expand our respective How's the Beach (HTB; howsthebeach.org), ShellCast (https://ncsu-shellcast.appspot.com/) and Beach Conditions Reporting System (BCRS; https://visitbeaches.org/map) initiatives. Working with public health officials, resource managers, municipalities, tourism and chamber of commerce officials, the public and other identified end users

we are:

- provide access to relevant data and information on water quality and safety to support improved decision making;
- geographic expansion of the HTB and ShellCast nowcasting / forecasting efforts in recreational waters and shellfish harvesting waters; and
- support the integration of the BCRS to allow for citizen reporting of beach conditions.

Highlighted Year 2 accomplishments include:

- Expansion of the HTB nowcasts in NC and initiation of discussion with the Institute for Water and Health at Georgia Southern University to expand the HTB into GA.
- Restructuring the ShellCast app's architecture and expanding into SC (to be released in Year 3), with the SC expansion being facilitated by engagement with the SC Departments of Health and Environmental Control and Natural Resources
- Executed a Data Sharing Agreement (DSA) between USC and the FL Department of Health to allow for pushing of enterococci bacteria monitoring data from the FL Healthy Beaches Program for ingest into the HTB nowcasts in support of expanding HTB to additional areas in FL.
- Implementation of technical plans to integrate the BCRS into the HTB decision-support tool, and HTB nowcasts into the BCRS via external links.

Year 3 objectives include working with EPA partners to assess their 'Virtual Beach' modeling toolset and host a modeling workshop for beach managers and regulators; the current ShellCast website will be reiterated with the expansion of forecasting of conditions in shellfish harvesting waters of SC; continue implementation of technical plans including web development and design, volunteer outreach and data sharing abilities for further integration of HTB, the BCRS and ShellCast to support geographical and thematic expansion of the decision-support tools and provide a transition plan; develop and disseminate educational and outreach materials to provide broader exposure to the SECOORA-supported tools and applications; and the development of an API to support automated pulling of nowcasts and forecasts.

Gray's Reef Mooring – University of Georgia

Ocean acidification time-series mooring at Gray's Reef National Marine Sanctuary
***Principal Investigators**: Scott Noakes, Ph.D., The University of Georgia*

Operation of the Grays Reef time-series mooring has been a multi-organization effort which has successfully collected high-resolution data since 2006. The mooring is located in the South Atlantic Bight offshore Georgia, USA and within the boundaries of Gray's Reef National Marine Sanctuary. It sits along the divide between the inner and middle shelf with water depths of 20 m. Water chemistry is primarily controlled by the middle shelf oceanic dynamics, but during heavy rain events, it can be affected by freshwater plumes coming from the numerous rivers along the Georgia and South Carolina coast. Temperature also plays a major role in the partial pressure of carbon dioxide (pCO_2) variability with seasonal changes being apparent. During summer months, GRNMS acts as a CO_2 source to the atmosphere while during winter months it is a CO_2 sink. The benthic community at GRNMS has proven to be hardy enduring large seasonal swings of seawater CO_2 and pH.

As with any research station located approximately 20 nautical miles offshore, biofouling, sea state, marine life and yes, humans have often made it difficult to keep the Gray's Reef monitoring station operational. It is not uncommon to find fishing hooks and line tangled in the data cables and tubing associated with the CO2 monitoring system. Hungry fish often bite the submerged cables and floating debris slam into the sensors mounted under the buoy. However, given all these challenges, the system has managed to operate with little down time.

In addition to the monitoring effort offshore and a direct response to the challenges just mentioned, a new buoy design is currently being investigated that will allow for the submerged sensors to be deployed from the surface rather than diver deployed. This design will protect the sensors and the

associated cables from being damaged while mounted under the buoy. Once divers are no longer required to work under the buoy, servicing operations on the CO_2 system can be conducted in slightly rougher seas making it a little easier to schedule offshore work.

Research planned for the sanctuary utilizing the CO_2 data will be aimed at determining how the organisms currently residing at Gray's Reef cope with the seasonal changes and how they will adapt to rising seawater CO_2 over time. Without the CO_2 data generated by this monitoring station, these studies would not be possible.

Ocean Acidification Monitoring in Lower Florida Keys - Mote Marine Laboratory

Coral Reef Acidification Lower (CoRAL) Keys: SeapHOx deployment to monitor long-term seafloor pH

***Principal Investigators**: Emily R. Hall, Mote Marine Laboratory and Janet Reimer, University of Delaware*

The Southeast is the only continental US region with expansive shallow-water coral reefs. Florida's coral reef is made up of zones of living coral reefs and associated habitats that parallel the Florida Keys. The adjacent Florida Bay lies between the Everglades freshwater ecosystem and the seagrass and coral-reef ecosystems of the Keys and often feeds fresher water into the Keys, causing large seasonal variations in temperature, salinity, and turbidity on the reefs, especially those nearshore. The lower Keys, Bahia Honda Key to Key West, harbor high biodiversity and the most abundant coral cover within the region. Looe Key is the second longest established Marine Protected Area (MPA) in the Florida Keys and has been studied for decades. These reefs represent one of the most vulnerable habitats to coastal ocean acidification (OA) in the US.

OA, or the pH decrease due to anthropogenically-induced pCO_2 increase, is a concern for the Florida Keys region and beyond. Coral reef species vary in susceptibility to environmental stressors, which leads to shifts in community structure. Recent studies indicate that OA is already impacting net reef accretion rates within some regions of the Florida Keys and that pCO_2 in Southeast sub-tropical waters is increasing. The increase in oceanic and coastal pCO_2 could profoundly affect organismal physiology, the carbonate structure of the substrate, and overall ecosystem functioning. The Southeast currently lacks a cohesive OA monitoring approach and network. There are only three climate-quality long-term continuous OA monitoring locations in the region: Cheeca Rocks in the surface waters of the Florida Keys (NOAA Coral Reef Conservation Program, NOAA Ocean Acidification Program), Tampa Bay (USGS, EPA, and Tampa Bay Estuary Program), and Gray's Reef National Marine Sanctuary (NOAA Ocean Acidification Program), along with a few grassroots and research-driven efforts. While there are multiple water quality programs throughout the Southeast, these programs lack the ability to directly measure carbonate chemistry with the quality and frequency necessary to determine acidification impacts to species and communities.

The project team will deploy a seafloor OA mooring that will produce directly measured climate-quality pH and other carbonate chemistry data products to establish a unique time series in the lower Florida Keys. This will also provide support for the Southeast Coastal and Ocean Acidification Network (SOCAN) for OA monitoring in the FL Keys, end-user engagement, increased spatial monitoring coverage for OA monitoring; all of which will ultimately support future spatio-temporal modeling for the Florida Keys and the South Atlantic Bight. Year 1 accomplishments to date include: secured funding, Florida Keys National Marine Sanctuary and Army Corps of Engineers permitting application process, purchase of a new SeapHOx and a seafloor mooring component.

Southeast Ocean and Coastal Acidification Network

Update on the Southeast Ocean and Coastal Acidification Network

***Principal Investigators**: Emily R. Hall, Mote Marine Laboratory and Janet Reimer, University of Delaware*

The Southeast Ocean and Coastal Acidification Network (SOCAN) was established in February of 2015 through a partnership with the Southeast Coastal Ocean Observing Regional Association (SECOORA) and NOAA's Ocean Acidification Program (OAP). The Acidification Networks are charged with catalyzing partnerships and leveraging resources to move regional acidification network efforts forward. SOCAN has significantly increased NOAA OAP's regional capacity building efforts by tailoring messaging to the unique societal climate of the US Southeast and working with stakeholders to build awareness and prioritize monitoring efforts for understanding acidification in this region. SOCAN has taken a leadership role in synthesizing and applying available science in addition to serving in funding proposal coordination roles throughout the Southeast since its inception. SOCAN continues its core commitments to advance acidification knowledge and communicate research findings to stakeholders and decision makers, as well as work to assess research and monitoring gaps, societal, economic, and vulnerability needs in the Southeast.

This past year, SOCAN committed to the work outlined in the Coordinated Ocean Observations and Research Act of 2020 and to working with the Interagency Working Group OA (IWGOA). SOCAN participated in more frequent collaboration among the CANs (especially the Gulf of Mexico CAN [GCAN]) to assess research and monitoring gaps as well as overall social and economic vulnerabilities and were awarded a build-out grant to collect information on social and environmental vulnerabilities in the US Southeast and Gulf of Mexico. Together, SOCAN and GCAN created a question-and-answer survey to engage stakeholders asking them to prioritize research and monitoring needs across both regions based on identified gaps in the draft IWGOA Coastal Communities Vulnerability Assessment. SOCAN and GCAN hosted a number of workshops (in person and virtual) to different stakeholder organizations throughout the regions providing a summary of OA work as well as the survey. Results of the survey are currently being synthesized.

SOCAN has held one virtual Townhall on OA and Mangroves and is planning a second Townhall on marine carbon dioxide removal (mCDR) and blue carbon. SOCAN has also continued its social media presence on Twitter, Facebook, Instagram, the Ocean Acidification Information Exchange, and email updates to members. SOCAN completed a major overhaul of the SOCAN website that includes Working Group members, links to data, links to recent Town Halls, reports, other related media, and recent research papers by members. SOCAN continued its core effort to submit proposals that include collaborations with members interested in pursuing acidification monitoring, coastal community vulnerability research, and outreach and education. SOCAN also continued to pursue new partnerships and collaborations with stakeholders. SOCAN participated in a number of workshops and conferences including the International GoM Ocean Acidification Meeting in Merida, Mexico, a MACAN webinar, the OA Day of Action, the South Carolina Water Resources Meeting, South Carolina Sea Grant's Science Educators Café, AGU, and the CHNEP Florida Climate Summit.

Sargassum Forecasting – University of South Florida

Monitoring and forecasting pelagic Sargassum in the South Atlantic Bight
***Principal Investigator**: Chuanmin Hu, University of South Florida*
***Project team:** Brian Barnes, Yuyuan Xie, Ruoying He, University of South Florida*

The overarching goal is to develop and operate Web-based system to monitor and forecast pelagic *Sargassum* in several coastal zones of the Florida Keys and South Atlantic Bight.

Year 1 and Year 2 objectives:

1. to develop and validate algorithms suitable for high-resolution satellite data to map and quantify *Sargassum* distribution and abundance.
2. to generate prototype high-resolution imagery products to map and quantify *Sargassum* distribution and abundance.

Year 1 and Year 2 accomplishments:

- Developed a machine learning algorithm to detect Sargassum on beaches and in nearshore waters from high-resolution (3-4 m) satellite imagery (Zhang et al., 2022). This will make it possible to monitor Sargassum in nearshore environments.

- Developed a machine learning algorithm to detect Sargassum from coarse-resolution images (e.g., MODIS) (Hu et al., 2023). This will make it possible to fill some of the data gaps in the nearshore environments (> 10 km from shore).
- Implemented infrastructure for automatic download and processing of Sentinel-2 data for selected areas (e.g., Florida Bay)

Challenges:

- More evaluation and improvement of algorithms and data products for automatic and operational production
- Near real-time satellite data stream from the data provider (e.g., PlanetScope)
- Implementation of algorithms and data products for automatic production on the Web
- Integration with numerical models

Plans for next year:

- Finish algorithm development, and make robust data products;
- Finish computer programs for automatic satellite data downloading and processing in near real-time;
- Start integration with numerical models.

Harmful Algal Bloom Monitoring in Georgia – University of Georgia

Establishing a monitoring program and identifying environmental drivers of HABs in a model estuary of coastal Georgia

Principal Investigators: *Natalie Cohen[1], Katie Higgins[2]*
[1]University of Georgia Skidaway Institute of Oceanography, [2]University of Georgia Marine Extension and Georgia Sea Grant

HABs are known to negatively impact ecosystem health along the southeastern US, yet monitoring efforts in Georgia (GA) lag behind those conducted in adjacent states. In 2017, a bloom of the dinoflagellate *Akashiwo sanguinea* resulted in a shellfish morality event at the UGA Shellfish Research Laboratory in the Skidaway River Estuary, demonstrating that HAB events that do occur in coastal GA have the potential to close fisheries. Historically, HAB events have been poorly documented and characterized in GA, likely resulting in an underestimation of their prevalence in the state. This project builds upon NOAA's existing citizen science-based initiative, Plankton Monitoring Network, by incorporating high resolution quantitative HAB monitoring over the course of two years in a model estuary. The overarching goal is to determine environmental conditions conducive to HAB formation in Georgia estuaries.

Weekly physicochemical parameters, cell densities, and nutrient measurements began in January, with daily sampling planned for late spring/early fall to capture biological and chemical transitions in the phytoplankton community. By monitoring over this period, we plan to establish the seasonal timing of HABs, and will begin to document their relationship with water quality parameters. Plankton Monitoring Network qualitative data and preliminary cell counts from Summer 2022 suggest the HAB species *Akashiwo sanguinea* increases in abundance in the late summer, coinciding with high estuary temperatures. If a high densities of *A. sanguinea* appear this upcoming summer, genomic sequencing will be conducted to examine molecular underpinnings of these events, which may elucidate drivers of their growth. This monitoring program is the first step in establishing a regional notification network in which HAB occurrences are communicated to local residents and regional aquaculture organizations. We plan to broadcast HAB occurrences on the SECOORA website over the summer months to inform stakeholders of estuarine conditions in near real-time.

Southeast US Marine Biodiversity Observation Network (MBON) – SECOORA

Climate Change Indicators Across the National Marine Sanctuaries System

Principal Investigators: *Frank Muller-Karger, University of South Florida (USF); Jennifer Dorton, SECOORA; Chris Simoniello, GCOOS; Joshua Kilborn, USF; Rebecca Zarger, USF*

Changes in climate have led to changes in physical and biogeochemical characteristics of the Earth's system that affect marine life and ecosystem services. The project team will co-develop operational data products for the NOAA National Marine Sanctuary (NMS) System based on historical and ongoing physical and biogeochemical datasets. The team is comprised of Investigators and Collaborators from the University of South Florida, SECOORA, GCOOS, Florida Keys National Marine Sanctuary, NOAA Atlantic Oceanographic and Meteorological Lab, NOAA CoastWatch, and Flower Garden Banks National Marine Sanctuary. SECOORA and GCOOS are leading the stakeholder engagement process. During Year 1, they are conducting interviews with the four NMS in the SE US (Monitor, Gray's Reef, Florida Keys, and Flower Gardens) and will host virtual meetings with NMS staff to identify essential ocean variables and climate threshold data and product needs. The project team and the NMSs will iteratively develop data products throughout year 1 that are relevant to Sanctuary Condition Reports and help with overall Sanctuary management. In years 2-3, GCOOS and SECOORA will expand stakeholder engagement to additional NMS.

Overall, the project will characterize the frequency, timing, intensity, and synergistic organization of Essential Ocean Variables (EOVs) that may affect biology and ecosystem processes throughout the NMS System. The approach will be to co-develop synthesis products based on historical time series of environmental observations, including indicators, and sets of user tools that are consistent and have the same user interface. Products will be developed jointly and transitioned to operations working with the Integrated Ocean Observing System including the Marine Biodiversity Observation Network (IOOS, MBON), the NOAA Science Council's Ecosystems Indicator Working Group (National Marine Ecosystem Status or NAMES), the NOAA Climate Program, regional Integrated Ecosystem Assessment (IEA) programs, and others as appropriate.

This project was funded through NOAA-OAR-CPO-2022-2006799

Size Matters: Innovative Length Estimate (SMILE) – SECOORA

Size Matters: Innovative Length Estimate (SMILE)

Principal Investigators: *Alli Candelmo, Reef Environmental Education Foundation (REEF); Julie Bryd, South Atlantic Fishery Management Council's (SAFMC) Citizen Science Program; Jennifer Dorton, Southeast Coastal Ocean Observing Regional Association (SECOORA); Lauren Showalter, Axiom Data Science; and Brice Semmens, The Semmens Lab at Scripps Institution of Oceanography*

Size matters – especially when it comes to fisheries management. A new collaborative project SMILE (Size Matters: Innovative Length Estimate) is now underway in the Florida Keys to help collect information about fish lengths. These data are critical for fisheries stock assessments, which are used to manage ecologically and economically important marine species. Funded through NOAA's Coral Reef Conservation Program (CRCP), the SMILE project involves volunteer divers, innovative underwater camera technology, and the expansion of a citizen science approach to collect length data for reef fish in the South Atlantic.

The SMILE project team includes Reef Environmental Education Foundation (REEF), the South Atlantic Fishery Management Council's (SAFMC) Citizen Science Program, Southeast Coastal Ocean Observing Regional Association (SECOORA), and Axiom Data Science. The REEF Volunteer Fish Survey Project, launched in 1993, has successfully worked with trained recreational divers to create one of the largest citizen science-based marine life databases in the world. The SMILE project will incorporate diver-collected fish length data, using stereo video technology, as a companion to the REEF Volunteer Fish Survey Project.

The new data sources will be incorporated into stock and ecosystem assessment processes. The project will also increase awareness of fisheries management issues to the dive community.

The camera technology for this project is being developed by a team of engineers at the University of California San Diego (UCSD), Engineers for Exploration program and The Semmens Lab at Scripps Institution of Oceanography. Field testing and camera technology development was previously supported by UCSD Kastner Research Lab and The Nature Conservancy California, and a grant from the nonprofit Fish & Wildlife Foundation of Florida (FWFF) via proceeds from the 'Discover Florida's Oceans' license plate. A stakeholder panel will provide expertise throughout the project on survey methodology, fish species of interest, and site selection for image collection.

All video files, images, fish species abundance and length data will be made publicly accessible for current research and management needs and future advancement of machine learning technologies.

Data Management, Data Visualization, and Modeling

Artificial Intelligence: Annotation, Data Standards, and Applications – Florida Fish and Wildlife Conservation Commission

Augmenting Ocean Observing through Artificial Intelligence: Annotation, Data Standards, and Applications

Principal Investigators: *Lucas McEachron, David Kochan, Florida Fish and Wildlife Conservation Commission; Lauren Showalter, Axiom Data Science; Enrique Montes, University of Miami; Frank Muller-Karger, Dan Otis, University of South Florida.*

Organizing specialized AI resources (e.g., annotation libraries and model repositories) in a way that allows an end-user to complete an applied AI project, from data formatting to model development to hosting, can be overwhelming. Our team is developing an AI resource on SECOORA's existing digital infrastructure that 1) serves as a gateway to complementary AI resources to avoid duplicity, and 2) hosts reproducible ocean observing pipelines to help regional partners complete AI projects through worked examples.

We continue to document AI annotation libraries, model repositories, standards, metadata and formatting requirements, and storage and access solutions for imagery, video, and acoustic data relevant to ocean observing. This year, we held eight meetings with different industry, academia, non-profit, and government AI stakeholders and domain experts; participated in two machine learning training exercises; participated in three symposia; and held two workshops to scope the research and management community's needs for additional AI resources. In doing so, we added to our knowledge base of available resources and started engaging new partners with the intention of directly linking existing AI portals to SECOORA's digital infrastructure.

Additionally, we advanced three worked example use cases across video, image, and acoustic formats. Our video use case ingests live video from the Florida Aquarium to an Axiom server that is running an anomaly detection algorithm to detect and record coral spawning. We adjusted this pipeline to demonstrate an edge computing application where a modular data buoy will be deployed on Florida's Coral Reef to monitor coral restoration activities via a related anomaly detection model in real time. To advance our imagery use case, we met with CoralNet colleagues to identify backend solutions to integrate with CoralNet's annotation library.

Last, to advance our acoustics use case, we hosted an Acoustic Anthropogenic-Biological Indicators Workshop. Over two days, participants brought together passive acoustic datasets from throughout the southeast, fit and compared novel machine learning models that identified fish and boat patterns, and agreed on metrics relevant to management from model outputs. The workshop identified clear challenges to developing acoustic metrics based on machine learning tools,

including annotation resolution and sound file lengths. Therefore, this demonstrates a clear pathway to address future issues through standardization. In fact, the entire pipeline, from data to model to an index, is in place for further study, and could be incorporated into the modular data buoy via hydrophones.

In the coming year, we will focus on organizing and presenting the AI resources we identified, formalizing connections to other portals, and summarizing our use cases all in a SECOORA hosted digital resource. We intend to have a beta version of the site available for testing and outreach by the end of next fiscal year.

Fisheries Data Access – South Carolina Department of Natural Resources

SEAMAP-SA Data Management Year 2 Abstract

Principal Investigators: *Tracey Smart, South Carolina Department of Natural Resources (SCDNR); C. Michelle Willis, SCDNR*

The Southeast Area Monitoring and Assessment Program, South Atlantic (SEAMAP-SA) fully or partially supports a variety of long-term living marine resource surveys in waters of the Atlantic coast off the Southeast United States (generally referred to as the South Atlantic). SEAMAP-SA supported surveys include the Pamlico Sound Survey managed by North Carolina Department of Environmental and Natural Resources (NCDENR), the Southeast Reef Fish Survey managed by South Carolina Department of Natural Resources (SCDNR) and Southeast Fisheries Independent Survey at the Southeast Fisheries Science Center, the Coastal Trawl Survey managed by SCDNR, and the Coastal Longline Survey managed by NCDENR, SCDNR, and the Georgia Department of Natural Resources (GADNR). In addition, SEAMAP-SA supports data visualization development for the South Atlantic Fisheries Management Council through the Florida Fish and Wildlife Research Institute (FWRI). SEAMAP-SA supports housing survey data in a publicly-accessible online database, but the current database is limited in functionality and user tools. SECOORA is currently supporting the migration of the SEAMAP-SA online database into the SECOORA data portal managed by Axiom Data Science to enhance user experiences and this migration is currently underway.

Year 2 objectives included providing updated and complete data provision from all surveys for the most recent sampling year available, the addition of turtle data, system testing for front-end user functionality, multi-species selections, and further DarwinCore metadata development and table header conversion. Accomplishing year 2 objectives started slowly, as portal development continued to be delayed from COVID-19 staffing issues. However, in the second half of the reporting period newly hired programmers were brought up to speed and portal development rapidly accelerated. New survey data was imported into the data portal and correctly displayed in the front-end component of the portal during testing. Axiom made significant progress on the administrative component of the portal, which will be used by SEAMAP-SA staff to upload and import data, update code tables, and make revisions to data tables as needed. SEAMAP-SA and Axiom staff met bimonthly to discuss progress, troubleshoot, and prepare for next steps. Bimonthly meetings are scheduled to continue into year 3 as the final phases of development are completed.

In year 3, we will involve data users in project development via polling for desired summarization products. SEAMAP-SA and Axiom staff will prepare training videos for data access, summarization, and visualization tools. Axiom will finalize the development of the administrative portal component for SEAMAP-SA administrators at SCDNR. Near the end of year 3, vigorous portal testing will be performed by SEAMAP-SA staff in anticipation of year 4 portal rollout.

Data Management and Communications – Axiom Data Science

SECOORA Data Management and Communications Services

Principal Investigators: *Lauren Showalter and Kyle Wilcox, Axiom Data Science*

As a member of IOOS, SECOORA has a mandate to collect, organize, and provide access to regional oceanographic data. These data need to be quality reviewed, understandable, discoverable, electronically accessible, and well organized to allow researchers, policy makers, industry, and the public to make well-informed decisions. To satisfy this mandate, SECOORA supports a web-based data portal for the region providing ocean, coastal, and watershed environmental data and information products.

The goals of the SECOORA data management system are to: i) curate multiple data streams from the sensors and models supported by SECOORA as well as from independent data providers, ii) document data using IOOS-approved metadata standards, iii) provide data to users via standard services and data products, and iv) archive data in long-term archives. The SECOORA Data System is based on a service-oriented architecture that employs interoperable systems to enable data discoverability via web services and catalogs. The vision of SECOORA is to be recognized in the ocean observation community as a trusted leader in FAIR data.

SECOORA partners with Axiom Data Science to provide a standards-based lifecycle data management framework that maximizes the discoverability, accessibility, and usability of data and information products and ensures their sustained use. SECOORA leverages Axiom's data systems that also support AOOS, CeNCOOS, IOOS Environmental Sensor Map, and the Animal Telemetry Network DAC to use common infrastructure which enables the dedication of more funds to system advancements and innovation than would otherwise be possible. The relationship between SECOORA and Axiom is a partnership designed not only to serve the needs of SECOORA, but also to allow for greater contributions to the larger IOOS community. SECOORA works closely with Axiom to develop and update data management plans, statements of work, facilitate the flow of data, and ensure a coordinated end-to-end system.

Key DMAC accomplishments during FY22 include:

- Portal release Version 2.14
- Transition from V1 to V2 sensor system
- Support and data ingestion for the water level team
- Updates and fixes to ERDDAP → NDBC pipeline
- Ingest CNAPS 7km NW Atlantic model
- Added HFR from Key West, Hightower, Haulover, and Treasure Shores
- Glider team support
- Support and tool development for WebCOOS
- Support data management, ingest, and visualization of data from various PIs

DMAC objectives FY23 include:

- Updates to storms pipeline
- Ingest and visualization of additional CNAPS runs
- Data ingestion and tool development for all SECOORA projects and PIs
- Portal release Version 2.15

The Southeast Marine Mapping Tool – The Nature Conservancy

The Southeast Marine Mapping Tool (Phase 2) ***Increasing access to regional ecological data to help inform offshore ocean use decisions: stakeholder engagement and mapping tool refinement***

Principal Investigator: *Mary Conley, The Nature Conservancy*

Proposed offshore projects such as wind energy sites or sand dredging have the potential to impact marine species and habitats across the South Atlantic (NC, SC, GA, FL). To sustain the region's rich marine diversity, it is important that the siting, construction, and operation of offshore development is done with the environment in mind. Environmental Impact Statements are required for every offshore development project, but stakeholders reviewing these projects often don't have the time or capacity

to compile and analyze all the available information. In addition, datasets are often viewed in isolation, without any interpretation to the broader context across region. To help overcome these challenges, The Nature Conservancy (TNC) worked with partners to develop a Southeast Marine Mapping Tool (https://maps.tnc.org/marinemap/se).

Released in February 2023, the online tool provides access to synthesized regional ocean features, species and management data. Information is summarized within user-selected sites and provides spatial and historical context. The project made use of regionally available ocean data and models, engaging technical working groups to review the analyses and presentation of information. The project's next stage will focus on engaging decisionmakers and stakeholders across the region in tool refinement, ensuring it is readily accessible and provides relevant information in a digestible format. Outreach will include user group meetings, surveys and communication materials. Feedback will be used to update datasets, refine the online tool and develop downloadable reports. We will also work to link the tool and its datasets with relevant portals and websites (e.g., SECOORA).

CNAPS Model – North Carolina State University & Fathom Science

SECOORA - Partnering to meet the needs of coastal communities for actionable information to protect lives and property

Principal Investigator: *Ruoying He, North Carolina State University & Fathom Science*

The primary goal of our project is to support all three SECOORA theme areas by developing the state-of-the-art prediction capability and near-real nowcast/forecast for regional-scale marine environment conditions. The resulting capability to model and predict the transport of heat, salt, organisms, nutrients, and pollutants bears materially upon SECOORA's ability to address all important scientific and societal issues related to i) *Coastal Hazards and Climate Variability*, ii) *Ecosystems (both living marine resources and water quality)*, and iii) safe and efficient *Marine Operations*.

In Year 2, we had successfully implemented the Ensemble Data Assimilation (ENDA) capability to assimilate regional observations from satellites, moorings, glider/ship surveys into our CNAPS modeling system. This ENDA CNAPS was then used to perform a 30-year (1993-2022) ocean circulation hindcast to generate regional ocean reanalysis and climatology (i.e., the baseline).

In Year 3, we will continued working on a series of peer-reviewed reports and papers on analyses of this new ocean reanalysis. With this 30-year, 4 km resolution, 50 vertical layer ocean reanalysis product, we can start generating regional ocean circulation climatology (i.e., the long-term baseline information that we will delivery in year 3), from which climate change impacts and its variability in the southern U.S. marine hydrodynamics will be quantitatively assessed. This data will be made publicly available in 2023. We expect there will many opportunities to collaborate with other research teams and stakeholders to derive additional ocean analyses and products.

Based on the 30-year hydrodynamic reanalysis, we will also work on the generation of marine biogeochemistry (BGC) reanalysis for the same period. To do this, we will refine the offline BGC model and have it ingest the CNAPS-2 ENDA ocean hydrodynamic reanalysis to generate 4-dimensional (x, y, z, t) daily output of key state variables (e.g., NO_3, chl a, DIC, pCO_2, DO) in the marine nitrogen and carbon cycles.

Additionally, we will continue: 1) conducting routine operations of the CNAPS system to deliver critical nowcast and forecast information (sea surface hight, sea surface temperature, sea surface salinity, and surface velocity) to support SECOORA efforts in addressing coastal hazards (e.g., storms), water quality (e.g., oil spills, harmful algal blooms), and marine operations (e.g., navigation, fisheries); 2) transitioning the CNAPS-1 system to the cloud-computing environment, including developing both pre- and post-process scripts needed for CNAPS-1 routine operations in the cloud.

RENCI Model – University of North Carolina at Chapel Hill

Multi-decadal reanalysis of coastal water level to support NOAA sea level and flood risk products

Principal Investigators: *Brian Blanton, Rick Luettich, Jeffrey Tilson, and Taylor Asher, University of North Carolina Chapel Hill*

NOAA Collaborators: Greg Dusek, Billy Sweet, Audra Luscher, NOAA

The University of North Carolina at Chapel Hill is computing a 43-year reanalysis (1979-2021) of coastal storm surge with the ADCIRC storm surge and tide model (http://adcirc.org, http://adcircprediction.org). Using the ECMWF ERA5 atmospheric reanalyses, NOAA observed water levels, and a data assimilation system for ADCIRC (Asher et al. 2019), the results will provide detailed datasets of long-term coastal water levels for use in a variety of applications, including evaluation of local extreme water level probability distributions over monthly to 100-yr return intervals that will be compared with the existing set of 1-degree gridded extreme water level probability distributions currently being produced from a tide gauge-based regional frequency analysis (RFA) for the U.S. coastline (Sweet et al (2020), Hall et al (2016)). The project reanalysis will produce a more accurate and precise local solution (lower root mean squared error) as compared to currently available information. This reanalysis will also permit testing of the RFA approach to hazard estimation between observation locations, since the spatial coverage of the reanalysis is coast-wide and includes the bays and estuaries.

The overall reanalysis process is as follows. For a specific geographical area, we compute the 43-yr simulation using astronomical tides and meteorology from ERA5 (10-m winds and atmospheric pressure at mean sea level), using the comprehensive NOAA/ADCIRC grid called HSOFS that includes the entire eastern and Gulf of Mexico coastal regions at a reasonable and consistent spatial resolution. The predicted water levels are then compared to NOAA NWLON tide gauge observations to quantify the time-dependent prediction error. This error is then input into the data assimilation scheme for ADCIRC that corrects for low frequency (sub-24 hr) contributions to the total coastal water level. The resulting posterior solution is a substantial improvement over the prior solution.

We have recently completed version 1.0 of the coastal reanalysis on the HSOFS grid. We will show long-term water levels from the prior and posterior at NOAA gauge locations and compare statistical metrics. The primary challenges are related to water level observations in early years of the period. Nonetheless, preliminary results indicate that the posterior solution is substantially better than the prior, improving estimation of (eg) the 1% water level exceedance values and other coastal flooding metrics. Version 2 of the HSOFS reanalysis is currently under way using an improved error analysis to address some data deficiencies, particularly int he Gulf of Mexico.

Model Evaluation: New York Harbor – University of South Florida

NOAA Model Evaluation: New York Harbor – Cook Inlet

Principal Investigators: *Yonggang Liu, Sebin John, Robert H. Weisberg, College of Marine Science, University of South Florida*

The University of South Florida (USF), Ocean Circulation Lab was selected to participate in a project of coastal ocean model software evaluation that is organized by NOAA Unified Forecast System Coastal Application Team (UFS CAT). The lab works as one of the testers to configure the unstructured grid Finite Volume Community Model (FVCOM) for the New York Harbor/ Cook Inlet region, and run it on NSF funded Texas Advanced Computing Center (TACC). Model performance will be evaluated against tide gauge and moored current velocity data available in the region. The outcome is providing skill assessment documentation and evaluating the model in the context of operations (stability, code management, ease of operation, etc.)

The project just started in October 2022. The USF lab has successfully recruited a postdoc for this project and participated monthly meetings. An unstructured model grid has been successfully generated for the study region with a focus on the New York Harbor – Cook Inlet area. Effort has

been made using both OCS and SMS software to generate a useful model mesh by taking into account of local coastal ocean dynamics, bathymetry and complex coastline. Currently, the lab is setting up a barotropic ocean model application (tides) using the latest FVCOM software, and compiling the source code on the dedicated TACC high-performance computing nodes. The work by the USF lab is on track and ahead of the other groups in terms of the anticipated progress.
Next step is to perform a quantitative evaluation of the tidal model against the tide gauge records in that region. Then, set up a wind-driven coastal ocean circulation model and nest it to an outer ocean model. Depending on the progress of this lab and others, NOAA will decide when to proceed to coupled modeling of currents and waves.
There are some uncertainties and challenges in this project. Most of the testers do not have the needed modeling expertise, thus may need a lot of guidance from more experienced labs and from the model developers.

St John's River Modeling – North Carolina State University

Developing an Integrated Coastal Water Predictive Capability to Promote Resilience to Water Risks – St. Johns River Prediction System

Principal Investigator: *Ruoying He, Fathom Science & North Carolina State University*

The goal of this project is to develop an integrated coastal water predictive capability to deliver new water intelligence products and information vital for decision making both during high-impact events, such as hurricanes, nor'easters, and storm surge, and for routine water management, including marine ecosystem health, transportation, and agriculture. As coastal ocean prediction science is pushed to the land-sea boundary, a critical need arises for implementation of a robust, efficient, multiscale, two-way coupling methodology to accurately describe interactions between terrestrial hydrology and the coastal ocean at high resolution and fidelity. Fathom Science is addressing this need by developing a prototype prediction system that couples three-dimensional baroclinic coastal ocean predictions with NOAA's National Water Model (NWM) forecasts and ultimately transition this capability to NOAA's National Ocean Service (NOS).

Our effort has focused on refining and transitioning the St. Johns River (SJR) modeling to NOAA NOS. Specific project objectives include:

1. Work on the SJR modeling system refinement for improved model skill performance. We have performed model refinements and conducted:
    a) One-year tide simulation.
    b) One-year hindcast simulation using operationally available forcing conditions.

2. Work on the project report and a journal publication to document the SJR model development and skill assessment.

3. Collaborate with NOAA scientists on the SJR modeling system transition.