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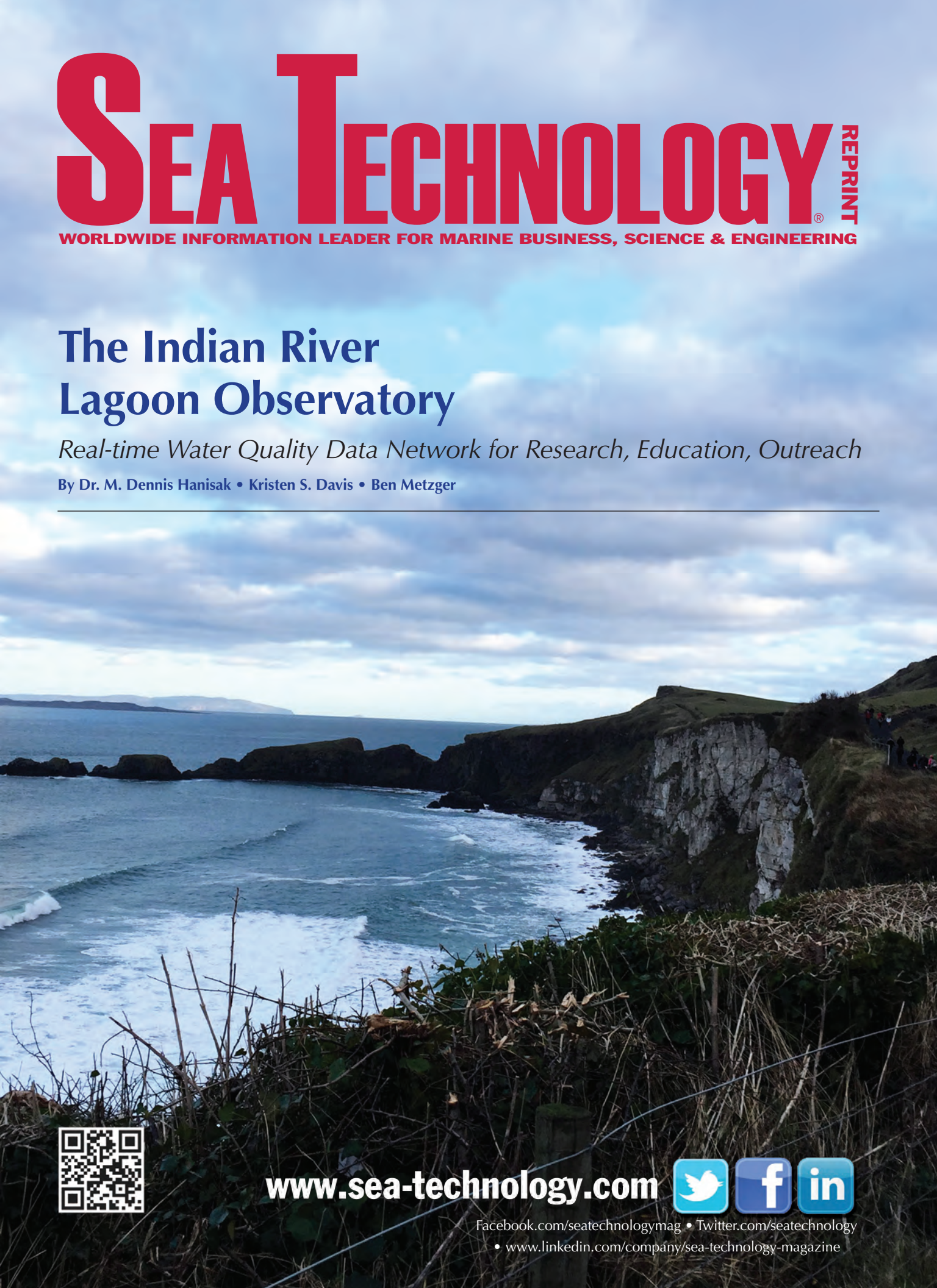
By Dr. M. Dennis Hanisak • Kristen S. Davis • Ben Metzger



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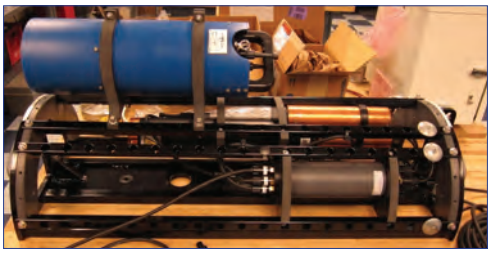
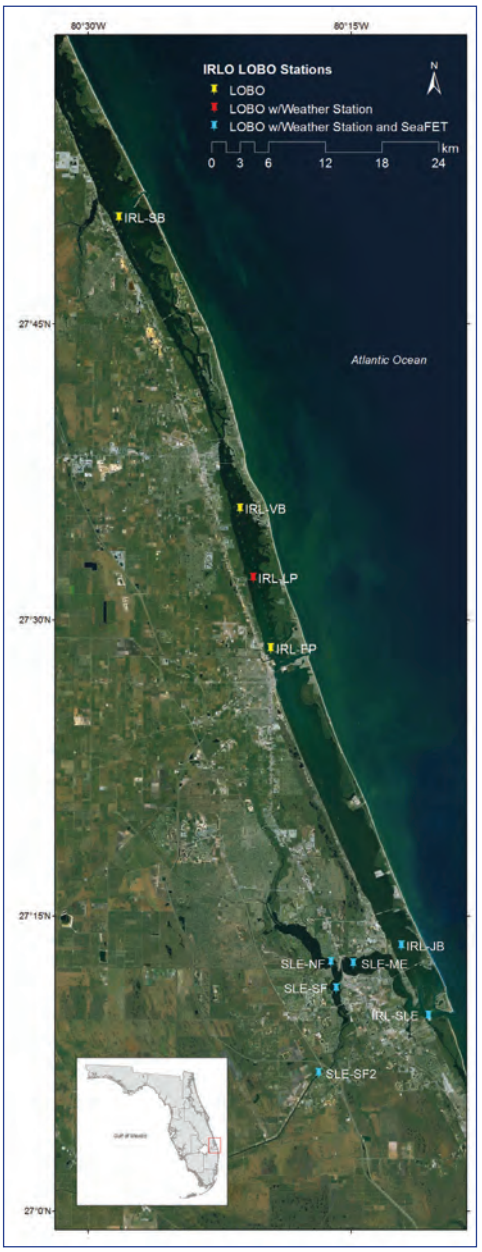
Real-time Water Quality Data Network for Research, Education, Outreach

By Dr. M. Dennis Hanisak • Kristen S. Davis • Ben Metzger

The Indian River Lagoon (IRL) is a unique, highly diverse, shallow-water estuary of national significance, stretching along 156 mi., or 40 percent of Florida's east coast. The IRL's economic value to Florida is estimated to be more than $3.5 billion per year. Urbanization, excessive freshwater releases, degradation of water quality, contaminant loading, loss of habitat (e.g., seagrasses, mangroves), harmful algal blooms, decline of fisheries, and emerging diseases in marine mammals and other biota are increasingly important issues in the IRL, as they are throughout the world's estuaries and coastal waters.



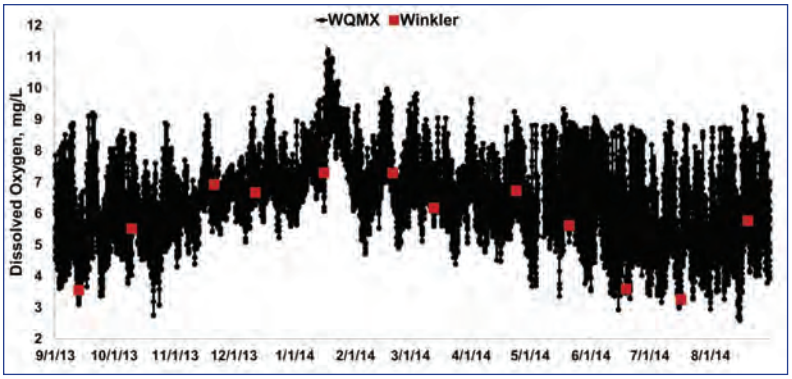


(Right) Location of the IRLO network of LOBOs in the Indian River Lagoon and St. Lucie Estuary. (Top Left) Each LOBO is an integrated package of sensors that allow continuous observation of critical environmental parameters in the estuarine environment. (Bottom Left) Installation of the pilot LP station near FAU Harbor Branch with the above-water weather station, solar cell and antenna for hourly transmission of data from the submerged LOBO unit.

The Indian River Lagoon Observatory (IRLO) at Florida Atlantic University's Harbor Branch Oceanographic Institute (FAU Harbor Branch) in Fort Pierce, Florida, is investigating the IRL's plants, animals and environment, and the impact of natural and human-induced stressors. The goal of IRLO is to acquire and disseminate data and knowledge on the IRL critical to ecological function and its sustainable management. The key elements of IRLO are: a long-term, multidisciplinary, ecosystem-based approach; collaboration among organizations; and a network of advanced observing stations. These elements integrate to serve a diverse array of user groups, including researchers, resource managers, educators, and the public.

LOBOs

IRLO research and education activities are being enhanced by deploy-



Validation of various parameters, such as dissolved oxygen, are performed monthly by comparing grab samples with continuous data measurements.

ment of an estuarine observation network of land/ocean biogeochemical observatory (LOBO) units and weather sensors to provide real-time, high-accuracy and high-resolution water quality/weather data through a dedicated interactive website. The LOBO was developed in 2003 by scientists and engineers at Monterey Bay Aquarium Research Institute (MBARI), with support from the U.S. National Science Foundation (NSF). Once developed, the LOBO was licensed to Satlantic for commercial production and use in estuaries and inland water ecosystems. The LOBO is used in several North American locations, including: the River, Estuary and Coastal Observing Network (RECON) by the Sanibel-Captiva Conservation Foundation; the Northwest Arm of Halifax Harbor in Canada; Oregon's Columbia River as part of the NSF Science and Technology Center for Coastal Margin Observation and Prediction; California's Elkhorn Slough by MBARI; Oregon's Yaquina Bay estuary; and Delaware's Murderkill Estuary. The sensors have been shown to provide a high level of data stability and only require an annual calibration. The units are intended for long-term moored applications where high biofouling is expected.

The LOBO units have the flexibility to substitute or add different sensor instruments as new scientific needs are identified. FAU Harbor Branch's IRLO network is designed to generate a time series of environmental data that will provide users reliable, continuous observations to understand and address both short- and long-terms issues and to better quantify and model relationships between environmental factors and biological processes in the IRL. This technology will enable users to observe long-term ecosystem changes and those driven by events such as freshwater discharges, algal blooms, storms, and drought conditions.

Our LOBO Configurations

Each LOBO comes equipped with instrument frame, wireless telemetry system, integrated sensor suite, automated processing software, and Web-based data visualization and display software. We are using the Dock LOBO configuration, which includes a solar panel to charge sensor and data modem batteries and can be attached to docks, pilings and bridge supports. The sensors are compact and the water quality sensor packages can be modified according to research and resource management needs. We specified sensor packages based on studies being conducted in the IRL, with physical parameters that include temperature, conductivity (salinity), pressure (depth) to measure tidal fluctuations, and turbidity (particles in the water); chemical parameters that include chromophoric dissolved organic matter (CDOM or water color), dissolved oxygen (DO), pH, and nitrate and phosphate (important nutrients for primary producers); and a biological parameter, chlorophyll fluorescence, that is a measure of algal chlorophyll in the water. We decided to use an hourly sampling frequency, given the rapid environmental changes that occur in estuaries.

Each LOBO unit uses a GSM cellphone modem in an NEMA enclosure with a marine-grade antenna and lightning protection. The modem is powered by a solar-charged 5-Ah gel cell battery. Each LOBO unit has a SIM card and a cellular modem interface to deliver continuous data to a Web-based data processing and visualization network Internet site called LOBOviz.

Data Access

All data from the IRLO LOBO units are freely available via FAU Harbor Branch's LOBOviz website, http://fau.loboviz.com, which provides rapid and easy access to the LOBO network from any Internet source, including mobile phone or wireless PDA with a WAP-enabled browser and data agreement. Tracking real-time data via Google Earth is also an option. The LOBOviz server has a public common gateway interface that provides tab-separated text data via HTTP. The interface provides the following features: access, view and plot data in real time; compare multiple sensors in time series; compare data from multiple sites simultaneously; display up-to–the-minute values (i.e., data are refreshed every two min.); configure quality assurance/quality control (QA/QC) alert thresholds with email notification; and access to archived long-term data sets. The LOBOviz software archives the original acquisition raw data and the database that contains the averaged data for each acquisition on the storage server, and these are automatically backed up from the server to Amazon S3 on a daily basis as well as at FAU Harbor Branch through an automatic file synchronization program.

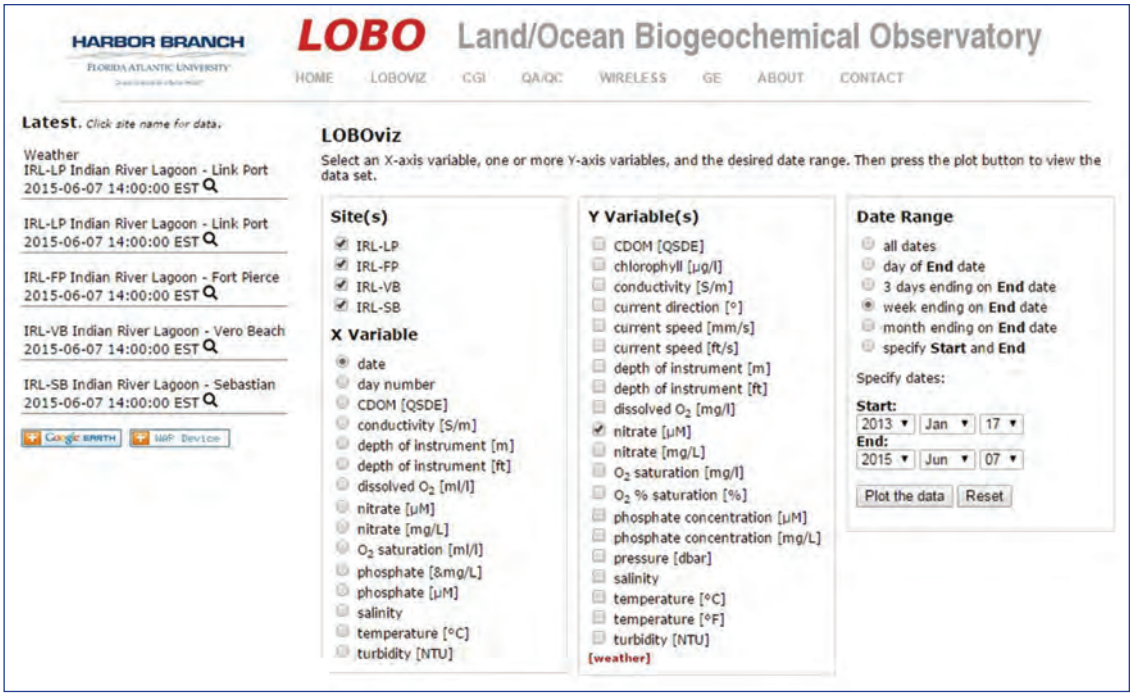
Plans are underway to make the IRLO LOBO data also available from the Southeast Coastal Ocean Observing Regional Association (SECOORA) database (http://secoora.org). SECOORA is one of 11 regional associations within the U.S. Integrated Ocean Observing System (IOOS), a national integrated system of ocean, coastal and Great Lakes observing systems coordinated at the federal level.

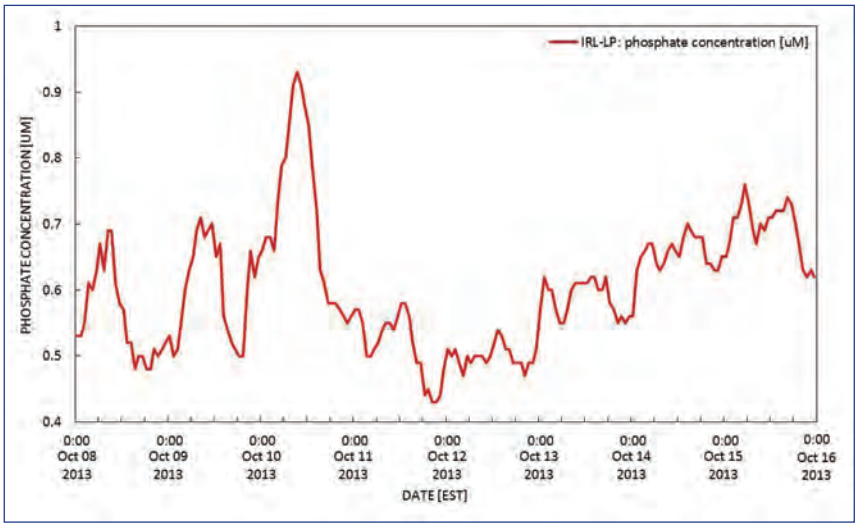
Data Reliability

Data reliability (and, thus, usability) is critical to an environmental observatory, and we have developed a robust QA/QC protocol for our network. Key components of our QA/QC program are: annual factory calibrations of all sensors, and FAU Harbor Branch staff conducting semi-annual sensor verification of all sensors, field sensor checks and biofouling mitigation every three weeks, and monthly validation and assessment of in-situ performance by comparisons of LOBO sensor data with analyses of grab samples at the sites.

LOBO Placements

We currently have LOBOs deployed at four sites in the





(Top) A screenshot of LOBOviz shows the many options available for retrieving and plotting data from the IRLO network. (Bottom) High-frequency monitoring provides much more data and captures events missed by discrete sampling, such as this weekly record of 168 data points for orthophosphate.

IRL in Indian River County and northern St. Lucie County, made possible by funding from FAU Harbor Branch and a grant from the Harbor Branch Oceanographic Institute Foundation. We are currently expanding the LOBO network with six new sites in the St. Lucie Estuary (SLE) and nearby IRL with funding from the 2014 State Legislative Budget (for five sites) through the Florida Department of Environmental Protection (FDEP) and the South Florida Water Management District (for one site). All of these sites are ecologically important because of the dynamic interface between oceanic water from the inlets with freshwater inputs from the river, canals and Lake Okeechobee.

This strategic placement of the units at 10 sites in the IRL and SLE was determined following a technical workshop with interested stakeholders comprising the Indian River Lagoon Observatory's Science and Technology Advisory Committee, with representatives from Indian River, St. Lucie and Martin counties; the agencies: South Florida Water Management District, St. Johns River Water Management District, FDEP, and Florida Fish and Wildlife Conservation Commission; the organizations: IRL National Estuary Program, Smithsonian Marine Station at Fort Pierce, Florida Oceanographic Society, and Ocean Research and Conservation Association; other universities: Florida Institute of Technology and University of Florida; and other interested stakeholders. The resulting plan was distributed to the public at http://www.fau.edu/hboi/meh/irlo.php.

Operations and Maintenance

The LOBO units are designed to minimize operational and maintenance costs. Before our LOBOs are deployed, we wrap them with waterproof tape and paint them with anti-fouling paint to reduce biofouling. Next, the units are placed in a test tank to check that the apparatus and all sensors are functioning correctly. After the testing period, FAU Harbor Branch staff transport and install the LOBO units at sites with permission of the U.S. Coast Guard. The LOBOs are attached to pilings with a pulley I-beam system designed and built by FAU Harbor Branch engineers for raising and lowering the LOBOs into the water. The instruments are equipped with a bleach injection system and/or a copper Bio-Wiper or Hydro-Wiper, which opens and closes to reduce fouling on the sensors.

FAU Harbor Branch staff check the incoming data on a daily basis to ensure that the data are reliable or see if the units need to be checked. Each LOBO unit is visited by boat every three weeks or more frequently if there is, for instance, a loss of incoming data or a data drift issue. During field maintenance, each LOBO is retrieved via a pulley system and the individual sensors are removed and serviced, which

includes basic cleaning of the equipment and refilling water chemistry solutions. As the sensors become biofouled, it is necessary to clean the sensors on site. Once a year, the units will be retrieved, cleaned and sent to the manufacturers for calibration. Upon return, the units will be taped and painted for anti-fouling and then redeployed.

Benefits of the IRLO LOBO Network

Estuarine research scientists and resource managers need reliable, continuous environmental data to better quantify, model and predict the relationships between environmental factors and biological processes.

The immediate use of the data will enable researchers to determine and document both short- and long-term environmental changes in the IRL and relate them to ecosystem functions; to assist resource and planning managers to make informed decisions for the good of the lagoon, e.g., on total maximal daily loadings and basin management action plans; to model and correlate environmental data to biological, chemical and physical phenomena; and to contribute to the northern end of the Comprehensive Everglades Restoration Plan.

Placing LOBO units in the SLE will also provide an unprecedented opportunity to conduct comparative studies with another Florida estuarine system on the west coast of Florida. RECON has similar LOBO units in the Caloosahatchee River and Estuary. A comparative study on the impacts of freshwater discharge from Lake Okeechobee on the occurrence of harmful algal blooms and estuarine habitat changes on each coast will substantially strengthen the observations, especially when the studies are conducted simultaneously with similar methodologies. Each estuary has been shown to have different ecological responses to wet and dry seasons, which makes this comparative research study valuable for researchers, resource managers and other users.

Some of the scientific questions this network will address are: How do freshwater discharges and watershed runoff impact water quality in the IRL and SLE? What is the nutrient (nitrate, phosphate) load? What is the impact on light attenuators (impact on seagrass)? What is the relationship to algal blooms? How does water from the IRL and SLE interact with oceanic water flowing through the inlets from the Atlantic Ocean? How does water flowing from the SLE impact water quality in the IRL? How much of the water from the SLE flows north in the IRL towards the Fort Pierce Inlet?

Education and Outreach

Using the LOBO units to research the dynamics of ecosystem change in relationship to spatial and temporal environmental changes will provide a platform for education and outreach activities. Through online access to free, real-time observatory data from the IRL and SLE via the LOBOviz website, students, teachers and faculty from schools, colleges and universities can experience and use this research data to bring ocean science into classrooms worldwide to improve ocean literacy. We can help teachers incorporate real-time water quality data and related research-based educational materials and activities into the curriculum. **ST**

Dr. M. Dennis Hanisak is a research professor at FAU Harbor Branch and director of its Marine Ecosystem Health and Education programs. He has more than 30 years of experience in marine biology and ecology, with a focus on marine plants, particularly macroalgae (seaweeds) and seagrasses. He has conducted research in the Indian River Lagoon and in other parts of Florida, the Bahamas and the Caribbean.

Kristen Davis has her B.S. degree in marine biology, with an emphasis in chemistry, from Millersville University of Pennsylvania. She has worked in Dr. M. Dennis Hanisak's lab for the past 10 years, running the day-to-day operations of the long-term water quality and seagrass monitoring in the Indian River Lagoon.

Ben Metzger has his B.S. degree in mechanical engineering from Northern Arizona University. He has worked in the Harbor Branch Engineering department for the past six years in the areas of project engineering, design, sensor deployments, systems testing, and field operations.