Southeast Coastal Ocean Observing Regional Association (SECOORA): Supporting Resilient Ecosystems, Communities and Economies

Revised Scope of Work - Year 4

TOPIC AREA 1: Continued Development of Regional Coastal Ocean Observing Systems
AWARD TYPE: Cooperative Agreement
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Project Summary

SECOORA is part of the US Integrated Ocean Observing System (IOOS®), and evolved out of several earlier sub-regional programs. Its footprint covers both the eastern Gulf of Mexico (GOM) and the South Atlantic, which are connected by the Loop Current- Florida Current- Gulf Stream continuum. Our members include a cross-section of regional interests from private industry, academia, non-governmental organizations and state and federal government. SECOORA integrates observations, models, data management and outreach to sustain and advance an end-to-end, regional coastal ocean observing system (RCOOS) responsive to societal needs. An information management system transforms and delivers value-added products and services consistent with priorities identified through stakeholder needs assessments. SECOORA emphasizes coordinating a multidisciplinary suite of coastal ocean observations with numerical models so that societally important phenomena may be described, understood and ultimately predicted via applications of best science practices. This work provides foundational observing, modeling and data management capabilities to predict and support preparedness to changing conditions, thus enabling resiliency.

US IOOS recognizes the importance of the coasts and ocean for their economic and ecosystem services values. SECOORA is a region where hurricane landfalls are prevalent and where consequences from oil and gas operations are significant. The region is also a major tourist destination and a commercial and recreational fishing hub. Through performance, SECOORA has demonstrated both a vision and set of accomplishments toward meeting the US IOOS goal of societally relevant applied science. SECOORA sustains observations consisting of High Frequency radars (HFR) for surface currents and waves; moored buoys for surface meteorology and water temperature, salinity and in some instances waves and currents; coastal stations for surface meteorology, water level and some water quality parameters; and, glider surveys, including bio-optical measurements, temperature, and salinity. These observational components inform and support models across multiple scales and applications. SECOORA-related modeling is used to explain various phenomena in the region, including harmful algal blooms (HABs), storm surges, oil spill trajectories, fisheries recruitment and beach water quality. SECOORA funding, therefore, supports an array of coastal ocean observations in addition to benefitting society across a spectrum of coastal ocean applications. This proposal seeks funding for the period from June 1, 2019 – May 31, 2020.

Priorities for SECOORA are to sustain critical observing, data management and modeling activities, build upon successes with users, seek new leveraging opportunities and add new multidisciplinary RCOOS components. With the $**3,383,723** funding, SECOORA specifically seeks to:

- Continue governance and management for the Regional Association (RA);
- Effectively engage users and other stakeholders to prioritize investments;
- Provide data management and communication (DMAC) infrastructure;
- Continue operation of the existing HFRs in the region, presently consisting of sites distributed from Cape Hatteras, NC to west Florida, and continue coordination with the national network;
- Continue operation of 21 *in situ* stations along the NC and SC coasts and the West Florida Shelf (WFS);
- Sustain modeling and other product efforts, including: 1) SECOORA-wide daily nowcast/forecast (N/F) system for currents, waves, and primary production, 2) statistical beach and shellfish water quality predictions; 3) a high resolution WFS circulation modeling system directly linking shelf seas with estuaries; 4) development of Python analysis tools for oceanographic services; and 5) support for several special projects.
- Address spatial observing gaps by: 1) continuing a glider observatory for the South Atlantic Bight (SAB) and 2) installing a coastal water quality and meteorological station in Charleston Harbor, SC.
- Fill the Gaps Campaign:

    - Collect acoustic data and develop machine learning processes to analyze the data; and create data products based on user need.
    - Conduct Harmful Algal Bloom (HAB) data collection and analysis activities in the eastern Gulf of Mexico in conjunction with state agency, academic, and GCOOS partners to better predict HAB locations and trajectories.
    - Provide O&M support for HFRs purchased through Year 3 Fill the Gaps campaign and support for Florida Atlantic University (FAU) CODAR.
- Additional Observations Initiative: Via a competitive mini-proposal process, SECOORA will support an effort to increase observing in the region that leverages ongoing partner activities to address highly visible ocean and coastal issues challenging the region:
    - Harmful algal blooms
    - Coral disease
    - Coastal resiliency

SECOORA works closely with partners to achieve our goals. Below are contributors to this effort:

- Federal: NOAA National Weather Service (NWS), Ocean Acidification Program (OAP), National Estuarine Research Reserve System (NERRS), National Marine Fisheries Service (NMFS), National Ocean Service (NOS), Ecological Forecasting Roadmap Team, National Centers for Coastal Ocean Science (NCCOS), Office of Response and Restoration (OR&R), and Gray's Reef National Marine Sanctuary (GRNMS), US Marine Corps, US Army Corps of Engineers (USACE), US Coast Guard (USCG), US Geological Survey (USGS).
- State: NC Department of Environment and Natural Resources (DENR), SC Department of Health and Environmental Control (DHEC), GA Department of Natural Resources (DNR), FL Department of Environment Protection (FDEP), FL Department of Health (FL DOH), FL Fish and Wildlife Commission (FWC).
- NGOs: South Atlantic Fisheries Management Council (SAFMC), Southeastern Fisheries Association (SFA), The Nature Conservancy.
- Emergency managers at Federal, state and local levels: NOAA OR&R, NOAA NWS Weather Forecast Offices (WFOs), county emergency managers.

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Introduction / Background

SECOORA seeks to leverage and augment existing observational, modeling, data management and product assets in the region; capitalizing on nearly two decades of RCOOS experience. This work provides foundational observing, modeling and data management capabilities to predict and support preparedness to changing conditions, thus enabling resiliency. RCOOS assets are used to characterize marine conditions, identify responses to stochastic events, validate existing and developing models, support decision-making and predict and verify short and long-term coastal ocean ecological and physical trends, all of which are necessary to achieve resilient ecosystems, communities and economies. SECOORA will continue engagement with regional partners and end users in the development and enhancement of products and services consistent with priorities identified by assessing their needs.

SECOORA's highest priorities are to continue supporting coastal ocean observing assets and models that provide real-time information to users, and generate long-term datasets necessary to detect, analyze and predict environmental and ecosystem changes in the SE coastal ocean. RCOOS assets to be supported with the funding include:

- Continue governance and management for the Regional Association (RA);
- Effectively engage users and other stakeholders to prioritize investments;
- Provide data management and communication (DMAC) infrastructure;
- Continue operation of the existing HFRs in the region, presently consisting of sites distributed from Cape Hatteras, NC to west Florida, and continue coordination with the national network;
- Continue operation of 21 *in situ* stations along the NC and SC coasts and the West Florida Shelf (WFS);
- Sustain modeling and other product efforts, including: 1) SECOORA-wide daily nowcast/forecast (N/F) system for currents, waves, and primary production, 2) statistical beach and shellfish water quality predictions; 3) a high resolution WFS circulation modeling system directly linking shelf seas with estuaries; 4) development of Python analysis tools for oceanographic services; and 5) support several special projects.
- Address spatial observing gaps by: 1) continuing a glider observatory for the South Atlantic Bight (SAB) and 2) installing a coastal water quality and meteorological station in Charleston Harbor, SC.
- Fill the Gaps Campaign:
    - Collect acoustic data and develop machine learning processes to analyze the data; and-create data products based on user need.
    - Conduct Harmful Algal Bloom (HAB) data collection and analysis activities on the west coast of Florida in conjunction with state agency, academic, and GCOOS partners to better predict HAB locations and trajectories.
    - Provide O&M support to HFRs purchased through Year 3 Fill the Gaps campaign and support for Florida Atlantic University (FAU) CODAR.
- Additional Observations Initiative: Via a competitive mini-proposal process, SECOORA will support an effort to increase observing in the region that leverages ongoing partner activities to address highly visible ocean and coastal issues challenging the region:
    - Harmful algal blooms
    - Coral disease
    - Coastal resiliency

  The goal is to increase observing within the region, provide outreach to stakeholders (e.g. state agencies, broader research community), and disseminate project results at a SECOORA meeting.

SECOORA's proposed activities are structured on IOOS system design and will continue SECOORA's contributions to national and regional components of IOOS (Appendix 1, Figure 1). The full-time Executive Director coordinates RA governance and management with a Board comprised of representatives from multiple sectors. Stakeholders are regularly engaged through formal and informal mechanisms that inform SECOORA's priorities. Sixty percent of the proposal budget is devoted to observing infrastructure and operations that include HRF systems, gliders, and moored and coastal stations, some of which have been in continuous operation for almost 20 years. The investment in DMAC functions assures IOOS DMAC requirements and standards are met and incorporated into operations. The planned modeling activities are tightly linked to the observing subsystem and support a suite of integrated products and forecasts that address priority stakeholder needs for decision support tools. The proposal team, comprised of 22 principal investigators, represents a broad range of scientific and technical expertise and experience, and are fully capable of implementing the proposed objectives. SECOORA activities are highly leveraged and supported by many partners and stakeholders assuring the available federal funding will have maximum impact, both regionally and nationally. To summarize, the goals, objectives and supporting information of this proposal demonstrates SECOORA's alignment with the requirements of this funding opportunity as well as US IOOS program goals.

Connections to Users/Stakeholders and Benefits

Regional and national stakeholders benefit from an enhanced and sustained RCOOS through easy access to data and information required for safety, commerce, public health and ecosystem management. Our major partners are identified in the Project Summary, and SECOORA also engages stakeholders through participation in regional and national teams, meetings, conferences, science fairs, newsletters and focused workshops as well as collaborations with the other RAs. Several students are directly supported as part of this proposal and many others are engaged by PIs, resulting in significant contribution to development of future scientists. Additionally, SECOORA actively participates in regional groups such as NOAA's Southeast and Caribbean Regional Team (SECART), the Southeast Disaster Recovery Partnership, the Southeast Ocean and Coastal Acidification Network (SOCAN), and the Florida Atlantic Coast Telemetry (FACT) Network which represent key stakeholder groups. Each of these collaborations further leverages SECOORA work and outreach.

Goals, Objectives, and Workplans

With the $3,383,723 funding, SECOORA will implement Goals 1 through 6 (as identified in our original proposal) to support SECOORA's base capacity and enhance the ROOS. SECOORA will maintain existing infrastructure and, barring significant accidents or failures, will target system uptime of 85%. SECOORA is adding new observing infrastructure (Goals 3 and 6) needed to fill long-standing gaps in our regional network and to build capacity required to ensure SECOORA's long-term viability as a regional enterprise.

SECOORA works to meet SE decision-maker needs for coastal and ocean information by sustaining and advancing the RCOOS through implementation of six goals. Objectives and tasks are also included in Table 3, Milestones. For each goal, the objectives, technical approach, data management, and product development are described.

Goal 1: Continue SECOORA's region-wide governance and communication structure to engage users and stakeholders in coastal observing science.

Objective 1.1: Maintain governance and management for the RA and RCOOS.

SECOORA's existing membership, governance, management, and communications enterprise uniquely positions SECOORA to coordinate the SE's coastal and ocean observing activities. SECOORA is a

nonprofit membership organization with four full-time and two part-time staff who provide program development, data and information management, communications, accounting and other program coordination and management services. Hernandez leads the team and oversees SECOORA staff and operations. Dorton is the RCOOS Manager and DMAC coordinator. Wakely is the Communications Director, leading outreach efforts including web and social media content development. Lee is the Chief Financial Officer and Kight is the part-time accountant. Kight is retiring and will be replaced by Tracy Buchman as accountant.

SECOORA is governed by a Board of Directors and by-laws that stipulate both geographic and sector (i.e. academic, private, public/nonprofit) representation. Members represent a broad range of stakeholders and expertise with interests in the coast and ocean. SECOORA Board of Directors serve three-year terms, with approximately 1/3 of the Board elected annually by the membership. Board responsibilities include oversight of fiscal matters, and development of proposals. As of May 2017, SECOORA is a certified Regional Information Coordination Entity.

Objective 1.2: Engage users and other stakeholders to prioritize investments.

All SECOORA members and PIs represent their institutions, peers, and/or interest groups in SECOORA decision-making and serve as ambassadors for SECOORA and IOOS. RA staff, PIs, and partners actively engage in local, regional, and national stakeholder groups (e.g. NOAA SECART, Florida Atlantic Coast Telemetry (FACT) network, Integrated Tracking of Aquatic Animals in the GOM (iTAG), American Meteorological Society, Marine Technology Society, etc.), which help SECOORA establish priorities, identify leveraging opportunities, and reduce redundant efforts in our region.

SECOORA uses formal and informal communications to engage members and stakeholders. Communication activities and products include an annual report,[1] informational one-pagers and other print material, presentations at meetings, press releases, e-newsletters, a webinar series, and content for website and various social media outlets. Finally, SECOORA regularly surveys[2] users and stakeholders regarding priorities and requirements. These efforts increase stakeholders' awareness of observing activities and their relevance.

Objective 1.3: Provide DMAC infrastructure to enable collaboration and decision-making.

SECOORA continues to enhance its DMAC subsystem to improve efficiency, coordination, and sustainability of the system as a whole, while maintaining all existing data partnerships. Axiom Data Science, LLC (Axiom) provides the DMAC infrastructure and management support for SECOORA. Dorton will coordinate the DMAC activities with the Axiom project team (Wilcox, team lead) and SECOORA DMAC will function under the direct supervision of staff. Axiom provides comprehensive technical solutions to meet data management needs, while using open source software resources, high performance computing clusters, and interoperability services. This framework leverages systems, capabilities and lessons learned from ongoing DMAC activities for the Alaska Ocean Observing System, the Central and Northern California Ocean Observing System, and US IOOS. The resulting DMAC system increases data access and use and allows SECOORA to develop new capabilities and tools to meet a variety of user needs.

SECOORA is committed to implementing the standards and guidelines set forth by the US IOOS DMAC subsystem. We will continue to work with our funded PIs and other RAs, data partners, and the US IOOS program office on the implementation of QARTOD (both technically and by providing feedback on draft manuals) and will participate in all national DMAC efforts and meetings. SECOORA will ensure that all data products and data feeds are discoverable and broadly accessible to users and stakeholders. When possible SECOORA will use standard IOOS services for data discovery (Open Geospatial Consortium (OGC) Catalog Service for the Web, Attribute Conventions for Dataset Discovery (ACDD)), access (Open-source Project for a Network Data Access Protocol (OPeNDAP), Environmental Research Division's Data

Access Program (ERDDAP)) and visualization (OGC Web Mapping Service, OGC Web Feature Service, Jupyter Notebooks).

Effective Communication with Users and Stakeholders:

Axiom continuously updates the SECOORA website and data portal in order to maintain a state-of-the-art streamlined platform to distribute information, tools, and products. New applications developed will follow the branded style guide. The Axiom framework manages a variety of ocean data types (*in situ*, mobile, remotely-sensed, numerical multidimensional grids, geographic information system, and other structured formats), exposes managed data through interoperability systems based on IOOS service standards, and uses several user interface tools that allow data to be discovered and explored by the broader community. Using this framework to power the SECOORA DMAC system will enable the partners to ingest or connect to data sources relevant to SECOORA and efficiently develop advanced user tools and data products. These data sources include SECOORA-supported assets as well as relevant data from local, state, regional, and federal sources. The SECOORA data catalog allows users to search and query the entire DMAC infrastructure and allows users to find all SECOORA data resources (e.g., buoy, HFR, glider, satellite or model), and immediately be presented with metadata and the ability to extract and visualize the data. Axiom will continue working with stakeholders, through web portal feedback and in-person workshops, to refine the SECOORA data portal and catalog based on user requirements.

Simplified Coordination and Integration of Data Lifecycle: The data provider relationship facilitates efficient data transfer. For example, *in situ* data providers currently submit their data to NDBC independently. In Year 4, NDBC will test an ERRDAP services to pull SECOORA provider data into the NDBC system. This will allow for a streamlined submission process for SECOORA data providers as they will only have to provide data to SECOORA.

SECOORA PIs are using Research Workspace, a scientific collaboration platform and data management tool developed by Axiom, to generate US IOOS compliant metadata, share data files among their collaborators, publish final data files to the SECOORA data portal and data catalogs, and ultimately archive datasets with NCEI for long-term preservation. Additionally, Axiom and SECOORA staff will work with data providers from SECOORA member institutions to share non real-time data and archived data, and to generate associated metadata through Research Workspace. These improvements to the DMAC infrastructure will allow for better quality control, reliable delivery of data and products, archiving to national data centers, distribution of data to NDBC and the World Meteorological Organization Global Telecommunication System, distribution through US IOOS standard services and data formats, and controlled metadata standards and vocabularies. This expertise and infrastructure will also be available to support appropriate inclusion of relevant local, state, and regional data sources not currently discoverable.

DMAC Sustainability: Through Axiom, SECOORA has access to large computational and storage resources. This allows processing and integration of larger and more complex datasets into the DMAC system and better positions SECOORA to respond to user requests for high performance computing, such as oil spill trajectory modeling[3]. The SECOORA data assembly center in Portland, OR is designed to be highly redundant to support recovery in the event of failure. All databases, code repositories, and datasets are backed-up on nightly, weekly and monthly schedules both locally and off-site. In-progress development is replicated to source control servers to ensure that source code is preserved. All servers undergo routine maintenance to swiftly address security vulnerabilities. Servers containing source code and databases are located behind an Enterprise level firewall and are physically secure with environmental regulation systems, redundant power, Uninterrupted Power Supply systems and fire suppression.

Goal 2: Continue existing core observation investments in the region.

Objective 2.1: Maintain HFRs distributed throughout the region.

HFR arrays currently maintained and operated in the region (Appendix 1, Figure 2) map surface currents at high spatial and temporal resolution across the coastal ocean, outer shelf, and slope. These arrays include Coastal Ocean Dynamics Applications Radar (CODAR) and Wellen Radars (WERA), most of which have operated for at least 10 years. Five SECOORA members (UNCCH, USC, UGA SkIO, UM, USF) operate priority HFRs distributed through the region. An additional priority radar will be deployed in North Key Largo (NKL) by UM in fall 2019. The permitting and NEPA requirements for this HFR are complete. Expansion of the HFR network, made possible through the Year 3 Fill the Gaps campaign, is covered in section 6.4.

All of the HFR provide surface current data in near real time (NRT) to SECOORA and to the HFR National Network at Scripps Institute of Oceanography (Scripps) and Rutgers through the US IOOS-sponsored HFR Surface Current Mapping Initiative. WERA installations also provide surface wave measurements as a function of position and time over a subset of the domain. Operational and quality metrics are routinely checked. This includes assessment of daily variations in coverage and uptime using metrics such as database latency, range of coverage, and number of solutions as implemented by the National HFR Network.

Objective 2.2: Maintain 21 *in situ* stations along the Carolina and WFS coasts.

Strategically placed *in situ* arrays address marine user observational needs and provide a critical component in the development, validation and application of state-of-the-art numerical circulation models. The observations and models are part of a coordinated system that informs a variety of scientific exploration and societally relevant (economic and environment) issues. Two institutions (UNCW and USF) will continue to operate and maintain 21 *in situ* stations along the coasts of the Carolinas and WFS (Appendix 1, Figure 2), several of which have been operational for almost 20 years. USF will sustain four offshore real-time meteorological/oceanographic stations (three buoys, one tower); two non-real-time subsurface stations; and five real-time meteorological and water level stations, some equipped with water temperature and salinity sensors. The Clam Bayou coastal station, maintained in partnership with YSI/Xylem, measures water quality variables[4] and Big Carlos Pass includes an acoustic sensor for measuring fish activity. UNCW will sustain nine real-time meteorological/oceanographic stations located offshore of NC and SC and one non real-time station located in Onslow Bay, NC. Two of the real-time stations include WaveRider buoys co-located with a meteorological buoy and these are operated and maintained in partnership with USACE and the Coastal Data Information Program (CDIP) at Scripps. One station includes a small co-located mooring with an ADCP/NEMO for the provision of waves and currents. All of these *in situ* stations augment a number of existing real-time observing sites operated by federal and state agencies. Table 1 provides the list of variables measured by the *in situ* assets.

The buoy and coastal station designs are robust, with both the Carolinas and WFS arrays surviving prior hurricanes. Moorings and coastal stations are generally deployed for one year with intermediate servicing as needed. This annual schedule requires instrument calibration and repairs, expendables replacement, ship-time, engineering support, and data management support. USF WFS network data telemetry is via the NOAA Geostationary Operational Environmental Satellite (GOES) network and UNCW uses Iridium and cell phone services. UNCW (through Second Creek Consulting) and USF address data management and US IOOS data certification requirements such as QA/QC, data delivery, operational system alerts and system performance monitoring. All data feeds into the SECOORA DMAC system.

Table 1. Moored and Coastal Stations

	Wind Spd, Gust, Dir.	Air Temp	Barometric Pressure	Rel. Humidity	SW/LW Radiation	Water Temp	Currents	Waves	Cond/ Salinity	Water Level	Fish Acoustic Sensors
UNCW Moorings											
LEJ3 - Outer Onslow Bay	X	X	X	X		X			X		X
LEJ3Wave						X		X			
ILM3 - Outer Onslow Bay	X	X	X	X		X			X		X
ILM2 - Inshore Onslow Bay	X	X	X	X		X			X		X
ILM2Wave						X		X			
SUN2 - Northern Long Bay	X	X	X	X		X			X		X
SUN2Wave						X	X	X			
CAP2 - Inshore Capers Island	X	X	X	X		X			X		
FRP2 - Inshore Fripp Island	X	X	X	X		X			X		
OB27 - Onslow Bay*						X	X	X	X		X
USF Moorings											
C10 - WFS Central nearshore	X	X	X		X	X					
C12 - WFS Central offshore	X	X	X		X	X					
C13 - WFS South	X	X	X		X	X					
C11 - WFS Subsurface*						X	X	X			
C15 - WFS Subsurface*						X	X	X			
C21 - Tower*	X	X	X	X		X	X	X			
USF Coastal Stations											
Shell Point	X	X	X							X	
Aripeka	X	X	X							X	
Fred Howard State Park	X	X	X							X	
Clam Bayou	X	X	X			X			X	X	
Big Carlos Pass	X	X	X							X	X

*Non real-time station

Objective 2.3: Maintain the sensors on NOAA GRNMS buoy (NDBC 41008).

SECOORA continues to support ocean acidification and water quality monitoring at the Gray's Reef National Marine Sanctuary (GRNMS) as part of NOAA's international effort to quantify the effects of ocean acidification on the world's oceans. The sensors deployed at this station include pCo2, pH, dissolved oxygen (DO), turbidity, chlorophyll, salinity and water temperature. UGA is responsible for the maintenance of the sensors on the buoy. Partners on the GRNMS water quality and ocean acidification buoy include NOAA PMEL, NDBC and the USCG.

During Year 4, the project team will develop a benchtop sensor deployment system to share with NDBC. The goal is to access the sensors from the topside of the buoy instead of SCUBA divers accessing the sensors from beneath the buoy. It is anticipated that future funding can be secured to make buoy modifications and install the benchtop prototype into the GRNMS buoy.

Goal 3: Begin to address geographic gaps in observations.

Although the SE region benefits from a number of legacy subregional observing programs, major gaps remain in the spatial extent of the observatory. SECOORA proposes investment in the Charleston Harbor station to continue to build-out the RCOOS in order to meet priority stakeholder needs.

Objective 3.1: Establish a regional glider observatory in the SAB.

Shelf circulation and water properties in the SAB are affected by a variety of processes and characteristics that are unique to the region (i.e., broad and shallow shelf, influence of strong boundary currents, strong tidal forcing, distributed river input, passage of powerful tropical storms and hurricanes). Those processes have wide ranges of spatial and temporal scales not easily observed with traditional technology, which has

led to a historic lack of information on density stratification[5] and horizontal and vertical structure of biologically relevant variables.

Glider data provides regional 4-D information on temperature, salinity and density structure, and oxygen/turbidity/CDOM/chl-a concentrations. These measurements will be used to: 1) investigate hydrography and circulation dynamics, bottom temperatures and cross-shelf pathways between the shelf edge and nearshore; 2) use control theory and ocean models to develop intelligent control capabilities[6] allowing gliders to recognize and correct for fronts and strong currents; 3) prepare glider data for integration into circulation and ecosystem modeling efforts; 4) efficiently deliver information to the modeling community and stakeholders (e.g., bottom temperature maps to NOAA fisheries science centers) through SECOORA DMAC and the IOOS glider data assembly center (DAC); and 5) use this base of regional glider operations for leveraged efforts supported by GRNMS, National Science Foundation, NASA, and state agencies.

Four gliders from the pool of instruments owned by SECOORA, SkIO, USF, and NCSU will be deployed from locations in Florida and Georgia on shelf- and shelf-edge sampling missions with northward trajectories. These mapping missions serve as a baseline of operations, providing spatial coverage for data assimilation and fisheries applications. In Year 3, SECOORA purchased a new G3 Slocum glider, through the IOOS Association Fill the Gaps Campaign. This glider is based at SkIO and it will improve operational capacity for the region.

USF and SkIO will deploy two gliders off Cape Canaveral and coastal Georgia, respectively, on shelf survey missions, with operations approximately between the 20m and 50m isobaths. The USF glider will use Gulf Stream currents to survey the shelf edge and Gulf Stream along the entire SAB before recovery off North Carolina. At least one of these missions will be timed with hurricane season to maximize the impact of near-surface heat content information for tropical weather prediction. An additional 1-2 deployments leveraged by SECOORA and GRNMS will focus on Gray's Reef National Marine Sanctuary for fisheries-driven studies that will double as test deployments for new instruments.

Glider operations will integrate and take advantage of *in situ* and HFR observations, satellite imagery, and regional model predictions to optimize glider tracks. All gliders incorporate Vemco Mobile Transceivers (VMT), acoustic monitoring receivers to track tagged fish[7] and gliders are outfitted with an integrated VMT to transmit detections in real time. Acoustic data will be shared with the fisheries research community (Ocean Tracking Network, FL Atlantic Coast Telemetry, GRNMS).

Objective 3.2: Install a new coastal water quality station in Charleston Harbor.

SC DNR worked with USACE and USCG to install a piling-based water quality station in 2017. The instrumentation deployed on the station included a YSI EXO2, data logger, and communications equipment. The YSI EXO2 measures water temperature, conductivity/salinity, dissolved oxygen, pH, turbidity, chlorophyll fluorescence, and water depth. In late summer 2018, the station was destroyed by a barge. During Year 4, SECOORA will install a more stable structure so that the water quality instrumentation can be reinstalled.

Goal 4: Continue delivery of operational model forecasts and products to serve priority users.

A central goal of SECOORA is to develop, in partnership with end users, operational products that will support decision-making. Along with ongoing delivery of the regional model forecasts that fill temporal and spatial gaps in observations, SECOORA will develop and enhance products in collaboration with our partners to support their operational needs. Product delivery plans are included in Table 2 and geographic scope is shown in Appendix 1, Figure 2.

Objective 4.1: Enhance and operate a Coupled Marine Environmental Assessment and Prediction System.

SECOORA implements an advanced regional marine environment assessment and prediction capability by using a suite of fully coupled ocean-atmosphere-wave-marine ecosystem prediction models informed and updated continuously through data assimilation. This system is used to predict coastal ocean conditions over the entire SECOORA footprint with a high degree of scientific accuracy and provide detailed sub-regional information though relocatable grid refinement and nesting technology. SECOORA will work with members at NCSU to build off of previous year advances, specifically: 1) sustain NCSU's ocean circulation nowcast/forecast modeling system to generate regional nowcasts and forecasts of ocean circulation, waves, marine weather on a routine basis and use google analytics to track their usage; 2) refine advanced ocean data assimilation (DA) schemes into the prediction system; 3) start running DA nowcast/forecast system in pseudo-operational mode; 4) continue model skill assessment for marine environmental variables through appropriate comparisons with independent (non-assimilated) observations (e.g., mooring observations); and, 5) continue refining low trophic level marine ecosystem predictions, and perform a suite of hindcast experiments for detailed performance evaluation.

Objective 4.2: Operate the West Florida Shelf (WFS) ocean model.

The WFS model focuses on the GOM and provides daily, automated ocean circulation N/F by nesting Finite Volume Coastal Ocean Model (FVCOM) into HYbrid Coordinate Ocean Model (HYCOM). The model simulations are quantitatively gauged against *in situ* observations[8] from west of the Mississippi River Delta to south of the Florida Keys with real time river inflows versus climatology. This West Florida Coastal Ocean Model (WFCOM), with resolution beginning with that of HYCOM (4km) along the open boundary, includes the various estuaries, telescoping down to 150m in both Tampa Bay and Charlotte Harbor. WFCOM provides the tracking capability for WFS HABs (in collaboration with FWC). The Tampa Bay Coastal Ocean Model (TBCOM) is nested in WFCOM. TBCOM provides resolution as fine as 20 m and includes Tampa Bay, Sarasota Bay, the Intra-Coastal Waterway and all of the inlets connecting these water bodies with the adjacent GOM. TBCOM provides automated daily nowcast/forecasts and captured the response of Tampa Bay to Hurricane Irma and provides critical HAB trajectory forecasts to local and state agencies as part of a collaboration with the Florida Wildlife Research Institute. Model simulations are accessed from NOAA GNOME through the NOAA GOODS using THREDDS data server capabilities developed with the assistance of SECOORA DMAC. These multidisciplinary applications will continue to develop new products via stakeholder outreach.

Objective 4.3: Provide an early warning system for swimming beach and shellfish harvesting waters.

There are currently no widely available tools to explore the likely effects of changing land-use practices and climate change scenarios on bacteria pollution in the coastal areas of NC, SC, GA and FL. The challenge is to develop tools that can forecast the frequency of events that will impact shellfish regulation and beach management under these new scenarios. The project team will enhance existing decision support tools available through How's the Beach and currently in operation in the Long Bay and Charleston Harbor regions of SC, Sarasota and Manatee county beaches of FL, Chesapeake Bay, MD, Kill Devil Hills, NC, and in development for Folly Beach, SC. These tools will be adapted for multiple management uses in areas identified through consultation with local resource managers and public health officials in the SECOORA footprint. Specifically, Year 4 efforts will: 1) Continue to provide the How's the Beach decision support tool that couples rainfall, water temperature, wind, tide, and salinity data (provided by the NWS, ocean observing systems, and state programs) with direct measures of *Enterococcus* concentrations to provide daily forecasts of bacteria concentration; 2) Expand the shellfish management decision support tool to selected areas in NC and SC based on stakeholder input. Currently the tool is in use for shellfish harvest areas in

Murrells Inlet, SC. 3) Continue working with the City of Folly Beach, SC to provide site-specific water quality data and nowcasts for swimming beaches on the Atlantic Ocean side of the island and shellfish harvesting waters of the Folly River; and, 4) Develop How's the Beach outreach materials for sharing on social media and distribution in locations such as marinas, fishing piers, and community events.

Objective 4.4: Optimize and enhance the SECOORA Marine Weather Portal (MWP).

The MWP upgrade is complete (http://mwp.secoora.org).

Objective 4.5: Develop Python data analysis tools for oceanographic services

Data analysis tools for oceanographic services are being developed by Filipe Fernandes. The primary Year 4 objectives are: 1) Assist in the development of the IOOS.us Documentation and Demonstration sub-pages; 2) Monitor and test DMAC products and services; 3) Technical research and engagement with external groups (e.g. Pangeo, ESIP); and, 4) IOOS GitHub software library curation and maintenance.

Objective 4.6: Implement special projects.

Unmanned Aircraft System (UAS) Workshop: SECOORA, in conjunction with NOAA SECART and CariCOOS, will host a UAS technology workshop in Beaufort, NC, March 31 – April 2, 2020. This workshop will address UAS use for estuary, coastal, and ocean research and coastal management issues. Workshop focus areas: 1) UAS applications; 2) legal and regulatory requirements for UAS operation; 3) data quality assurance and quality control; and, 4) data processing and management.

Biology pilot project: SECOORA and Axiom Data Science will continue to work with SC DNR to incorporate SEAMAP-SA survey data into SECOORA data management system and ultimately share with the IOOS MBON portal. Year 4 tasks include: 1) finalize the structure of tables and relationships for the Reef Fish Survey and other fishery surveys; 2) SC DNR will transfer the data to Axiom Data Science; 3) develop and enhance interactive visualizations of fishery survey and biodiversity metrics data, and 4) make final data and metadata available in the Darwin Core standard available for public access through the SECOORA and MBON data portals.

Increasing awareness of ocean acidification in the Southeast: The Southeast Ocean and Costal Acidification Network (SOCAN) was established in 2014 through a partnership between NOAA's Ocean Acidification Program (OAP) and SECOORA. In Year 4, SOCAN will: 1) continue to fund a part-time program coordinator; 2) lead capacity building proposals; 3) continue website updates, including the creation of a Florida-specific OA page; 4) target engagement with NERRS, Sea Grant, and Long Term Ecological Research (LTER) sites in the southeast; and, 5) continue communication strategy (e.g. newsletters and webinars)

Regional Ocean Data: SECOORA will work with representatives from NC, SC, GA, and FL coastal zone management programs, as well as other regional stakeholders on a regional ocean data sharing initiative. Major tasks include assessment of existing regional portals and coastal studies (e.g. MARCO, USACE South Atlantic Coastal Study), engagement of a steering team of state coastal zone managers and other stakeholders to assess lessons learned from other regional portals and identify data gaps in current portals and regional studies, especially related to sand and bathymetry data since these are key datasets for coastal management.

Southeast and Caribbean Disaster Recovery Partnership (SCDRP): The SCDRP fills a critical gap for regional resilience coordination in the Southeast and Caribbean and brings together partners such as

emergency managers, coastal managers, non-profits, and businesses. These partners are integral to successful disaster recovery planning across the region. Funding will be used by the SCDRP to complete its strategic plan; develop new strategic partnerships; apply for leveraged grant support; and, continue communications and outreach with partners.

Additional Observations Initiative: Via a competitive mini-proposal process, SECOORA will support an effort to increase observing in the region that leverages ongoing partner activities to address highly visible ocean and coastal issues challenging the region:

- Harmful algal blooms
- Coral disease
- Coastal resilience

$62,865 is the anticipated award value. The goal is to increase observing within the region, provide outreach to stakeholders (e.g. state agencies, broader research community), and disseminate project results at a SECOORA meeting.

Goal 5: Initiate new operational products to meet additional user needs

Objective 5.1 Implement a HAB forecasting system for the WFS.

The scope and scale of recent Harmful Algal Bloom (HAB) events have highlighted significant gaps in the ability to detect, respond to, and mitigate *Karenia brevis* blooms and their impacts. Efforts to improve HAB observations and forecasting are ever evolving to integrate more comprehensive, interdisciplinary data streams and models. In the Gulf of Mexico, a suite of observational and modeling approaches are necessary for advancing our knowledge of *Karenia brevis* bloom dynamics. This toxic dinoflagellate forms high biomass blooms nearly annually on the WFS. Currently, 4-day predictions of HAB transport (USF/FWRI) and respiratory irritation (NOAA/FWRI) are issued; however, an overarching goal of collaborative efforts involve generating longer term forecasts (1-2 weeks to seasonal) to improve management and mitigation of the impacts of these blooms. The following tasks will be undertaken: 1) Two, 2-4 week glider missions will be conducted annually. The gliders will be outfitted with a Solid Phase AbsorptionToxin Tracking (SPATT) sampler to provide a cumulative assessment of brevetoxins over the duration of the deployment; 2) Ship-based field surveys will be expanded spatially along the WFS; 3) Satellite remote sensing image processing will refine algorithms used for tracking red tide using ocean color; and, 4) In situ physical data from moorings, HFR, and gliders will be coupled with ecological modeling to evaluate *Karenia brevis* bloom dynamics.

Objectives 5.2 - 5.3: Funds are not available for these objectives

Goal 6: Continue building critical elements of the observing system by adding biogeochemical and marine sound sensors, and HFRs

Objectives 6.1-6.2: Funds are not available for these objectives.

Objective 6.3: Implement a regional ocean sound observing initiative to characterize and measure sources of sound production and establish acoustic baseline levels.

Acoustic data previously collected from known or suspected spawning sites of important commercial reef fishes (groupers/snappers) will be used to create a library of labeled sounds from known and unknown sources. Hundreds of thousands of acoustic files from different habitat types are available for review and classification for this project. Because fishes make species-specific sounds, machine learning algorithms

can be trained to identify sounds produced by different known species automatically in large data sets. Sounds of unknown biological sources and anthropogenic sources (boats, ships, drilling, hydroacoustic surveys for oil/gas) can also be classified for automatic detection. Advances in machine learning for processing acoustic wav files will be shared with SECOORA/Axiom and with the IOOS Data Management and Communications community. Additionally, acoustic receivers will be deployed in stationary and mobile platforms to collect new data for processing and analyzing through the machine learning techniques.

Objective 6.4: Install and operate new HFRs

Through funding generated during the Year 3 IOOS Association Fill the Gaps Campaign, SECOORA PIs are expanding HFR coverage along the U.S. East Coast. HFRs are being deployed and maintained as follows (see Appendix 1, Figure 3):

- CSI is operating the OCRA WERA located on Ocracoke, NC.
- Florida Atlantic University will maintain the HAUL CODAR located near Miami, FL.
- FIT is in the process of siting two HFR on the east coast of Florida. One at Sebastian Inlet State Park and the other at Patrick Air Force Base. The Patrick Air Force Base location is under review by the Department of Defense and a base-siting action is forthcoming. These two WERA were purchased by SECOORA and will be operated by FIT.
- USC is working with stakeholders to identify a location for a WERA in Myrtle Beach, SC.
- SkIO is identifying locations to deploy two WERA in south Georgia or north Florida.

User Benefits and Product Delivery

SECOORA's approach to developing end-user applications begins with identification and engagement of local, regional, and national partners who have articulated a need that can be addressed through coastal ocean observations or applications. Partners are engaged to develop specifications that guide the product and service development effort. End-users participate in the design, development, and validation of such products. Each product or service to be developed under this proposal has a clear link between specific stakeholders and specific SECOORA-supported observation, model, or prediction data. SECOORA ensures that proper and complete metadata are generated and maintained, and that products are made available to the wider user community through commonly used dissemination protocols via SECOORA DMAC system. All observational data, maps, models and other coastal and ocean observing information and products are easily accessed via the SECOORA website, social media outlets, and e-newsletters.

Our product delivery plans are tailored to meet user needs and provide important benefits. All SECOORA generated data is delivered through a variety of web services and webpages, and benefits include support for NOAA NWS marine weather forecasts and marine hazards advisories, USCG SAR operations, and USACE modeling and sediment management applications. Data and data products also support ecosystem management and fisheries stakeholders. Resource managers, recreational anglers and commercial fishers will benefit from improved efficiency in catching target species and less fuel usage. SECOORA's rich data repository also allows stakeholders to access historic data. Examples of uses of this archived data include: 1) informing managers and the public of the paths and intensities of past tropical storm systems and coastal water levels associated with these events; 2) visualizing when and where polluted water could move into coastal areas; and 3) providing data to inform climate vulnerability assessments. Table 2 outlines additional delivery plans for products included in this proposal and Figures 2 and 3 in Appendix 1 show observing locations and areal extent of products included in this proposal.

Table 2. Product Delivery Plans and Users

Goal and Objectives		Delivery Plans and Users:
4	**Continue delivery of operational model forecasts and products to serve priority users**	
4.1	Coupled Marine Environmental Assessment and Prediction System	N/F model results served via web services. Stakeholder groups include USCG, NOAA NMFS, NOAA OR&R, Bureau of Ocean Energy Management, NC DENR, SC DNR, GA DNR, FL FWC, NWS and SAFMC.
4.2	West Florida Coastal Ocean Model	N/F model results served via web services. Stakeholder groups include USCG, FL FWC, recreational mariners, NOAA Office of Response and Recovery.
4.3	Advisory System for Beach and Shellfish Waters	Smartphone apps and web services. Products include forecasting products for beach and shellfish water quality. User groups include: resource managers, public health officials, and representatives of potentially vulnerable populations.

Summary

The proposed $3,383,723 funding will support the core RCOOS framework which provides:

- Regional coverage over a geographically large and diverse section of the US coastal ocean;
- Stakeholder engagement relative to RCOOS components, including moorings and coastal stations, HFR, and model data on which citizens, decision-makers, and scientists have come to depend;
- Cross-state and intra-regional cooperation;
- Maintenance of critical in-water infrastructure, data flow from offshore to the web, and proven technical capabilities and experience in operational coastal ocean observing; and,
- Expansion of SECOORA's ocean observatory through the IOOS Fill the Gaps campaign.

As a mature RA in a region with significant observing gaps, SECOORA must balance maintenance, filling important gaps in observations and creating new connections to users through thoughtful expansion of products and services to build-out the RCOOS. The proposed activities will deliver stakeholders the ongoing observations and modeling products they rely on, and new integrative project components that leverage existing SECOORA efforts (observations, models and DMAC) to create new and exciting opportunities. For example, the glider observatory will use SECOORA HFR data and circulation N/F model predictions to optimize glider data collection, which will then be assimilated into the newly enhanced regional modeling N/F system and inform fisheries managers. The MWP, regional ocean model, WFS model and shellfish and beach advisories will incorporate SECOORA data streams to improve decision-making. The DMAC system will enable users and stakeholders to combine various components of the SECOORA network in novel ways. By creating synergies, adding new capabilities in an intelligent way and supporting core operations, SECOORA will continue to lead observing science in the SE.

Milestones and Cost Proposal

Table 3. Goals, Objectives/Milestones and Schedule

Goals and Objectives	2018-2019 (Quarter)			
	1	2	3	4
Goal 1: Continue SECOORA's region-wide governance and communication to manage RA and engage users and stakeholders in coastal observing science				
Maintain governance and management for the RA and RCOOS	x	x	x	x
Engage users and other stakeholders to prioritize investments	x	x	x	x
Maintain and operate DMAC	x	x	x	x
Goal 2: Maintain existing core observation investments in the region				
Maintain 15 HFR distributed throughout the region	x	x	x	x
Maintain 21 *in situ* stations along the Carolina and WFS coasts	x	x	x	x
Maintain the Sensors on NOAA GRNMS Buoy	x	x	x	x
Goal 3: Begin to address geographic gaps in observations				

Goals and Objectives	2018-2019 (Quarter)			
	1	2	3	4
Establish and maintain a regional glider observatory in the SAB	x	x	x	x
Purchase a new glider and integrate into the SECOORA glider fleet		x	x	x
Install a new coastal water quality and metrological station in Charleston Harbor, SC	x	x	x	x
Goal 4: Continue delivery of operational model forecasts and products to serve priority users				
Enhance and operate a Coupled Marine Environmental Assessment and Prediction System for the SE	x	x	x	x
Operate the West Florida Shelf Ocean Model	x	x	x	x
Provide an Early Warning System for Swimming Beach and Shellfish Harvesting Waters	x	x	x	x
Python Data Analysis Tools for Oceanographic Services	x	x	x	x
Special Projects	x	x	x	x
Goal 5: Initiate new operational products to meet additional user needs				
Implement a HAB Forecasting system for the WFS	x	x	x	x
Goal 6: Continue building critical elements of the observing system by adding biogeochemical and marine sound sensors, and HFRs				
Acoustic sensor data analysis, machine learning processing techniques	x	x	x	x
Work with SECOORA PIs to expand HFR footprint within the region	x	x	x	x

Cost Proposal. Summarized costs of this 2019-2020 effort are in Table 4. $3,383,723 support Goals 1 through 6. All components of this effort are leveraged; however, it is difficult to provide exact dollar values on contributions. Most of the observing assets were purchased with non-IOOS funds, and ongoing maintenance is subsidized by other grants. The same is true of most of the modeling work, i.e. models were initially developed with other funds. Five percent of the SECOORA Executive Director's salary is supported from member dues, as is a portion of her travel. Finally, a number of PIs are working at very subsidized rates or at no cost.

Table 4. Costs by Objective, PI and Institution

Obj.	PI/Contractor	Inst.	YR 4
Goal 1	**Governance, Outreach & DMAC**		
1.1-2	Hernandez (Governance & Outreach)	SECOORA	516,471
1.3	Wilcox (DMAC base, HABS support, Acoustics support)	Axiom	224,716
	Goal 1 Sub-total		**741,188**
Goal 2	**Maintain existing core observations**		
2.1	**High Frequency Radars**		
	Shay	UM	123,800
	Voulgaris	USC	91,000
	Edwards	UGA/SkIO	91,000
	Seim	UNCCH	55,407
	Muglia	CSI	68,393
	Weisberg	USF	110,000
	Hernandez (Operating funds for FIT & additional HFR)		140,400
	Sub-total HFR		***680,000***
2.2	**Moored & Coastal**		
	Leonard (Carolinas)	UNCW	372,300
	Weisberg (WFS Moor.)	USF	255,000
	Luther (WFS Coastal)	USF	51,000
2.3	***GRNMS Buoy***		
	Noakes (Gray's Reef)	UGA	25,325
	Sub-total Moored & Coastal & GRNMS		***703,625***
	Goal 2 Sub-total		**1,383,625**
Goal 3	**Address geographic gaps in observations**		
3.1	**Gliders**		
	Edwards	UGA/SkIO	45,000
	Zhang	GA Tech	29,000
	Seim	UNCCH	28,000
	Lembke	USC	40,000
	Hernandez (Holdback for expenses)	SECOORA	11,000
	Sub-total Gliders		***153,000***
3.2	Sanger (Chas. Harbor)	SCDNR	20,000
	Goal 3 Sub-total		**173,000**
Goal 4	**Continue delivery of operational models and products**		
4.1	He (Regional Model)	NCSU	132,600
4.2	Weisberg (WFCOM)	USF (Funding included in Objective 2.2)	
4.3	Porter (Beach/Shellfish)	USC	102,000
4.5	Fernandes (Python Tools)	Brazil	77,858
4.6	Special Projects (UAS workshop, Bio. data, OA, SCDRP, Reg. Ocean Data, Mini-proposal)	Various	374,294
	Goal 4 Sub-total		**686,752**
Goal 5	**Initiate new operational products to meet additional user needs**		
5.1	Hubbard (HABS)	FWRI	200,000
	Goal 5 Sub-total		**200,000**
Goal 6	**Continue building critical elements of the observing system by adding biogeochemical and marine sound sensors, and HFRs**		
6.3	Locascio (Acoustics)	Mote Marine Lab	190,000
6.4	Baxley (HFR)	FAU	9,159
	Goal 6 Sub-total		**199,159**
	GRAND TOTAL		**$3,383,723**

Appendices

Appendix 1: Maps and Figures

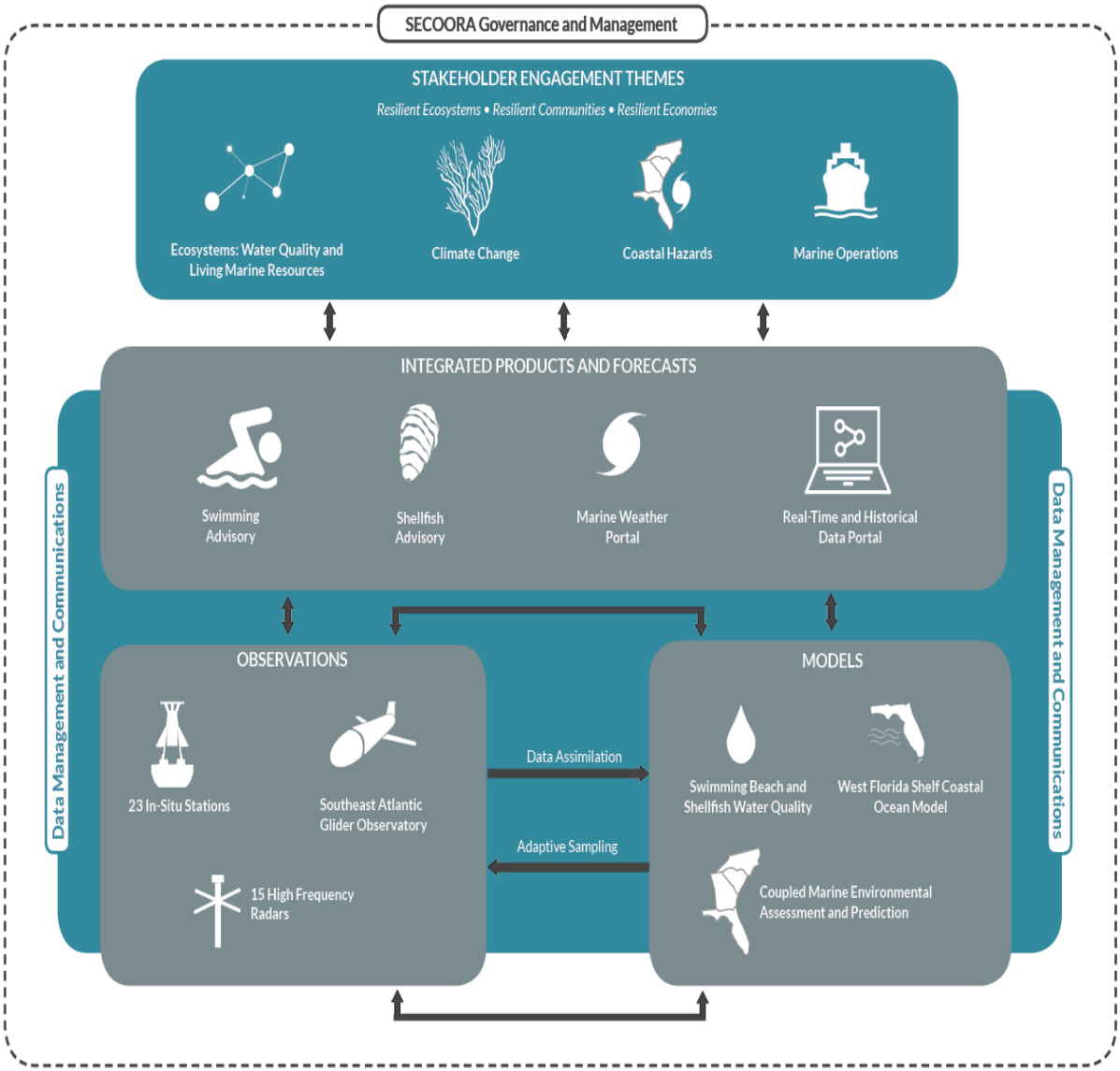

Figure 1: This schematic is a visual representation of the overall proposal. With oversight from Governance and Management, and in collaboration with PIs, Data Management and Communications successfully manages and integrates data for a suite of tools and applications. Each component is linked to priority stakeholder needs under four theme areas.

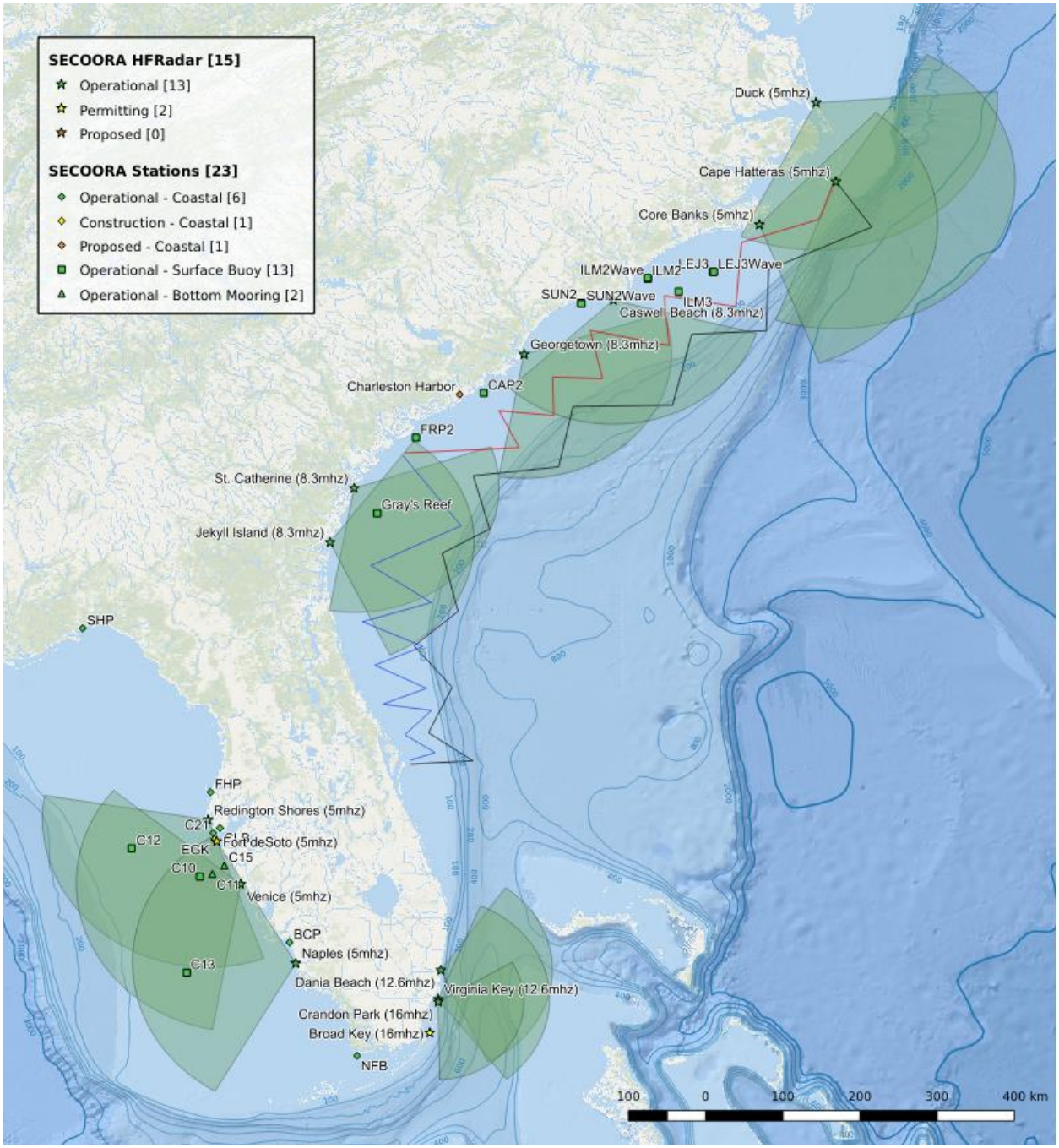

Figure 2: Map of existing SECOORA observations (buoys, coastal and HFR station locations). Glider sampling missions in South Atlantic Bight (SAB) are represented by blue, red and black sawtooth lines.

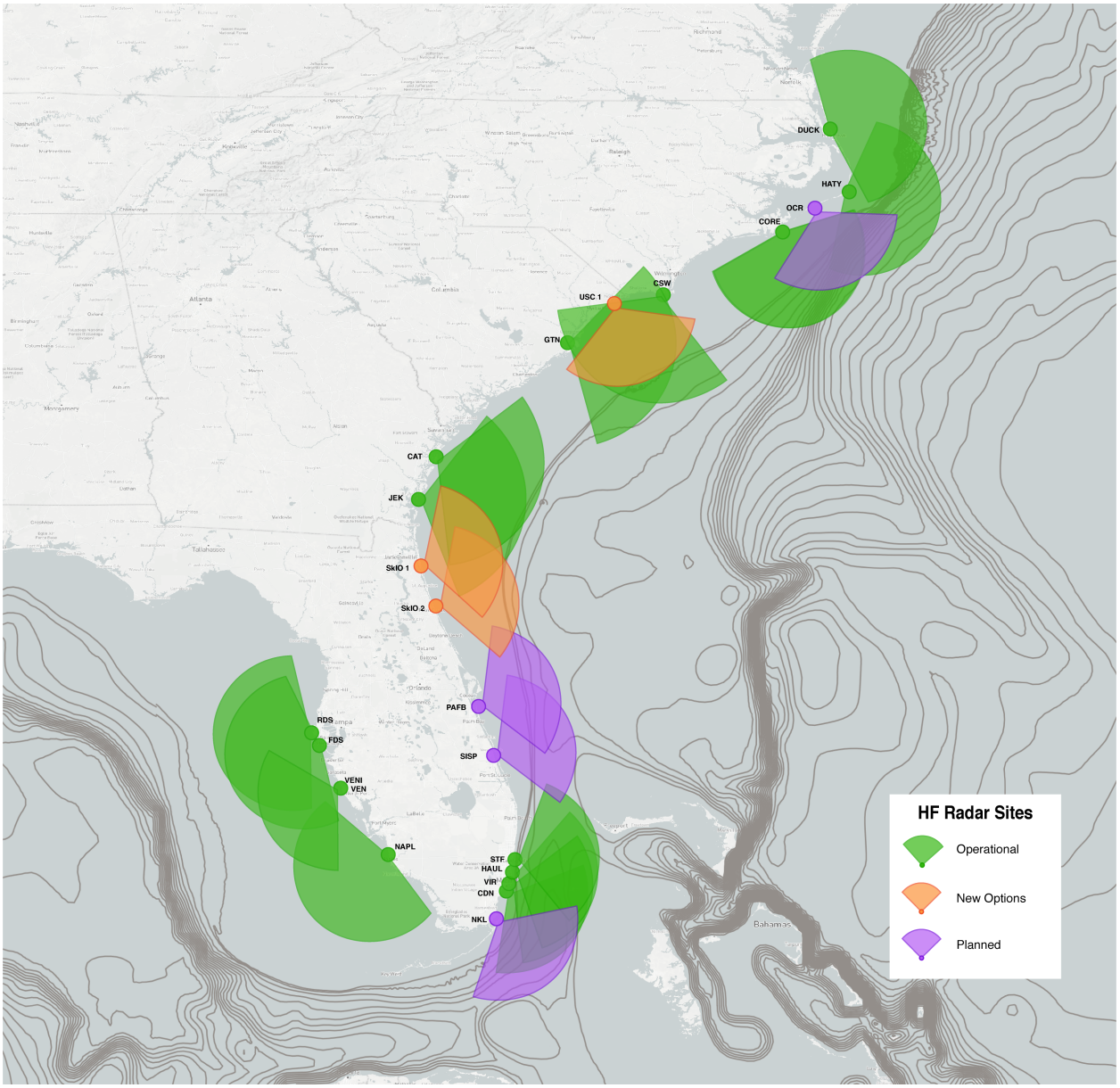

Figure 3. Currently deployed SECOORA and FAU HFR are highlighted in Green. The planned HFR (in purple) are nominal locations for the two sites will be deployed by the Florida Institute of Technology near Cape Canaveral, FL, University of Miami in North Key Largo, FL, and UNC Chapel Hill in Ocracoke, NC. The locations noted in Orange are potential locations HFR that SECOORA and Skidaway Institute of Oceanography (SkIO1 and SkIO2) and the University of South Carolina (USC1) are deploying.

Appendix 2: References

[1] SECOORA Communications Page, http://secoora.org/communications
[2] SECOORA Member and Stakeholder Survey (2014). http://secoora.org/webfm_send/1581
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[8] Zheng, L. & Weisberg, R.H. (2012). Modeling the West Florida Coastal Ocean by Downscaling from the Deep Ocean, Across the Continental Shelf and into the Estuaries, *Ocean Modeling*, 48 (2012), 10-29.