Developing Florida's Coastal Ocean Observing System

By Rick Cole, Founder and President, RDSEA International, Inc., St Pete Beach, FL, Scott Duncan, Founder and President, Navocean, Seattle, WA, and Florida

Florida's coastal regions are low, flat, heavily populated, barely above sea level and are extremely vulnerable to impact weather, pollution, acidification, algal blooms, and fisheries decline. All of which are aggravated by climate change and sea level rise. Sea level rise alone threatens to submerge thousands of square miles of coastal land, displacing millions of people, and hurricanes, once rare, are now an annual severe threat. Decisions made during this new decade will have life altering implications for Florida's 20 million plus residents. What's more, Florida's location and shape define the flow of the Gulf Stream and Gulf of Mexico Loop Currents originating from Caribbean and Meso-American regions. Understanding the coastal ocean processes of Florida is crucial to understanding the oceanic processes of the entire region. National and State funding shortfalls and a divided plan continue to leave Florida's ocean observing systems with gaps spanning hundreds of miles with limited measurement parameters in critical areas.

RDSEA International, Inc. (RDSEA, St Pete Beach, Florida) in partnership with Navocean (Seattle, WA, and Florida) have set forth plans for a comprehensive "Florida Coastal Ocean Observing System" (FLCOOS™) beginning along the east coast of Florida's coastal/littoral zone and wrapping around the south and west coasts to fill data gaps to the Alabama border. The backbone of this proposed FLCOOS™ system is an array of Coastal Warning and Rapid Response Data Density (Sea-WARRDD) observing stations, comprised of RDSEA Coastal Hybrid Buoy Systems and Navocean Nav2 Automated Surface Vehicles (ASV) working in tandem. The FLCOOS™ Sea-WARRDD array will provide capacity for high quality (surface, water-column, bottom) sensor data with near-real-time telemetry to stakeholders and fill gaps to existing monitoring efforts, addressing Florida's pressing needs.

FLCOOS™ will provide near-real-time coastal metocean+ data for: Government agencies, academics, marine science partners and stakeholders to assess ocean processes. It is increasing the region's *in-situ* footprint, advancing new ocean technologies, contributing to coastal flooding/sea level rise and hazards, and is feeding into NOAA's National Weather Service (NWS) and Hurricane Center missions. It also supports a vast number of activities around County emergency management decision-making, tourism, marine recreation, beach safety, maritime operations and navigation, U.S. Coast Guard offshore security issues, search and rescue, water-quality, harmful algal bloom (HABs) monitoring, human and ecosystem health, spills, ocean-acidification studies, estuary and river coupling, intrusion/inundation, fisheries biology, and enhances education outreach. Data also adds focused *in-situ* input to existing and new regional modelling efforts.

The FLCOOS™ measurement plan includes monitoring:

- **Sea Level Rise:** Waves (height, speed, frequency, direction), currents, coastal erosion, sediment, nutrient and pollution event plume tracking.
- **Impact Weather**: Barometric pressure, wind (speed/direction/gust), sea-surface temperature, solar radiation, relative humidity/dewpoint, wave spectra, water column density (conductivity, temperature, depth - CTD), and currents measurements.
- **Mangroves, Seagrass and Reef Restoration**: Ocean processes modeling, anoxia, and pollution tracking.
- **Acidification and Oxygen Depletion:** pCO_2 and O_2 measurements.
- **Water-Quality/Red Tide:** Harmful Algal Bloom (HABs) detection, tracking/prediction, and mitigation support.
- **Fisheries:** Acoustic hydrophone recordings for fish tracking and population assessment.
- **Search and Rescue:** Detailed waves, weather/meteorology, and ocean currents updates to rescue crews.
- **Regional Modelling:** Ocean model ensemble time-series made available for input/output.

Contributing towards the UN Ocean Decade

In the south, in parallel to standard metocean/water-quality monitoring, a data focus will be on coral reef health. The Florida Reef (also known as the Great Florida Reef) is the only living coral barrier reef in the Continental U.S. The third largest barrier reef system in the world (Great Barrier Reef in Australia and Meso-American Barrier Reef, #1 and #2). Coral reef systems world-wide are in peril and mitigation must be in place to prevent further loss and to create new growth. This also opens up partnerships to the east, in the Caribbean Sea and south, to Meso-American countries surrounded by reef and mangrove systems presently in dire straits that must be monitored, managed and protected. New Marine Protected Areas (MPAs) for these regions are in discussion as part of the UN Ocean Decade plan for future sustainability, of which FLCOOS™ will participate and contribute.

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The Sea-WARRDD System

The stationary RDSEA buoy (Fig. 1), provides full water-column fixed time-series measurements including acoustic Doppler current profiler (ADCP) "clean currents" (bottom mounted, unobstructed/unbiased datasets where possible, in near-real-time). Surface buoy steady time-series data anchors and ground truths peripheral, and roving ASV measurements (Fig. 2). The high endurance mobile Nav2 ASV, outfitted with complimentary sensor suites (Fig. 3), expands the relevance of the stationary measurements across a region and provides the capability to respond to and survey ocean events as they occur. Real-time Sea-WARRDD data is transmitted back to FLCOOS™ servers via cellular/satellite networks, providing immediate review of ocean events in progress. Meanwhile a highly detailed full data log is saved onboard for retrieval, further post processing and archiving.

Emerging Tech Integration

New Technology (also called Blue Tech) is emerging within the ocean observing community. FLCOOS™ has the potential to "re-engineer" the idea and concept of ocean observing systems (both coastal and deep). Working exclusively with patent holders of sub-sea radio-frequency modem technology (i.e., subsea Wi-Fi) we plan to transmit seafloor and water-column data to the surface, without the use of cabled/acoustic systems (a normal weak-link and contributor to data loss). Using "wire-crawlers" on the buoy moorings (wave activated sensor movement up and down the mooring wire), allows for full water-column density (CTD) data to be collected. Water-quality sensors can also be integrated. There are also plans for a profiling CTD winch onboard the Navocean Nav2 ASVs, for water-column measurements away from buoy locations.

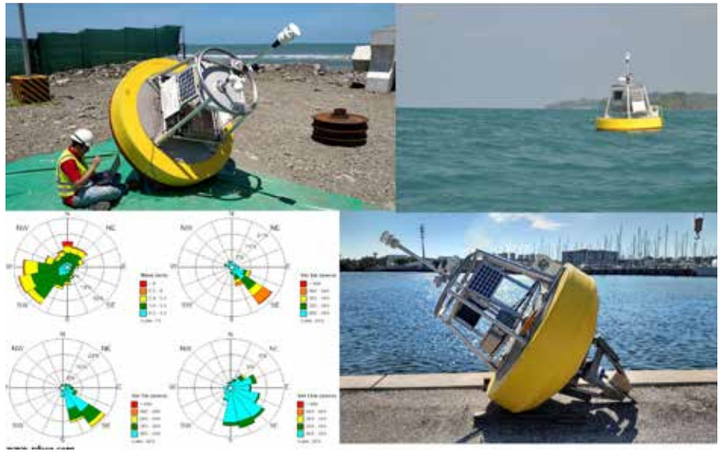
The new "buzz" within the community is eDNA sampling and AI computing. eDNA sensors are in the testing phase by a couple of suppliers now and will be available for integration soon. AI processing of ocean data is the next step in the evolution of ocean, bay, and estuary modelling programs.

To gain a better understanding of the regions fish, mammal and turtle species, passive acoustic recording systems are also planned for systems integration. This will provide behaviorally specific information across multiple trophic levels in tandem with physical and chemical/biological measurements.

In the deep regions, it may soon be possible to transmit deep-water current speed and directional data, in near-real-time, from subsurface mooring systems, without the continued use of a surface structure above. This innovation is in discussion and will be tested westward of the WFS break (FL Escarpment) where the depth quickly drops to over 3,000 meters, merging offshore deep data with nearshore coastal data, contributing to a better understanding of Loop Current mobility on and off the shelf and the processes surrounding it.

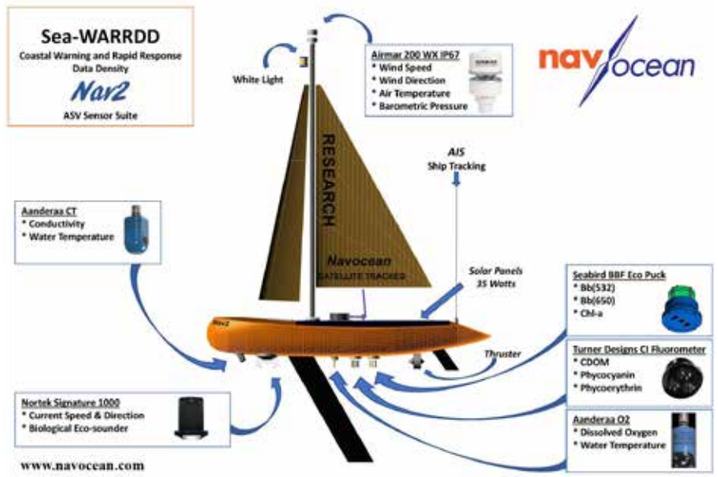
Existing Observing Systems and Collaborators

FLCOOS™ is designed to augment and collaborate with the existing elements of coastal observing systems supported by multiple entities within the region. NOAA's NWS deploys and maintains various surface buoy locations on the WFS and along the east coast, Cape Canaveral area, as well as many pier-mounted tide gauge and met stations. These systems provide surface meteorology (tides/met along the coast) contributing to weather models and prediction. The U.S. Army Corps of Engineers' Coastal Data Information Program (CDIP), managed by Scripps Institution of Oceanography (San Diego, CA), maintain coastal waves climatology sites for operating and maintaining coastal projects and infrastructure nationwide. CDIP occupies eight sites in Florida, four along the east coast, and four in the central-south-eastern Gulf of Mexico. The University of South Florida's, College of Marine Science (St Petersburg) maintains and operates the Coastal Ocean Monitoring and Prediction System (COMPS) along the WFS, Gulf of Mexico. COMPS provides *in-situ* metocean (offshore and coastal) and modelling information including high frequency radar (HFR, surface currents) data for the region. Other academics also provide HFR data along the east coast. FLCOOS™ will weave an array in between these programs (GA to AL) to form a more comprehensive system of monitoring for the entire State. Figure 4 displays this concept of filling "gap areas" along the coast and in some deeper regions.

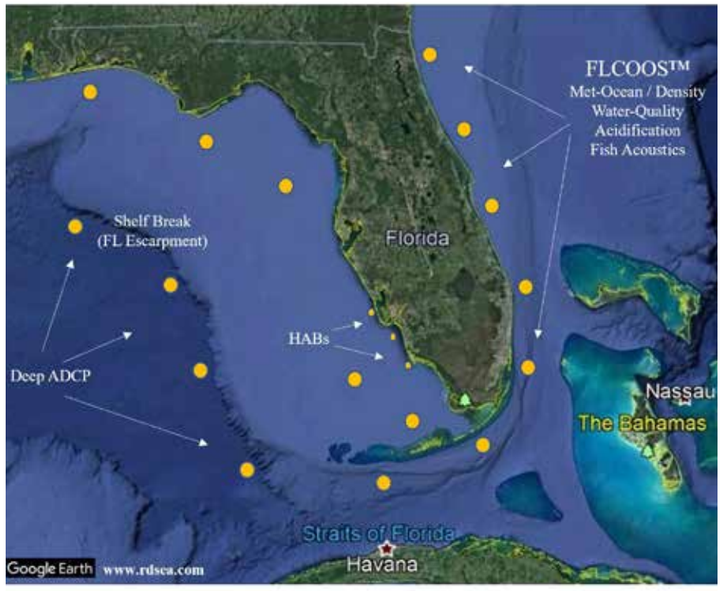


RDSEA Hybrid Coastal Buoy System.
(Lower left panel displays wind speeds at the surface (upper left plot) over ADCP velocity and direction at 12 meter depth in the Caribbean Sea, east of Costa Rica)

The Nav2 Solar / Sailing Drone and Examples of Mission Tracks Along the Coastline.
(This is a region of high HABs congestion in SW FL, a "Zoom-in" focus of FLCOOS™)



Navocean's Nav2 Automated Surface Vehicle with Sensor Suite Options.



A Fully-Funded FLCOOS™ Data Gaps Filling In-situ Concept.
(Deep, Coastal, Shallow)

The FLCOOS™ team will include the academic sector. Florida Institute of Technology (FIT, Melbourne, FL) conveniently located along the central region of the State will be our east coast hub for data dissemination. West coast academics, USF, Florida Gulf Coast University (FGCU) and others as well as local non-profit programs will be able to take advantage of datasets. The South-Eastern Coastal Ocean Observing Regional Association (SECOORA), and the Gulf of Mexico Coastal Ocean Observing System (GCOOS), both regional branches of NOAA's U.S. Integrated Ocean Observing System (NOAA IOOS, governed under the ICOOS Act signed into law in 2009 by President Obama) and stakeholders, will also have access to critical FLCOOS™ data. IOOS is part of the Global Ocean Observing System (GOOS) which supports development of observing systems, data management and models for forecasting deep-ocean and coastal ocean environments. SECOORA and GCOOS support a broad variety of academic coastal research projects.

Of course, all mentioned above requires serious amounts of capital/funding and labor. We believe that legacy forms of such funding, Federal, State and County, will not fulfill what is required but can contribute greatly to Florida waterways data collection. A full FLCOOS™ with extensions east (Caribbean Sea) and south (Meso-America) will require a new mindset and means of funding sources, from individuals and groups that support this coming ocean decade movement. This is the dream and purpose of the UN Decade of Ocean Science for Sustainable Development. Our "Rising Seas" depend upon it.

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