

ENVIRONMENTAL monitor

winter 2013

Application and technology news for environmental professionals

CROSSING THE PACIFIC



Predicting a Path
for Gulf Oil Spills

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NASA's Ocean
Monitoring Armada

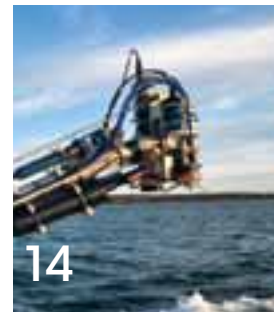
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WELCOME...

Welcome to the Winter Issue of the Environmental Monitor. We're hitting the high seas this edition with a look at a fleet of Pacific-crossing, sensor-toting gliders and a NASA-led voyage to the saltiest spot in the Atlantic. We also have the largest-ever deployment of floating GPS drifters, which will help model currents in the Gulf of Mexico to predict the movement of oil spills. Our Environmental Education department stays inland, where we check in on students in Wisconsin and Ohio that are getting hands-on experience monitoring local water quality.

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Cover Photo by Liquid Robotics

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EM ONLINE RECENT FEATURES



Breaching Pescadero Lagoon

Along the California coast, sandbars occasionally form temporary freshwater lagoons at the mouths of coastal streams. This is prime habitat for stream-born steelhead to bulk up before heading out to sea when the sandbars breach. But in 2011, 235 steelhead in Pescadero Lagoon went belly up before they got the chance.

Photo: Sarah Swenty, USFWS



Hurricane Sandy's Storm Surge

Hurricane Sandy hammered the East Coast with powerful storm surges, and U.S. Geological Survey sensors were on the front lines, strapped to piers, pylons and seawalls to track how high sea levels climbed. Sensor recovery crews fought gasoline and lodging shortages and lost only a few instruments to the destruction.

Photo: NASA



Three Rivers Quest

A West Virginia Water Research Institute monitoring program that helped cut total dissolved solids in the Monongahela River is expanding to the Ohio and Allegheny Rivers. The new Three Rivers Quest program is funded by a grant from the Colcom Foundation and will work with local watershed groups to cover the river systems from their main stems to their headwaters.

Photo: Mike Rhoads

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Algal Bloom Mystery

Locals turn to a data buoy to diagnose what ails Lake Lillinonah

BY JEFF GILLIES

Lake Lillinonah has a garbage problem. The lake sits behind a dam on the Housatonic River and is the first large reservoir encountered by debris that washes into the river upstream. The lake, Connecticut's second largest, acts as the watershed's catch basin for stream-bound refuse, natural or otherwise.

"Anything you can think of, we found it," said Greg Bollard, executive board member of Friends of the Lake, a community-building and water quality advocacy group for Lake Lillinonah. "From refrigerators to propane tanks to engines to vehicles to docks to boats."

Depending on how the lake's level is manipulated in support of hydroelectricity generation at the dam, the debris can range from thick enough to hamper boat navigation to "not a stick on the water," Bollard said. But there is one piece of hardware that Friends of the Lake is happy to keep floating out there. In 2011, the group launched a water quality monitoring buoy that could help unravel the mystery behind another issue on the water: algal blooms.

The lake is eutrophic and algal blooms are a big concern, said Jen Klug, an associate professor of biology at nearby Fairfield University. Klug works closely with Friends of the Lake on the buoy project and other monitoring efforts.

What triggers the blooms isn't clear, Klug said. Blooms are often a symptom of excess nutrients, which Lake Lillinonah has in abundance thanks to loading from the basin's wastewater treatment plants, lawn fertilizers and stormwater. But it seems to be more complicated than that. The lake's phosphorus levels are generally high enough to support an algal bloom, but algae isn't always blooming.

So what else could be causing the blooms? One possibility that Klug and other researchers are looking into is the lake's mixing patterns. For example, the lake's layers of warm and cool water could play a role in either flushing algae out of the system or churning an extra dose of nutrients up from the bottom and fueling algal growth at the surface.

But as an impounded river, mixing can be highly variable and the layers can change quickly, making it a difficult thing to track.

"For example, during the rain following Hurricane Irene last fall, the lake completely mixed in the course of a couple hours," Klug said.

That's where the buoy comes in. A string of sensors hanging from the float measures temperature at 15 depths, every 15 minutes. That kind of high-frequency monitoring can give researchers a better picture of temperature stratification on a dynamic system like Lake Lillinonah.

The buoy is also measuring dissolved oxygen, conductivity, pH, chlorophyll and phycocyanin near the surface, and dissolved oxygen near the bottom. Researchers don't yet have enough data to draw any conclusions about the blooms, but they are learning things about the lake. In the dry July of 2011, for example, the buoy data showed the lake was strongly stratified despite spot sampling that suggested otherwise.

For Bollard, the buoy has already succeeded in sending a clear message that Friends of the Lake may be an advocacy group, but they're not biased.


"For us as an organization, the single largest thing that the buoy has accomplished for us is it gave us a sense of credibility," he said. "Anyone who looks at our organization first off recognizes that we're using science, not emotions." 



Photo: Tod Osler

Service Learning

In 2011, Audrey McGowin converted the environmental chemistry course she teaches at Wright State University into a service-learning experience that put her students at the helm of a long-term water quality monitoring project at a nearby nature preserve.

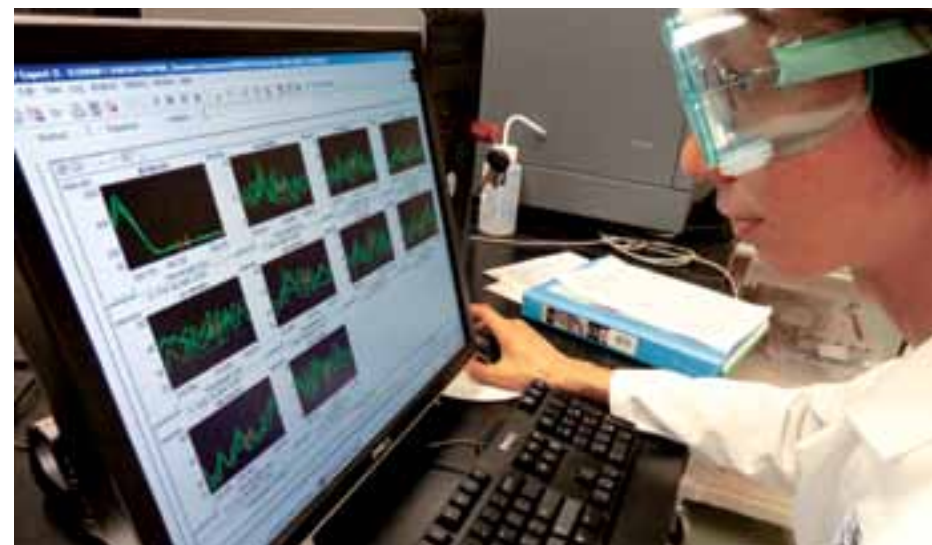
McGowin, an associate professor of chemistry at the school in Dayton, Ohio, wanted to shift the course's emphasis from tests and lectures to real-life experience that could help the community.

"I got to thinking about making chemistry more relevant and having the students doing something real," she said.

In its first year, the class consisted of upper-level undergraduate and graduate chemistry students from Wright State and students participating through a first-year seminar course on water at Antioch College, a small liberal arts school in Yellow Springs, Ohio.

The students planned sampling trips at Antioch College's 1,000-acre Glen Helen Nature Preserve. The Little

Teaching assistant Triet Truong performs heavy metal analysis on sediment samples collected by students from Glen Helen streams.



Miami River and Yellow Springs Creek flow through the preserve and face water quality threats from stormwater, industrial runoff and discharges from a nearby wastewater treatment plant.

The students measured pH, temperature and dissolved oxygen on site and collected samples for laboratory analysis. The class also emphasized proper note taking and development of standard operating procedures based on U.S. Environmental Protection Agency methods. That gives the students realistic professional experience that isn't always a part of science education.

"When I went out in the world of work with a Ph.D, I didn't have any idea what good laboratory practices were," McGowin said. "No one ever mentioned it."

Students say the course is more challenging than the previous lecture-based version, but they tend to learn more. Meanwhile, the people at the Glen Helen Ecology Institute are pleased to have an environmental monitoring program providing them with quality data, McGowin said.

The students and community aren't the only ones who benefit.

"It's been rewarding for me as a faculty member. It's rejuvenated my teaching," McGowin said. "The main issue to me is doing something relevant."

—Jeff Gillies

Boat of Knowledge

Southeast Ohio schools tend to have two things in common. Many are underprivileged, and many are near rivers and streams that roll through foothills of the Appalachian Mountains. Students may see water every day, but tight class schedules and a lack of funding for science equipment can leave their understanding of water murky.

High school teachers and Ohio University graduate students and professors are trying to clear things up with a hands-on water quality monitoring experience that combines classroom sessions and a boat trip to teach students about water. The goal is to give students a new perspective on the brook running under the bridge they might cross on the way to school every day.

"You can be taught something from a textbook, but you learn so much more when you have your hands on it," said John Bentz, a graduate fellow in the Boat of Knowledge in the Science Classroom, or BookS, program.

Classes are assigned to a graduate fellow who teaches lessons on water. Then each class gets a day to hop on the Boat of Knowledge and ride down the Ohio River to an area where they collect data on pH, nitrates, fecal coliform, conductivity and E. coli.

The BookS program, funded by the National Science Foundation's GK-12 program, offers an opportunity to use water monitoring technology that students wouldn't see in a regular science class.

Photo: Audrey McGowin

One tool the graduate fellows use for both education and research is a Hach CEL/890 Portable Laboratory for nutrient testing. Bentz said not all the students can make it on the boat trip, so the portable lab gives them opportunity to test water quality in their classroom. He encourages his students to bring in their own water samples to test.

Bentz said many of his students know about pH, but know little about other testing parameters.

"After they see what all gets studied, why it gets studied ... they see the importance," Bentz said.

—Austen Verrilli



Ohio University graduate students take high schoolers on the Ohio River for a hands-on experience testing water quality.

Lower Fox River

A group of high schoolers in the Green Bay, Wis. area is learning about careers in environmental science thanks to the Lower Fox River Watershed Monitoring Program. The program, supported by the University of Wisconsin, has involved more than 700 students since its 2003 launch.

"We have almost ten years of data," said Annette Pelegrin, program coordinator. "It began in 2003 with five watersheds.

Students collect water samples as part of the Lower Fox River Watershed Monitoring Program.



We've trained teachers and schools that are interested and showed them how to measure different parameters."

Those include flow, temperature, transparency and turbidity of the program's streams. YSI 55 meters are used to measure dissolved oxygen, and levels of phosphorus, ammonia and nitrogen are checked with a Hach colorimeter. Populations of local frog and bird species are also tracked.

"At each stream, we pick 10 sites at road crossings. Students go out with expert

birders to learn how to identify sound and appearance of the birds. They write down what they see and are able to track the numbers over time," said Pelegrin.

The data collected since the program's launch has been used by monitoring professionals and researchers at the University of Wisconsin - Green Bay.

"It's more than just citizens monitoring. Our data is high-quality. It goes through a quality-control process before it enters our database," said Pelegrin. "And all of the teachers are trained."

The students have helped on other local projects. When the city of Appleton, Wisc. was evaluating water in its flood retention basins, students did the testing. They've also assisted in work to mitigate farm runoff.

In the past year, students from 11 high schools conducted testing in seven watersheds. Youngsters from the Green Bay Boys & Girls Club also joined in. It's one of the biggest groups yet.

"They're really learning about careers in environmental science," said Pelegrin. "Many of them go into it, and it's because we're capturing their interest at a younger age."

—Daniel Kelly

Sensing PROGRESS

BY JEFF GILLIES



Around a decade ago, a branch of the federal government that funds research and development for environmental sensor technology wasn't satisfied with its return on investment.

"They would get a prototype at a lab bench that a university professor and his post-doc could run, but they weren't really seeing an operational tool that they could use and the community could use," said Mario Tamburri, professor at the University of Maryland Center for Environmental Science. "They wanted a program to help push those technologies along and take over where traditional funding sources stop."

That led to the Alliance for Coastal Technologies, or ACT. Funded by the National Oceanic and Atmospheric Administration, the program is a partnership between university research institutions, environmental agencies and technology manufacturers. The group is also a part of the Integrated Ocean Observing System. ACT works to advance sensor development, helping manufacturers strengthen the weak spots in their products while educating users on how to get the most out of their tools.

"Our goal in evaluating technologies is to provide a resource both to the people who develop and sell these instruments and the users," said Tamburri, who also serves as the director of the alliance.

One of the program's most important jobs is to serve as an independent, unbiased testbed for emerging technologies, as well as established tools that are already on the market. For off-the-shelf products, an ACT evaluation puts an instrument through its paces in diverse environments, including the Great Lakes, Chesapeake Bay, and the coastal waters of Hawaii and Alaska. Lab tests give a controlled look at a tool's performance in areas like accuracy, precision and range.

Though the group issues a report on each tool that describes the results of the evaluation, they stay away from recommending one product over another. That would change their relationship with the manufacturers, whose participation is crucial to the ultimate goal of improving technology, Tamburri said.

"We don't want to alienate them in any way," he said. "But they know going in, that because we're a federally funded effort, that all the data is made publicly available. So they know that good, bad or otherwise, the data is going to be out there."

An upcoming round of testing will focus on pH sensors. The ability to measure pH in situ has become increasingly important as scientists seek to better understand ocean acidification, which is tied to the ocean carbon cycle. Although technology for measuring pH is widely available, the probes are prone to fouling.

“How good are those numbers, and how good are they over time, is our first big question.”

-Mario Tamburri

Alliance for Coastal Technologies director

"That's always been a challenge as soon as you put those instruments in the water. An hour or two later, how reliable are those readings?" Tamburri said. "How good are those numbers, and how good are they over time, is our first big question."

In addition to evaluating tools that are already widely used, ACT also runs tests to demonstrate emerging technologies. The group most recently performed a demonstration on sensors that measure partial pressure of carbon dioxide, another important parameter in understanding the ocean carbon cycle. That analysis found that the sensors work, but require a level of expertise about small issues that can make a big difference in the readings.


"You have to know what you're doing," Tamburri said. "But I think that is one of those issues that can be overcome. The

more we learn about this, and the more they're packaged better, the more user-friendly they are and the better those readings are going to be."

One reason to believe these issues will be resolved is that, not long ago, the industry was in a similar situation with another set of relatively young sensors tied to an emerging environmental issue.

Though resource managers at the time were becoming increasingly aware of algal blooms and hypoxia caused by excess nutrients, they didn't trust the nascent technology that would allow them to capture high-resolution data on nitrogen or phosphorus in their water bodies. The instruments were expensive and were prone to clogging or other issues, and people were more comfortable with collecting samples and measuring phosphorus in the lab.

An evaluation of nutrient sensors found that the fundamental measurement technology was sound, Tamburri said. The packages housing the sensors were causing most of the trouble. The collaboration with ACT helped the manufacturers identify and resolve mechanical issues with the packages. Meanwhile, the group worked with users to alleviate some of the anxiety over transitioning to a new measurement approach.

"I think those nutrient analyzers are very operational now," Tamburri said. "And I hope that ACT played a large role in making that possible." 

An ACT workshop trained resource managers, scientists and students on in situ nutrient analyzers.



Photo: Alliance for Coastal Technologies



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Changing Channels

Tracking the ecological effects of Pennsylvania creek dredging

BY JEFF GILLIES

Tropical Storm Lee brought massive flooding to Pennsylvania in 2011. The storm also kindled a resurgence of a long-standing flood control tactic in the region: channelizing creeks with heavy equipment, scraping stream beds clean of cobble, tree trunks and anything else that might slow down rising water.

The idea behind the excavation is that straightening and smoothing the streams will keep flood water moving downstream quickly without spreading out into the floodplain and threatening the homes and other structures people built there.

While the process might help ease the minds of floodplain dwellers, it's likely less beneficial for some of the region's other residents.

"These are nice little trout streams," said Steven Rier, an associate professor of biology at Bloomsburg University in Pennsylvania. "These are not little agricultural ditches in the Midwest. These are actually nice little mountain streams that are full of brook trout."

Though it seems clear that scouring classic fish habitat from a stream will be bad for fish, the potential for more channelization leaves Rier with questions about the potential impact on the broader ecological functioning of stream systems.

"What does that do in terms of ecosystem services and the overall health of the stream?" Rier said. "What does it do to the ability of a stream to process nutrients? What does it do to the ability of a stream to store organic matter, and ultimately translate that into fish production?"

To find some answers, Rier and colleagues are studying creeks in north-central Pennsylvania with recently channelized stretches. They'll compare measurements in the altered sections with nearby segments that have been left alone. The goal is to express the effects of channelization in terms of stream metabolism, and eventually economic value.

One method to assess metabolism is comparing 24 hours worth of dissolved oxygen measurements at two locations in a

stream. The fluctuation in oxygen levels over that span can give researchers an idea of the daily proceedings of the stream's plant, animal and microbe communities.

"It's a way of getting at the amount of oxygen that's being released due to photosynthesis and the amount of oxygen that's being taken up due to respiration," Rier said.

Rier measures oxygen with a series of YSI optical dissolved oxygen meters. By adjusting for the time it takes for water to flow from one meter to the next, researchers can track oxygen fluctuations in one parcel of water as it moves downstream. Measurements also have to be adjusted to account for other sources of oxygen variation, like atmospheric exchange.

The project will also assess how well the study streams process nutrients. The streams don't carry much phosphorous, but receive some nitrogen through atmospheric deposition.

"The healthy streams are taking up a good part of this nitrogen before it ends up going downstream to the rivers and ultimately, in our case, Chesapeake Bay," Rier said. "Which obviously has some real nutrient issues."

Channelization could cut nutrient uptake by smoothing out the twists, turns and structures where leaf litter and other natural debris collects. Those organic matter deposits are the base of operations for the microbes that take up nutrients.

Though stream metabolism is an important scientific indicator of overall stream health and function, Rier eventually hopes to express the cost of dramatically reshaping streams in more widely understood terms: dollars and cents.

"How much value do you lose if you decrease the fishery of a particular stream?" he asked. "How much value do you lose if you decrease the retention of nitrogen, which ultimately has an impact on Chesapeake Bay?"

Photo: Steven Rier

DRIFTING THROUGH THE GULF

BY DANIEL KELLY



A research consortium formed after the Deepwater Horizon oil spill has deployed more than 300 GPS drifters near the rig's explosion site to study surface currents in the Gulf of Mexico. Known as the Grand Lagrangian deployment, it is the largest of its kind in history.

By logging the drifters' locations as they move, scientists have gained insights into the effects sea currents have on the transport of crude oil. The data, collection of which began in July 2012, will help emergency planning and improve forecasts of the pollutant's movement in future oceanic disasters.

The Consortium for Advanced Research on Transport of Hydrocarbon in the Environment (CARTHE) won funding for the project from the Gulf of Mexico Research Initiative. The research initiative was founded through an agreement between the Gulf of Mexico Alliance and BP to provide \$500 million in funding for independent scientific research related to the Deepwater Horizon incident over the course of 10 years.

"We are a modeling group, and we want to make a forecasting system that is suitable for pollution transport," said Tamay Özgökmen, director of CARTHE and professor at the University of Miami. "The cheapest, most ecological way to do that is through surface drifters."

The project began with help from the U.S. Coast Guard, which has routinely used data from drifters in search and rescue missions. The Coast Guard agreed to drop a few drifters into the Gulf in exchange for use of the experiment's data when it was fully up and running.

"We made an agreement with the Coast Guard to release four by air to get a sense of circulation before the mass deployment," said Özgökmen. "Then we released 24 around Deepwater Horizon and about 90 each day at different sites. Most of the deployments took place in three days.

"We made data available immediately to the U.S. Coast Guard. They used it the whole time for test missions and whenever Hurricane Isaac hit. They saw ours and needed to deploy fewer of their own. They put theirs where there were gaps," said Özgökmen.

In all, 317 drifters were placed into the Gulf, each one about three feet tall with floats and support screens that keep the GPS unit stable and vertical. Özgökmen says a typical research project would only need 10 to 20 drifters.

The GPS transmitters relay the coordinates of each drifter to a satellite, which provides updates to researchers every five

minutes. That transmission frequency made it possible for them to find more variations between data points.

"The current model is not very good. This is an area where satellite forecasts don't work very well," said Özgökmen. "The Earth's rotation tends to create huge oscillations that keep it going round and round, like a pendulum. Our major goal is now to improve the forecasting system. The data has been unavailable in such large quantities and it takes time."

The oil industry's presence in the Gulf also complicates research there.

"You can't see them on the coast, but you go 10 miles out and there's a forest of oil rigs. In the middle of nowhere, there's a city of these things," said Özgökmen. "There are 4,000 oil rigs in the Gulf and the companies are digging deeper and deeper."

“For me, it's the biggest project of my career. It's an emotional project... This work is contributing to society.”

-Dr. Tamay Özgökmen

CARTHE director, professor at the University of Miami

He says heat in the Gulf also affects the water currents there and is another consideration to take into account. The Florida Straits were a factor, strong currents which Özgökmen says only took a few drifters out of the Gulf.


In addition to improving forecast models that can be used by the Coast Guard and emergency responders in future disasters, Özgökmen says the research is valuable in other ways.

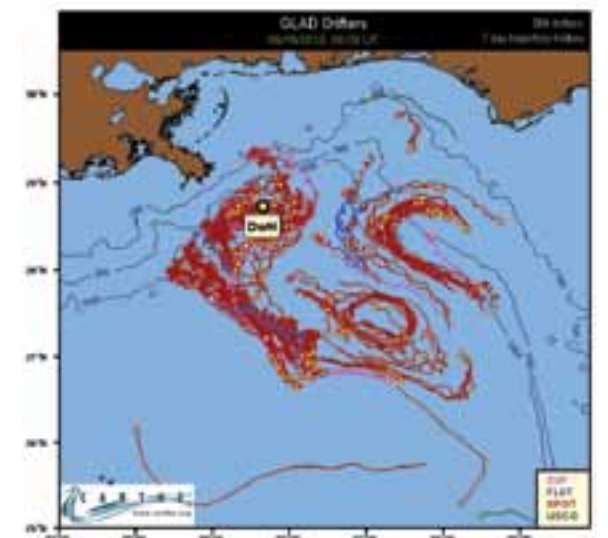
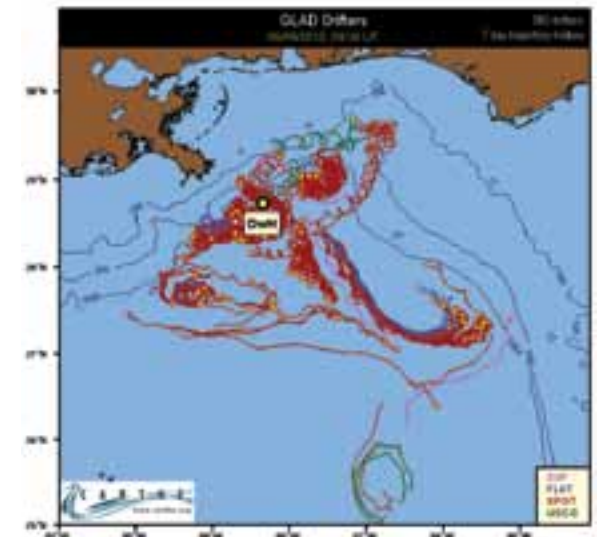
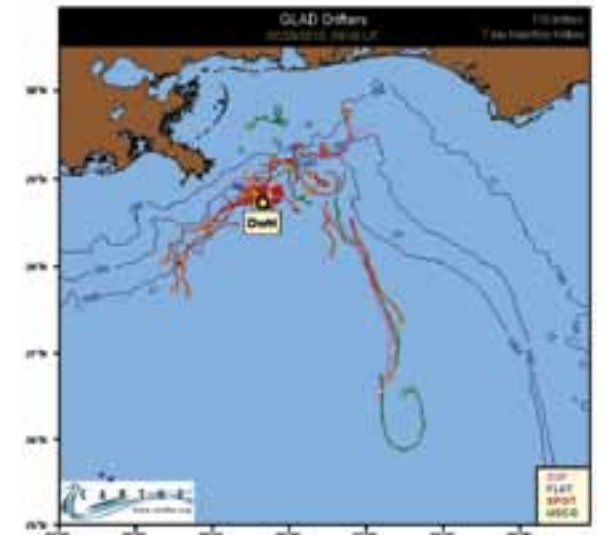
"For me, it's the biggest project of my career. It's an emotional project," said Özgökmen. "We're usually running models on computers, but this work is contributing to society. Fisheries will benefit from this work. Students are getting educated. It's a meaningful research."

On average, there is one oil spill per year in the world's oceans. Improved forecasting models could help contain them better. The Naval Research Laboratory will likely use the data to strengthen its models.

As to what happens when a drifter goes offline, Özgökmen says fishermen find them and send them back to CARTHE. He says CARTHE is working on a prototype drifter that is biologically degradable and about the size of a sushi box. Ten prototypes were tested in the deployment.

"At the current rate, we'll run out at the end of the year. We're losing about two drifters every day. Sometimes three, sometimes one, but averaging two each day," said Özgökmen.

When transmissions end, CARTHE will begin analyzing the more than five million data points that have been collected. 



View the path of the drifter buoys at http://carthe.org/glad/GLAD_drifter_movie.gif

Photo: Tamay Özgökmen

Beneath the Sea

BY AUSTEN VERRILLI

A recent survey of juvenile scallops using an advanced underwater camera rig on the U.S. East Coast revealed that the population there experienced a substantial upshift.

The study by scientists at the National Oceanic and Atmospheric Administration's Northeast Fisheries Science Center found that juvenile scallops are particularly prolific in an area of Delaware Bay.

Preliminary numbers for the 2012 study show between 2.5 billion and 5 billion juvenile seed scallops in the Mid Atlantic study area. Scientists are waiting for the results of a second study next year to give final numbers, said Deborah Hart, mathematical biologist with the fisheries science center and leader of the sea scallop stock assessment.

Surveys in 2002 and 2003 found record numbers, turning up six billion to eight billion seed scallops. The 2012 count may be the second-highest ever if the follow up study confirms the numbers.

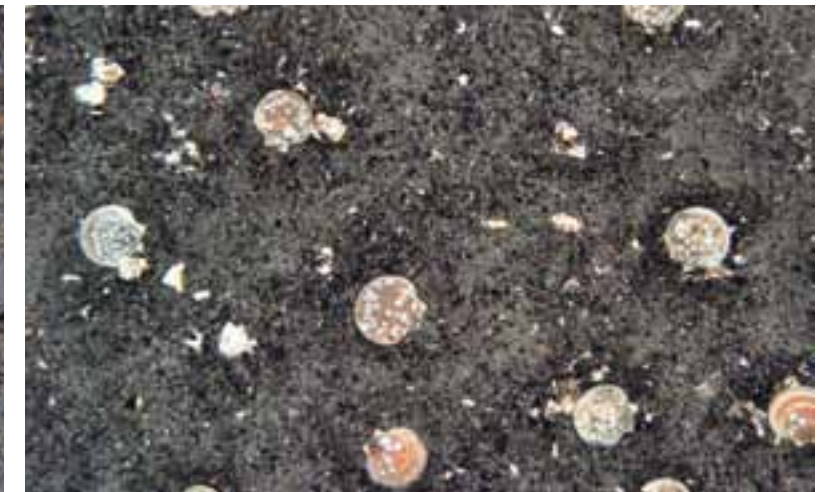
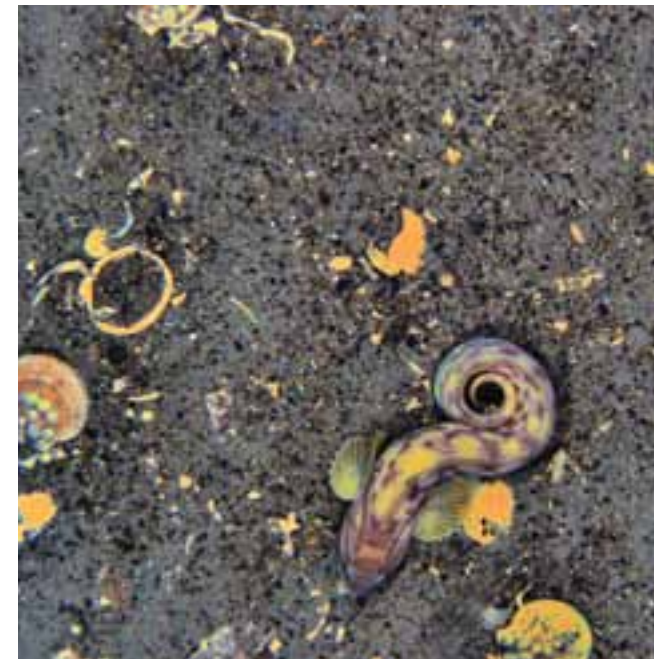
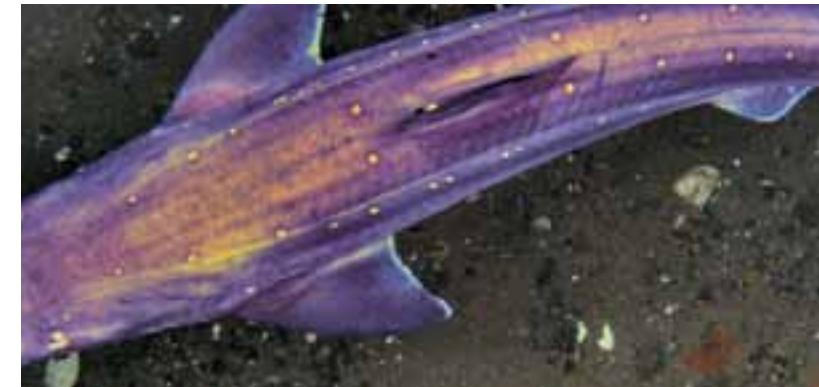
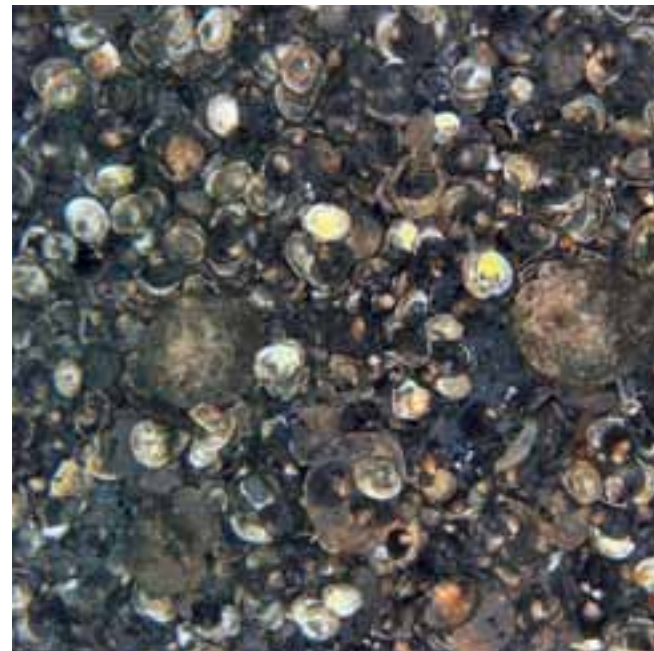
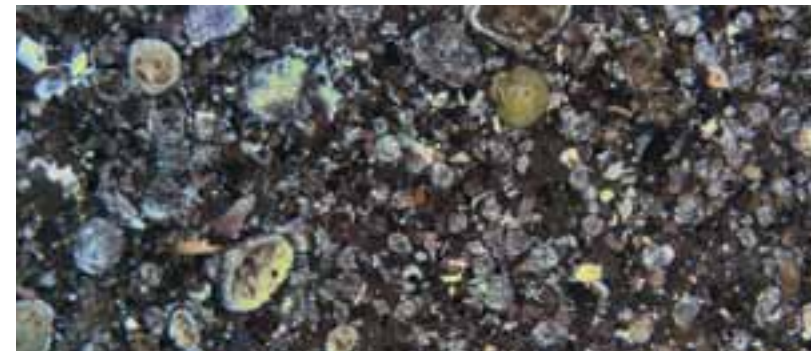
Similar numbers were seen by unaffiliated organizations in the fishing industry and the Virginia Institute of Marine Sciences, according to a press release on the findings.

Scientists at the Woods Hole Oceanographic Institution developed the special monitoring rig, called the "Seahorse" for its angular shape.

Researchers tow the Seahorse at a cruising speed of around seven knots. It glides two meters over the sea floor collecting data. The rig carries a fluorometer, spectrometer, dissolved oxygen sensors and a conductivity, temperature and depth sensor. It also has a side-scan imaging system to plot benthic topography.

The Seahorse's main tool is the latest version of the Habitat Camera Mapping System, or HabCam. The HabCam takes strings of pictures, which can be intertwined to give a mosaic of the ocean floor. The Seahorse allows scientists to observe bottom dwelling fish in their element.

Hart said the camera adds a new facet to scientific scallop observation. "You're not just catching what's at the bottom," she said. "You can actually see where the scallops are and see what other animals are doing there as well."



Scallops are the most valuable fishery on the East Coast. One reason scientists monitor them is to create sustainable fishing quotas. Once mature, the estimated seed scallops from the 2012 survey should bring in more than \$500 million at the dock.

For example, the camera showed scallops tend to stay together in the troughs of sand waves at Georges Bank. Sand dollars, on the other hand, aggregated on the crests of sand waves. That's not something that a dredge tow would necessarily show.

The HabCam also shows tracks from fishing dredges, which can help researchers and regulators identify what is being fished in the area.

The HabCam took 7 million photographs during one 30-day leg of the journey. The researchers couldn't sort through all 7 million images by hand. Instead, they went through every 200th picture, or about 35,000 total. That's a picture approximately every 100 meters, Hart said. Other survey techniques have data points every four miles at best.

HabCam data showed that scallop population estimates from dredges were not far off. Hart said the validity of dredge counts has been a controversial topic, but the Seahorse only showed about a 10 percent deviation in findings.

Hart said it's hard to be certain why seed scallop populations ballooned this year, but she has a few ideas.

First, 2011 saw several strong rains from tropical storms and hurricanes. This flushed more nutrients into Delaware Bay, where seed scallops were most prolific. Nutrients fed plankton growth, which could have fed more young scallops and helped them flourish. Still, that's a big "could," and Hart is not ready to point to the bloom as anything other than an unproven possibility.

A second possibility is that ocean currents may have carried young scallops into the study area from a nearby section of the ocean that is periodically closed to commercial fishing. Hart said when scallops spawn, they float up into the upper layers of the ocean, and the current could have sent them southward. She said she has twice seen populations spike after fishing closures. "Both times the biomass skyrocketed after the closure," Hart said.

Despite these ideas, Hart said scallop populations spike and fall in unpredictable patterns. AV

All Photos: NEFSC/NOAA Habcam

LIGHT | SOUND | SEDIMENT

USGS research takes optical and acoustic sensors to the seabed

BY JEFF GILLIES

When a month-long oceanographic mission on the Atlantic seabed ends with an 11-foot steel tripod capsizing and destroying part of its multi-thousand-dollar sensor payload, you might expect that to dampen the researchers' spirits.

Apparently, at least some oceanographers are optimists.

"From a technical point of view, it was a very successful experiment," said Chris Sherwood, an investigator on the tripod project and a research oceanographer with the U.S. Geological Survey's Woods Hole Coastal and Marine Science Center.

Before it tipped, the custom-built tripod spent most of October 2011 sitting under 40 feet of water around a mile offshore from Martha's Vineyard. The structure was loaded with instruments to measure the effect of currents and waves on sediment and other suspended material near the seabed. Several sensors were mounted on an arm that extended 8 feet from the rig. A motor slowly swung the arm in an 8-foot vertical arc, allowing the devices to capture how particle composition and behavior changed along with depth.

Though carried out by the USGS, the study was partially funded by the U.S. Navy's Office of Naval Research. Despite the military backing, the work will have clear contributions to civilian life, including the development of numerical models that can help predict sediment-related events like shoal formation, movement of contaminated sediments and filling of dredged shipping channels.

The Navy also has a stake in sediment behavior. For example, they'd like to be able to predict underwater visibility at a particular location without having to be there to take measurements.

"They'd like to be able to remotely predict whether or not, say, their SEAL team is going to be able to see anything or not," Sherwood said.

The project is one of many under the Navy's Optics, Acoustics, and Stress In Situ project, a major component of which is exploring the relationship between data generated by acoustic and optical instruments. Several sensors of both varieties were installed on the tripod.

Acoustic instruments, which generate measurements by bouncing sound waves off suspended material, are well-established and very effective in the ocean, where sound can travel great distances. However, acoustic instruments can't deliver very detailed information about the individual particles themselves. Optical

instruments, on the other hand, operate by bouncing light off particles. Though light doesn't travel through the ocean as well as sound, its short wavelength allows optical tools to generate high-resolution information on suspended particles.

Where acoustic instruments can tell how much material is suspended in the water, optical instruments can tell whether a single particle is a grain of sand or colony of phytoplankton.

"It's much easier to make an optical picture of a small particle than it is an acoustic picture of a small particle," Sherwood said. "In acoustics, you basically get a much fuzzier return because you're working with a much coarser wavelength."

Some of the most interesting particle-level optical data came from a submersible holographic camera from Sequoia Scientific, Inc. The camera, which cost around \$35,000 and is one of the first of its kind available commercially, captured discernible images of phytoplankton on the scale of tens of micrometers.

The camera also produced a lot of data, capturing a 2-megabyte image every 30 seconds. The large files and extra power needed to swing the instrument-bearing arm up and down meant that the tripod couldn't operate on battery power and data loggers alone. The project made use of the Martha's Vineyard Coastal Observatory operated by Woods Hole Oceanographic Institution. Underwater cables running from the tripod to the observatory provided power and an Internet connection.

In addition to the power and Internet hookups, the location is ideal for this type of study because the region often catches a glancing blow from a hurricane in the fall. For scientists interested in the effects of wave action on sediment, that's a good thing. A rollicking storm makes for great data.

That's also one of the reasons that the nor'easter that blew in and crippled the tripod didn't spoil the experiment, Sherwood said. That, and the scheduled mission had already ended.

"The mission was already over, although the data right at the very end is great storm data, even though it tipped over," he said.

And, while instruments come and go, data is forever.


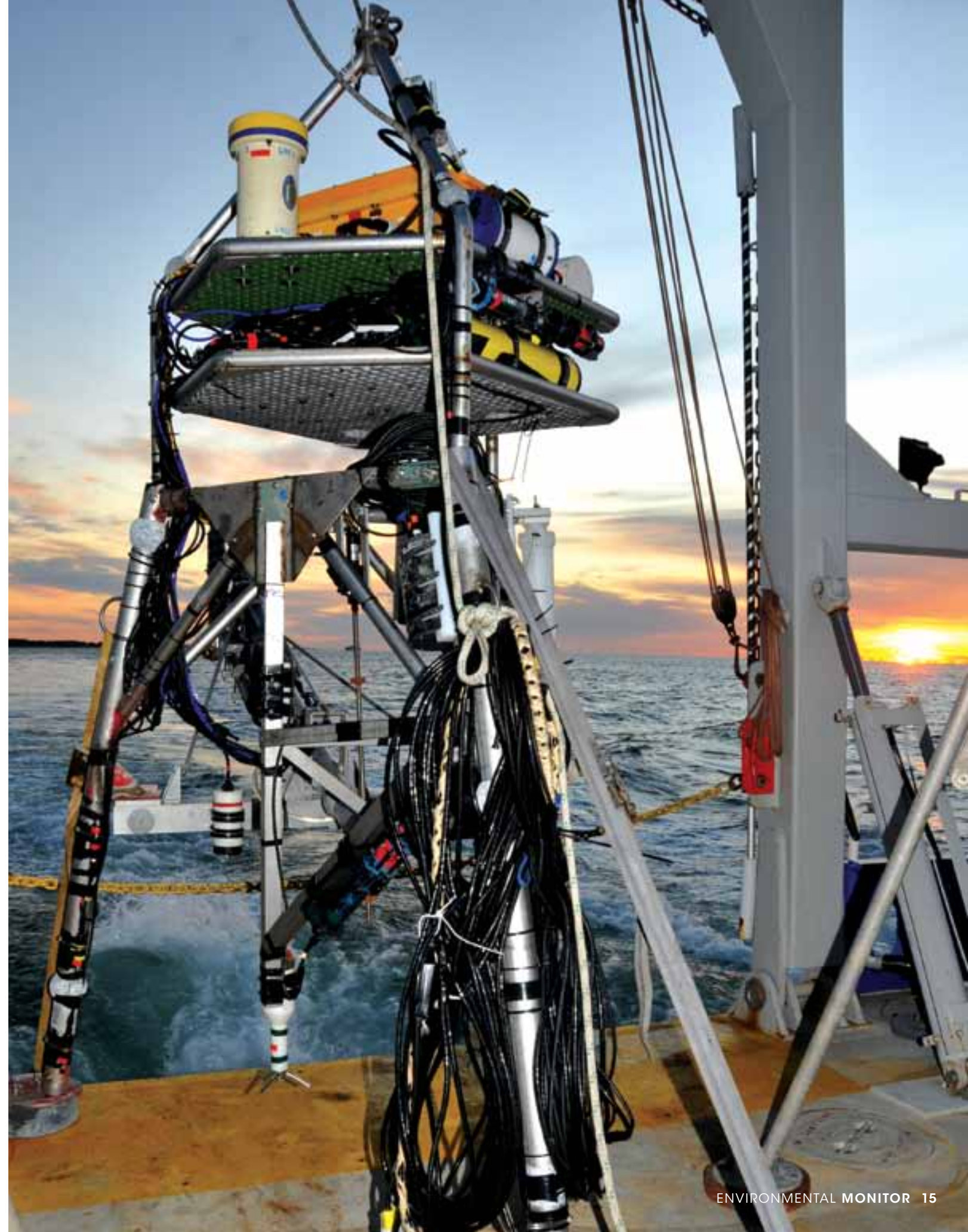
"We broke a couple of instruments, but we got all the data back, which is always key," he said. "There's certain instrument attrition that we have to factor into this anyway." 

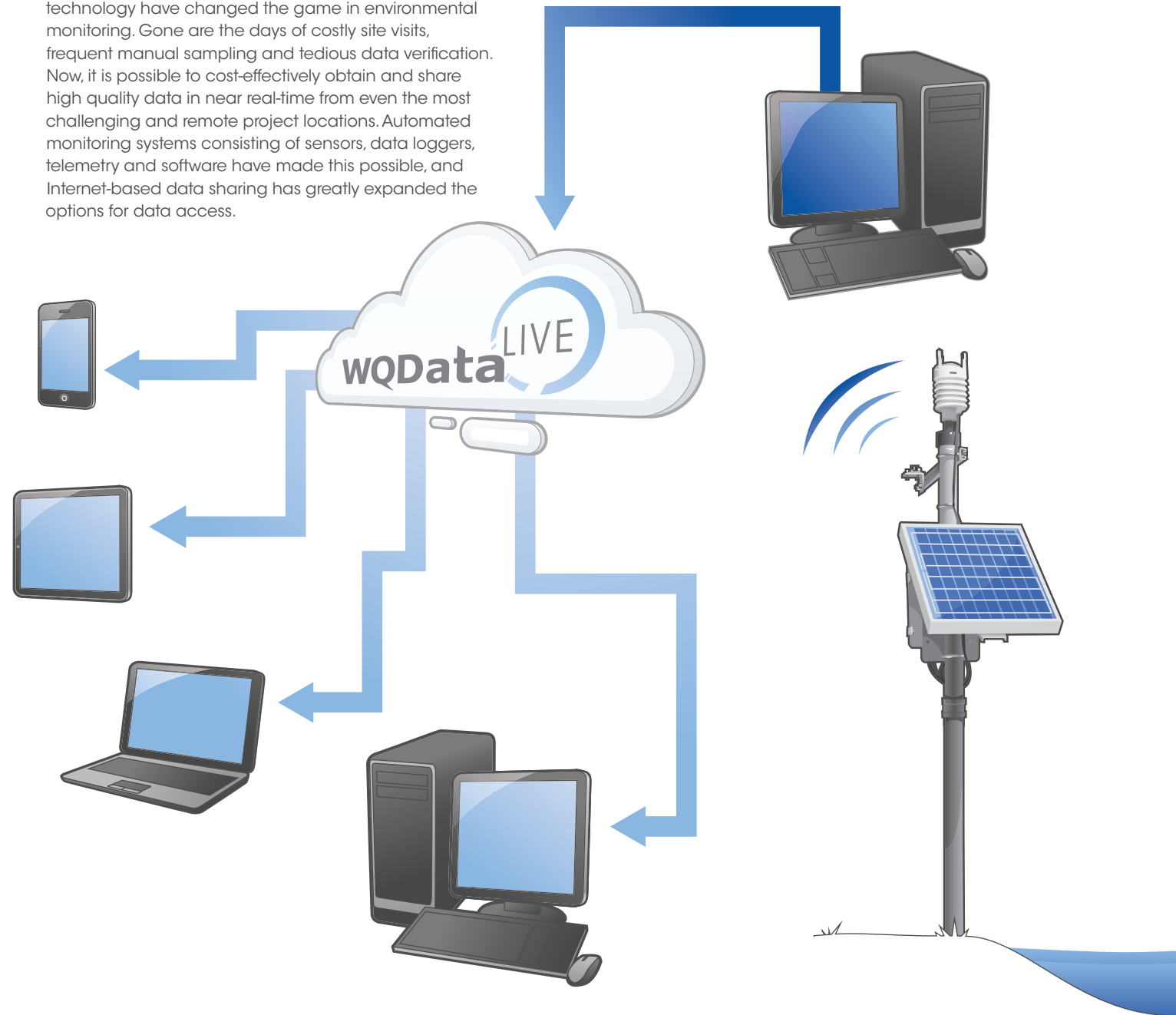
Photo: Dann Blackwood, USGS



WQData LIVE

BY MIKE VOELLMECKE

Recent advances in data acquisition and management technology have changed the game in environmental monitoring. Gone are the days of costly site visits, frequent manual sampling and tedious data verification. Now, it is possible to cost-effectively obtain and share high quality data in near real-time from even the most challenging and remote project locations. Automated monitoring systems consisting of sensors, data loggers, telemetry and software have made this possible, and Internet-based data sharing has greatly expanded the options for data access.



System Deployment

The environmental data logger acts as a centralized hub for sensor connections and data telemetry modules. In the past, integration of multiple sensors from multiple vendors has presented a challenge in setting up an environmental monitoring system. While opportunistic vendors have somewhat limited the standardization of sensor connections, many data loggers now accommodate several connection types.

NexSens loggers, for example, incorporate sensorBUS architecture to combine a variety of industry-standard analog and digital interfaces onto a single 8-wire bus. These fully submersible connections replace the parallel wiring often found on analog and SDI-12 systems.

Environmental data loggers are ruggedized and have non-volatile onboard memory with available solar charging options to reduce maintenance. To extend deployments and improve data quality, many sensors incorporate self-cleaning and anti-fouling technologies. The new YSI EXO multi-parameter sondes accommodate a central wiper to regularly clean all connected sensors. For high-fouling environments, the sondes can be fitted with fouling-resistant copper probe guards and sensor screens.

Data telemetry allows users to monitor near-real-time data and quickly identify the need to calibrate or service sensors. With the expansion of cellular infrastructure and the development of satellite networks, data can now be sent wirelessly from almost anywhere on Earth to a PC connected to the Internet.

Data Sharing

For 24/7 instant access from any location, many environmental projects are making use of web datacenters to share data and project information. Collaborators, clients and other interested parties access the data with any Internet browser.

The NexSens WQData LIVE web datacenter includes a variety of advanced features for data sharing and presentation. Project data and the applications themselves are hosted on a secure, scalable and reliable server. This "cloud computing" model allows full data access to users without needing to maintain the supporting software infrastructure.

Individual projects are set up as password-protected or open access, and portals can be configured to selectively present information. This allows research team members complete access while limiting the general public to certain parameters or most recent data sets.

WQData LIVE allows project-specific information and details to be displayed on the project overview screen, which can be customized with a theme, project description, data disclaimer and site photos. The high-resolution mapping feature enables site locations to be geographically pinpointed. A quick 'mouse-over' of one of the site markers identifies the site and provides the current status and latest readings.

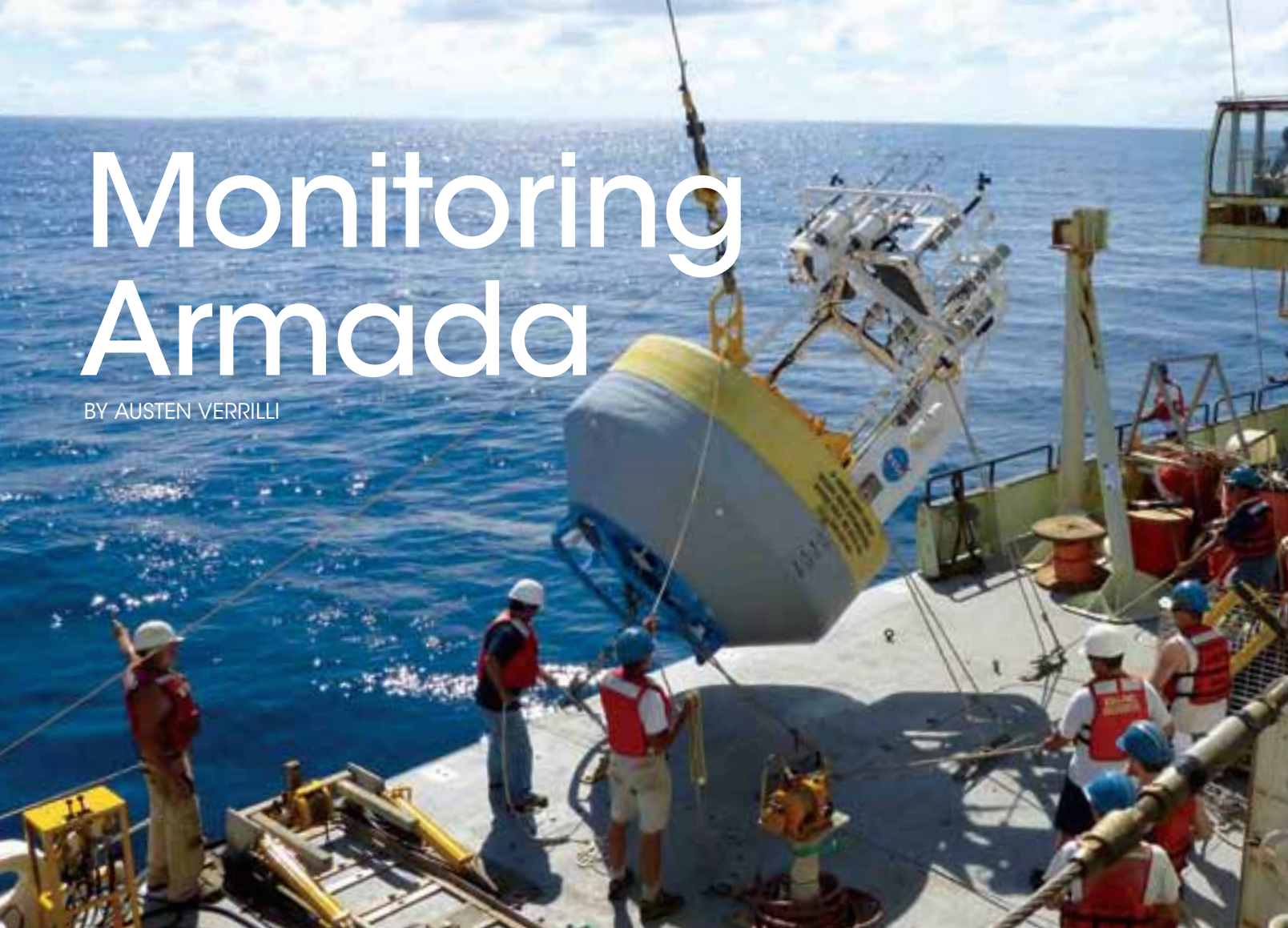
Data presentation is simplified through easy-to-use reporting tools. Individual parameters or sites are quickly selected, and tabular or graphical data is displayed for the current day, week, month or year, or from within a user-defined timeframe. The 'Select All' feature displays data from common parameters shared by multiple sites. Updated graphing features allow users to present data in an easy to read format. Reports generated on the datacenter can be exported to a Microsoft Excel-compatible format or to PDF.

A standard web applet can easily be embedded into company or agency websites to provide a snapshot of the latest data, and an HTML link can direct visitors to the complete web datacenter. The web datacenter's responsive design accommodates webpage display on desktops computers, tablets and smartphones.



Monitoring Armada

BY AUSTEN VERRILLI



NASA-sponsored scientists used a dream team of instruments this summer to analyze salinity of the saltiest place in the Atlantic, which is a model for extreme shifts in ocean salinity seen in the past few years.

The official mission of the Salinity Processes in the Upper Ocean Regional Study, or SPURS for short, is to collect data for calibration of NASA's Aquarius salinity monitoring satellite.

Scientists working on the project acknowledged the importance of the satellite, but they had another goal in mind.

"Our real motivation is trying to understand how salinity is related to the global water cycle," said Raymond Schmitt, a Woods Hole Oceanographic Institution senior scientist and chief scientist of this SPURS expedition.

Scientists postulate that the extreme weather patterns the past few years are a result of climate change. "What we think is going on is, with the increasing air temperature, the atmosphere can hold more humidity and that causes more evaporation in dry regions and more precipitation in wet regions," Schmitt said.

Ocean salinity is the best lens through which oceanographers can view these trends. Salt content in water fluctuates with evaporation and precipitation. "(It) turns out that 90 percent

of evaporation comes from the ocean," Schmitt said. "So the ocean is really the source of the global water cycle."

Recent aggregated data shows that salty areas are getting saltier and fresh areas are getting fresher with an intensity at least four times greater than what models predicted, Schmitt said.

Salinity is important because it essentially dictates water density in the ocean. Density, in turn, affects ocean mixing, and mixing affects water temperature.

SPURS scientists studied the saltiest spot in the Atlantic, which sits between the Bahamas and the West Coast of North Africa. The area, known as the surface salinity maximum, keeps getting saltier. This summer was one of the saltiest on record there, Schmitt said.

Scientists used an array of instruments to monitor the area. The research vessel Knorr, on which the SPURS crew traveled, houses a weather-monitoring station and CTD (conductivity, temperature and depth) sensors, said Dave Fratantoni, WHOI associate scientist. The ship has a traditional CTD rosette for site sampling. An Underway CTD profiled salinity while the ship traveled. A microstructure profiler recorded small-scale salinity observations.

Photo: NASA

Once at the site, the SPURS team deployed three mooring devices, developed by WHOI and the National Oceanic and Atmospheric Administration. The moorings will track surface weather and deep water salinity conditions.

Several surface-drifting instruments will record data in the upper region of the ocean. Twenty-five modified Argo floats measure surface salinity, wind speed and rainfall. A Lagrangian drifter, named for its ability to maintain neutral buoyancy, rides currents to monitor how water mixes in the Atlantic.

Scientists also deployed autonomous gliders and submersibles. Two IVER2 vehicles conducted small scale salinity surveys. Two Slocum Gliders observed the intensity of ocean mixing.

Three Sea Gliders measure temperature, salinity and microstructure in the area. Three wave- and solar-powered Wave Gliders measure surface chemistry conditions.

Some of the monitoring equipment returned to shore after the three-week voyage, but much will remain collecting data for the next year. The moorings, Wave Gliders, drifters and floats will all stay in the Atlantic collecting data. The Sea Gliders will remain in the Atlantic for six months and then will be replaced with three new units.

The array of instruments should give a multidimensional picture of the ocean that will greatly help scientists understand salinity patterns. "All this information is fed back to shore where it's integrated into sort of a coherent picture of what the ocean is doing on scales from the entire Atlantic down to centimeter scales," Fratantoni said.

Scientists hope the study will give them a better model of ocean mixing. They also hope that research will support theoretical climate change arguments which seem to continually make headlines and hypotheses.

Researchers emphasized that this study will mainly be used for a tune up of the Aquarius Satellite. Eric Lindstrom, NASA physical oceanography program scientist, said Aquarius has more precision and reach than any other salinity monitoring system, but it is still limited.

The satellite maps salinity across the entire surface of Earth's oceans each week. Data from the expedition should tune up the satellite's modeling to make it even more precise.

Since data will only come from one year of sampling, no findings on climate change will be considered fully conclusive. Still, the information collected should give scientists a more complete picture of salinity and ocean mixing than ever before seen.

There will be a second SPURS mission in an oceanic area that has very low salinity, though that location has not yet been chosen. AV



The Environmental Monitor checked in with SPURS' Chief Scientist Ray Schmitt, an oceanographer at the Woods Hole Oceanographic Institution, during the voyage.

EM: How was the departure to the surface salinity maximum? Did scooting by Hurricane Michael and Hurricane Leslie go as planned?

RS: It looked like both storms could be a problem for us. Pounding against high seas and strong winds is tough on everybody and the gear, and consumes a lot of fuel as well. The Captain chose to put on extra speed to get ahead of Leslie's projected track northward. Fortunately it slowed down and we were able to pass to the north of it. That afforded us some new sampling opportunities: the profiling floats we are deploying are equipped to make ambient noise measurements, which can be used to estimate wind speed and rain rate. We had planned to deploy some on the way to the SPURS site, so we dropped two in the projected path of Leslie. It appears our marksmanship was excellent. It actually does not rain a lot in the SPURS area, so those floats may have a more interesting signal.

EM: What does the daily routine look like for the crew on the Knorr?

RS: We had about a one-week steam to get on site, then spent most of time deploying the various instruments. During this period, each instrument team would be called upon in turn to get their gear in the water. The large (Woods Hole Oceanographic Institution) flux mooring was an all-day affair, the deployment of floats and surface drifters just a brief stop. We completed nearly all the gear deployments yesterday and have now started on a regular schedule of CTD casts and microstructure profiling near our moorings.

EM: How much preparation, onboard the ship, does it take to ready for instrument deployments?

RS: Most of the preparation occurred many months ago ashore. The WHOI Flux Mooring was by far the biggest challenge on the ship, spools of wire and rope had to be craned into position, lots of gear had to be shackled together or bolted to the wire in the proper sequence. (Continued on page 21)



Divide and MONITOR

BY AUSTEN VERRILLI

Scientists at the National Oceanographic and Atmospheric Administration grew weary of large, cumbersome moorings traditionally used to deploy water monitoring technology in the ocean. So they invented a new model.

Chris Meinig, director of engineering at the NOAA Pacific Marine Environmental Lab where the mooring was developed, jokingly said the team engineered the device after suffering with traditional moorings for years.

Traditional water monitoring moorings are heavy, labor-intensive pieces of equipment. Ship crews have to assemble the rigs at sea and deploy the behemoths with great caution. Rough seas make this task even more difficult and dangerous.

The new NOAA mooring is called the Platform and Instrumentation for Continuous Observation, or PICO. It comes as one compact, pre-assembled unit with a buoy, mooring line, sensors and anchor.

It arrives on a special pallet, which is not just for the forklift. The pallet attaches to a ship crane to easily deploy the mooring.

Once the device hits the water, the buoy separates from its base, which doubles as an anchor. A spool of cable integrated into the base unwinds as the anchor sinks to the seafloor. Then it gets down to sampling.

There are two versions of the PICO concept. One is used for tsunami detection with a pressure sensor on the seafloor.

Meinig said the sensor is so sensitive it can detect a millimeter of sea level rise. Sheer depth filters out interference from wind or waves.

The other PICO application is for global ocean observations. One instrument on the system is a Prawler, a combination of profiler and crawler, which characterizes the method in which the device takes measurements. A pod of sensors the size of a coffee can rides the mooring line, continuously sliding down and crawling up.

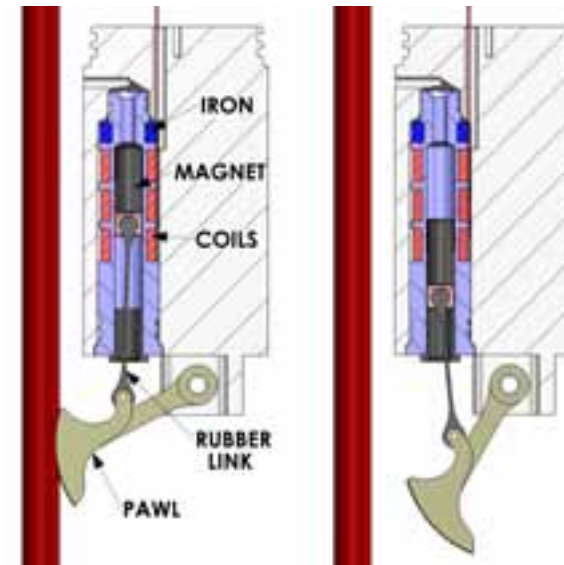
The sensor pod travels up the mooring line by harnessing ocean waves with a special cam device. The device, like a ratchet, allows free travel in one direction. In this case, it allows the cable to move toward the sea floor. As the mooring line rises with a wave, the ratcheting mechanism grabs the line, pulling the pod up.

Special fins on the sensor pod keep it from sinking during upward crawls. One vertical cycle of the sensor pod takes about an hour.

The beauty of the sensors moving up and down the mooring line is that it gives a vertical profile of an area. Sensors on traditional oceanographic moorings, in comparison, take data at fixed points.

Vertical crawling is adjustable but limited to about 1,900 feet of the approximately 15,000 foot cable.

Photo: NASA



The crawling feature is impressive, but “the secret sauce in the whole thing is really the mooring line,” Meinig said.

Typical mooring lines are full of joints, chains and swivels. The Prawler’s line is woven into a single unit.

Meinig said the line is composed of sections designed for different places in the water. The upper section of the line is protected from shark bites, and a plastic casing ensures low friction for the crawler. Below that is a shock-absorbent line. The lower section is lighter duty floating line. At the anchor, a high-strength section makes sure nothing snaps.

Data is transmitted from the sensor pod through an inductive modem to the buoy on the ocean’s surface. An Iridium satellite modem transmits information back to shore.

Two salinity-monitoring Prawlers are at sea on the Salinity Processes in the Upper Ocean Regional Study, sponsored by NASA. They are part of a vast array of monitoring instruments being used to calibrate NASA’s Aquarius Satellite.

Meinig said the Aquarius Satellite is very powerful, but it is limited in how deep it can see into the ocean. He describes the satellite’s reach into ocean layers as “skin deep.” The compilation of monitoring equipment on the SPURS mission, Meinig said, should give the satellite better reference, by peering down into the ocean where the action happens.

The PICO Prawler moorings will be deployed for 14 months collecting data on the SPURS mission. Meinig said the deployment will be the longest time Prawlers have ever been at sea.

“We’re trying to push the endurance level in terms of the quality and fatigue,” Meinig said. PICO Prawlers have previously seen up to eight months in the ocean. Tsunami monitoring versions have seen over three years of constant deployment. AV

(Continued from page 19) Some of the gliders required fine tuning of the ballast, which we were able to do using a small boat. There are always plenty of volunteers for a boat trip in this fine weather.

EM: What has been the most difficult instrument to deploy ?

RS: The WHOI Flux Mooring. It started after breakfast with deployment of the large disc buoy with all its delicate instruments. It’s quite heavy, the ship is rolling and you keep a lot of lines on it connected to air-tuggers to maintain control. The boat then steams away from it, dragging it along and adding all the gear that it has to support.

This takes a long time, as sections of chain, instruments, wire rope with instruments attached in the right places are all added to the mooring. Toward the end you are streaming out synthetic line, then glass spheres, releases and finally the 10,000-pound anchor. Deploying a mooring is a carefully choreographed ballet of physics. It’s a marvelous thing to watch. Just before dinner the tension on the line pulls the anchor off the stern with a huge splash, at just the right spot that you picked out from the bottom survey. It takes an hour for the anchor to reach the bottom then you range on the releases acoustically to see how well you hit your target.

EM: What will you take away from this expedition besides a mountain of data?

RS: I certainly will have gained a few pounds; the food aboard ship is excellent and plentiful, and I seem to have twice the appetite I have at home. I’ll also have made some new friends; you get to know people really well spending so much time with them in the confined space of a research ship. And there is some personal growth as well, this project is sufficiently large that my obligation to manage the enterprise precludes getting too involved in the details of instruments and sampling the way I used to. I just have to step back and let these wonderfully clever young people make the most of their opportunities.





The R/V Jag Ski

BY AUSTEN VERRILLI

Bret Webb had a plan: outfit a Jet Ski with equipment capable of mapping underwater coastal topography in Alabama's Mobile Bay. The plan changed in the spring of 2010, when the Deepwater Horizon drilling rig exploded and unleashed the biggest accidental marine oil spill in history on the Gulf of Mexico.

Webb, an assistant professor of civil engineering at University of South Alabama, wanted a personal watercraft that could conduct bathymetric surveys in shallow coastal waters inaccessible to the larger vessels ordinarily equipped for that kind of measurement. He outfitted a 2008 Kawasaki Ultra Lx with an acoustic Doppler current profiler capable of both bathymetric surveys and current profiling.

"It was really going to stop there, and then the oil spill happened," Webb said.

Water from the Gulf feeds into Mobile Bay, which is right in the university's backyard. Webb knew he had to add water quality monitoring capability to his creation.

He equipped the personal watercraft with a YSI Portable SeaKeeper, customized to fit his personal watercraft. He

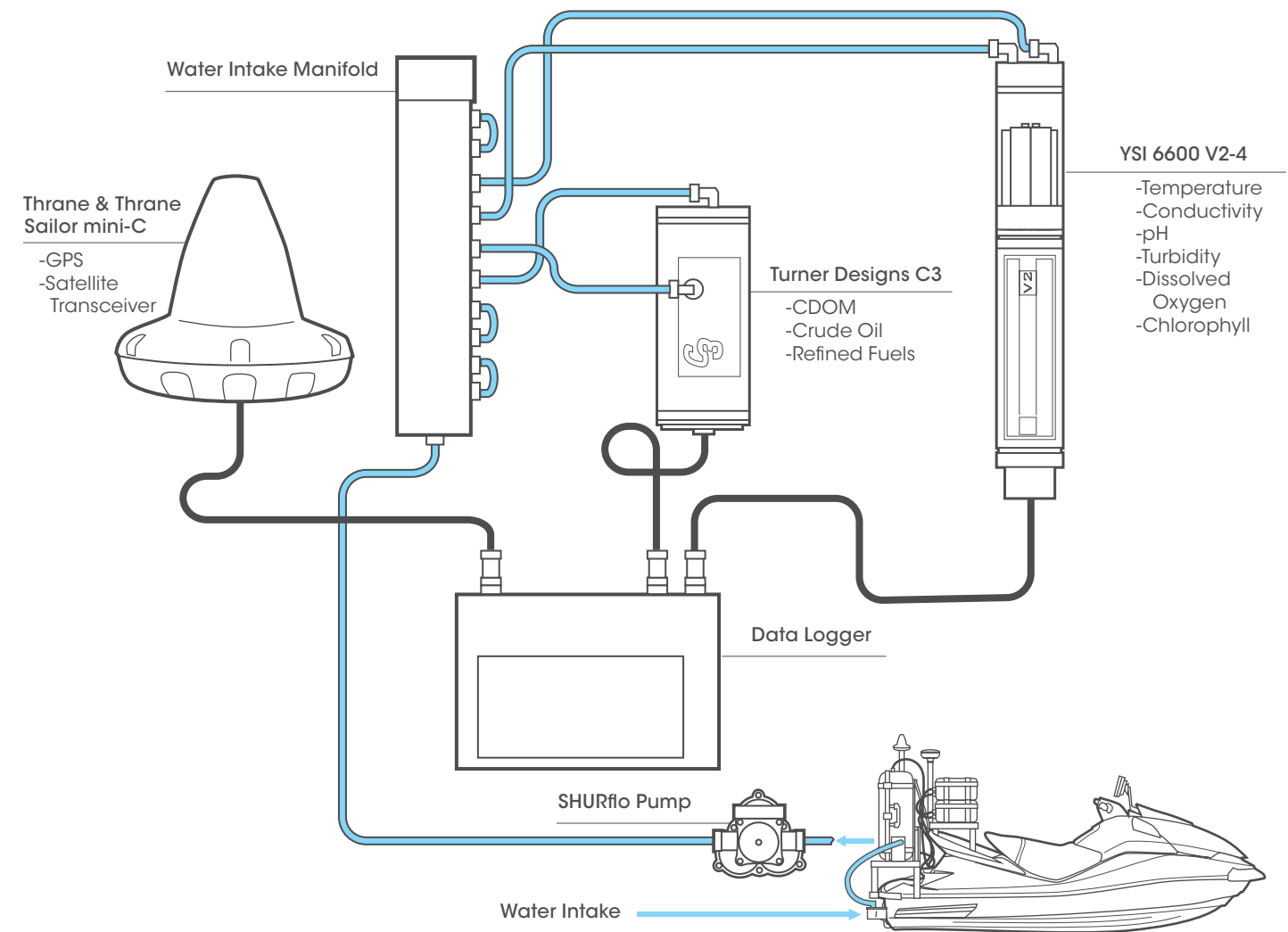
used the custom-built, compact unit in concert with a Turner Designs fluorometer, which measures hydrocarbons in water.

The YSI team created a special ram intake so that water would flow to the monitoring equipment at any speed. A water pump keeps water pressure stably feeding sensors. A weather monitoring station supplements surface water data.

Named for the University of Southern Alabama's Jaguars mascot, the Jag Ski had its first major mission in 2010. Five years earlier, Hurricane Katrina cut a channel through a barrier island at the mouth of Mobile Bay. After the Gulf spill, BP officials suggested filling the breach to block oil from flowing through and into the bay.

Webb saw a research opportunity. Breaches usually close up over time, he said, but this one remained for years. Intrigued, he took the Jag Ski through the breach and found that the depth was irregular and water recirculated, but mainly flowed seaward. He learned there was too little sand in the area to close the breach naturally.

Later, Webb used the Jag Ski to monitor shipping channels in Mobile Bay, where he found the channel affected tidal mixing and speed.



The equipment's surface water quality monitoring chops were tested on the Dog River, which contributes fresh water to the Mobile Bay. Sensors showed that hydrocarbons increased near marinas and boat ramps.

Webb tested the SeaKeeper at a reservoir that provides drinking water to Mobile. There he deduced that the Jag Ski's speed only affected readings of turbidity and dissolved oxygen sensors.

Webb spent three months searching for the best personal watercraft to transform into a water monitoring vehicle. It had to handle the weight of the monitoring technology and needed a layout for attaching the equipment without drilling any holes.

A 2008 Kawasaki Ultra Lx three-person watercraft was the most ideal platform. The large, 160-horsepower watercraft easily handled the extra weight of monitoring equipment, which Webb and his team attached with built-in fasteners and clamps.

Before modification, the watercraft's top speed was 60 miles per hour. After 200 pounds of monitoring technology was attached, it still can reach 48 miles per hour, Webb said. It burns 24 gallons of fuel in 10 hours at moderate, consistent speeds.

While the Jag Ski has worked well for Webb, there are a few disadvantages. It does not have the range or protection of larger vessels. It also has a smaller carrying capacity, which Webb says is now at its limit.

Limiting factors force the surveyor to take a break and return to shore if inclement weather is on the horizon, but that's a good thing, Webb said.

Webb said the personal watercraft platform was ideal for surveying coastal areas and surf zones. "It's maneuverable and it's agile, and if it flips you can just turn it back over and keep going," he said.

For the record, he said he's only flipped it once during testing. Though he was nervous, everything fared well. AV

Photo: Bret Webb

Illustration: Nate Christopher



Stevens POGO

Collect soil moisture, electrical conductivity and temperature measurements with the new Stevens POGO.

The POGO is ideal for spot checking native soil and performs well in high-salinity environments. Standard soil measurements require no calibration; however, a custom calibration is available for peat, grain, and organic soil, making it a useful tool for agricultural applications.

The unit is internally powered by AA rechargeable batteries. A Wi-Fi interface with Apple and Android devices automates data transfer. The Stevens HydraMon App facilitates email and Excel data processing.



Vaisala GM70

Conveniently collect carbon dioxide measurements in laboratories, greenhouses, agriculture facilities, HVAC and industrial applications.

The GM70 uses the advanced Vaisala CARBOCAP Sensor, which prevents the measurement accuracy from being affected by dust, water vapor or most chemicals.

With a short warm-up time, the meter is sample ready in minutes. Two probe inputs allow for calibration comparison to a second sensor and facilitate differential measurements. Interchangeable probes are available for various measurement ranges. Samples are collected through diffusion or pump aspiration, and displayed numerically and graphically.



YSI EXO2

A revolutionary new product in the multi-parameter sonde market, the EXO2 works well in both freshwater and saltwater applications. The EXO2 contains six universal sensor ports for simultaneous data collection. Welded titanium sensors perform to depths of 820 feet below the surface.

The sensors maintain accuracy specifications in a variety of conditions.

All sensors include integral memory and signal processing, making it easy to calibrate in one location and distribute to various field sites.

The sensor parameters include temperature, conductivity, depth, dissolved oxygen, pH, ORP, total algae (phycocyanin and chlorophyll), turbidity and fluorescent dissolved organic matter. Active port monitoring

will detect an error if a sensor is damaged and will initiate an automatic shutdown to prevent further damage to that sensor.

The EXO handheld meter works well with EXO sondes, both wirelessly and cabled. The handheld is compatible with the KOR interface software to easily manage, visualize, and organize a large quantity of data.



NexSens SDL500

The NexSens self-powered submersible data logger is engineered for deployment and data collection in any field condition. The remote data logger is capable of collecting data in natural waters, storm sewers and culverts with a sealed and waterproof housing and battery compartment.

The system is easily integrated with multi-parameter sondes, temperature strings, water level sensors or weather stations, and can run unattended or transmit data in real-time through radio, cellular or satellite networks.

Eight D-cell alkaline batteries provide power for weeks of operation, or optional solar kits are available for long-term projects. No programming is required, as iChart software offers a simple point-and-click interface.

YSI EcoSense

This compact and accurate meter simultaneously measures conductivity, specific conductance, salinity, total dissolved solids (TDS) and temperature.

The EC300A is an affordable meter with a digital display, 50 point memory and an IP67 environmental specification. The unit provides automatic conductivity ranging, automatic temperature compensation, and prompts users through calibration and measurement procedures on a large LCD.

Meter kits are available in 1, 4 or 10 meter cable options. YSI provides a 1 year warranty on both the meter and electrode.



Thermo Orion VERSA STAR

Measure and analyze temperature, conductivity, dissolved oxygen, pH and selective ions with one versatile electrochemistry meter. The VERSA STAR is customizable with easy-to-use key layouts and graphics that give the choice of a one- or four-channel view. The meter automatically recognizes any module change, reducing the need for recalibration.

The electrode arm and newly designed probe holder makes it simple to maintain and place probes into samples. The two Orion Star stirrer probes easily mix samples with direct control.

A universal power adapter provides energy to the meter through almost every AC power source. The powerful memory function time- and date-stamps up to 2,000 measurements that can be easily transferred to the data analysis software for real-time readings.



Crossing the Pacific

Long-range unmanned gliders open new doors to ocean observation

BY JEFF GILLIES



Somewhere east of Hawaii in the open Pacific Ocean, a five-day February 2012 storm's gale-force winds whipped up 20-foot waves and snapped off a sailboat's mast. The boat was crippled, leaving its sailors to await a nerve-wracking rescue by the crew of a 890-foot container ship.

Around 600 miles away, four other craft eventually weathered the same storm system intact. Those four craft were environmental sensor-toting Wave Gliders, the world's first wave-powered marine robot, in the midst of a record-setting voyage across the Pacific.

"It was a really good test for the technology," said David Bailard, vice president of product marketing and strategic planning for Liquid Robotics, Inc., the company that develops and produces the gliders. "Really, a major-league storm."

An important part of the technology that the storm tested is the glider's unique propulsion mechanism. Though most models of autonomous vehicles used in oceanographic research offer a longer period of data collection for less money than a ship-based research cruise, the Wave Glider's innovative method for movement takes that advantage to new extremes.

The forward thrust is completely powered by waves, meaning the gliders can stay at sea even longer than vehicles depending on a charged battery or sunny skies. A rudder controlled through wireless communications keeps the glider on a programmed path.

"To be able to send something out and gather the data continuously over months at a time is a whole new capability," Bailard said.

The design came about when the Hawaii-based Jupiter Research Foundation, a scientific research non-profit, needed help broadcasting humpback whale songs live over the Internet. Early attempts to suspend microphones from buoys ran into trouble. If a buoy was too close to shore, the clamor of breaking waves and clacking marine life overwhelmed the microphone. Mooring a buoy farther offshore was too difficult.

After considering that a mobile, boat-like platform might be the answer, the Jupiter Research Foundation brought in Roger Hine, a mechanical engineer and the chief technical officer for what would become Liquid Robotics.

Hine and his collaborators arrived at the idea of a platform with propulsion that takes advantage of a principal of wave action—that water below the ocean surface is much calmer than the waves above. Even in rough seas, the water becomes predictably less turbulent as depth increases.

The glider features a heavy array of fins suspended underwater from a surfboard-like float. When a wave lifts the float, a connecting line jerks the fin apparatus through the calmer waters below. The angle of the fins thrusts the apparatus forward, towing the float behind. When the float rides the other side of the wave back down, the fins are pushed down for another forward boost.

In an effort to show off the Wave Glider's long-term mission capability and drum up interest in the kind of ocean exploration it allows, Hine conceived PacX, a journey across the Pacific Ocean. In November 2011, four gliders were launched from San Francisco Bay, bound for Hawaii. From there, two would head for Australia and two for Japan. Each carries four sensors measuring more than a dozen parameters of water quality, weather, and wave characteristics. All the data is freely available online for those who register.

There's more to the mission than showing off the gliders. The PacX Challenge Prize program invited researchers to propose a project that will use data collected during the crossing. The winner gets a \$50,000 research grant and support for a six-months of Wave Glider mission of their design.

The journey has gone well, already breaking the Guinness World Record for the longest voyage by an unmanned ocean vehicle. But it hasn't been without surprises, Bailard said. The first occurred around 400 miles off the California coast when all the gliders suddenly and mysteriously strayed from their intended paths.

"All four of them started to scramble and head in different directions within a very short amount of time," Bailard said. "It was very abrupt. It wasn't forecasted. We had to dive in and understand what was happening there."


The gliders were caught in small eddies that form where a current running along the California coast meets the prevailing current in the open ocean. The gliders were straightened out and sent on their way to Hawaii, though before they arrived they had to weather the mast-snapping storm.

And there was the shark attack.

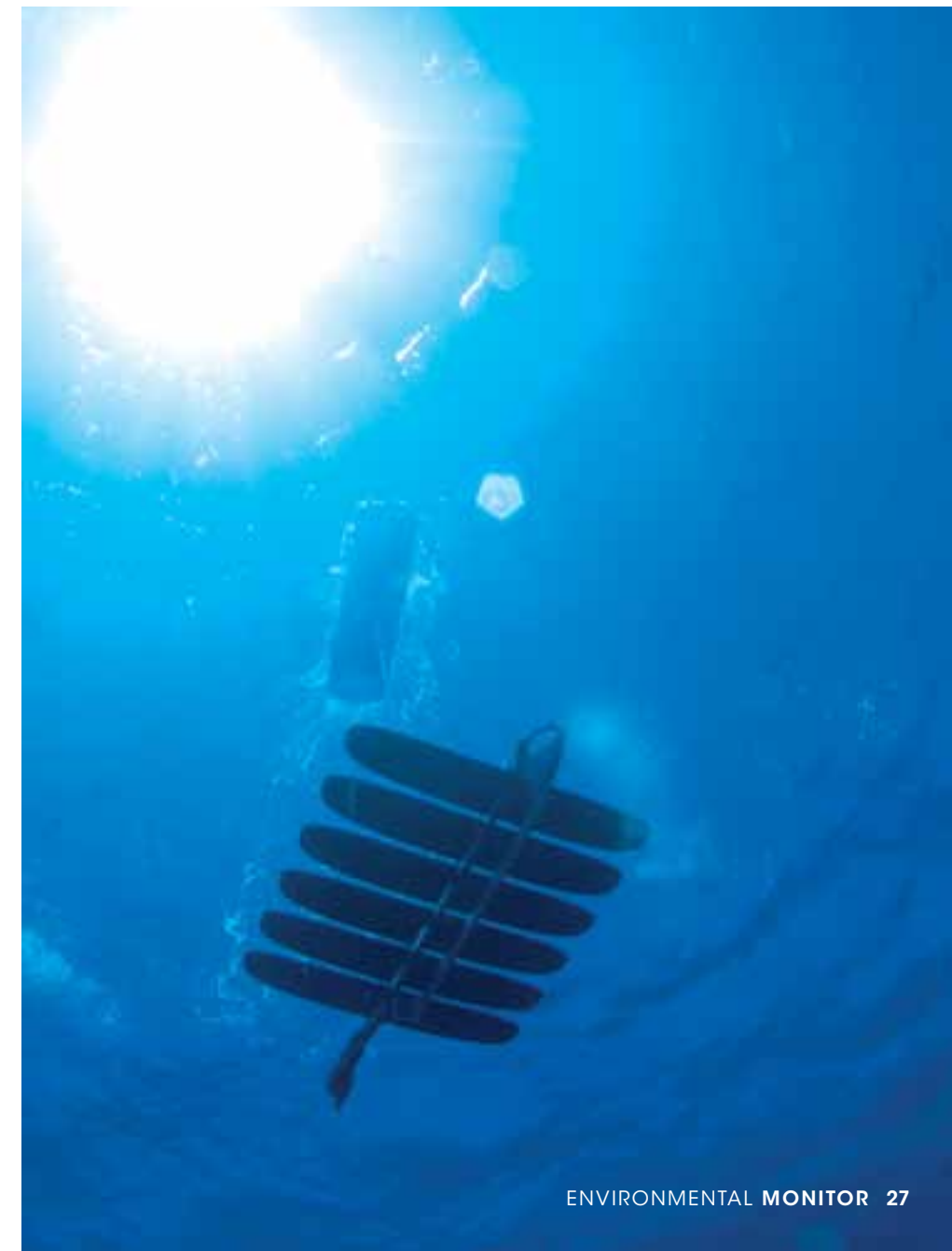
"We did get a shark attack on one of the gliders as it neared the coast of Hawaii,"

Bailard said. "We actually had to go rescue it because it lost rudder control after the shark bit through the control cable. There was a tooth left in the control cable."

The surprises have been about more than the perils of a Pacific crossing. The gliders have also had a chance to flex their environmental monitoring muscle. Shortly after departing Hawaii for the second leg of the voyage, the fluorometers on gliders bound for Australia picked up a spike in chlorophyll a levels. The readings stayed high for another 300 miles, indicating that the gliders were cruising through a massive phytoplankton bloom in the relatively barren open ocean.

"Scientifically, they had projected that these blooms were out there," said Joanne Masters, who handles public relations and media for Liquid Robotics. "But to really go through it and be able to provide live data is just exciting for the scientists." 

The Wave Glider's propulsion mechanism is based on a heavy fin array suspended below the floating platform.



All Photos: Liquid Robotics

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Q&A Turner Designs

Turner Designs has been in the fluorometer business for more than 40 years. Their technology monitors for some of the most publicized parameters in water quality monitoring. Most recently, Turner Designs Fluorometers were used in monitoring the aftermath of the Gulf oil spill.

The Environmental Monitor caught up with Pam Mayerfeld, Turner Designs' vice president for marketing and sales, to ask her how the company has changed over the past four decades.



INDUSTRY PROFILE



Q There have been many environmental disasters since Turner Designs' initiation, which could use fluorometers to monitor cleanup and maintenance. Algal blooms and two huge oil spills immediately come to mind. Did any environmental disasters impact product design or business in a significant way?

A Absolutely. Probably the most recent and visible disaster which spurred on several new products for us was the Gulf oil spill. The spill drove interest in both our crude oil and refined fuels sensors as well as our C3 Submersible Fluorometer which is used in the U.S. Coast Guard's SMART protocol for oil spill tracking and dispersant monitoring.

Algal blooms and the resultant fish kills have been major driving forces behind the development of several fluorometer platforms—long-term in situ instruments to monitor trends, online instruments to provide an early warning signal, and handheld instruments to facilitate measurements in the field.


Q Have the parameters scientists want to measure with fluorometer technology changed over time?

A I don't think that the scientists have changed their interests so much as technology has enabled detection of new parameters. The introduction of solid-state technology enabled smaller, lower-cost, more stable instruments. The introduction of lower wavelength LEDs enabled detection of UV and deep UV parameters such as CDOM/FDOM, crude oil, optical brighteners, refined fuels and tryptophan.

Q Has the cost of the fluorometer technology decreased in the digital age?

A Yes! Solid-state, in particular, has enabled manufacturers to build fluorometers at a lower cost yet with similar performance to earlier designs.

Q If there is one thing overall you could say about the progress of the company from the 1970s to today what would it be?

A In some ways, it's amazing that after 40 years, Turner Designs is still focused on George Turner's vision—enabling the use of fluorescence in many different studies. We've targeted different markets over the years—environmental, industrial, biotech, and oil, but we've maintained our focus on fluorescence and the customer. Quite honestly, George probably didn't think there was a fluorescent market that could support a company for over 40 years. 

Q What initiated the creation of a fluorometer company?

A George Turner founded the company over 40 years ago, and I wish I could ask him this question. From what I've learned over the years meeting customers who knew him, he was an engineer who loved technology. His developments initially targeted the medical market, but over time he became interested in ways fluorescence could be used by scientists—particularly chlorophyll and dye tracing. Fluorescence methods detecting chlorophyll were being published in the early 1960s and George was quick to focus on introducing products in this area.

Q Did the Clean Water Act have any impact on the start of the business?

A Interesting question. Fundamentally, I guess it did in that it drove the message that clean water is important. I'm not aware of anything related to it in particular driving George to start Turner Designs, though.

Q What did fluorometer technology look like when the business started? What were scientists measuring?

A When the business started, fluorometers were big, analog, laboratory instruments. Chlorophyll and fluorescent dyes were the main areas of study. Turner Designs introduced what became the industry-standard field fluorometer, the Model 10, in 1973. The Model 10 greatly expanded the scope of the studies scientists could do as they didn't have to worry about preserving and transporting samples back to their lab.

Trace-level Air Quality Monitoring

A research and development firm in Massachusetts has developed air quality monitoring equipment capable of detecting more compounds at lower levels than current commercial systems.

OPTRA, Inc., of Topsfield, was recently awarded a Small Business Innovation and Research program grant from the U.S. Environmental Protection Agency for its air monitoring efforts. The company has been working on the new system for over a decade.

"Trace levels are concerning if it's a particularly toxic compound such as a chemical agent or one with very low vapor pressure, such as many explosives," said Julia Rentz Dupuis, chief technology officer at OPTRA. "Trace levels are also interesting for some process monitoring applications where very low levels of contaminants pose serious threats to

the quality of the product. An example is semiconductor manufacturing."

By integrating a chemical agent detector that it had been developing since 1998 with a device that studies gases using light waves, the company was able to find compounds at trace levels previously unattainable.

"The overall solution lets us measure very low concentrations of a wide range of chemicals of interest for air quality monitoring applications," said Dupuis.

Tens of compounds can be detected simultaneously and hundreds on an individual level. The integration of the two devices provides an advantage over some commercial systems that still only detect one compound at a time.

In addition to providing a more useful testing system to its customers, OPTRA was able to improve its technology base with the new device.

"We saw this as an opportunity to expand the functionality of our FTIR (Fourier transform infrared) modulator and fill a potential market gap. To the best of our

knowledge we are the first to develop a broadband system," said Dupuis.

The company plans to use the EPA grant to produce a prototype of the monitoring system. OPTRA is also pursuing ways to automate the detection and identification of compounds by using algorithms.

—DANIEL KELLY

New Sensor Sniffs Out Stressed Plants

Researchers at the University of Georgia are developing an "electronic nose" that may help lower the use of pesticides, herbicides and fungicides, in addition to saving farmers money.

The tool in development detects compounds, called green leaf volatiles, emitted by plants in distress from disease or other external forces. The compounds

are invisible and odorless to humans and are often released before outward signs of trouble show.

"The sensor works based on electrochemical detection principles," said Ramaraja Ramasamy, assistant professor of engineering at the university. "We would like to achieve ultra-low detection limits in addition to achieving highly selective detection of the target volatile of interest."

The researchers note that the volatiles emitted by plants vary depending on the type of stress experienced, which could one day widen their focus.

"Right now we are interested in the fundamental science behind the sensing, rather than the type of chemical itself," Ramasamy said. "We chose to work with a specific chemical as our target compound for detection. It has been established that this chemical is released by pepper plants when they are infected by fungal pathogens."

Crop loss and disease transmission could be diminished by detecting pathogens and other problems earlier than humanly possible. Other beneficial applications of the technology could include use by produce distributors to catch unhealthy fruits and vegetables before they are sent to market.

The sensors, which are described in an article published in the journal *Analyst*, could also be employed in a grid pattern to quarantine harmful agents in one section of a field. That could localize and reduce the application of crop treatments, estimated to cost American farmers nearly \$33 billion each year.

Though the potential payoff of deploying the sensor looks promising, the research team is mindful to keep the associated costs low.

"It is too early to make an estimation on this (deployment cost), but our goal is to use materials and components that would make it affordable for practical applications," Ramasamy said.

—DANIEL KELLY



Screen printed electrode used in detecting green leaf volatiles.

Low-cost Farm Runoff Monitoring

Farmers along the Mississippi River often hear agriculture contributes to hypoxia-fueling nutrient pollution, but rarely have a clear picture of what's flowing from their fields into the Gulf of Mexico. A federal boost to a University of Arkansas Extension initiative could help make monitoring technology more accessible to farmers who want that data.

"We felt like it was a great way to get farmers engaged into some of these issues," said Mike Daniels, extension water quality and nutrient management specialist for the University of Arkansas System Division of Agriculture.

A \$960,000 grant from the U.S. Department of Agriculture's Natural Resources Conservation Service will help the extension program test low-cost monitoring technology that could equip interested farmers for edge-of-field monitoring for around a quarter of the price.

The edge-of-field monitoring equipment that the grant will fund works similarly to

more expensive units already in use. A flow sensor triggers a pump that fills a sample bottle, then continues to measure the volume of runoff that moves through the system.

While the low-cost equipment, which has been under development at the University of Wisconsin-Platteville, serves the same purpose, it's specifically designed for this kind of monitoring.

"There's nothing wrong with the equipment that's available now," said Dennis Busch, research manager at UW-Platteville's Pioneer Farm. "But it's designed to do a whole bunch of different things. That makes it a little more complicated to operate in the field and makes it more expensive."

The new system saves costs with custom electronics from the university's electrical engineering department and creative use of off-the-shelf components, like a sensor originally designed to monitor bilge water in ships.

"Ours is custom-designed to a single purpose, which is determine the discharge volume at edge-of-field sites, and collect a flow-based composite sample," Busch said.

—JEFF GILLIES

Solid model drawing of OPTRA's prototype, a combination of its Fourier Transform Infrared Modulator and a cavity ring down spectrometer.

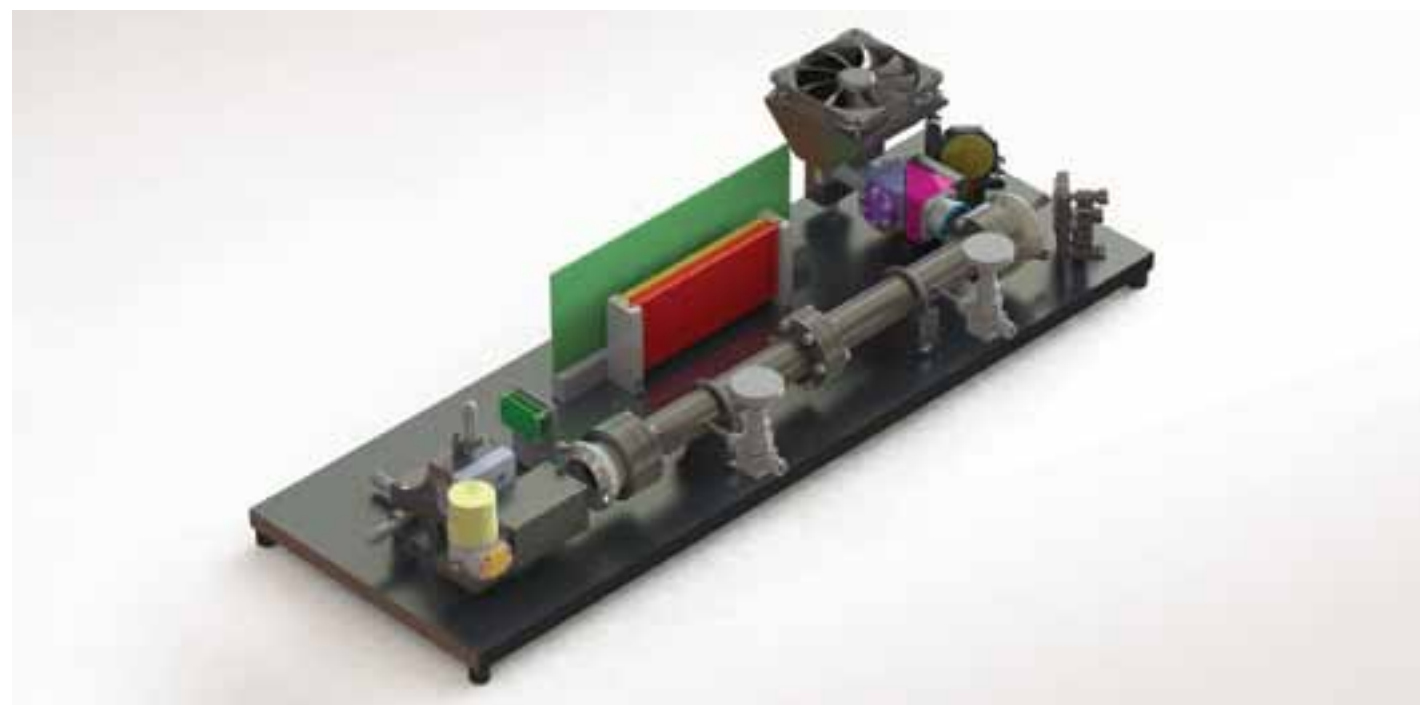
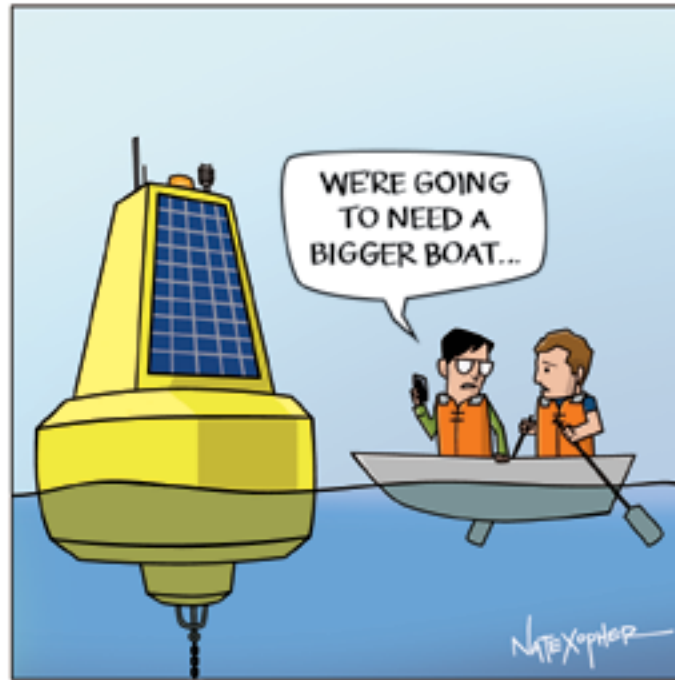


Photo: OPTRA, Inc

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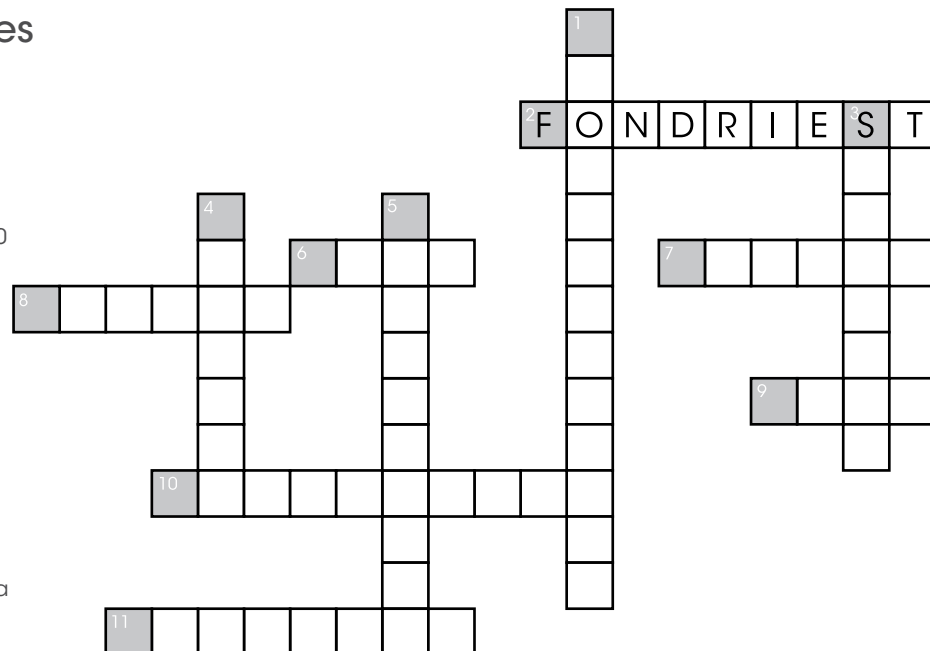
World's Most Extreme Lakes

Across

- 2. Where to buy a lake monitoring buoy
- 6. Shrank by 95% since 1963
- 7. U.S. lake is likely the clearest
- 8. Deepest lake
- 9. Released a CO₂ cloud in 1986, killing 1,700
- 10. Longest lake
- 11. Russian lake thought to be the most polluted on Earth

Down

- 1. Highest elevation lake (20,965 feet above sea level)
- 3. Largest freshwater lake by area
- 4. Lowest elevation lake (1,385 below sea level)
- 5. Largest saltwater lake by volume and area



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