Application Note

Pontoon-Mounted Autonomous Monitoring System Keeps Constant Watch on Harmful Algal Blooms

Continuous water quality monitoring equipment offers a tremendous toolkit for scientists researching the complex interactions among water quality parameters and harmful algal blooms (HABs). HABs are triggered by a wide range of variables, ranging from flow rates to nutrient concentrations to light cycles, and the origin of the bloom can be separated both temporally and spatially from the source of the changes in flow and water quality.

Because real-time monitoring platforms such as MARVIN can collect valuable data with extremely high temporal resolution and don't miss key storm or water release events, continuous monitoring programs are much more effective than grab sampling programs for identifying relationships among the variables that influence algal blooms. And because the monitoring platforms operate unattended and require relatively little maintenance, continuous monitoring programs quickly become more cost-effective than programs that rely on data-gathering crews.

Above: Solar-charged batteries, flow cells, and satellite transmitter allow the equipment on a mobile MARVIN system to maintain around-the-clock data collection schedule with maintenance just twice per month. Below: Solenoid-governed water samples drawn from two or three depths pass through flow cells for monitoring, minimizing biofouling and increasing service life. An automatic wiper on this YSI 6600EDS multiparameter sonde also reduces maintenance needs. [Photos: Brian Bendis]

The pontoon-mounted MARVIN (MERHAB Autonomous Research Vessel In-Situ) platform allows researchers from the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) to deploy an array of monitoring instruments for long periods, automatically drawing samples for analysis from two or three depths and transmitting data back to research facilities in near-real time. Most of MARVIN's instruments are above the waterline; pumping water to the surface, running some through flow cells and capturing samples for laboratory analysis when needed reduces biofouling and maintenance demand. However, MARVIN has also proven to be an excellent test platform for instruments deployed in the water and attached to the system's solar power supply, satellite transmitter, and central processor.

Currently, two MARVIN platforms are deployed on Florida's Caloosahatchee River to study HABs. MARVIN 1 is positioned approximately 24 km from the mouth of the Caloosahatchee in approximately 4 meters of fast-running, dark water. There, it can record influences from Lake Okeechobee, Interstate 75, a Ft. Myers power substation, and the agricultural lands that surround it. MARVIN 2 is positioned in 3 meters of water 3.7 km from the mouth of the river, in the clear, slow-moving estuary where saline, oligotrophic water from the Gulf of Mexico mixes with enriched river water.

MARVIN 1 was deployed in the Caloosahatchee in January 2005 to study harmful algal blooms, including cyanobacteria, diatoms, and dinoflagellates such as Karenia brevis, the organism that causes Florida red tides. MARVIN 2 was deployed in January 2007 to augment upstream data with information on downstream water quality, and to track the movement of algae in the mixing zone.

HABs generate extensive news coverage in Florida, especially when fish or mammal kills result. Blooms of cyanobacteria appear to be linked to releases of nutrient-rich water from Lake Okeechobee, and some stakeholders believe that Florida red tides respond to the same stimuli. However, FWRI's research indicates that Florida red tides start in oligotrophic offshore waters and are pushed into coastal waters by winds and tides.

FWRI has been at the forefront of research on HABs in Florida

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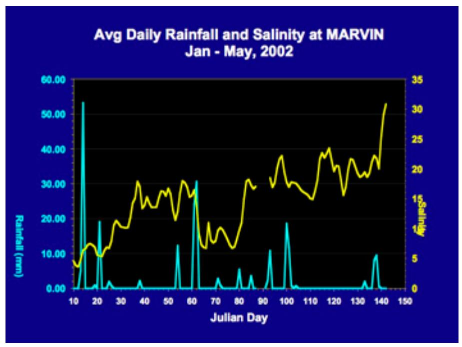
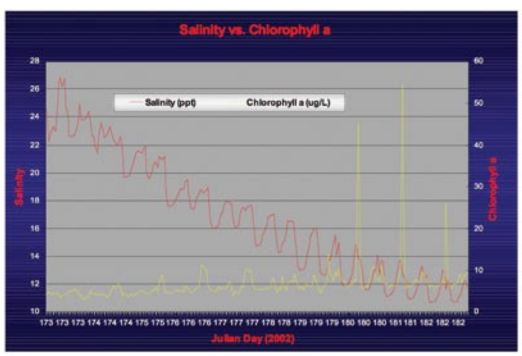
since 1955, and its researchers are trying to close the gaps that exist in the knowledge of the life cycle and behavior of K. brevis. Current research, including the MARVIN data, may help determine with greater certainty what causes K. brevis to bloom offshore, and whether traveling Florida red tides are further affected by pollution or nutrient enrichment when they reach the coastal environment. Studying the Caloosahatchee, a main outlet for releases that manage lake levels in Okeechobee, puts significant pressure on the team to deliver thorough, meticulously collected data, as discussions surrounding releases from Lake Okeechobee can be highly controversial, politically charged, and minutely scrutinized.

MARVIN Equipment

The MARVIN platform was designed by a team of engineers, programmers and scientists from AMJ Environmental in St. Petersburg, Fla., formerly a division of AMJ Equipment Corp. and now a subsidiary of Ohio-based YSI Inc. Mounted catamaran-style on two pontoons, the platform includes a Vaisala WXT510 weather transmitter on a meteorological tower to collect data on wind direction and speed, barometric pressure, air temperature, relative humidity, and rainfall. Sturdy, locked toolboxes contain an array of sampling instruments, including a YSI 6600EDS multiparameter sonde that monitors pH, dissolved oxygen (DO), specific conductivity, turbidity, water temperature, salinity, and relative fluorescence (an indicator of the presence of chlorophyll); a YSI 9600 nitrate monitor with a pre-filter; and an ISCO water sampler capable of collecting 24 one-liter samples. LI-COR quantum sensors for ambient and underwater photosynthetically active radiation (PAR) hang off the stern, and a SonTek/YSI ADCP velocimeter records current velocity, direction, and water level.



Data on rainfall and salinity collected on the MARVIN platform illustrates the effect of rain events on salinity (above). Data collected simultaneously reveals an algal bloom (below). Autonomous data collection is helping scientists understand the links between harmful algal blooms and water quality parameters.



The MARVIN 1 and MARVIN 2 systems are controlled by Campbell Scientific CR23-X dataloggers, which manage four solenoids; a new MARVIN on the drawing board will incorporate the updated CR100 datalogger. Three of the solenoids govern the flow of water drawn via a peristaltic pump attached to 3/8-inch tubes that extend to predetermined depths in the water column, and one is connected to the ISCO sampler. A GOES satellite transmitter, cell phone modem, cell phone, and Turner Designs Phytoflash also share space in the control box. Power for the entire MARVIN system is supplied by two 12-volt deep-cycle marine batteries charged by solar panels mounted above the equipment boxes.

The equipment array is designed for ease of maintenance, which is scheduled for twice-monthly visits to calibrate equipment and replenish reagents and other supplies. A roomy deck allows a generous workspace. Equipment boxes are easy to open, and probes and wires are accessible. Flow cells keep most of the probes out of the river, reducing biofouling and increasing their expected life cycle (an automatic wiper on the YSI 6600EDS also keeps that sonde's sensors clean). Bendis chose peristaltic pumps to prevent contact between pump parts and the water, keeping fouling off of the pump head and air out of samples.

AMJ Environmental staff and an FWRI team headed by HAB research scientist Merrie Beth Neely use a 5.5-horsepower outboard engine to position the MARVIN platforms. Once the unit is shackled to several anchors – which limit the pontoons' swinging in the current, preventing tangling of overboard lines – they remove the engine and bracket and leave MARVIN to sample twice an hour and report back to the lab via satellite.

Data Flow

MARVIN platform data are transmitted via GOES satellite in a five-to-15-second window hourly or once every three hours, depending on the data telemetry setup for the site. Data are acquired by a NOAA-National Environmental Satellite, Data and Information Service (NESDIS) ground station at Wallops Island, Virginia, re-transmitted, then acquired by satellite downlink receivers at the College of Marine Science, University of South Florida (USF) in St. Petersburg. At the university, Vembu Subramanian leads a team that parses data using decoding scripts and storing them in a database. From USF, data are then disseminated via internet to a variety of users, following the Integrated Ocean Observing System (IOOS) Data Management and Communications Standard. The MARVIN data are combined with data from NOAA C-MAN and National Data Buoy Center (NDBC) buoys and USF West Florida Shelf Coastal Ocean Monitoring and Prediction System (COMPS) weather stations to provide a comprehensive look at regional marine weather conditions.

Neely notes that there are challenges to data collection with MARVIN. Some are a factor of the river: for example, readings from the relative fluorescence sensor on MARVIN 1 have to be corrected for extremely high background levels caused by tannins in the water (Neely reports Secchi readings as low as 0.2m at the site). The suite of equipment aboard MARVIN, which allows for comparisons and correlations among a wide range of data streams, helps accomplish those corrections. Neely's team also ground-truths the MARVIN data during maintenance visits, using traditional analysis methods for nutrients and extracted chlorophyll as well as measurements taken with a duplicate YSI sonde. The hand-collected data is used to correct MARVIN data in post-processing.

Because of their HAB mission and the array of data-gathering tools they carry, the MARVIN platforms generate tremendous insight into the variability of physical and biological water quality parameters. One set of graphs from MARVIN 1's deployment on the St. Johns illustrates the effect of a 100-mm rain event on salinity at the surface of the river, chronicling the long-lasting effect on salinity caused by runoff from the surrounding land. As salinity drops to about 12 psu six days after the storm, a Microcystis bloom appears in the chlorophyll data, which tracks the HAB through its diurnal cycles. Correlations with PAR, low tides, pH, and nitrate values may help Neely and her team evaluate the conditions that favor the development of HABs.

A second graph from MARVIN's current deployment on the Caloosahatchie tracks the precipitous rise in salinity at two depths – surface and bottom – following the end of releases from Lake Okeechobee on April 30. The salinity peaks on June 4; review of meteorological data from the MARVIN platform can be overlaid to show a rain event that diluted the brackish flow.

Beyond the FWRI labs, users of the MARVIN data range from modelers of water circulation and biology of the Caloosahatchee system to emergency managers to dive boat captains seeking up-to-the-minute insight on water conditions. Beachgoers check to see if red tides are expected, pilots assess currents, search and rescue teams check visibility, and school groups learn about biological cycles.

Because MARVIN collects a steady stream of data around the clock for months or more, temporal resolution is extremely high. The resulting data is extremely accurate, and researchers are able to track storm events, lake releases, seasonal patterns, and even diurnal cycles that would likely be missed by a crew on a periodic schedule. The result is a data set that is far more instructive than a weekly or even daily sampling regimen would provide.

Beyond the far superior data, the cost-effectiveness of the autonomous sampling platform also quickly becomes apparent. The initial investment in MARVIN – about $150,000, as equipped and programmed for FWRI's Caloosahatchee project – and the cost of regular bi-weekly maintenance is far lower than deploying crews for long-term monitoring programs.

Future Efforts

In addition to analyzing the stream of detailed data flowing from the MARVIN platforms, FWRI has been looking to future uses of the pontoon deployment systems. Limited only by equipment power requirements and the amount of data that can be transmitted in narrow GOES windows, the team has hosted beta-testing of a variety of exciting instruments, including a UV sensor that can "see" in extremely turbid water, new CDOM technology, and a mass spectrometer that MARVIN ushered on transects in the Indian River Lagoon near Cape Canaveral to search for organic carbons in the water.

MARVIN has been a proving ground for the Environmental Sample Processor (ESP), which Chris Scholin of the Monterey Bay Aquatic Research Institute developed to use genetic tags to identify red tide organisms. It may someday host the innovative Breve Buster, designed by Gary Kirkpatrick of Mote Marine Laboratory to use the signature pigment array of K. brevis to identify red tides and calculate the concentration of organisms in the sample.

As the demand to understand complex coastal systems grows and budgets remain tight, real-time monitoring data of coastal waters will only grow in importance, and water quality monitoring equipment will continue to become more sophisticated. Versatile, flexible platforms like MARVIN will certainly play an increasingly important role for scientists and resource managers in coastal systems – and companies like AMJ Environmental and YSI are focused on the continued development of such systems to meet this growing demand.

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