

# ENVIRONMENTAL monitor

WINTER 2016

APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS

## NITROGEN DYNAMICS



### West Okoboji Lake

With new buoy, Iowa lake joins GLEON

### Developing Models

Data-backed tools have global implications

### Resilient Reefs

Can corals adapt to ocean acidification?



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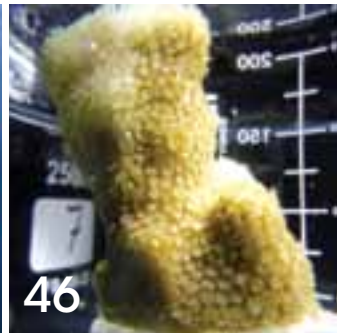
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The National Oceanic and Atmospheric Administration is testing a new buoy platform in preparation for increased monitoring in the United States' Arctic Exclusive Economic Zone.

Cover Photo: Nate Christopher / Fondriest Environmental

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**WELCOME...**

Welcome to the Winter 2016 edition of the Environmental Monitor, a quarterly collection of the best of our online news publication. A series of stories in this issue follows the ever-growing trend of environmental modeling. We take a look at several projects that showcase the fieldwork behind collecting data for models, as well as modeling's strength as a research tool. Stories include a look at saltwater intrusion modeling by University of Georgia scientists studying sea level rise; NASA's work to study the Gulf Coast's changing wetlands; and a tool in development at Michigan Tech Research Institute to minimize flood and landslide risk after wildfires.

You'll also read about the Iowa Lakeside Lab, which provides science classes and research opportunities for university students throughout the state. Many of these activities are supported by West Okoboji Lake, the site of a new Global Lakes Ecological Observatory Network buoy.

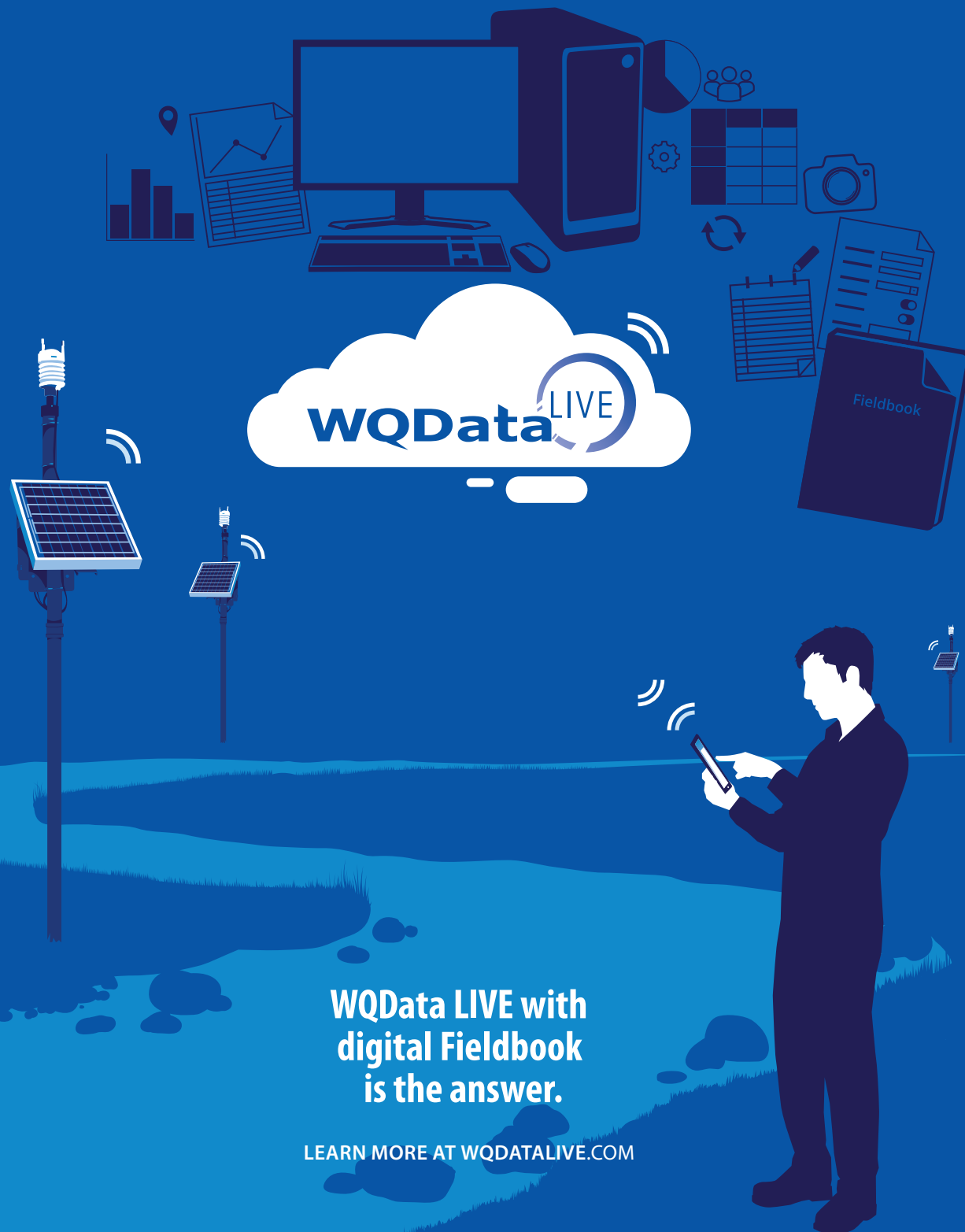
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# Managing environmental project data should be easy



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## WEB EXCLUSIVES

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### Lake O' The Cherokees Buoy Network

Keeping beachgoers informed of water quality conditions in Grand Lake o' the Cherokees is important, especially for alerting them to algal blooms. Thanks to large-scale harmful blooms impacting lakes in the United States, particularly Lake Erie, many have seen the implications that toxic blooms can have: no-contact warnings, beach closures and drinking water advisories.

To help keep an eye on those things, the Oklahoma Water Resources Board launched four NexSens MB-300 Data Buoys in Grand Lake this October. Platforms were placed in each corner of the lake and equipped with YSI 6600 Multi-Parameter Water Quality Sondes to monitor temperature, conductivity, pH, dissolved oxygen, chlorophyll and blue-green algae. NexSens SDL500C Submersible Data Loggers with cellular telemetry gather data and transmit them to officials at the Grand River Dam Authority.

"They'll ... report data every 15 minutes. A threshold will be set and it will send out an alarm that GRDA should go out and collect samples," said Jason Murphy, rivers and streams project coordinator at the Resources Board.

### Penn State's Living Filter Site Of Study Into Emerging Contaminants

Penn State University's Living Filter is a 600-acre area of farm and forest land that is filled with crisscrossing pipes and sprinklers. These pump the university's treated wastewater into the lands where they settle and get sifted through a natural Earth landscape. The idea for such a Living Filter is a good one, and it has been used by the university to clean wastewater for more than 50 years. It inexpensively maintains groundwater levels and helps with meeting pollution-control requirements at the same time.

But the water isn't so clean before it runs through, and there are questions as to what effects it has on lifeforms that live there. Researchers at the university recently undertook an investigation looking at amphibians dwelling in the Living Filter and how they respond to the levels of contaminants present in treated wastewater sprayed onto the lands. These substances include caffeine, pesticides and synthetic estrogen, among other things.



### Coastal South Carolina Study Reveals Increasing Salinity, Ecosystem Effects

In dissecting the effects that rising sea levels could have in a climate change future, scientists are coming at the issue a lot of different ways and with varying questions in mind. For some, the focus is on melting ice caps, while others are zeroing in on forecasting which areas could suffer most. But for researchers studying along the South Carolina coast near Georgetown from 2011 to 2012, the issue was far more unseen: the effects of salinity increase (think seawater) on plant productivity.

The effort was led by scientists at Auburn University, but involved others from the U.S. Geological Survey, Clemson University and Bloomsburg University. Work focused on three tidal forest sites along the Waccamaw and Sampit Rivers. These were dominated by bald cypress trees and one marsh that had salinity concentrations near or just above 0.5 parts per trillion. Over the study period, researchers documented how the forested wetlands were changing in response to rising sea levels and increasing salinity.

# IN THE NEWS

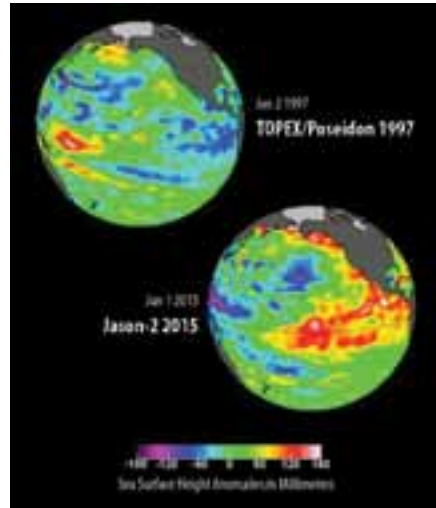


## Unstable Amundsen Basin Could Contribute To Antarctic 'Tipping Point'

Researchers at the Potsdam Institute for Climate Impact Research have learned that the relatively small Amundsen Basin, if destabilized, could act as a trigger causing melt of the entire Antarctic ice sheet, according to a release. A collapse of the Antarctic ice sheet could cause a sea level rise of 3 meters.

Computer simulations were used to show that several decades of warming oceans would be enough to cause a tipping point in the enormous Antarctic ice sheet, which could not be reversed for thousands of years. If the Amundsen Basin in particular destabilizes, scientists say that could be enough to cause irreversible melt.

Current information shows that the Amundsen Basin has already been showing a decline in stability. It is not clear that a rise in greenhouse gas emissions is the cause of Amundsen Basin instability, but more greenhouse gas emissions and further global warming would not help prevent Amundsen Basin and Antarctic ice sheet collapse.

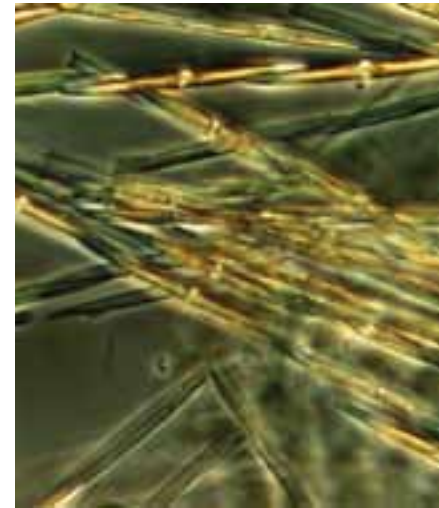


## NASA Satellites To Dissect 2015 El Niño Better Than Ever Before

El Niño has been appearing every 2 to 7 years, not only warming oceans but influencing weather events all over the world, including hurricanes, droughts and storms everywhere from the U.S. to the Philippines to Australia. Since the strongest El Niño event in 1997 to 1998, NASA has launched 19 satellites to observe El Niño and other phenomena, according to a release.

The 19 satellites combined with super-computer processing for modeling climate systems will give scientists more analytical tools for monitoring and analyzing this year's El Niño than ever before. Data that will be collected include sea surface temperatures, sea surface height, surface current direction, atmospheric wind movement and ocean coloration.

All of the data will give a global picture of El Niño activity and severity which was never before possible. Especially important is that the global data gathering will allow researchers to track droughts, improve warnings of impending floods and monitor fisheries and farmlands.



## More Harmful Algal Blooms Expected Due To Global Warming

Concern about more harmful algal blooms in the future is spreading, according to a release from the National Oceanic and Atmospheric Administration. Recent observations suggest that longer bloom seasons have developed, more phytoplankton have moved northward and more HAB events have been chronicled, all factors which suggest HABs may become more prevalent in the future.

It is believed that the HAB increase could be fueled by human activity and worldwide climate change. Ocean surface temperatures, nutrient availability, light and ocean water acidity are all being affected by global warming and an increase in atmospheric CO<sub>2</sub>.

The danger of algal blooms vary. Even though the phytoplankton in an algal bloom normally would help boost an ecosystem, some phytoplankton blooms drive the oxygen level in the water too low and cause massive death of marine animal species. Which phytoplankton are to blame for harmful blooms, and interactions between harmful and non-harmful phytoplankton, are not yet well understood.

Photo: (left) Jane Peterson / NASA; (right) NOAA / NWFSC



## Science's Understanding Of Evaporation Found To Be Flawed

A new study indicates we were wrong about evaporation, according to a release from the Institute of Physical Chemistry of the Polish Academy of Sciences.

Traditionally, evaporation rate was understood using the Hertz-Knudsen equation. However, sophisticated computer models showed that some numbers for criteria describing evaporations were many times larger than predicted by the equation. Interestingly, the gas freed from the liquid during evaporation changed very little in spite of marked changes in pressure. Researchers concluded that the rate of evaporation and vapor pressure were not closely related, as was previously thought.

The former go-to model for evaporation was founded on the conservation of mass principle. Scientists believe the principle of the conservation of momentum should be used instead. This new discovery is important because it challenges existing knowledge of evaporation and its roles in climate change, which means current model predictions must be re-evaluated.

Photo: (left) Public Domain; (right) Landsat / NASA



## Chesapeake Bay Surface Water Temperatures Rising Faster Than Air Temperatures

The Chesapeake Bay is a highly productive estuary formed by the confluence of freshwater from multiple rivers with salt-water from the Atlantic Coast. According to a recent study, parts of the Bay have seen water surface temperatures (WST) rising faster than the surrounding air temperatures, indicating that a heat source other than the air is partially responsible.

The culprit may be the increase in urban land cover from approximately 5 percent to greater than 10 percent since 1975. University of Maryland researchers used the U.S. Geological Survey's Landsat thermal imaging system to monitor spatial-temporal changes to WST and coastal weather stations to measure air temperatures.

They fed the data into an Annual Temperature Cycle model and compared the estimated WST with actual water temperature measurements. The team found that while maximum WST are influenced most strongly by depth and inputs from rivers, minimum WST are driven primarily by the distance to the ocean.



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## Norway Beach Construction

Not far from Oslo, Norway, a massive effort is underway to expand a public beachfront. The work is taking place along an area of Oslofjord called Kadettangen, a small peninsula that juts out into the bay.

Project engineers working to expand the beachfront have been trucking in large rocks and boulders from a nearby tunnel construction project. These are laid in the bay to form support for the new beaches. Meanwhile, monitoring efforts around the work are headed up by Cautus Geo, an environmental consultant, to make sure the project has minimal impacts to aquatic life.

Because of all the work near the bank to build out new land areas using boulders, a turbidity curtain has been deployed in the harbor. This helps to mitigate the movement of stirred up sediment from the bay's bed as work progresses. Around this curtain,

Cautus Geo has deployed two NexSens CB-150 Data Buoys. These platforms were chosen because of their suitability to the harbor's wave and weather conditions. In addition, deploying and moving them around is easier than with larger platforms because of their small footprints.

The buoys are equipped with data loggers, sourced by Cautus Geo, that sit within each CB-150's instrument well. These are powered by three topside solar panels on each buoy and are connected to water quality sensors below. On the bottomside, multi-parameter water quality sondes record measurements of the bay's temperature, conductivity and turbidity, among other parameters. These are transmitted to project managers via cellular telemetry and displayed to them on a custom data management system.

Photo: Mike Voellmecke / Cautus Geo



## Water Quality Class

Learning about things in a classroom can be fun, but book learning can only take students so far. Some need hands-on experience to really make the lessons stick. That principle is incredibly important for science courses, where paper-based information and tests just don't hold a candle to getting out in the field to study.

In one real-world example of this method in practice, a teacher at the University of Iowa's Lucille A. Carver Mississippi Riverside Environmental Research Station (LACMRERS) runs a summer field class that gets down into the nit and grit of water quality sampling on the Mississippi. The connections that it makes for students are just too valuable to pass up, he says. The summer field class began about seven years ago and has become extremely popular with students at the school.

"I think part of that is because it makes the connection between what they study in class and what they see in the field," said Doug Schnoebelen, the water quality class instructor and director of LACMRERS. "They can make connections with the river by doing papers, etc., but I love when that light bulb comes on and they can see how whatever they're studying is used."

The list of things that students get to learn about in the class is quite extensive, and that makes sense because there are so many methods out there for assessing water quality and the

creatures living in the Mississippi River. Some of the techniques that they get into include electrofishing, water sample collection and assessing streamflow measurements by looking at velocity and discharge. Students also learn to take sediment core samples.

Sonar equipment is used to study locks and dams along the river, Schnoebelen says, and he tries to plan activities that allow students to learn about wells and their abilities to process nutrients going into the river. Looking at the interactions between groundwater and surface water is important, he says.

YSI and Hach water quality meters, OTT Hydrolab sondes and SonTek flow meters are some of the equipment used during sampling trips in the lab's pontoon boat up and down the Mississippi River. These are done twice a week to reinforce classroom lessons with real-world examples. A partnership with a nearby Iowa Department of Natural Resources fish hatchery yields a research vessel used for catching fish. The vessel has been the setting of some great fishing stories, Schnoebelen says.


"We were doing some electrofishing one time and we caught a 60-pound flathead (catfish). One of the gals that caught it was a visitor from Iowa," said Schnoebelen, chuckling while he recalled the big catfish. "She was a very petite young woman and I don't know how they got that fish in the boat." 

Photo: University of Iowa



## Hydrogeology Field Course

The Hydrogeology Field Course at Western Michigan University is one of the few such courses available in the United States. It aims to train students on the equipment involved in field work like collecting measurements, keeping records and filing reports.

"We provide students with a capstone opportunity to get a vocational, or applied, portion of training that they didn't get in the classroom," said Tom Howe, director of the field course. "It helps make them employable by providing that experience to them."

Howe says that a number of students have gone on to work for government agencies including the U.S. EPA and U.S. Geological Survey, or have gained positions as staff geologists at environmental consulting firms.

"They're going in and, right off the bat, they're doing the things we taught them to do," said Howe.


The six-week summer course is taught at the Asylum Lake Preserve, which is preserved as a recreation and research area under an agreement between the City of Kalamazoo and Western Michigan University. It involves an intensive training on monitoring gear, including handheld meters and sondes, soil samplers and groundwater pumps, like a Proactive Stainless Steel Hurricane XL Pump.

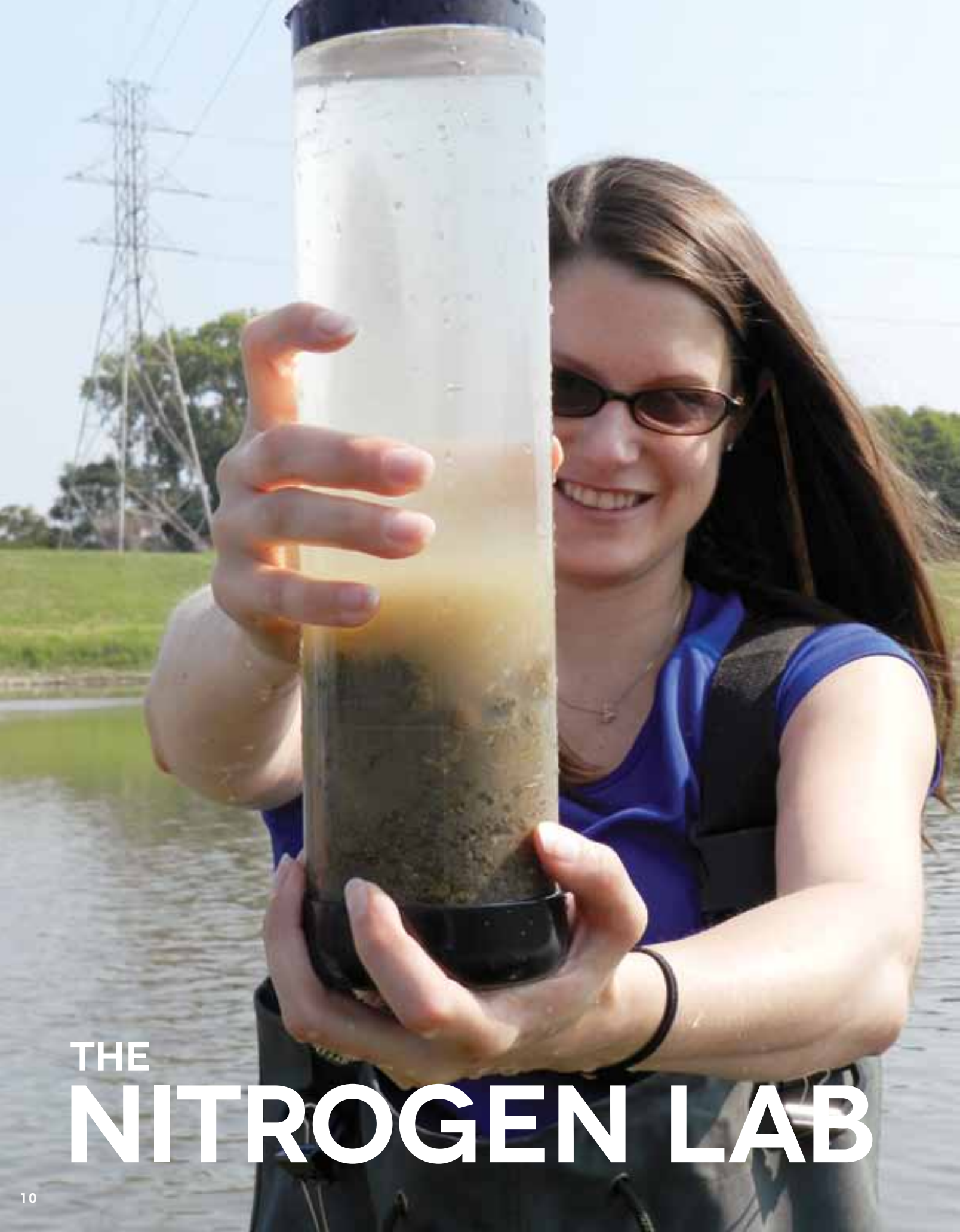
Photo: Tom Howe / Western Michigan University

"With the Hurricane, we're usually training students to do low-flow sampling, running into something with a flow cell, where we need to control the flow," said Howe. "That's where we use YSIs (sondes) to monitor things like temperature, pH, conductivity, ORP and turbidity. And also dissolved oxygen."

The field course uses several Proactive pumps, says Howe, but he got the Hurricane XL because there was a need for a high-quality, submersible pump with minimal maintenance concerns. One of the features he likes is how easy it is to swap out motors when the time comes.

"I haven't seen another stainless (pump) where you can just unscrew it, put the new motor in there and then turn it on," said Howe.

The course not only educates college students, but it also trains industry professionals in hazard response situations. Howe says that the Hazardous Waste Operations and Emergency Response unit of the course is always packed with both students and pros. The course also gets international students, says Howe, and has taught pupils from Denmark, Japan, Norway and Peru, among other countries. 



# THE NITROGEN LAB

With more support for dual nutrient management strategies, Wright State researchers show us how they're studying nitrogen's role in runoff and algal blooms.

BY DANIEL KELLY

After the 2014 harmful algal bloom in Lake Erie's western basin that knocked out Toledo, Ohio's drinking water supply for several days, there was a rapid scale-up of efforts supporting the study and protection of the lake's water quality. Some of these included new monitoring initiatives, like a large number of new data buoys deployed around the western basin throughout the year that followed. And the network itself is a good example of increased cooperation between government agencies working around the lake to cover as much water as they can and share the data they collect.

But the Toledo Water Crisis, as it was widely called in news reports, also brought increased public attention to the issue of farm runoff and the bloom-feeding nutrients that flow with it. This led many scientists, as well as politicians, to evaluate the need for new regulations that could keep such a crisis from happening again. In April 2015, Ohio's General Assembly passed a law to regulate how and when farmers living in the Maumee River watershed can apply fertilizers to their fields. It also establishes new monitoring regimes for phosphorus testing by publicly owned treatment operations.

Since phosphorus has no gas phase that can be "fixed," unlike carbon (CO<sub>2</sub>) and nitrogen (N<sub>2</sub>), the long-held and popular belief is that you can focus on treating it, and the lack of phosphorus will limit algal growth. But Mother Nature is full of surprises, and it turns out that many of the little algae cells out there really like nitrogen.

In fertilizers, nitrogen is commonly added in the form of ammonium and urea. Why is this important?

"There is a theory that these bacteria that are sort of the linchpin of the nitrogen cycle — they're called nitrifiers — and what they do is they link ammonium, which is something that is often added as fertilizer, to a form that can be removed from the ecosystem," said Silvia Newell, assistant professor of aquatic biogeochemistry in the Department of Earth and Environmental Sciences at Wright State University. "Ammonium is like the dollar bill. It is the cheapest, easiest currency to use. You never have to worry about anybody breaking it, anybody having change; you know your dollar bill is the easiest thing to pay with. Well, that's what ammonium is like. It's so easy to use and to take up."

She and others talked with the Environmental Monitor about some studies underway at her lab to explore the significance and nature of that chemical relationship during field work along a stretch of the Lower Great Miami River near Dayton, Ohio. These involve several ongoing projects including an investigation into the river's nutrients and others that touch on water quality issues in Lake Erie and China's Lake Taihu.



Lee Slone (left) secures a sediment core on the Lower Great Miami River.

## LOWER GREAT MIAMI RIVER

Luckily for the scientists and our fearless photographer, water flows in the Lower Great Miami were low as they waded out to begin taking sediment cores. This meant that there was little risk of getting knocked over by swift currents. And the weather was good too, as a mild, beaming sun lit up the river and a partially removed dam they worked around.

Of interest to the crew are nitrogen levels and how they are affected by water treatment plants along the river. They specifically want to find if the nutrients are released naturally by sources going into the river or are linked to the treatment plants. If they are not from the plants, then looming new requirements and expensive retrofits proposed for the treatment operations would be a waste.

The study is part of Lee Slone's master's thesis work. He was aware of the issue and pitched the study to Newell, who helped him design the experiment.

"What I said was, 'I want to do this. This is interesting to me. Phosphorus is already being dealt with by the Miami Conservancy District and the Hammerschmidt Lab at WSU,'" said Slone, a master's student in the Newell Lab and an attorney. "And Silvia said, 'That's great, focus on the nitrogen.'"

Getting at those levels, and identifying where along the river they are highest, involves a decent amount of scientific equipment and varying methods. On the field work side, Slone and others collect cores upstream of the dam in a gradient moving toward it and then follow that with water quality measurements

All Photos: Nate Christopher / Fondriest Environmental



Silvia Newell (right) and Lee Slone collect water samples upstream of an impoundment.



Daniel Hoffman filters water samples on a Lake Erie sampling trip.



Algae in Lake Erie's western basin during the peak of the 2015 bloom.

taken by a multi-parameter sonde linked to a tablet computer. The sonde gathers data on water temperature, specific conductance, depth, blue-green algae, chlorophyll, dissolved oxygen, turbidity and pH. The scientists collect nutrient samples for nitrogen and phosphorus concentrations, immediately filtering them. They also gather more water samples in 5-gallon water bags. Once the upstream sampling is done, they head to the other side of the dam and do it all over again.

The team uses similar sampling efforts all up and down the Lower Great Miami River, looking specifically around impoundments that cross its wake. After they survey a site, the sediment cores and water samples go back to the lab, where Slone analyzes them.

There are a few expectations for what data from the site we visited will reveal.

"This is urban. Our expectation is that this is going to be a lot of urban runoff," Slone said, while transferring a sediment core to a large white cooler. "When it rains on your lawn, if you have a dog and it poops, you don't clean it up, or you fertilize your lawn, that goes into runoff. And here, it'll go into the street, and the stormwater comes right into the river. Not just this one, but the others that feed this river."

As for any inputs from combined sewage overflow, the Dayton area doesn't have a system that joins stormwater and sewage pipes together, so it's not a concern. And with no treatment plant upstream, the scientists guessed that most of the site's runoff would come from areas around it.

"When you look at the state as a whole, the majority of nutrients that are being added through runoff are coming from farms," said Newell. "And wastewater treatment plants are a smaller percentage of that."

Some of the lab methods that Slone uses to verify or disprove his expectations rely on a mass spectrometer. With that, he analyzes samples from a continuous-flow incubation that simulates what is happening in nature as best as possible. One of the large, 5-gallon jugs of water serves as part of the experiment's control, marked with a "C," to which he doesn't add anything. The other two jugs are marked with "A" or "N," like their sediment core counterparts, and get treated with ammonium or nitrate.

"In the A, I add heavy ammonium, so  $\text{NH}_4^+$ , but the N that's on the  $\text{NH}_4^+$  is a 15 (isotope) instead of a 14," said Slone. "And the N, I add nitrate, and the N is 15 instead of 14. So I add heavy nitrate to one tub of water, and I flow that through these two (N) cores. I duplicate cores, and I flow heavy ammonium through these (A) cores, and the controls through these (C) cores. And that's six up (upstream), six down (downstream)."

Slone says that the work is in beginning stages, and there's still plenty of data to be collected, but the hopes are that the effort will yield something useful to those working to maintain the health of the Lower Great Miami River.

"We're using very careful analytical methods to quantify rates of nitrogen transformation, and with those numbers, we can go to the Miami Conservancy District, or to the EPA or to the wastewater treatment plants and say, 'Here's what we found. Here's what we think is going on,'" said Slone. "And it's always a battle

between people and nature. Got to feed all the people, got to put fertilizer on all the fields, but at what cost, and where's the balance?"

## LAKE ERIE

Growing interest into nitrogen's role in algal blooms has in part spurred another study underway in Newell's lab. Like the Lower Great Miami River work, it is zeroing in on ammonium but relies on data collection a few hours north of Dayton.

Daniel Hoffman, a doctoral student in the lab, is leading the work. We caught up with him on an exposed sandbar while Newell and Slone gathered sediment cores upstream of the dam.

"Specifically what I'm looking at is ammonium. And the reason I'm looking at ammonium is that it is the most reduced form (of nitrogen) in terms of its oxidation state. So what that really means for things that want to grab it is it's the easiest to grab. It's the easiest to cross the cell membranes without a whole lot of extra energetic work being put in," said Hoffman. "And ammonium favors the growth of cyanobacteria, like the toxin-producing *Microcystis* that is currently blooming in western Lake Erie."

Part of the reason that researchers elsewhere have not done such a good job measuring ammonium concentrations accurately is that it just gets taken up so quickly, Hoffman says. It is simply in very high demand for biological use. His work so far, as well as studies that Newell has helped on in the past, show just how these concentrations have been missed.

Scientists go out, collect samples and then take them back to the lab for analysis hours later. But after those long periods, Hoffman says, the ambient ammonium concentrations they see aren't accurate because of the extra time that biological communities within the samples have had to take them up or regenerate them, such as when cells break open or are eaten.

Hoffman is working to alleviate that data gap and learn more about the dynamics of ammonium use through regular trips to Lake Erie, where he gathers samples with help from ship time donated by the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab. Scientists from the lab are also sharing data with Hoffman, who will be repaying the favor when his work is finished.

He typically uses a Niskin water sampler to collect discrete samples at varying depths in the lake's western basin. Samples are gathered about a meter below the surface, just under where blooms typically are, as well as deeper down near the lake bed.

"Kind of tricky, but when you get into the difference of a thermocline, where the temperature difference is, you've got a change in nutrient concentrations. And especially where we have these blooms, things are going to be consumed very quickly at the top, though they may not be at the bottom," said Hoffman. "So we don't yet know what those differences are, but we're going to look and see."

Hoffman gathers in-situ samples for ammonium before making the drive back to Dayton. The water is run through filters that limit the tiny lifeforms within from taking it up.

Photos: Nate Christopher / Fonciest Environmental

Photo: Daniel Hoffman





Daniel Hoffman (left) and Lee Slone gather sediment cores on the downstream side of a dam.



"We go out and we collect the water and immediately filter it to 0.2 microns, which removes most of the potential bacteria that are going to take it up — it's a very tiny pore size on that filter — which means that we're seeing much higher ammonium concentrations, or at least different ones, than the people who were filtering or freezing after an hour or even days," said Hoffman.

Other ammonium dynamics he's looking at rely on lab techniques. One is a total nitrification rate experiment in which ammonium is converted in a multi-step process all the way to nitrate. The nitrifiers compete with *Microcystis* for ammonium, which could determine a threshold the *Microcystis* have to overcome to bloom. An ammonium oxidation experiment lets him dissect the rate-limiting step of the nitrification process, and he'll correlate that through a gene's expression later in the work. He is also studying ammonium uptake and regeneration. Those experiments are complemented, he says, by using <sup>15</sup>N, a stable isotope of nitrogen that can be measured using mass spectrometry.

"And that means that we can say, 'alright, well, if I know that I'm adding this much of the <sup>15</sup> labeled stuff in this form, and it comes out in a different form, there's a process occurring there, and we know what that process hypothetically is and how fast it goes,'" said Hoffman. "Genetic work is the next step in terms of verifying that, but there are only a handful of processes that are going to contribute to one output from one input. So we can make a pretty good guess just based on that."

In the future, he would also like to quantify the communities of micro-organisms that take up ammonium to see how many *Microcystis* there are versus how many are ammonia-oxidizing bacteria and archaea.

"If there are certain species that could potentially outcompete *Microcystis* for the available ammonium, that could lead to some ideas about how we mediate these really nasty blooms. Because there are tons of other bacteria and archaea in these systems, it's just that *Microcystis* are dominant and they happen to be the dominant toxic species as well," said Hoffman. Figuring out how to shift away from those toxic species and back toward typical phytoplankton dominance would be a great help to all the systems, he adds.

Those and other questions are yet to be answered by Hoffman's work, which is just beginning. But hopes are that answers to them will one day make splashes in the Lake Erie environmental policy world.

"That's what we're hoping. I mean we'd like to be able to get enough information," said Hoffman. "So we mentioned that nitrogen currently isn't regulated in Ohio. But as of last year or earlier this year, the EPA has kind of started to say, 'we should really be looking at a dual nutrient management strategy with both N and P instead of just P. But that's still in its nascent stage and people are still talking about it.'"

### BRINGING IT ALL TOGETHER

There is a growing realization among scientists and policymakers that more attention needs to be given to monitoring and regulating nitrogen making it into U.S. waterways. Recently, that has been given more credence by a bulletin issued by the U.S. Environmental Protection Agency advocating for a dual-nutrient strategy.

"That means that, right now, phosphorus is being monitored and regulated everywhere, and nitrogen is not. So the U.S. EPA is saying, 'Hey, we should do this.' So they haven't made it a law yet, but I really believe that it will be in the next few years," said Newell, speaking with us after the crew had moved downstream of the dam to begin round two of sampling. "And the trouble with that is that we don't have much data to base our laws on. We have very few measurements of ammonium in Ohio in rivers. Some people are doing it, but there's a lot of variability in terms of how the samples are collected, like how people actually collect their samples and run their method."

For example, some researchers use filters that go down to 0.2 microns whereas others use filters that come in at 0.7 and clear out fewer of the tiny lifeforms that continue to use ammonium. More method variability is also introduced by scientists who freeze samples after collection to halt reactions while others do not.

"There are some flow gauge stations along the river that will actually collect water samples, and they sit there for up to a week before somebody comes and collects them and measures them. And so, that's obviously kind of a problem for trying to get an accurate measurement," said Newell. "We want there to be good data for these laws, whatever they are, to be based on. We want to have a good idea of how much nitrogen we have in our rivers and lakes, how much is going in Lake Erie, and what percentage of that nitrogen is ammonium specifically."


The ongoing projects may also have implications for another one that Newell has been working on for years with co-investigator Mark McCarthy, a research scientist in Wright State's

Department of Earth and Environmental Sciences. It is focused on hypereutrophic conditions in China's Lake Taihu, which are choking the water body with bright-green algae just like in parts of Lake Erie.

"It's very similar to the western basin of Lake Erie in that they're both shallow, so they're well mixed," said Newell. "And they both have big problems with harmful algal blooms, specifically *Microcystis*. And we are hoping that what we learn from one can be applied to the other and vice versa."

Of course, the western basin of Lake Erie is a lot different when compared to other parts of the Great Lakes, she says. Lake Superior is a pristine water body by comparison, mostly because of its great depth and the fact that it can't be mixed as well as Lake Erie.

But there will likely be insights from all the projects going on in Newell's lab that contribute to improving water quality in lakes and rivers in the Great Lakes basin and elsewhere.

"This project is very local. It's locally focused and mostly has impacts for the Dayton wastewater treatment plants," said Newell of the Lower Great Miami River work. "But what's happening in Taihu and what's happening in Erie, I think are especially important for water regulations across the nation and in Ohio. We don't have nitrogen regulations across the board. I think we're going to. I think it's very important to understand the Great Lakes. So I think understanding how nitrogen is cycled and moves in the different kinds of lakes and different systems is very important, and there's been very little work done on it." 

Photos: Nate Christopher / Fondest Environmental



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## LI-COR Terrestrial Light Sensors

A modular redesign improves convenience and durability.

BY DANIEL KELLY

For environmental professionals looking to measure light, the sun's energy or photosynthetically active radiation, there is no better choice than LI-COR's all-new line of terrestrial light sensors. The series, including the LI-190R, LI-200R and LI-210R, has been redesigned from the ground up and is more convenient, reliable and durable than ever before.

The new design centers on a modular setup that lets users detach the sensor head from the base. This makes it possible to swap out sensor heads for calibration or to measure different light parameters. In addition, it adds to project flexibility, saving users time and money.

"After 40 years of manufacturing light sensors and receiving feedback from scientists and researchers around the world, we found that we could implement design changes to improve both the performance and the durability of our sensors," said Dave Johnson, senior product manager at LI-COR Biosciences.

Johnson goes on to identify two key advantages of the new design. For one, it eliminates the intensive work some customers had to do in the past to send light sensors in for calibration, including digging up conduit to remove entire sensor-and-cable units from monitoring stations.

"To remove this complexity, we designed the sensors so that the heads can be removed from the cable and then simply shipped to LI-COR for recalibration, said Johnson. "Our pyranometers are very popular among the solar industry, and this is where we have seen most of the excitement about this feature."

The second key advantage touches on savings when it comes to maintenance. As the LI-COR sensors are typically deployed outside, they are at nature's mercy. Wild animals can chew through cables and the sensors are also subjected to lightning strikes. Common human errors, like dropping sensors or accidentally cutting cables, also sometimes happen.

"If damage happens to either the cable or the head, then only that component would need to be replaced," said Johnson. "This can be done at a fraction of the cost, delivering the customer significant savings."

In addition to the lower maintenance costs, being able to swap sensor heads means that scientists interested in more than one parameter can now use one base with multiple LI-COR sensors. So a researcher can easily measure the amount of photosynthetically active radiation impacting plants in an area with a LI-190R




Quantum PAR head and then swap in a LI-200R Pyranometer head to measure solar radiation coming from the sun.

Johnson points out that the new Quantum PAR sensor has improved optics, which lets it equally measure light across a waveband of 400 to 700 nanometers (light that plants use for photosynthesis) better than any other PAR sensor on the market. That means its measurements are more accurate.

"With the new optics in the quantum sensors, we improved specifications to make an even more accurate sensor for scientists interested in research-grade measurements," said Johnson. "That is very important for researchers and scientists who are carefully studying our climate's interactions between ecosystem and atmosphere."

There are no new maintenance concerns for the redesigned line of sensors, which is owed to a more robust housing that helps bolster durability in extreme conditions. Johnson says that users can buy a Sensor Base Cover to put over the sensor base when heads are sent in for recalibrations. Other than that, the only other accessory is a Mounting and Leveling Base that keeps the sensors level, important for collecting accurate data.

"Our team is extremely satisfied with the ability to provide these high-performance sensors at a cost that allows users accessibility to the measurements they need," said Johnson. 

# TOXIC RIVER

Early during the Animas River disaster, New Mexico State University scientists had a rare chance to gather baseline data before the toxic plume arrived.

BY DANIEL KELLY

As toxic waste from a long-shuttered gold mine made its way down the Animas River in August 2015, communities along the waterway shut off their irrigation operations ahead of the orange plume's arrival. The move was meant to protect public health, but had an unintended side effect: It gave scientists at New Mexico State University a truly rare opportunity to gather baseline data before the toxic plume got there.

Their target areas were ditches along the New Mexico stretch of the river. They rushed to sample them not long after learning about the Gold King Mine spill near Silverton, Colorado. By getting there while irrigation was shut off, the scientists ensured that none of the data collected would reflect any infiltration by pollutants flowing in the river.

Sampling began Aug. 7, just two days after the abandoned Gold King Mine had released its polluted waste into the river. And now, months after the accident, the researchers are surprised by a lack of funding to remediate the affected areas.

"One thing I'd like to emphasize is that although it has been nearly three months since the spill, no major federal assistance has been allocated," said April Ulery, professor of soil and environmental sciences at New Mexico State. She worked with Kevin Lombard, an associate professor of horticulture at the university, to gather the valuable baseline data.

"No major funding has come down the pipeline. I'm personally invested in it as a scientist and a landowner, but funding wasn't thought of when we started," said Lombard. "That's probably not the best way to do science, but when you're faced with something you've never seen before in your life, it's our obligation as community members."

And so with that sense of fervor at their backs, the two led a sampling effort that raced against the clock to collect data on soil health in irrigation ditches before the plume passed their stretch of the river. A GPS receiver helped them tag the sites they worked in. From there, most of the actual sediment samples were gathered with stainless steel soil augers approved for use by the U.S. Environmental Protection Agency.

The efforts covered nearly 20 ditches on and off the Navajo Nation in northwestern New Mexico and scientists were able to gather somewhere between 200 and 300 samples. They are approaching analyzing them with the hypothesis that pollutant levels in the soil won't go up over time, something that they can only hope turns out to be true.

"I want to know the impacts of the contaminants to the farm fields. And those dry-ditch samples we retrieved pre-plume, we'll never be able to grab again," said Lombard. "Many of us farm. Some of my staff raise livestock and so we had access to community ditches before any response teams could get there, including the (U.S.) EPA."

Ulery says that their work was part of a collaboration between state agencies including the New Mexico Cooperative Extension Service, the New Mexico Environment Department, the New Mexico Department of Agriculture, and the New Mexico Office of State Engineers.

"The big story for the New Mexico agricultural department was that the water cleared fairly quickly. That's why the order was



New Mexico State University employees from the Agricultural Science Center at Farmington help take soil samples in irrigation ditches while gates were closed.

given to open irrigation," said Ulery. "But that doesn't mean that the metals are gone. They've just precipitated into the streambed and onto the river banks."

Metals that passed through in the water, which Lombard likened to macaroni and cheese in color, included lead, iron, aluminum, arsenic and copper. In the river, levels of these metals spiked with the plume's arrival and dropped as it passed.

Lombard says that the closer you got toward the source, the higher the sediment levels in the river were. But once the plume had passed, there were still notable impacts left behind.

"We were seeing orange sediment along the river banks. And that's not to panic anybody, but we want folks to be concerned about public health and their livelihoods," said Lombard. "We'll make recommendations on remediation if it's needed at all, but there are still sediments that could wash into irrigated fields. That's why it's important to resample every year."

But first the researchers will have to work through analyzing all of the samples they currently have. Preliminary analysis of the soil samples has been supported by emergency funding from the New Mexico State University Agricultural Experiment Station and a small grant from the Natural Resources Conservation Service of New Mexico. Future funding will be necessary to complete these analyses and accurately evaluate long-term impacts to the region.

"There's no fast turnaround on getting either the water or the soil data. Kevin and colleagues did some portable samples, but we still need to acidify and digest them in the lab," said Ulery.

She says that it is also daunting at the outset because of varying reporting practices between agencies regarding the metals that washed through the Animas River. For example, some reported both total metals (including dissolved as well as in the particulates in the water) while others didn't. "We were also answering basic questions about the difference between parts per million and parts per billion," said Ulery. "That confusion led to a lot of worry and concern."

It also underscored the rare nature of the type of disaster scientists were facing.


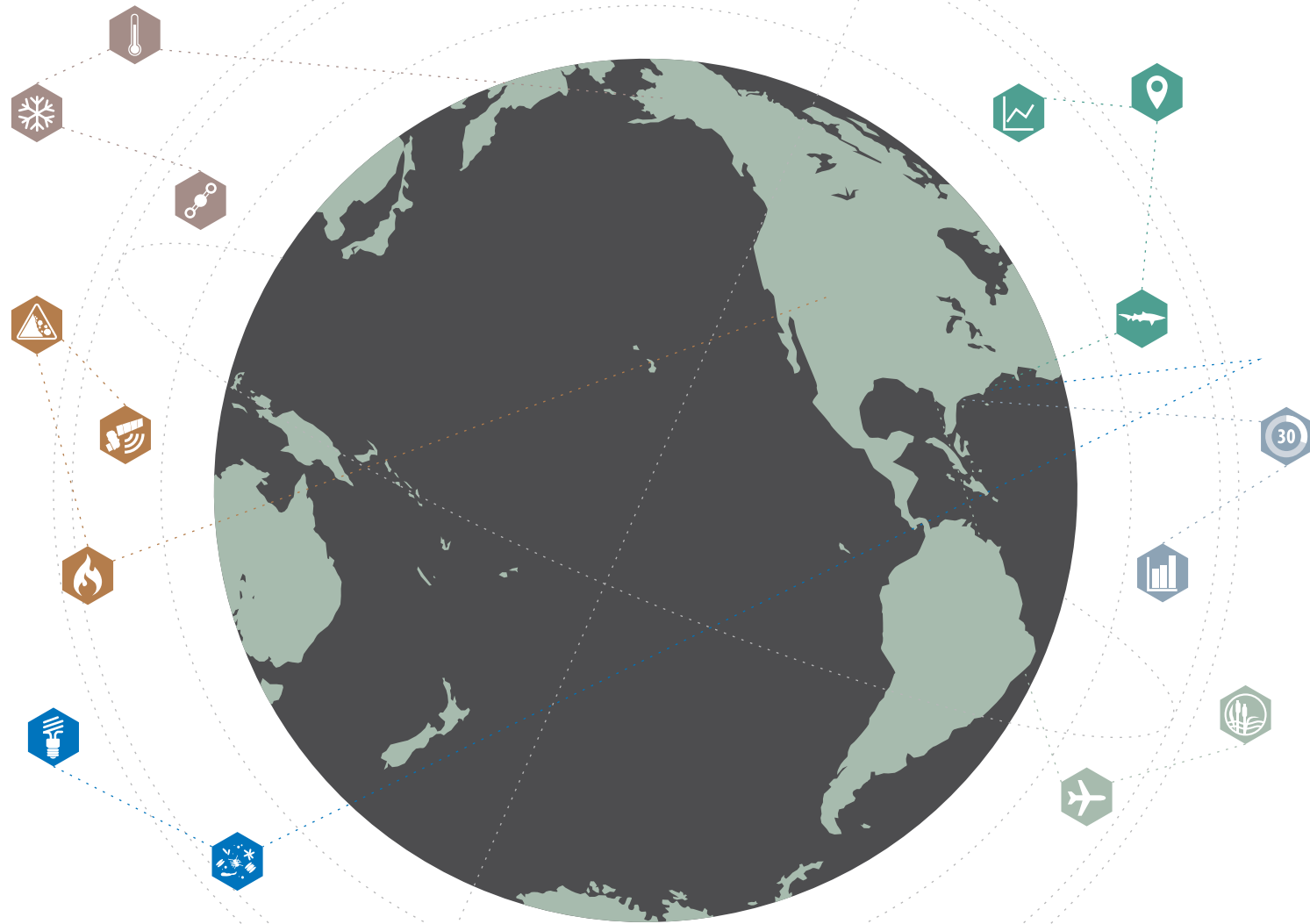
"Federal agencies don't usually cause accidents," said Lombard. "It's a great case study." 

Photo: (left) Riverhugger / CC BY-SA 4.0; (top right) Jane Moorman / New Mexico State University

# MODELING THE ENVIRONMENT



Across most any field, those working within it are trying to harness the power of data to inform better decisions and processes.

In the environmental monitoring space, this push is no different, as researchers across the industry are looking to leverage the strength of data to develop accurate tools to meet all sorts of needs. But the data these pros are collecting don't just impact a small section of society — in many cases, they have global implications.

In this section, we touch on a few examples of this trend, from modeling the changes occurring in wetlands on the Gulf Coast

to dissecting the prominence of a bioluminescent alga in Chesapeake Bay.

We also dive into a project tracking the migration patterns of vulnerable sand tiger sharks and others looking at rising sea levels, carbon emissions from thawing Arctic permafrost and flood and landslide predictions following wildfires.

These projects and others show the potential of data and modeling tools to reveal new findings, advance conservation goals and even protect people and property after natural disasters.

Illustration: Nate Christopher / Fondriest Environmental

# CHANGING WETLANDS

NASA scientists combine remote-sensing technology and on-the-ground fieldwork to survey Gulf Coast wetlands.

BY DANIEL KELLY

Using sophisticated satellite technology and ground-based field work, NASA scientists have finished a routine surveying effort of wetlands along the Gulf Coast. Surveys of the region are completed several times a year, as scientists with the agency assess how it's changing over time.

Of interest to scientists are a number of things. One is the Wax Lake Delta in Louisiana, one of the few deltas worldwide that is actually growing through natural sedimentation.

"The Wax Lake Delta study aims to improve modeling of delta formation, which is important for determining how to prevent erosion and restore deltas," said Cathleen Jones, radar scientist at NASA's Jet Propulsion Laboratory in Pasadena, California.

Most deltas are highly engineered, inhabited areas that are in danger from a combination of subsidence and sea level rise, says Jones. That happens because dams upstream and levees in the deltas prevent the natural process of sedimentation from offsetting subsidence. And so it is interesting to watch Wax Lake Delta's growth in contrast with others that aren't expanding.

Scientists want to dissect the delta's changes, as well as those involved with subsidence in the Mississippi River Delta and the Gulf Coast ecosystem overall. The progression of the Bayou Corne sinkhole, an expanding sinkhole in Louisiana that threatens surrounding property, is also of interest to scientists.

Photo: NASA

The effort relied on a large number of instruments to collect measurements, most of which were mounted to NASA research planes that made flights over the region. They included the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) instrument; the Next-Generation Airborne Visible/Infrared Imaging Spectrometer (AVIRIS-ng); and the Air Surface Water and Ocean Topography (AirSWOT) instrument.

Jones says the UAVSAR instrument helped researchers look at subsidence and levees. The AVIRIS-ng, a hyperspectral imager, collected measurements on marshland vegetation.

"We used...coastal bathymetry at Wax Lake Delta and the Bayou Corne sinkhole," said Jones. AirSWOT, a Ka-band radar, was used "to measure water surface elevations and currents at Wax Lake Delta and in the adjacent coastal marshlands."

The goal of the research is to provide data to federal and local agencies, which use the information to determine where to concentrate resources and combat the negative effects of wetland loss and floods. The data will also be used to improve modeling of delta land building and can be applied to help restore deltas worldwide.

So far, scientists have yet to draw complete conclusions from the measurements they've taken. "We are still analyzing the data, so we don't have full results yet," said Jones.

# TRACKING SHARKS

University of Delaware researchers use acoustic receivers and an underwater glider to study sand tiger shark movement along the Atlantic Coast.

BY DANIEL KELLY

**P**opulations of sand tiger sharks (*Carcharias taurus*) worldwide have been on the decline in recent years. And though the animals are not endangered currently, they are vulnerable to becoming so.

With their population numbers on the edge, understanding the life cycles and choices of sand tiger sharks has never been more important. To that end, scientists have ramped up efforts to put a pulse on the sharks' declines and are using a variety of methods to do so. One recent investigation, conducted by researchers at the University of Delaware, relied on acoustic tracking devices implanted in the sharks and a Slocum glider to map the locations of sand tigers down the United States' East Coast, from Delaware's Indian River Inlet to Chincoteague, Virginia.

"We chose this area to study because previous research has shown it to be an area where sand tigers seem to congregate during the fall and spring as they are migrating in the nearshore waters off the coast," said Danielle Haulsee, a doctoral candidate at the school and the lead author on a paper detailing the work published in the journal *Marine Ecology Progress Series*. "Having the sharks congregated increased our chances of encountering sharks carrying tags with the underwater robot, as well as allowing us to measure the environmental characteristics of an area of high use by the sharks."

Using the glider to take those measurements added an environmental context to the acoustic detections of sand tiger sharks.



All Photos: University of Delaware



Traditional, moored, stationary acoustic receivers are limited because they can only detect acoustic pings, says Haulsee. The glider, on the other hand, can detect the sharks' acoustic tags as well as ocean parameters along the way.

Of interest to the researchers during the work were measurements of water temperature, dissolved oxygen, salinity, chlorophyll and color dissolved organic matter, or CDOM. CDOM is a mix of dissolved plant and animal material floating in the water. It typically makes for a yellowish-brown color, says Haulsee.


The glider collected data on those parameters as it zig-zagged its way down the coast over 19 days, encountering some 23 sand tiger sharks. During that time, moored receivers counted 300. The glider's measurements for most metrics were fairly straightforward, but those for CDOM revealed an interesting relationship about the paths that sand tigers were taking.

"The sand tigers encountered by our underwater robot were significantly associated with nearshore waters that were lower in salinity and higher in color dissolved organic matter than the waters available to them," said Haulsee. "We interpreted these results to be cues for feeding or navigation while they migrated south along the coast."

Since CDOM is not normally measured in the field as part of shark studies, Haulsee says the investigation is the first, as far as she knows, to show an association of a shark species with its presence.

"From a biological perspective, it makes sense that this parameter might matter to a shark because of their well developed olfactory (sense of smell) systems," said Haulsee.

The finding, along with others relating to how sand tiger sharks make their habitat selections, will be used to form a species conservation plan to help better protect the species and hopefully prevent the sharks from being listed as endangered.

"Sand tigers are currently considered a threatened species and so it is important for us to take steps now to help their populations recover," said Haulsee. "In addition, the results from this study will help inform a predictive habitat model for sand tigers in the Delaware Bay and surrounding coastal waters to help prevent bycatch of the species in our area by commercial fisheries." 

# SEA LEVEL RISE

30

Scientists study saltwater intrusion and elevation in five coastal river systems in Georgia to inform modeling work of sea level rise for the state's coast.

BY DANIEL KELLY

Georgia has about 30 percent of all the existing salt marsh on the United States' eastern seaboard. Much of that is expected to migrate inward with predicted sea level rise in the future, possibly impacting plant and animal habitats and commercial fisheries.

Understandably, scientists have many questions for what these moving marshes could bring about. A few at the University of Georgia's Skidaway Institute of Oceanography and Georgia Southern University have embarked on a study to model what the state's coasts will look like within the next 100 years.

Scientists are focusing their efforts on five coastal river systems: the Savannah, Ogeechee, Altamaha, Satilla and St. Marys. Work has been completed to gauge saltwater intrusion on three of those. Two more are expected to be surveyed by early September. After data collection is finished, all of the measurements will be plugged into the Sea Level Affecting Marshes Model (SLAMM) developed by the National Oceanic and Atmospheric Administration. This will allow scientists to accurately predict the impacts that sea level rise could have on the area.

"There are a number of saltwater marshes along the coast that don't have a river at their head," said Clark Alexander, professor at the Skidaway Institute. He is working with Christine Hladik, an assistant professor of geology and geography at Georgia Southern University to complete the work. "These are more influenced by saltwater intrusion than a river."

It is along these waterways that scientists sample in a boat, starting from their mouths about an hour before high tide and then continuing along while taking measurements all the way to the spot where saltwater intrusion ends, usually a distance of about 35 to 40 kilometers. A lot of this work relies on a Seabird CTD (conductivity, temperature, depth) sensor deployed in a flow-through chamber on the side of the boat that scientists pump water through as they move along their sampling route.

Researchers are also using a YSI Castaway CTD that gets lowered off the side of the boat to capture measurements in a profile. Since the device has integrated GPS, researchers can know exactly where each point was taken.

"It gives us a good representation of what is throughout the water column," said Alexander. "In general, we have a lot of tidal elements in our system. It's a 3-meter tidal range. Water quality is pretty well mixed."

Taking data from the two CTDs together, researchers are populating a highly accurate set of measurements on saltwater intrusion in the five coastal river systems. But those are not the only pieces of the puzzle. To complement those measurements, Hladik is working with LIDAR (Light Detection And Ranging) data



to gauge what sort of effects elevations in the marshes could play.

But there's an issue with those measurements, as some of the vegetation in the study area is too dense for LIDAR to cut through.


"The marsh grass is so dense that the laser pulses don't make it to the ground," said Alexander. "So we're having to develop correction factors for LIDAR based on vegetation type."

Some of the grasses are tall and dense, he says, while others are short and thin. So Hladik goes to different areas within the marshes with a Trimble R6 GPS unit and compares LIDAR measurements to Real Time Kinematic GPS data. In layman terms, this means they compare elevation data taken with LIDAR to elevation data Hladik collects on the ground.

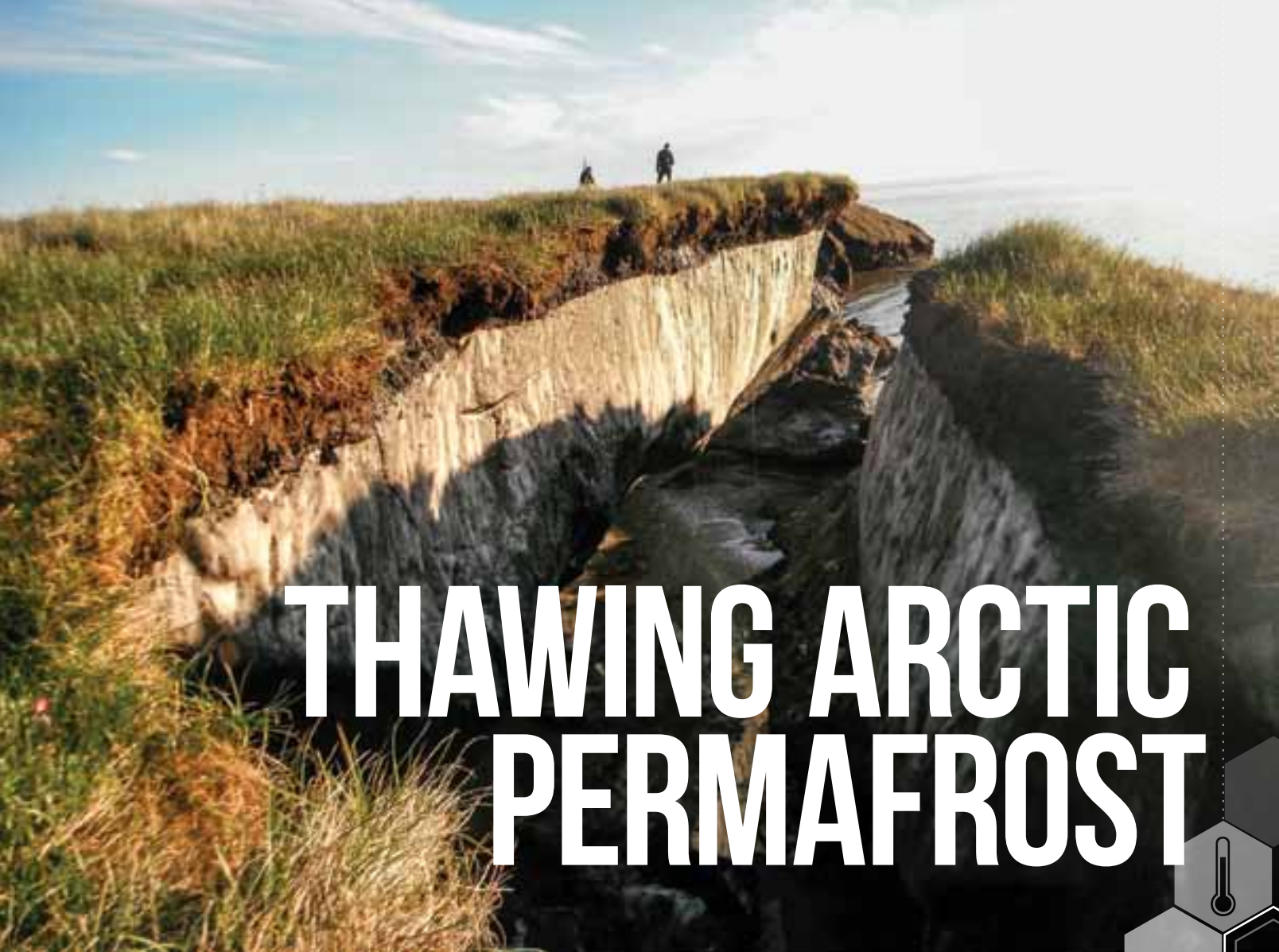
"For example, if the LIDAR measurement is too high, we can figure out how much we need to subtract," said Alexander. "We want to do it so that the elevations of the marsh are accurate because if you want to know when the marsh is going to be flooded by tides, you need good elevation data."

Alexander says the team has collected about 500 data points so far. The hopes are that those and others to be collected will result in a SLAMM simulation for the region that can predict what rising sea levels could do there within the next 100 years.

From there, the model could play a big role in preparing the region for possible sea level rises in the future.

"We're hoping that, as we get a better idea of where marshes migrate over time, there will be a concerted effort to maintain them," said Alexander. "Armoring of the coastal zone could help keep them from migrating inland. If we can identify where movement is possible in the future, we can also maintain areas where future marshes might migrate. The model could also be used for better storm inundation preparedness." 

All Photos: Skidaway Institute of Oceanography, U. Georgia



# THAWING ARCTIC PERMAFROST

Berkeley National Lab researchers use direct sample observations and Arctic tundra carbon mapping to create a new model of Arctic permafrost carbon release.

BY LORI BALSTER

As global warming continues, a question that hangs over the Earth quite literally is what the contribution will be of all the carbon that is stored in permafrost in the Arctic, which includes regions in Alaska, Canada and Russia.

Charles Koven, a research scientist at the Lawrence Berkeley National Laboratory, along with a team of other scientists, has come up with a new way of modeling permafrost carbon using direct permafrost carbon observations instead of estimating carbon release based on complex Earth system models.

"Although typical Earth system models contain a wide range of atmospheric and land surface phenomena, they lack direct observations of permafrost soil carbon which could serve as useful modeling constraints," Koven explains. In addition, the

Earth system models do not contain some new soil carbon mapping information that has recently emerged.

Koven set about to incorporate direct observations of permafrost soil carbon and the latest carbon mapping information into his simplified model. Instead of using atmospheric and land surface phenomena and asking how close the answers came to observed carbon stocks, Koven decided to start with direct observations of carbon stocks plus use recently developed soil carbon maps in Alaskan, Canadian and Russian permafrost soils. The relatively simple and direct observation-driven model he has constructed also includes a meta-analysis of several lab studies where permafrost soil was held at constant above-freezing temperatures for months or years.

The model was run in two scenarios: 1) carbon release from permafrost soil if global warming is mitigated by reducing greenhouse gas emissions by the middle of this century and 2) carbon release from permafrost soil if warming accelerates because carbon emissions continue unabated.

"Essentially, it was found that for every 1 degree C (Celsius) of global warming equals 1.5 years carbon dioxide global emissions equivalent for permafrost carbon release, creating a feedback loop that leads to more warming," Koven says.

The model itself consists of three parts: 1) large-scale soil carbon maps, which include where the soil carbon is and its depth; 2) decomposition dynamics, which include information on how quickly the soil decomposes and how carbon is released when soils thaw and 3) soil temperature data, which come from climate models. The decomposition dynamics piece is based on incubation data of actual permafrost soil samples. A soil sample is taken, held at a single temperature for a set amount of time and stored in refrigeration, from 1 year up to 10 years. The soil's decomposition and carbon release behavior are noted.

The soil carbon information Koven has been using also has deliberately included not just surface soil data but also soil data at different depths, as the decomposition behavior is likely to be different at various depths. Carbon dioxide in these soils is measured in a closed vessel headspace and samples are weighed for evaluation. The incubation data give an estimate of how much carbon is lost. The incubation temperatures are chosen based on knowledge of the soil and typical seasonal variations in temperature in the soil locations of interest. Knowledge includes where and when the soil goes above zero during typical seasonal shifts, which influences decomposition rates. The seasonal soil decomposition trend, including soil location and depth, is incorporated into the model, and then global effects are added to the local seasonal variations. The model was used to explore permafrost soil carbon release behavior up until the year 2100.

Koven used all the permafrost soil carbon data he was able to get. "There is not much field data currently available for Siberia, since it's a rough environment, a difficult environment to get samples," he explains.

A key development has been for scientists to work together through the Permafrost Carbon Network. It is an international organization that brings permafrost soil carbon data together for scientists to use in their model-building and other research.



"Basically, to advance our current model, we need more permafrost samples, particularly in Russia. We need more shovels in the ground," Koven says. It is not realistic at this point to remotely monitor permafrost soil carbon by satellite, he says. And although automatic permafrost temperature sensors exist, they are currently mainly in Alaska and Canada, and there aren't many.

In the future, Koven feels there needs to be more data gathered on the relationship between soil temperature and soil hydrology. "That is still a large unknown," he says. "Another piece that needs to be incorporated is the role of plant growth and how that impacts permafrost carbon release."

To summarize, Koven says the basic question they are trying to answer with their modeling work is, "How much carbon dioxide can people add to the environment and still be safe?" Current international negotiations have set 2 degrees of global warming as an upper boundary to avoid some of the worst effects of climate change. The question is, how much carbon dioxide could humans release but still be under the 2 degrees C temperature rise?

"About a trillion tons of carbon seems to be the carbon budget limit," Koven says. Of that, about 40 billion tons could be from permafrost soil carbon release due to the 2 degrees of warming. But toward the end of the century, we may start to exceed that. "It looks like, by 2100 to 2300, carbon release will no longer be balanced by plant uptake."

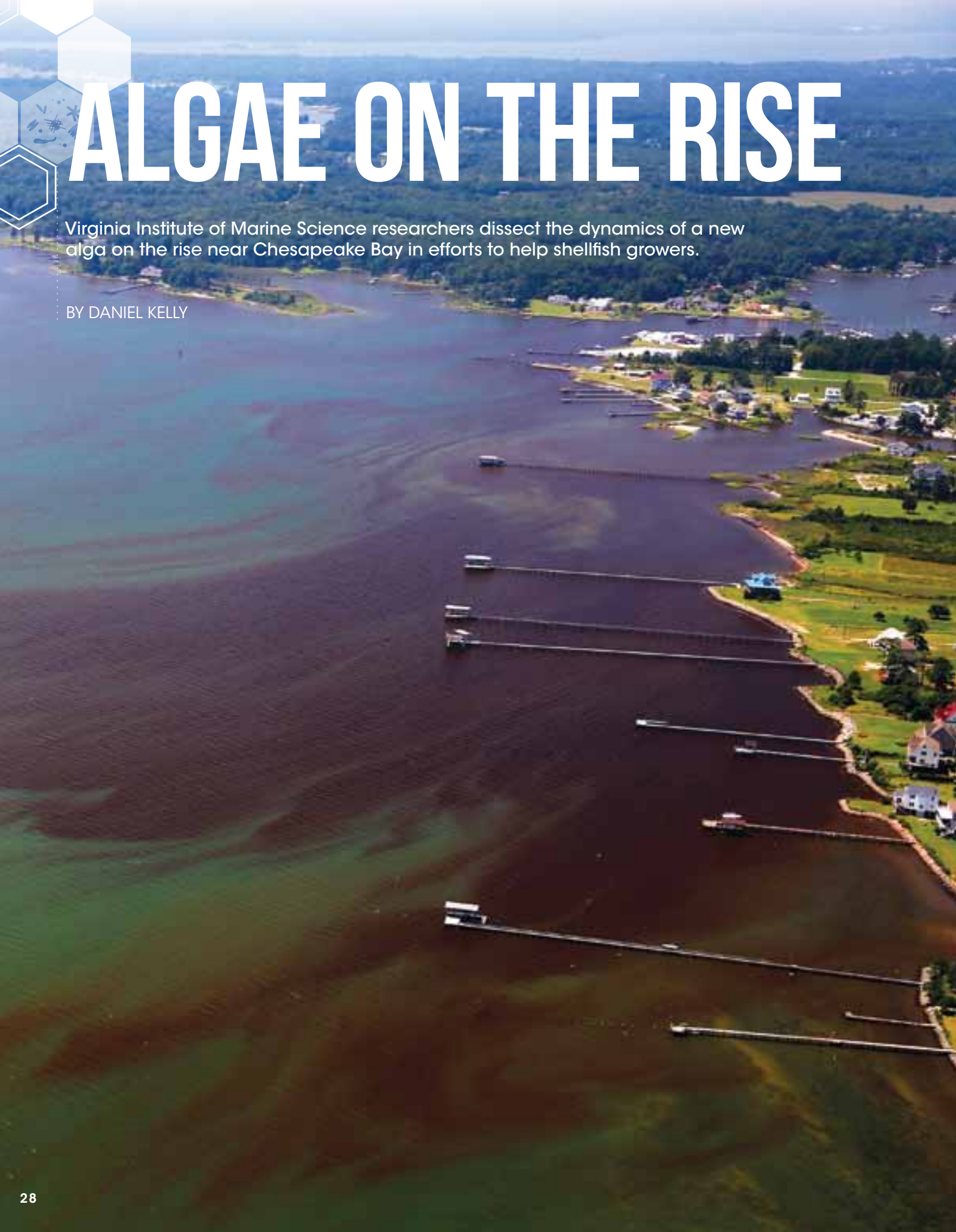
Given all the global warming changes that have happened already, even during a "safe" amount of carbon release, the prospect of "unsafe" levels of carbon is sobering at the very least.

Koven emphasizes, "When modeling carbon emissions and projected global warming, it's important to incorporate permafrost soil carbon release and the feedback loop it creates. Otherwise we will overshoot our target and carbon dioxide concentrations will get too high."



Photo: Brandt Meixell / U.S. Geological Survey

Photos: Mike Beaugard / CC BY-SA 2.0



# ALGAE ON THE RISE

Virginia Institute of Marine Science researchers dissect the dynamics of a new alga on the rise near Chesapeake Bay in efforts to help shellfish growers.

BY DANIEL KELLY

In mid-August, scientists at the Virginia Institute of Marine Science measured algae concentrations near the mouth of the York River, which drains into Chesapeake Bay's western half. One of their measurements hit a high of 200,000 algal cells per milliliter, one of the densest they had ever seen.

The blooms, which carried on through August and weeks thereafter, were dominated by *Alexandrium monilatum*, a type of algae that is relatively new to the area. Scientists at VIMS don't know as much about the new algae as they'd like to and are dissecting the ways that it reproduces (sexually and asexually), what factors influence its abundance, as well as a beautiful bioluminescence its cells sometimes give off.

Of course, *Alexandrium* is not the only kind of algae that lives in the area and VIMS researchers note that *Cochlodinium polykrikoides* is found much more commonly.

"That organism has been in the York River and it blooms pretty regularly," said Kim Reece, chair of the Department of Aquatic Health Sciences and professor of marine science at VIMS. "But in 2007, we began to see *Alexandrium*. It has impacts on shellfish and may have impacts on finfish. It turns out that, in the mid-1990s, that *Cochlodinium* had spread into Chesapeake Bay. It looks like the same sort of pattern may be happening with *Alexandrium*."

With its spread comes new threats to a rebounding shellfish industry in the mid-Atlantic region, Reece says. And that is one reason that she and other scientists at William & Mary are so interested in studying the blooms. So far, they have thrown a lot at the problem, including aerial photography, satellite measurements and field sampling to gather measurements directly from the blooms.

That is in part because studying the blooms is really very complex. Reece says that you can be boating through a section of *Alexandrium* one second and then be in clearer waters the next. All the wave action in the Bay, influenced a lot by weather changes, is on the list of things researchers want to tackle.

"The conditions this year were quite favorable for an *Alexandrium* bloom. We want to understand what those are. That's part of what the Dataflow does," said Reece. The Dataflow is



Photo: (left) Wolfgang Vogelbein; (bottom) David Malmquist; (top) Susan Maples / Virginia Institute of Marine Science



a ship-mounted suite of sensors that can be run through an ongoing bloom to take measurements on many parameters influencing or relating to the bloom, like temperatures, salinity, pH and chlorophyll levels. "We want to better understand what's driving the blooms. Clearly the temperatures and nutrients, but we think there are physical patterns at play like wind. They're very patchy with heavy concentrations shifting quite a bit."


That is where the satellite and aerial measurements, gathered with help from NASA flyovers and space-fielded instruments, come into play. VIMS researchers are comparing data they've collected using the Dataflow and during manual sampling efforts to images of the blooms taken by the NASA tech. These include cameras and hyperspectral sensors.

From that ground-truthing effort, they are then plugging findings into models that relate to water's movement in Chesapeake Bay. If they can nail down how all the conditions work together, perhaps they can develop useful forecasting tools for those who depend on the Bay for their livelihoods.

"There are watermen and oyster growers all along the Bay. The shellfish industry has been growing in Virginia and the mid-Atlantic region in general," said Reece. "Blooms have impacts on their animals. We want to inform the public and the aquaculture industry so they can take proper precautionary approaches."

Some of those could include shutting the water intakes of hatcheries when blooms were abundant, Reece says, adding that the researchers at VIMS commonly employ that technique when they have sensitive study subjects in their labs that need protection.

Officials at the Virginia Department of Health are also very interested in knowing more about these blooms, including how they form, where they're going and what algae species make them up.

"We hope to be able to use remote sensing to track the blooms. Satellites give us new tools to predict their behavior and it's much more difficult to chase these blooms around in a boat," said Reece. "We'd like to be able to do that down the road with the spectral sensing to get a better idea of what is blooming, where it's blooming and when it's blooming." 



# RISKS AFTER WILDFIRES

A tool in development at Michigan Tech Research Institute looks to minimize risks of landslides and flooding after wildfires clear out trees and soil cover.

BY DANIEL KELLY

More than 300 homes were lost in the Waldo Canyon Fire that blazed a few miles from Colorado Springs, Colorado, for nearly a month in 2012. One of them belonged to Mary Miller's friend.

Miller, a research engineer at Michigan Technological University's Michigan Tech Research Institute, would go on to volunteer on a Burned Area Emergency Response (BAER) team working to help after the fire. The concern, as is the case after many forest fires, was that the loss of trees and plant life would lead to increases in runoff from the charred slopes, which could lead to flooding. Heightened erosion rates that typically follow forest fires also threatened landslides.

"Due to post-fire flooding and erosion, people lose their lives," said Miller. "It's very serious."

Her volunteer work involved rapidly compiling data on those risks, which she says had to be completed within a few weeks. This was to avoid having to submit an environmental impact statement that could put proposed remediation and risk-reduction methods on hold. It was through that experience that she first got involved with BAER teams and the work of controlling erosion and runoff risks after forest fires.

An issue she saw was that assessing the risks simply took too long. In a project that is helping to speed things up, Miller is using data from NASA Landsat satellites and BAER teams on the ground to build a nationwide model that can assess erosion and runoff risks faster than old practices. It is in the beginning stages at this point, but has grown from an idea to a web tool covering 17 fire-prone western states.

"What used to take four to five days to assemble data can be done online," said Miller. "Our database does it in a couple of hours now."

The Landsat images contribute information on a fire's burn scar, which is easily viewable from space. From there, Miller assesses which areas look to have been burned more or less severely. This helps BAER teams know how much ground has been exposed by a blaze.

Miller says that BAER teams also gather useful data on the ground to assess burn severity and post-fire surface cover.

"They (BAER teams) may use a water drop test or a mini-disc infiltrometer to measure hydraulic conductivity of the soils (a



measure of how fast the water can move in the soil) as they can change post-fire," said Miller.

By combining the remote sensing data and findings gleaned from BAER ground samples with land cover and other conditions, the modeling tool can provide the hydrological inputs so that the BAER teams can respond to predicted runoff impacts quickly. The database also reveals erosion risks, she says.


"For fire remediation, protecting ground cover and the soils might require mulching where there might be risk," said Miller. Which is exactly what happened after the 2014 King Fire in California. The tool showed how much erosion could be reduced by applying mulch as new ground cover. From there, the BAER team used the data to justify the cost of mulching to state forest officials. "With our modeling data, we saved them millions of dollars," said Miller.

Moving forward with the work, Miller is looking to continue refining and validating the modeling tool. Part of that will be helped by scientists at Colorado State University, who are completing a related investigation into burn severity's effect on a watershed. They're using tipping bucket rain gauges and stream gauges as part of their effort that's yielding plenty of weather data for Miller to use.

"We're recreating the climate in the last three years (for their study area), just for the fire data," said Miller.

The precipitation measurements and flow data are being used in creating a climate file to predict for erosion, Miller says. That will be compared to other such data at similar sites. She has done this type of thing with observations collected at the 2012 High Park Fire, which was a good opportunity for refining the tool's capabilities.

Miller says it's important to keep validating and tweaking the model because of the high uncertainties that come along with predicting what will happen after forest fires.

"The uncertainty is huge. On orders of magnitude, we can predict PCBs (polychlorinated biphenyls) in water better. It ranges across the country and there is quite a bit of variability," said Miller. "The key to my database is preparation ahead of time so that (BAER) teams can rapidly respond with process-based hydrologic models and remote-sensing data." 



All Photos: Mary Miller / Michigan Tech Research Institute



Photo: Doug Nguyen

# BUILDING ON HISTORY

A new buoy on West Okoboji Lake is adding real-time, high-resolution data to the Lakeside Lab's more-than-century-long dataset.

BY DANIEL KELLY

The Iowa Lakeside Laboratory is a special place. It has existed as a limnological field station for 106 years, while most others only make it to 16.

Located in the Okoboji region, it sits at the center of a string of lakes that are unusual because of their location so close to the Great Plains. It is somewhat remarkable that they're there at all given the drier regions nearby. The crown jewel of these is West Okoboji Lake, a large, deep lake with good, clear water and plenty of activity around it.

For more than a century, the Lakeside Lab has offered courses and research opportunities for students interested in studying West Okoboji and other lakes nearby. These include activities like sampling diatoms and algae, taking Secchi disk measurements or tracking dissolved oxygen levels in the water.

With such an extensive record in place, it didn't take long for researchers with the Global Lake Ecological Observatory Network, or GLEON, to realize the potential of West Okoboji Lake as a new member site. There was just one thing missing – a buoy.

"Since our lake has been well studied – Birge and Juday (legendary limnologists) came here in the 1920s – this lake has been a focus of limnology," said Michael Lannoo, director of the Iowa Lakeside Laboratory. "They (GLEON) approached us about the possibility of putting a buoy in."

Soon after the idea was put forth, Sarah Spaulding, an ecologist with the U.S. Geological Survey and former visiting professor at Lakeside Lab, joined with Mindy Morales, a doctoral student at Iowa State University, to put together a white paper and a prototype proposal for the buoy. Lannoo began taking those to meetings with citizen groups around the lake to get their support.

It wasn't hard to sell the project to the groups, as most everyone would benefit from it. The lab, as well as the lake's health, would benefit scientifically from its data, while boaters and fishermen would benefit because it could let them know when conditions were safe to go out on the water. And researchers around the world could gain access to data on West Okoboji Lake.

Community groups that Lannoo presented to include the Dickenson County Clean Water Alliance, Friends of Lakeside Lab, Okoboji Foundation and the Okoboji Protective Association. Funding, however, ultimately came from the State of Iowa Hygienic Lab and the University of Iowa Research and Economic Development Group. Within 10 months, the project had gone from idea to reality, which is remarkably fast.

A NexSens CB-450 Data Buoy is the core of the monitoring platform, supporting a NexSens iSIC-CB Data Logger equipped with cellular telemetry. Connected to this on the topside is a Lufft WS600 Multi-Parameter Weather Sensor that collects measurements on air temperature, humidity, barometric pressure, rainfall and wind movements. Sitting next to it is a solar marine light that acts as a beacon to let boaters know its location on the water when the sun goes down.

On the buoy's bottom side is a YSI EXO2 Multi-Parameter Water Quality Sonde that measures West Okoboji Lake's water temperature, conductivity, pH and dissolved oxygen levels. There is also a Vaisala GMT222 Carbon Dioxide Transmitter fitted with a special membrane to let it collect data on CO2 levels underwater, which is a pretty rare sensor for a buoy. The whole platform was deployed on April 30.

"We got it in the water a lot quicker than we thought we would," said Lannoo, noting that his team is still learning its ins and outs. "It's like having a new computer that you've owned for a few days, but not quite having all the software installed."

Part of getting used to the buoy is using the WQData LIVE Web Datacenter where its data are displayed online. It partners with the LIVE Datacenter smartphone app to show the buoy's data in a mobile format. That's something the residents living around the lake have been intrigued by as well, says Lannoo, who has been making rounds making presentations on the new buoy to community groups.


"I always ask at meetings – 'You wanna know what you got for your money?'" said Lannoo. "Well, pull out your smartphones, download this app and use it."

Support for the new buoy has been quite good, says Lannoo. He adds that it has infused a lot of energy into the field station and surrounding community, which can't often be said of scientific equipment.

"They (community members) really have adopted it," said Lannoo. "It's a point of pride."

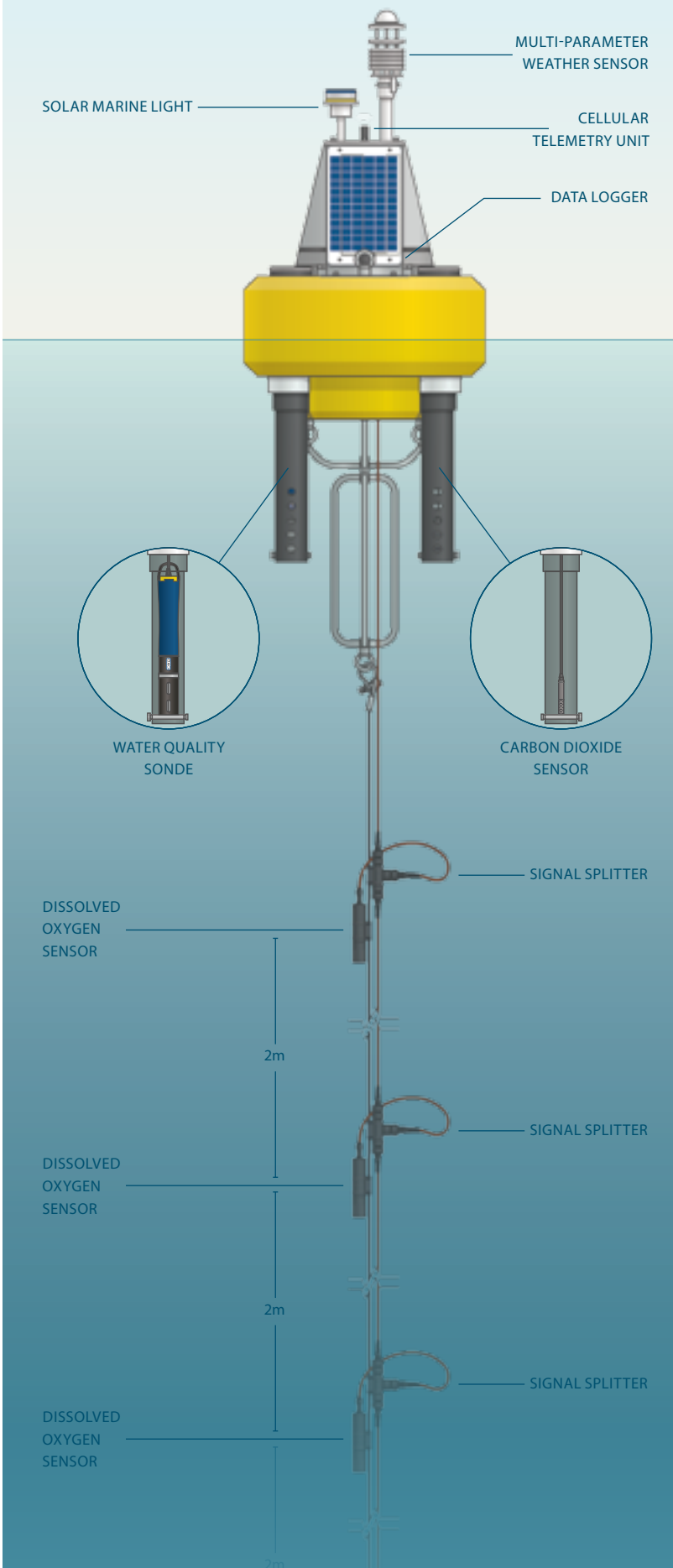
So far, the buoy's data have helped locals, as well as tourists, keep track of conditions on the water. But they haven't revealed any big surprises yet. Lannoo says the oddest things that the buoy's picked up have been anomalies, like storms, but he's hopeful they will reveal other conditions that impact the workings of West Okoboji Lake.

With a database going back almost a century, the buoy is adding real-time, high-resolution monitoring of lake conditions in advance of more short-term changes, says Lannoo.

Some of those that scientists at Lakeside Lab are interested in include recent invasions of zebra mussels, Eurasian carp and curly-leaf pondweed; the effects of climate change; and more general questions concerning how the lake stratifies. 

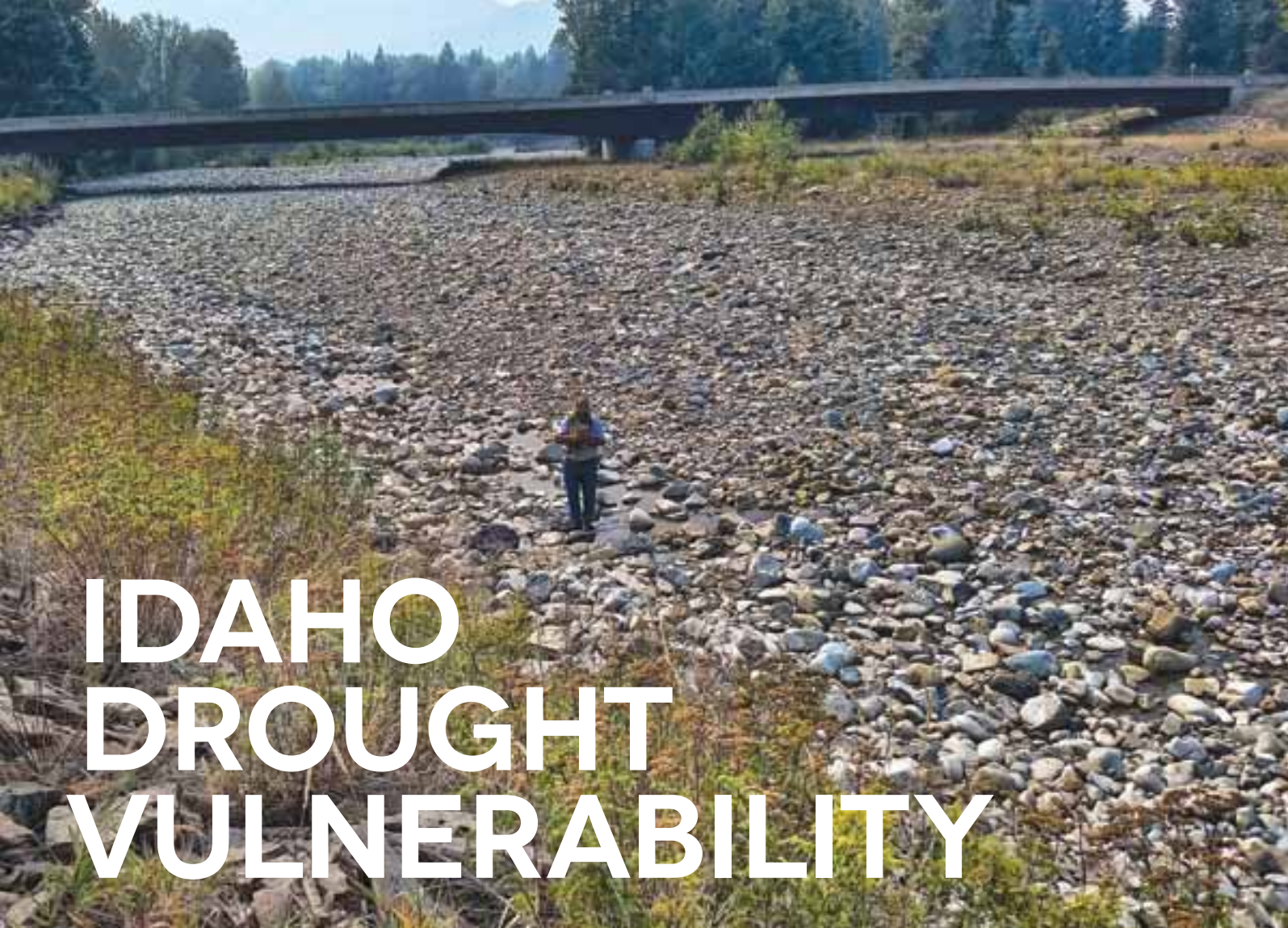
## LAKESIDE LAB BUOY SYSTEM

A NexSens Technology CB-450 data buoy provides a floating platform for the West Okoboji system. A Lufft WS600 Multi-Parameter weather sensor and a solar marine light are mounted to the buoy's top plate. Two deployment pipes are used for both a YSI EXO2 Multi-Parameter Water Quality Sonde and a Vaisala GMT222 CO2 Transmitter. A string of In-Situ RDO PRO-X sensors measures dissolved oxygen and temperature at 13 points down the water column. Data from the sensors are sent to the NexSens data logger inside the buoy before being transmitted via cellular telemetry to the WQData LIVE Web Datacenter.



Members of the Iowa Lakeside Laboratory help deploy a new data buoy in West Okoboji Lake.

Photo: (Left) Doug Nguyen; (diagram) Nate Christopher



# IDAHO DROUGHT VULNERABILITY

Scientists with the U.S. Geological Survey gather data on streams in Idaho and five other western states to assess drought vulnerability.

BY DANIEL KELLY

All across the state of Idaho, 27 researchers with the U.S. Geological Survey studied 150 different stream sites to gather baseline data helpful for assessing just how vulnerable streams in the state are to drought conditions.

Their preferred time of year for attacking the issue is late summer, right before the rainy season starts. That's because the streams will be at their lowest during that period, giving an easily identifiable baseline on which scientists can build throughout future studies.

"The reason why we had so many people is so we can get it done as quickly as possible. It's a snapshot in time," said Dave Evetts, data chief at the Idaho Water Science Center. "It's really important that we get these measurements at the lowest point in the year — late summer and early fall. It's a short window to work with."

Add a couple of ongoing wildfires to that time crunch and things can get a bit hairy. Evetts says that the study had a mid-September target for being done, but that a few sites still needed to be assessed. Those were located in areas affected by fires near Clearwater, Idaho.

Once USGS scientists got access to them, they used methods that they've employed to study other streams in the investigation.

"Most of the sites are pretty small. They're streams you could straddle," said Evetts. Typically, FlowTrackers are used to measure velocity by a researcher outfitted in waders. Those measurements are complemented by measures of a stream's width and depth that can be used to calculate discharge. "We also measure temperature, which impacts fish, and conductance. It tells us if the source of the water is groundwater or snowmelt."

Evetts says that Idaho has been lacking quality snowfall in recent years. Snowpack is much more valuable in terms of ensuring water availability throughout the year because it melts slowly and adds to streams incrementally. Rainfall, by contrast, comes rolling through and pushes streams higher for only a short period of time before moving on to waterways downstream.

The state has had a fairly normal amount of precipitation recently but most of that has come in the form of rain.



Hydrologic technicians from the USGS Idaho Water Science Center measure streamflow around the state.

**"THE REASON WHY WE HAD SO MANY PEOPLE IS SO WE CAN GET IT DONE AS QUICKLY AS POSSIBLE. IT'S A SNAPSHOT IN TIME."**

**-Dave Evetts**  
Data chief / Idaho Water Science Center

"It's a unique opportunity to see how that affects stream systems in Idaho," said Evetts. "Some potential causes for that — the obvious one is climate change. We also have a very strong El Niño that is forming in the Pacific."

He continued, "Basically, off of personal experience, we seem to be trending to get more rain instead of snow. Idaho's been lucky to store water in reservoirs and it's been able to call on that. If that continues, we could see more severe impacts in years to come."

As for the results of the work, Evetts said that he didn't have any expectations for what the data could reveal. Still, the findings will

likely be useful to water managers across the state. By pinpointing which streams are most vulnerable to drought conditions, the officials can change conservation approaches or adjust how water resources are allocated. In addition, fish and game organizations can use the information to see how drought conditions could affect fish and wildlife.

In the future, further study on these streams would be incredibly valuable for helping the management of water resources, but that is up in the air right now.

"We'd like to see if we can get cooperation with state and federal agencies. This study in Idaho is completely funded by the USGS," said Evetts. "Additional data collection for years to come would help establish trends that could help us deal with sustained drought conditions, to gauge if it will be here a while, increase or be more severe."

The work in Idaho was part of a larger effort supported by the USGS that was underway in a total of six western states to assess vulnerability to drought. Nearly 500 other scientists aided efforts also taking place in California, Nevada, Oregon, Utah and Washington.

All Photos: U.S. Geological Survey

# EL NIÑO & LA NIÑA

El Niño-Southern Oscillation, or ENSO, is an irregular climate phenomenon causing disruptions in ocean temperatures and weather patterns in the Tropical Pacific. The two opposite phases of the ENSO cycle are El Niño and La Niña which directly affect the central and east-central Pacific along the equator and cause further effects around the globe. While scientists can often predict the arrival of ENSO, it is impossible to predict the consequences of an El Niño or La Niña event.

## EL NIÑO

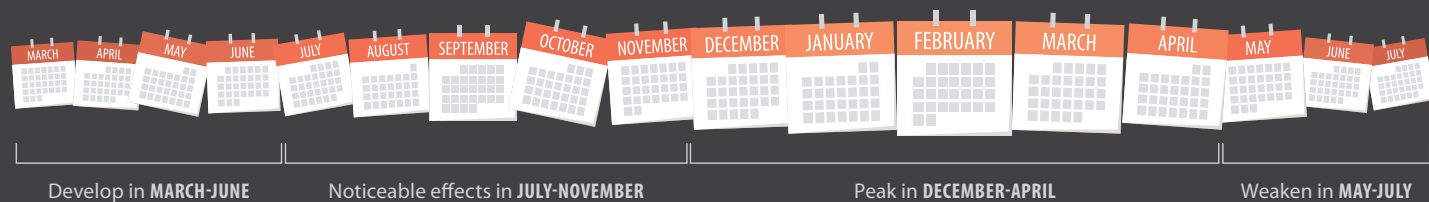
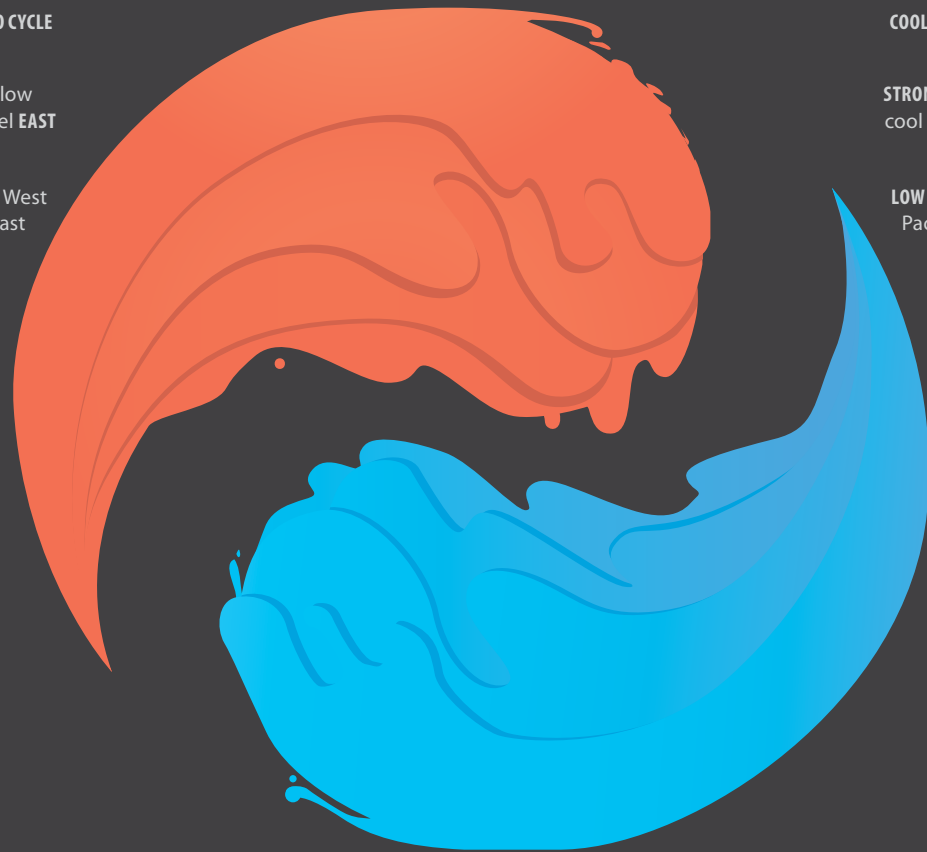
Name means "THE LITTLE BOY"  
Originally named for the CHRIST CHILD because it occurs around Christmas

- WARM phase of ENSO CYCLE
- WEAK tradewinds allow warm water to travel EAST
- HIGH air pressure in West Pacific and LOW in East

## LA NIÑA

Name means "THE LITTLE GIRL"  
Sometimes called EL VIEJO, ANTI-EL NIÑO or simply A COLD EVENT

- COOL phase of ENSO CYCLE
- STRONG tradewinds allow cool water to travel WEST
- LOW air pressure in West Pacific and HIGH in East

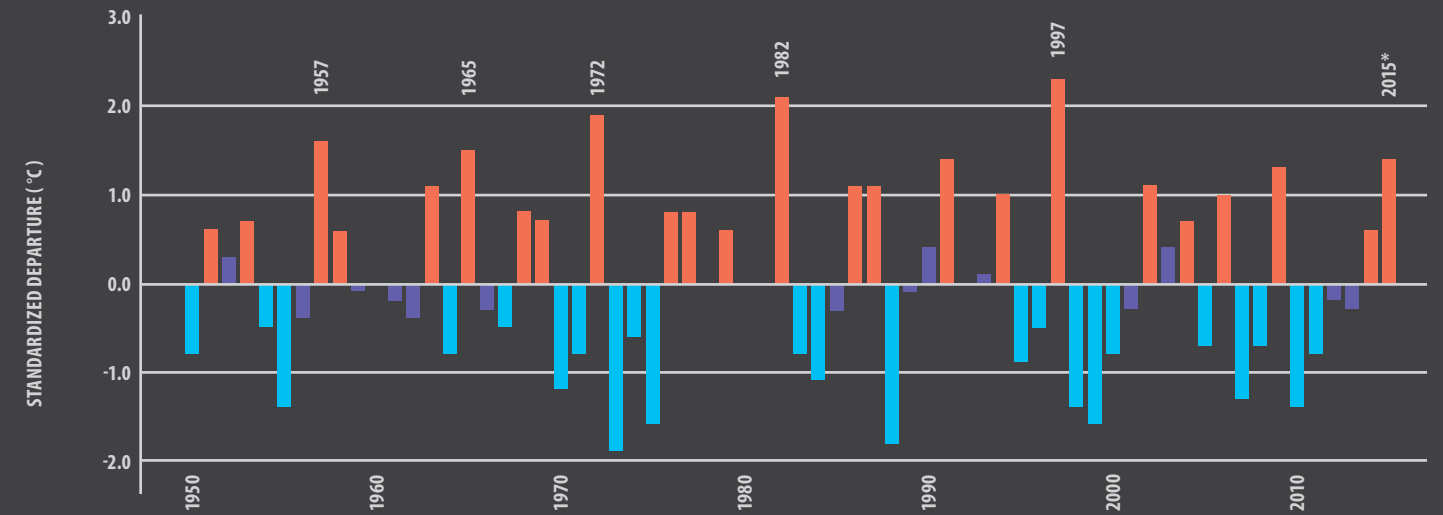


## PAST ENSO EVENTS

To be considered an El Niño or La Niña event, there must be an anomaly of sea surface temperatures in the Pacific of at least 0.5°C for at least THREE MONTHS. They don't occur every year or on any kind of reliable schedule. On average, El Niño shows up every 2 to 7 YEARS.

## 1997-98

The strongest El Niño on record was the infamous event that started in 1997. This event brought El Niño into the public eye, launched several observational satellites and even inspired a popular sketch on Saturday Night Live.

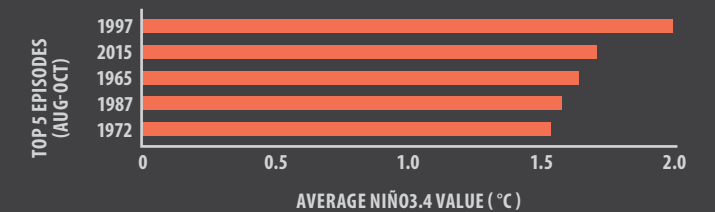


- El Niño
- La Niña
- Neutral range

\*Temperatures reflect measurements from peak months — November, December and January — except for 2015, which only has data from June, July and August.

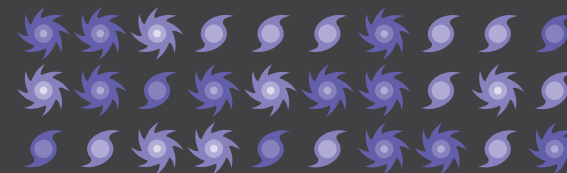
## 2015-16 FORECAST

Early forecasts for the 2015 El Niño predict that it will be among the harshest to date. Data from August through October show that the average anomaly in the Niño3.4 region (an area of the Pacific commonly used for El Niño analysis) was the SECOND HIGHEST on record.

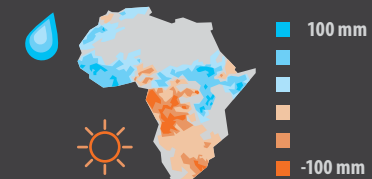


## 2015 SO FAR...

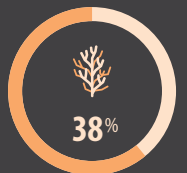
The full extent of the 2015 El Niño won't be known until the spring of 2016, but the extreme weather conditions have already had effects around the world.



The 2015 Pacific hurricane season saw 30 CYCLONES between May 28 and November 28. These included 16 HURRICANES, 10 of which were Category 4 or 5.



Africa has had a 10-100MM difference in monthly precipitation during the "short rains" season with excess in the east and drought in the south.



The intensely warm waters have impacted 38% of the world's coral reefs — almost 95% of those in U.S. waters.

All Graphics: Nate Christopher

Information from:  
 National Oceanic and Atmospheric Administration — [elnino.noaa.gov](http://elnino.noaa.gov)  
 Earth System Research Laboratory — [esrl.noaa.gov/enso/enso.different.html](http://esrl.noaa.gov/enso/enso.different.html)  
 Climate.gov — [climate.gov/news-features/department/18443/all](http://climate.gov/news-features/department/18443/all)  
 International Research Institute for Climate and Society — [iri.columbia.edu/our-expertise/climate/enso](http://iri.columbia.edu/our-expertise/climate/enso)  
 NASA Earth Observatory — [earthobservatory.nasa.gov/Features/ElNino](http://earthobservatory.nasa.gov/Features/ElNino)  
 Deutsche Welle — [dw.com/p/1GMuR](http://dw.com/p/1GMuR)

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# Airmar WX WeatherStations

An in-depth look at which WeatherStation model is best for different project types.

BY DANIEL KELLY

Monitoring the weather isn't just important for producing forecasts on TV news. It's key to managing a whole host of other things, like expensive livestock, commercial fishing operations and even in the success of military warfare.

The folks at Airmar Technology Corporation know this firsthand, as weather monitoring products they make have been integral to the good outcomes of many projects over the years. Their current lineup of weather stations is full of high-quality sensors that deliver results, including the 110WX, 150WX and 200WX Ultrasonic WeatherStation Instruments.

These three options all boast the ability to gather basic weather parameters, but are ideally suited for different projects. Since it can sometimes be difficult to sift through the variation between the models, we talked to Stephen Johnson, business development manager at Airmar, who clued us into which type of weather station is best for some of the common applications out there.

## AIRMAR 110WX ULTRASONIC WEATHERSTATION INSTRUMENT

The 110WX is essentially the base model in the line, and is most ideally suited for stationary platforms. It measures wind speed and direction, air temperature, barometric pressure and humidity in a compact unit with no moving parts.

Like the other two models, it can be mounted on a standard pole with 1-inch to 14 UNS or 3/4-inch NPT threads. It has an IPX6 waterproof rating. But by adding an optional humidity sensing module, this changes to IPX4.

Johnson says that the 110WX allows customers to come at their projects in innovative ways to fulfill the monitoring needs that they have.

So, for example, customers working in agriculture or livestock management can deploy the sensor to keep tabs on changing climatic conditions that affect their crops or large herds of animals. This means they can be coupled with a solar panel and data logger and deployed in the middle of a field. Or the 110WX can also be mounted near the ceiling of a large building containing animals.

For customers looking for a marine monitoring solution, the 110WX is best deployed in a stationary setup near the water body of interest.



"Weather impacts every aspect of operations on marine vessels; from racing and cruising sailboats to yachting and commercial fishing," said Johnson. "Rapid changes in weather and sea conditions make monitoring of both meteorological and oceanographic parameters a critically important part of ensuring safety, but also maintaining operational efficiency."

Reliable weather monitoring, he says, is important both where you are and where you're going so that operational decisions are based on real-time, site-specific data rather than intuition.

"The highly changeable conditions at sea make offshore operations particularly challenging," said Johnson.

Some other things to note about the 110WX include that it can output information in RS422 and CAN Bus. Wind data can also be adjusted and unfiltered to make it possible to collect maximum wind gust measurements.

## AIRMAR 150WX ULTRASONIC WEATHERSTATION INSTRUMENT

The next step up in the WX line is the 150WX instrument. Instead of being limited to stationary deployments, this weather station is much more versatile. It is also functional in portable, deployable systems, as well as mobile applications on land.

It measures apparent and true wind speed and direction, barometric pressure, air and wind chill temperature, relative humidity (as an option), dew point, heat index and GPS position. In addition, it incorporates a solid-state compass and an accelerometer that measures pitch and roll. The same deployment options apply in its case as for the 110WX and it also has an IPX6 waterproof rating.

With all of those thrown in, Johnson notes its value for first responders in emergency situations.

"Weather monitoring equipment is used to measure weather conditions at and around incident sites; this is particularly important for incidents involving the release of hazardous materials into the atmosphere in or near population centers," said Johnson. "Knowledge of weather conditions is needed to assess risks, establish exclusion zones, protect downwind areas, position incident command posts and develop plans of action."

The U.S. Coast Guard is one agency that uses the sensor for those purposes. The true wind readings are particularly valuable in that agency's case because guardsmen can use them in predicting conditions at disaster sites before they ever arrive.

The sensor also adds value in agricultural monitoring applications. For example, weather can influence a host of crop-management decisions, such as when to sow, plant or harvest crops.

"Wind can cause problems with the operation of sprayers. Wind problems consist mainly of 'wind drift' away from the site, therefore operators must document the direction of the prevailing wind in the area," said Johnson. "Spraying would have to cease when the effect of the wind drift (wind speed and direction) would cause spray (fertilizer, weed killer, etc.) to be carried off the intended site."

Like the 110WX, the 150WX can output information in RS422 and CAN Bus. Wind data can also be adjusted and unfiltered to make it possible for maximum wind gust measurements. But unlike the 110WX that only measures apparent wind, the 150WX is ideal for applications requiring measurements of both true and apparent wind data.

## AIRMAR 200WX ULTRASONIC WEATHERSTATION INSTRUMENT

The top of the line is the 200WX, featuring functionality for demanding mobile, land-based weather applications. It can be deployed on a standard pole with 1-inch to 14 UNS or 3/4-inch NPT threads and has an IPX6 waterproof rating.

It measures apparent and true wind speed and direction, barometric pressure, air and wind chill temperature, relative humidity (as an option), dew point, heat index and GPS position. It also has 3-Axis Solid State Compass, 3-Axis Rate Gyro (gyroscope) for rate of turn and 3-Axis accelerometer that has the best pitch and roll accuracy in its class.

Johnson says that customers have used it in a lot of different applications over the years, including on the tops of TV news weather vans and in securing the success of airborne military warfare operations. Both of those need reliable true wind speed and direction data.



"Virtually all mechanical and ultrasonic anemometers report apparent wind speed and direction. The Airmar WX Series is unique because it calculates both true and apparent wind speed and direction," said Johnson. "When the WX Series is mounted on a moving vehicle or vessel, the apparent wind is the wind you would feel on your hand if you held it out while moving." This true wind speed and direction calculation is possible through the GPS and compass and based on the apparent wind measurement, in addition to the speed and heading of the platform.

For military operations, terrain is often a concern. Johnson adds that the compass is reliably accurate in those sort of situations.

"The Model 200WX 3D compass with dynamic stabilization provided by the 3-Axis Rate Gyro also enhances the rate of turn data," said Johnson. "The Model 200WX maintains dynamic compass accuracy when in hilly and mountainous terrain common in many military (applications)."

The GPS also provides a general position point, helpful for letting project managers know where stationary or mobile platforms are at any time. This feature is particularly useful for buoy projects or other offshore weather monitoring applications, where conditions can change quickly and complicate operations.

"Having worked with many autonomous vehicle and buoy OEMs (original equipment manufacturers), we have further developed the WeatherStation Model 200WX to become more robust to meet the operational challenges of this extreme, harsh environment," said Johnson. "We have an IPX7 version of the Model 200WX designed specifically for buoy, USV (unmanned surface vehicle) and other offshore platforms." This version has low power requirements that help it to perform well in portable battery and solar-powered applications.

But the best feature of the 200WX, Johnson says, is its compactness while still retaining all of its functionality.

"What has always set our product apart from the competition is the integration of multiple sensors in a compact, all-in-one housing at an extremely attractive price point," said Johnson. "The internal GPS and magnetic compass, complemented with our ultrasonic wind solution provides functionality that is normally only achieved by combining data from at least three separate sensors."

Photo: Airmar Technology Corporation

Photo: (left) Josephine Johnson; (right) Zaki Moustafa / SFWMD

# CONNECTING RIPARIAN CORRIDORS

Washington State scientists use GIS data, hydrography maps in an ongoing attempt to encourage connection of riparian corridors and help species flourish.

BY LORI BALSTER

Riparian corridors provide water and hospitable land which can allow creatures to migrate. In many cases, however, many animals lack access to such pathways and are unable to migrate if the need arises. As the climate continues to change and human populations continue to increase, it will be more important in the future for creatures to be able to move to habitat that better suits their needs for food, shelter and security.

Luckily, researchers like Alex Fremier, associate professor of riparian and aquatic ecology at Washington State University, are working to solve that problem. As Fremier and others have discovered, many of the pieces to provide the necessary riparian corridors for animal migration all over the country already exist; it is just a matter of connecting the pieces so that animals can take advantage of them.

Fremier has been working on aquatic and terrestrial management issues with connecting parks and other protected areas. His hope is to join resources that already exist and use laws already in place to create a better environment for animals that may need to migrate as their habitats change. His paper on riparian corridors is intended as a "gauntlet paper" as he calls it, which means he and other researchers are pitching it to the community at large and asking for community support in their efforts.

Fremier is not currently conducting field data collection, but is rather using datasets that already exist. Fremier uses a geographical information system which allows him to capture, analyze, manipulate and manage needed spatial and geographical data. For him, hydrography maps from the U.S. Geological Survey are the backbone of his research.

He uses a protected area database, which gives him data on all existing protected areas as well as most public lands. He also uses the National Conservation Easement Database, which contains information on which lands are under conservation easements and whether the land is in short-term or long-term easement. These properties could become part of the larger riparian corridor network Fremier and others are hoping to build.

"Riparian corridors, conservation easements, parks, protected land and networks set up to manage them all vary a lot from state to state," said Fremier. "California is different from Colorado, which is different from the upper Midwest and the Northeast."

In the next stage of his riparian corridor project, Fremier hopes to create electronic maps for landowners so they can look at all the data gathered on their land and consider whether becoming part of a corridor network would be beneficial for them.

Fremier also hopes to spatially coordinate riparian corridors, and focus on water quality. "Is it a stream region we can easily restore? What is the surface water quality? These are the questions we hope to be able to answer," he said.

So far, Fremier has done a preliminary geographic analysis and policy analysis of the feasibility of connecting riparian corridors, and has looked to see if there was any bias for protection using GIS information.

"I've seen a lot of positive indicators," he said. "And there is a certain bias in the U.S. for protecting riparian areas which is good."

While the pieces seem to be there, there is no clear coordination of riparian areas yet. "That's what we're aiming for," said Fremier. "Riparian restoration tends to be local and oriented toward protecting a specific species. Our study tries to go beyond the local motivations and we didn't want to be limited by the movements of a specific species."

Fremier says it's also important to look at whether there would be winners and losers if riparian corridor connections are made.

"Pronghorn and antelope escape predators in the open, so they wouldn't use riparian corridors, for example," said Fremier. "In the next step of our work, we will need field biologists to find real details of riparian movement and which species will use it." Fremier says cameras will likely be important tools for tracking species movements.

Fremier and his colleagues have been active in engaging the community and getting support for their riparian corridor connection project. He has been giving talks at Washington State and has been getting some attention for the idea. Fremier has also been working on a beta version of the GIS program which would allow spatial overlay, aiding landowners in visualizing their terrain and deciding how they could use their land to help preserve a given species.

He is also looking at a water quality input. Water quality includes considerations such as how to protect water from agricultural chemical runoff and soil erosion.

"The Yukon and Yellowstone areas already have nice connectivity. We think of them as good examples of what we hope to



Animals, including bears, use riparian systems to migrate.



Photo: Alexander Fremier / Washington State University

Photo: (top) Joseph Parzych; (bottom) Jonathan Stahl

achieve in other areas," said Fremier. "We would like to connect things at the watershed scale."

But there are still many areas that would benefit from riparian corridor connections, Fremier emphasizes. "We were surprised that no one had brought all the pieces together that already existed. But our recent paper published in Biological Conservation is a first step in establishing that connectivity."

Some important pieces that already exist include the Farm Bill, which would support connectivity work. There are also Landscape Conservation Cooperatives and there is the great Northern eco-region, which is coordinated ecologically and has funding and policies in place which would allow for riparian corridor connection.

"A challenge is that many of the pieces are coordinated under states right now, which makes political but not ecological sense," Fremier adds.

Connecting riparian corridors also requires people in different areas of expertise, such as ecology, wildlife and environmental policy. Currently, Fremier works with nine other people to cover all the bases. Amanda Stahl, a doctoral student in his lab, for example, provides geology, conservation and legal expertise to the team while several graduate students perform computer programming and macroscale biology and ecology work.

Fremier emphasizes, "Once you get into the work of connecting riparian corridors, you need people. You need social connectivity to get riparian connectivity." **LB**



MONITORING  
GEAR

### YSI EXO Wiped Conductivity

Guard against biofouling and ensure reliable data with the YSI EXO Wiped Conductivity & Temperature Sensor. Swapping in this new sensor, which can be done by the user, means that all sensors on a YSI EXO2 sonde with central wiper can now be wiped, lowering cleaning and maintenance needed to keep accurate data coming in. By permitting the cleaning of biofilms, barnacles and other sensor-clogging lifeforms, the EXO Wiped Conductivity & Temperature Sensor can pay for itself in under a year by reducing site visits alone.



### PME Cyclops-7 Logger

The Cyclops-7 Logger from PME connects directly to all Turner Designs Cyclops-7 Submersible Sensors with metal bodies, including those for turbidity, chlorophyll, rhodamine, fluorescein, blue-green algae, CDOM, crude oil, PTSA dyes, refined fuels and tryptophan. The logger features replaceable batteries, waterproof construction and is made of high-performance Delrin. It is a reliable tool for recording measurements from Cyclops-7 sensors and comes with software for calibration and sampling setup. The logger can be configured to sample at rates from 1 minute to 60 minutes, with memory to support 28,800 data points. All measurements can be offloaded to a computer via a standard USB cable.



### Vaisala WXT530

The Vaisala Weather Transmitter WXT530 is a series of weather instruments that provides six of the most important weather parameters, including air pressure, temperature, humidity, rain-fall, wind speed and direction through various combinations. The WXT530 Series provides maintenance-free operations in a cost-effective manner. Users can select the transmitter with the parameters needed for their application, with a large variety of digital communication modes, voltage ranges and also a heated option. Low-power consumption enables long-term, solar-powered projects.



### OTT Pluvio<sup>2</sup> S

The OTT Pluvio<sup>2</sup> S Precipitation Gauge uses the weighing principle to accurately and dependably measure rain or snow in changing weather conditions. It features a collecting area that supports up to 400 millimeters of precipitation and can capture events up to 3,000 millimeters per hour. The Pluvio<sup>2</sup> S is designed for use in data networks or urban precipitation monitoring applications and can be easily fitted to existing installations. The gauge is ideal for replacing aging tipping bucket rain gauges and other manual gauges. It has a 2-inch pedestal that supports installation on small posts, or even on existing platforms.



### Geotech SS Geosub

The Geotech SS Geosub Sampling Pump provides solid sampling performance in harsh well conditions. Constructed with mostly stainless steel components, the Geosub supports sampling down to 200 feet. This performance is aided by a user-enabled dry run protection that shields pumping mechanisms from damage. The pump can sample as low as 10 millimeters per minute and features a field-changeable motor to minimize down time.



### YSI CastAway CTD

The CastAway CTD is a hand-deployable conductivity, temperature and depth instrument for hydrologic profiling. An integrated LCD screen displays an intuitive user interface for deployment and immediate review of collected data including both statistics and profile plots. The watertight, compact design features a tough rubber jacket for additional durability in harsh conditions. The system uses Bluetooth wireless communication, so no field cables or connectors are needed. Two AA batteries power the CTD for several days at a time and are easily replaceable without the need for tools.



### Airmar Dual Frequency EchoRange

The Airmar Dual Frequency EchoRange Smart Sensor is a sonar sensor that measures distance to bottom in hydrographic surveys, dredging, or bottom-characterization projects. It uses a bi-directional interface compliant with NMEA 0183 and a transmit-only interface with a proprietary protocol using RS485. This new protocol provides the user a powerful way to present detailed echo envelope data. Pairing the Dual Frequency EchoRange with a computer or other instrument provides a low-cost hydrographic survey unit.



### Observer NEP5000

The ANALITE NEP5000 digital turbidity sensor provides extremely stable and accurate readings, even at NTU levels below 10. Since each sensor stores calibration information onboard, swapping a sensor in the field is possible without the need for recalibration. The NEP5000 features an integrated wiper to guard against biofouling and is compatible with any standard MCIL 6-pin female cable assembly. Its operation can be programmed through a Configuration Kit, which also supports troubleshooting and calibration to 10 NTU, 400 NTU and 1,000 NTU.







# RESILIENT REEFS

Scientists at Ohio State and University of Hawaii test the hypothesis that corals can adapt to ocean acidification conditions and warmer temperatures.

BY DANIEL KELLY

In 2014, an extensive bleaching event was observed in the waters surrounding Hawaii. This bleaching event was caused by warmer water temperatures that reached their second highest around the archipelago. It impacted 75 percent of the dominant coral species in Kāneʻohe Bay. The bleaching event for this year is expected to be even worse.

Do the recurring bleaching events mean that the corals in this region are doomed? Scientists at Ohio State University and the University of Hawaii are approaching that question with an interesting hypothesis: That corals can acclimate or adapt to ocean acidification conditions and warmer water temperatures.

Following the extensive damage Hawaiian reefs experienced during the 2014 bleaching event, researchers at the two universities were awarded funding from the National Science Foundation's RAPID program. It allowed them to respond quickly to the bleaching event and collect coral samples they would need for the investigation. Their methods of choice involve looking at the respiration and photosynthesis rates of the corals, as well as their eating habits, to see if and how the corals are recovering.

Hundreds of coral samples were gathered for the work, and Ohio State scientists say that its technical nature makes for some complex and fascinating study. Some of the gear they're using add to that too.

Scientists have set up some intriguing experiments to gauge the resilience of corals they collected from reefs off the coast of the Aloha State. These include the use of custom-built respiration chambers where coral samples are placed on individual grids above magnetic stirrers that spin to maintain full circulation of dissolved oxygen that corals can tap for respiration. YSI ProODO Optical Dissolved Oxygen Meters are used within the chambers to measure how the levels change.

"The ODO meters are awesome compared to the old ones that have the membranes (YSI Pro20s)," said Andrea Grottoli, professor of earth science at Ohio State and head of the Division of Climate, Water and Environment there. "We use six or seven at


a time. They're fast to calibrate and easy to install. It's just one cap. They're running continuously for three-hour stretches and fully standing up to the job." When coupled with the submersible stirring plates, she says they can run so many more samples than in the past.

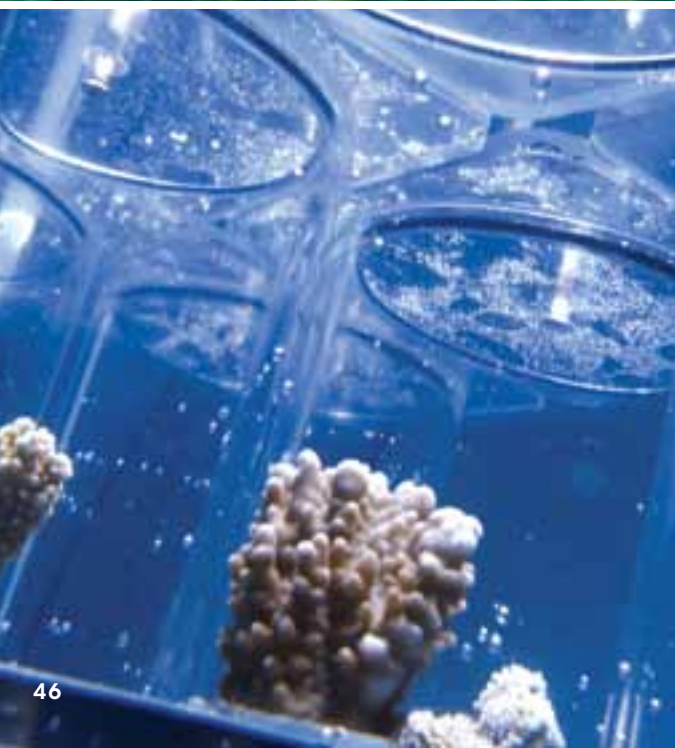
The corals are first run through the respiration chambers with the lights on while researchers measure dissolved oxygen. Changes in oxygen are used to calculate the rate of photosynthesis of each coral. Light levels are tracked using an Apogee Instruments' MQ-200 handheld meter that measures photosynthetically active radiation. After the treatment in light, the coral samples are then subjected to the same conditions in the dark. Decreases in oxygen in the dark are used to calculate the coral's respiration rate. With both photosynthesis and respiration, researchers can assess how robust coral metabolism is.

Grottoli says the photosynthesis rates are assessed every six months. That determination is in addition to work that is looking into the corals' lipids, protein, carbohydrates and endosymbiotic algal density. The scientists are also seeing how feeding them affects their resilience.

"Our second hypothesis is that if you feed coral, that offsets the negative effects of ocean acidification," said Grottoli. "So half are fed and half are not fed." Portions of the study relying on lipids and proteins help to show how corals cope with ocean acidification, Grottoli says.

Bringing it all together, the scientists are assessing rates of recovery, photosynthesis and respiration, in addition to feeding, and forming a total carbon budget. But they won't have all of the data to calculate these budgets for another few months.

As for what the work may reveal, Grottoli doesn't yet know. Some of the corals under study appear to have higher mortality rates from others, but those aren't seemingly related to acidification. Another type looks to be recovering, or getting browner, faster. But all results so far are preliminary. 



All Photos Courtesy of Andrea Grottoli

# MICROSCOPIC INVADERS

Creative methods and gear aid a study of biofilms on the walls of ship ballast tanks and the risk they pose for harboring Great Lakes invasives.

BY DANIEL KELLY

In August 1984, things were ramping up at the San Diego shipyards. Crews with the National Steel and Shipbuilding Company had an order to fill. And the customer, an energy corporation, was riding high on a massively successful ad campaign promising gas so good that it would “put a tiger in your tank.”

It took a year to complete the construction and the newly built ship would not launch until October 1986. But the brand new vessel did have a name: Exxon Valdez.

At the time, single-hulled tankers were common and the Valdez was no different. Nearly 1,000 feet long and 167 feet wide, the ship was a formidable oil transporter. Indeed it was a welcome addition to Exxon’s fleet, which it joined a few months after its launch.

But we know how this story ends. Just a few years into its seafaring work, in 1989, the Exxon Valdez would find itself crashing into a reef in Alaska’s Prince William Sound. All that cargo space turned into a liability, as the volumes of crude oil it held, 11 million gallons by many estimates, leaked out through its hull

and into the Sound and the Gulf of Alaska. At the time, it was the worst single oil spill to ever occur in United States coastal waters.

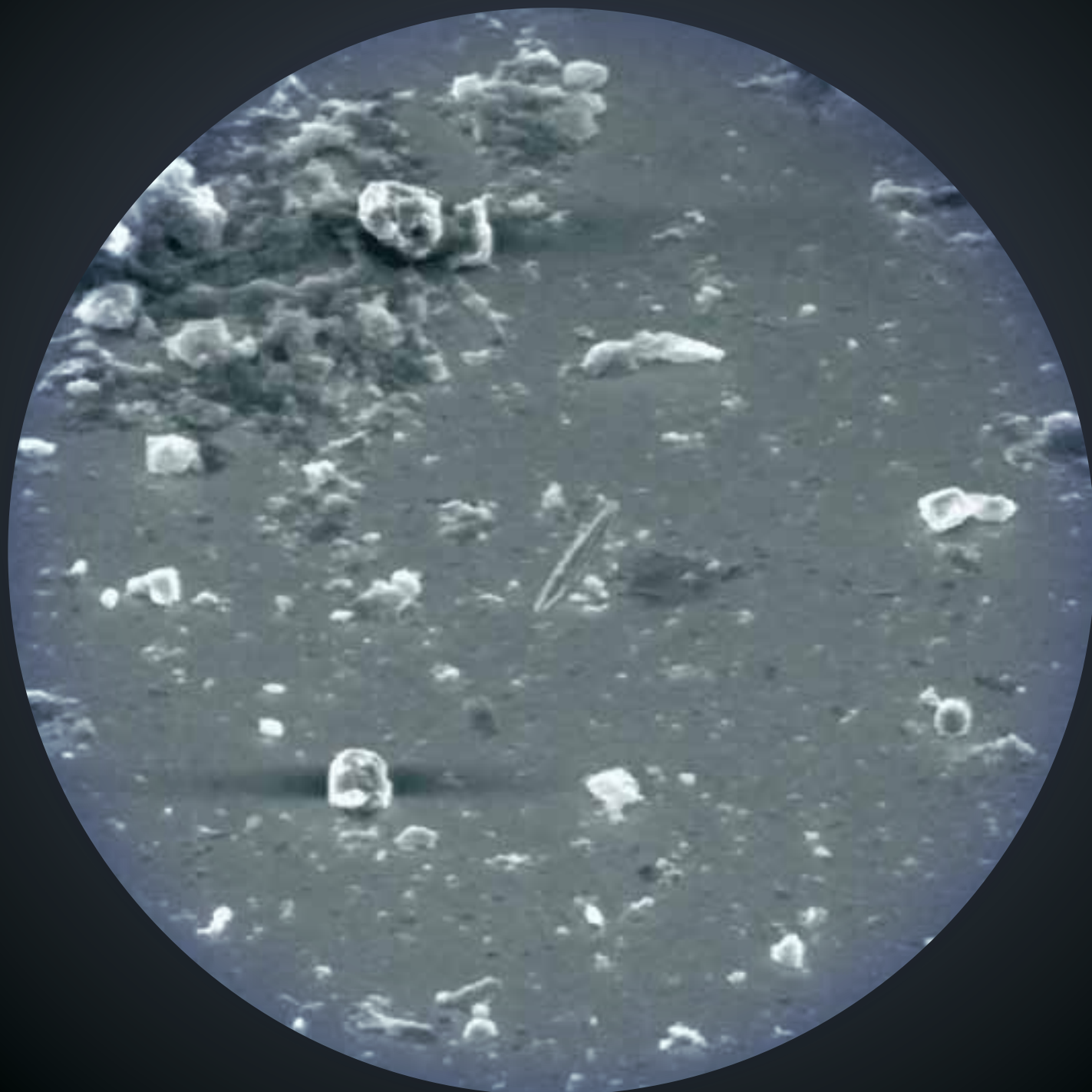
Following the disaster, extensive cleanup work began that saw volunteers and government workers scrubbing beaches, cleaning oil-covered wildlife with soap and taking sediment samples to gauge oil seepage, among many other things. Policymakers also took action, putting forth proposals they believed would help prevent spills like the Valdez in the future.

Passed not long after, the federal Oil Pollution Act of 1990 began requiring all new tankers built in the United States to be of double-hull construction. All existing single-hull tankers were to be retrofitted with an extra hull or completely phased out of operation by 2015. Over the years, these requirements have had positive effects, as studies into the effectiveness of double hulls show that they are better at decreasing the risk of oil spills than other hull constructions.

But there have been negative consequences to this shift, as two hulls provide a space for ballast water, the emptying of which in ports worldwide has increased the risk of spreading aquatic invasive species. Arguably, the effects of the two-hull standard have been seen in the Great Lakes, where the presence of many aquatic invasives is believed to be linked to ballast water discharge.

The famous invasives, like zebra mussels, quagga mussels and eurasian ruffe, have been well documented in the basin. Round gobies, now an essential part of Great Lakes food chains, have too. But what about the life forms that are too small to see?

Researchers at the University at Buffalo set out to answer part of that question, in a decades-long investigation studying biofilms that form on ballast tank walls in transoceanic ships. The work began in the 1980s, but this story focuses on a project



60µm 500X

Photo: University at Buffalo

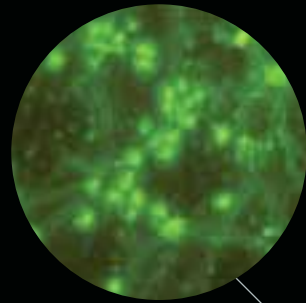
Photo: U.S. Navy



The aftermath of the Exxon Valdez oil spill included cleanup efforts and policy changes.

## GREAT LAKES INVADERS

Examples of microscopic views of ocean biofilms after immunofluorescent staining.



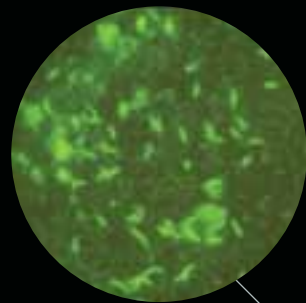
*Comamonas terrigena*

Gram negative

Found in soil

Motile by use of 6 flagella

Can degrade phenols and cause infection



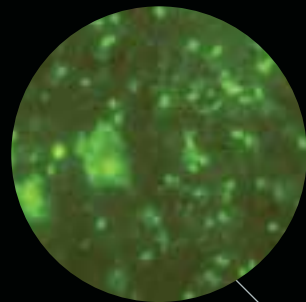
*Vibrio alginolyticus*

Gram negative

Found in marine waters

Can cause skin and tissue infection in open wounds

Can cause otitis



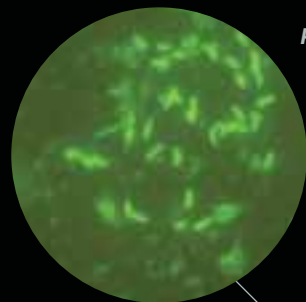
*Achromobacter*

Gram negative

Motile by use of 20 flagella

Found in fresh and marine water

Can cause infections



*Pseudomonas putrefaciens*

Gram negative

Found in marine waters

Associated with odor of rotting fish

Can cause infections

completed in the 2000s and led by New York Sea Grant's Robert Forsberg, who was a master's student at the university at the time. Results of the study have been published in the journal *Management of Biological Invasions*.

"All of those things led us to study this. More specifically, due to zebra mussels. They used to exist only in Europe to begin with, in freshwater in Europe," said Bob Baier, director of the Industry/University Center on Biosurfaces at the university. "All of a sudden, they showed up in Lake St. Clair and now they're dominant. They've marched across the country and yet there's a great, big, salty ocean between that they can't enter."

Baier says that the research is looking to prevent similar invasions in the future, and he cites the Asian clam as one species that is knocking on the door of the Great Lakes. Asian carp is another. But those encroaching invasive species weren't the subject of the investigation; instead, it was all the microscopic life forms thriving in biofilms on the walls of ballast water tanks.

As can be imagined, it's not easy studying something that you can't see. So the scientists devised special tactics and equipment to get the job done. Along the way, they came up with creative names for their inventions as well.

"We actually created the unit — we call it a BOB, Ballast Organic Biofilm sampler. It's an object that looks like a long, thin football," said Baier. "Inside are two slides and it rides suspended in the ballast tank. We've actually done this with three ships going in and out of worldwide harbors, studied the buildup of biota, what it is and why it's there."

In addition, scientists also used flow cells located in the ballast tanks of the ships to study the slimes forming on walls. If there weren't flow cells to use, they would make what they called Portable Biofouling Units (PBUs). These were essentially large coolers with openings, manifolds and pumps that moved water in and out and allowed researchers to gather biofilms within.

The BOBs and PBUs hitched rides in ships that made some 80 transits across the world's oceans. Once the U. Buffalo researchers got them back, they analyzed the microscopic life forms growing on the BOB slides and within the PBUs using microscopy and spectroscopy methods. They made several surprising finds.

"What Forsberg found was that, no matter where these ships went or for how long, these biofilms eventually became equal to one another," said Baier, who also teaches dental medicine at U. Buffalo. "Taking an example from the world of dentistry, the plaques on your teeth, my teeth and people from Eskimo villages are all the same because there's been enough kissing, spitting and trading of saliva over time. We see that the strongest and most persistent are the organisms that survive."

That's a good example to explain the biodiversity loss, but the bacteria in the biofilms are a lot different than the ones found on human teeth. Several found in the biofilms were of unique interest to the scientists, including a strain of cholera. Another has been found in infected wounds and implicated in causing ear and eye infections, as well as gastro-intestinal issues. And still another is believed to cause meningitis.

Baier says that these organisms can be sloshed up into the air as ballast water rushes from tanks and points to a case reported



by the Cleveland Clinic of a water skier who got an ear infection from one of the bacteria. That presents a risk for asthmatics and those who have difficulty breathing.

But perhaps most intriguing are all the unknown constituents living in the biofilms. Some other researchers at Old Dominion University are stymied, Baier says, by what they're finding. "In these ballast waters, they're seeing what they can only call 'virus-like particles,'" said Baier. He mentions that they've found one that is believed to attack fish.

Other researchers around the Great Lakes basin are working to describe all the microscopic lifeforms found in ballast water, but knowing what's in the water may not be enough to solve the issues that ballast tank biofilms pose.

"The problem is so severe that, in Lake Superior, they're designing units to clean the ballast water on the ship itself," said Baier. "That cleans the water, but it doesn't clean the walls."

He describes bioadhesion, or how the creatures stick to tank walls, as an important consideration when trying to get rid of the biofilms. Baier notes that the biofilms were found to use their sticky strengths to remain in place.


"The harder you push on it, the tougher the film actually sticks. It protects itself. It's why they can exist through storm surges. You can see rocks after hurricanes nearshore and mussels and clams are still there," said Baier. "It usually takes about 2,000 PSI to remove them."

Baier and others were surprised to find that the biofilms were persisting despite open-ocean saltwater purging done across the shipping industry. The best way to fix the problem, he says, is to use a special coating to make the walls of ballast tanks so slick that the organisms simply can't hang on.

Getting the job done won't be easy, but he thinks it's possible. And it can be done without using poisons or causing harm to other creatures.

"Our approach is to go to a non-stick, easy-release coating so that the stuff that stays will slough off. It'll be clean and sustainable," said Baier. "I have one that I favor called Wearlon. It's a proprietary coating by a small manufacturer in Saratoga that's a mix of silicone and epoxy. It's hard and tough. It's not quite as good as silicone, which is too soft, and it's not as bad as epoxy, which is too sticky."

Of course, getting enough ships to apply the coatings to make a dent in biofilms across the Great Lakes shipping world would be quite an undertaking. Baier envisions crews of longshoremen applying the coatings while ships are docked and unloading. He says that the Port of Buffalo, home to a remediated Bethlehem Steel plant, would be an ideal spot to set up such a coating station.

"We think it's Buffalo's place to be better stewards of the Great Lakes," said Baier. "Every ship that's coming in that still has the plaque needs to get its teeth brushed." 

Photos: University at Buffalo

Photo: Randen Pederson / CC BY 2.0



# Erie Under Ice

BY TRAVIS HARTMAN

BROUGHT TO YOU BY  
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The last two winters have renewed many anglers' interest in Lake Erie ice fishing after well over a decade of relatively warm winters with inconsistent ice coverage. After two extremely good seasons, it's clear that Lake Erie ice can produce numbers of walleye with many approaching trophy sizes. While the basics of Lake Erie walleye ice fishing are similar to other fisheries in the upper Midwest there are differences that make Erie's western basin unique.

## TRAVEL

The single biggest obstacle to consistently catching Erie's nomadic walleye through the ice is having reliable transportation to get out to the best bite that could be 6 to 10 miles or farther from many of the common access points. There are plenty of options and the "best" option often changes with conditions. Snowmobiles are probably the most universal means throughout the entire ice season, although they can be limiting if you're trying to haul other people or lots of gear with you. Four wheelers and side-by-side utility vehicles offer advantages when it comes to hauling capacity, but can struggle in big snow drifts. Airboats built for the ice are becoming more common on Lake Erie and are probably the safest option, but can be difficult to control in high winds and are more cumbersome for towing and maneuvering around filled parking lots at access points. You can always walk out and fish when the bite is nearshore, but often the best nearshore bites are only early or late in the ice season.

## ELECTRONICS

It's certainly possible to head out on Lake Erie's ice, find "shanty town," and drill holes to start catching fish without any electronics at all; however, Erie's walleye are so migratory that yesterday's hot bite can be dead water and you wouldn't know it until you've wasted valuable time not catching fish.

On Lake Erie as much as anywhere, I would argue that you need to know what is below you and there are only two ways to confidently cut down your search time: A good sonar or flasher will help you "mark" fish and a good camera will quickly tell you what's going on below the ice to confirm what you've seen on your electronics. In most cases, you will be fishing mud flats and looking for schools of walleye that are milling around or passing through. Since there isn't significant structure that they are holding to, you have to find them and then move with them as they move.

Personally I drill two extra holes in addition to the holes that I'm fishing in. One is for my Lowrance sonar's transducer and the other is for my FishSens SondeCam camera. The two make a great combination because the SondeCam connects to the Lowrance and can be displayed right beside the sonar in split-screen mode. Not only can I watch one or both of my lures while I'm fishing, but I can see when fish higher in the water column show up on the sonar so that I can reel up to them in time to have a chance at catching them.

It is like playing video games as you watch your lures and the fish on both the camera and also the sonar. When paired with a FishSens DVR, you can record all of the camera video for later viewing on a computer or TV. It's really interesting to watch how fish react under different conditions.

Many of the fish hit so quickly that they're hooked before you have a chance to realize what is going on. Others come in slowly and need to be teased into hitting. One thing I noticed right away was that excessive noise in the shanty definitely spooks interested fish away. They don't seem to care that the camera is there, as fish that I've caught have bumped the camera as they swam into hit my lure.

I figured out right away that even in 20-plus feet of water it pays to keep noise to a minimum. Maybe the most surprising observation is that many fish will hit multiple times on multiple lures if you don't catch them on the first hit. I've had fish hit or chase up to three lures in the same shanty before finally being hooked and caught. A few even got lifted a few feet on the first lure that they hit, and then bit again and were caught on the next lure after shaking free from the first lure.

## GEAR

For rods I use 30-inch medium heavy spinning rods and size 10 or 20 spinning reels loaded with 15-pound test braided line tipped with about a 3-foot, 12-pound test fluorocarbon leader. It's best to attach the leader with a ball bearing swivel to reduce line twist. Lures of choice on Erie are many of the various jigging spoons designed for ice fishing such as Swedish Pimples or even simple Hopkins spoons, or jigging lures such as Rapala jigging raps. Most colors will work when fishing is good, but my confidence colors include silver or gold-based baits with blue, green or chartreuse accents.

There are days that you won't need to tip your lures with live emerald shiners, but at times finicky walleye prefer as many as three emerald shiners on one jigging spoon. Play around with different numbers of shiners and different hooking locations to determine what profile and action they want. If you're keeping walleye to eat, you'll certainly want a gaff handy when a keeper walleye gets near the hole. Because many of Erie's walleye are so big, you'll want at least an 8-inch auger and I prefer a 10-inch auger. Nothing is worse than getting a giant walleye near the hole and then struggling to land it because the fish is too big for the hole or the ice is thick enough that you can't easily get your hands on it because you didn't bring a gaff.

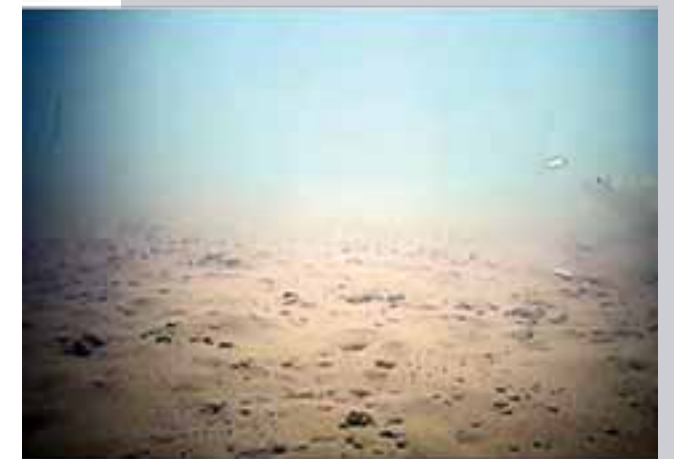
## CREATURE COMFORTS

I have to admit that I probably wouldn't do much ice fishing without a good shanty and heater. New designs like the popular "hub" style shanty set up in minutes and easily accommodate three to four anglers. On even the coldest days, it's possible to set up, fish an area for a short time, and then move on to the next spot if necessary without committing lots of time to setup and teardown. Throw in a propane bottle-fueled heater and it can be downright comfortable even though you're sitting on 12 inches or more of ice. I like to use a simple padded bucket-top seat so that I can store tackle and tools in the bucket and it doubles as a seat.

## PUTTING IT ALL TOGETHER

If you are able to combine the right transportation with the right electronics and gear, and then keep yourself comfortable with a heated shanty, it can all lead to an extremely enjoyable day of Lake Erie ice fishing. When the fish cooperate, you'll stay busy hooking numbers of fish and a few over 10 or 11 pounds are a common occurrence.

Even in the harshest winter, Lake Erie ice deserves extreme caution and conditions can change as quickly as the northern Ohio weather. Compared to smaller protected systems, ice plates can shift, exposing large expanses of open water and current under the ice can eat away thick ice to leave areas that are unsafe that might not be visible, especially under snow cover. It goes without saying that you need to contact local anglers, guides or bait shops to fully understand how to make the safest trip out on to dangerous Great Lakes ice. If you aren't familiar with the area, it makes a lot of sense to go out with a guide or local friends that are familiar with Erie before venturing out on your own.



A series of underwater images shows the action beneath the ice.

All Photos: Travis Hartman

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## IMPASSABLE WATERS

Lake Minnetonka spillway on May 1, 2014 (left) versus on June 20 (right).

After the wettest half-year ever, crews at Minnehaha Creek Watershed District worked through summer 2014's high waters to gather data and inform the public.

BY DANIEL KELLY

In the first half of 2014, the Minneapolis-Saint Paul metro area got more rain than it had gotten since modern water level record-keeping began there. For those working to track flow and water quality on streams in the region, keeping up with all the extra water was a huge undertaking.

Lake Minnetonka, as well as many streams in the region, were greatly impacted. The lake saw its height above sea level reach 931.11 feet, exceeding the record by 7 inches. And 26 other lakes and streams around the Twin Cities set new all-time records for elevations or flows.

Officials at the Minnehaha Creek Watershed District were on the ground and fighting against the high waters to take measurements throughout the ordeal that caused more than \$1 million in damage to streams across the District. Some of their monitoring sites had been completely flooded out. Meanwhile, the SonTek Flow Trackers that they typically used to track discharge were rendered useless because it was simply too unsafe to wade out into the streams to collect data.

As a workaround, they employed an OTT MF Pro Flow Meter. It operates with an electromagnetic sensor head that allowed them to take measurements from a safe distance. Gathering data during this time was important, as the District worked diligently to share information on water levels and quality, as well as safety tips to the public during the high water conditions.

"Since we were unable to enter the water, we purchased the Pro Flow meter so we could safely measure the flow over culverts and

bridge decks," said Yvette Christianson, water quality manager at the District. "Typically, Minnehaha Creek is flowing anywhere from 20 cfs (cubic feet per second) up to 150 cfs. There is a controlled dam at the outlet of Lake Minnetonka where it can release between 12 cfs to 300 cfs. Using the flow meter, we measured up to 503 cfs."


As for the flow of Minnehaha Creek, it shattered its previous record as well, logging some 889 cubic feet per second. This finding was captured by a U.S. Geological Survey gaging station about 20 miles downstream from the Lake Minnetonka outlet.

"We typically would be using the SonTek Flowtracker during this time, but due to the record-high rain and 100 year-stream flow event, we were unable to wade in the streams to get the discharge," said Christianson.

She notes that discharge was one important parameter that they were tracking. That's because it factors into calculating stream loading, a measure of the solid matter the waterways were carrying.

Measures of loading, as well as other physical and chemical parameters, helped to inform a report on the flooding's impacts. Christianson says that the data were also useful in judging how the health of the system is impacted by high water flows.

She notes that the flooding and erosion that came with it led to higher nutrient loading. That really was no surprise, especially in comparing data from previous years' investigations.

"It was a crazy and hectic year of monitoring both lakes and streams. To-do lists were prioritized to focus on the collection of data in these systems to get a better understanding of how 100-year events affect the ecological system of our watershed," said Christianson. "Having the right equipment allowed us to accomplish this goal." 

Photos: Minnehaha Creek Watershed District

# IN THE GREAT LAKES



## RESEARCH FROM AROUND THE BASIN

### SUPERIOR

Due to *Diporeia* population declines seen in the lower Great Lakes, production of these zooplankton are of increasing interest to scientists. Though many believe the populations may have been impacted by the introductions of zebra and quagga mussels, researchers at Michigan Technological University have considered a different factor: dissolved oxygen levels. Using Clark-type polarographic DO sensors, the scientists measured respiration rates in a series of experiments using individual *Diporeia* selected from Lake Superior for three length classes, based on body length. The *Diporeia* were also photographed and weighed, to judge biomass. Though the researchers didn't find a significant relationship with mass-specific respiration rate, they found that *Diporeia* dry weight showed a significant relationship with oxygen depletion rate in each mesocosm used. The data collected will help in estimating the viability of *Diporeia* under future environmental stressors.

*Nancy A. Auer, Miles Corcoran, Martin T. Auer (2015), Measurement Of Diporeia Respiration Rate For Lake Superior. Accepted Author Manuscript.*

### MICHIGAN

Researchers at the Wisconsin Department of Natural Resources have quantified the levels of polychlorinated biphenyls (PCBs) in Lake Michigan chinook and coho salmon fillets since 1975. With access to the large historical dataset, scientists at the DNR used linear models to evaluate the levels to estimate trends in the fish from 1975 to 2010. These were selected from a candidate set of models that included linear time trends, total body length, lipid percentage and collection season, among other variables. PCB concentrations in both species of salmon was found to have gone down over the time period, with chinook registering a drop of 16.7 percent and coho a drop of 23.9 percent, until the intersection of the two trends. From the intersection year to 2010, PCB concentrations declined at an annual rate of 4 percent for chinook and 2.6 percent for coho.

*Paul W. Rasmussen, Candy Schrank, Meghan C.W. Williams (2014), Trends of PCB concentrations in Lake Michigan coho and chinook salmon, 1975-2010. Journal of Great Lakes Research.*

### HURON

Lake Huron researchers are busy at work studying shipwrecks in the expanded Thunder Bay National Marine Sanctuary, according to the Associated Press. Their method of choice is advanced 3D imaging that allows them to photograph entire shipwrecks in incredible detail. It is a first for the shipwreck scientists, as they have lacked such imaging tools in the past. They had instead relied on more standard photos and videos taken of wrecks during limited periods of diving time. After collecting the 3D images, they are run through a software program that spits out detailed visuals of the well-preserved wrecks. Sanctuary managers are aiming to use the images in educational programs to help communicate the value of studying shipwrecks.

*Associated Press. (2015, Sept. 8). How 3-D imaging could reveal new view of old Lake Huron shipwrecks. The Christian Science Monitor. Retrieved from <http://www.csmonitor.com/Science/2015/0908/How-3-D-imaging-could-reveal-new-view-of-old-Lake-Huron-shipwrecks>*

### ONTARIO

After decades of work fighting invasive sea lampreys, officials with the Great Lakes Fishery Commission say that their numbers are down across the Great Lakes. In Lake Ontario, sea lamprey levels are below targets after being too high over the past decade. In Lake Huron, lamprey populations have reached a 30-year low, while they have hit a 20-year low in Lake Michigan. Lakes Erie and Superior both still have populations above what are desired for them, but trends are still going down in both water bodies. Work to fight the invasive species has commonly included using lampricides, barriers and traps in rivers around the Great Lakes where sea lampreys go to spawn each year. Managers have experimented with sex pheromones as another way to interfere with lamprey production. The commission partners with Fisheries and Oceans Canada, the U.S. Fish and Wildlife Service and the U.S. Geological Survey in the efforts.

*Great Lakes Fishery Commission. (2015, Sept. 23). Sea Lampreys Reach Twenty-Year Low In Lake Michigan, And Trend Downward In The Other Lakes. Retrieved from <http://www.glfc.org/pressrel/sea%20lamprey%20abundances%209-23-15.pdf>*

### ERIE

Along with scientists from the National Oceanic and Atmospheric Administration, researchers at the University of Michigan are leading an 18-month effort looking into the factors relating to algae toxicity in Lake Erie. It involves collecting water samples once a week from six sites in Lake Erie's western basin, including near the City of Toledo's water intake. In looking at water samples taken from near the intake after the 2014 bloom, scientists saw a peak in the toxin microcystin in the first week of August. The peak was then followed by a rapid drop in the toxin's levels that carried through the summer and fall of that year. After analyzing the drop, researchers found that the abundance of *Microcystis aeruginosa*, a cyanobacterial species, went down around the same time that nitrate levels started dropping. Scientists think a non-toxic strain of *M. aeruginosa* may have become more abundant than a closely related toxic strain in response to declining nitrate availability.

*University of Michigan. (2015, July 24). Multiple factors, including nitrogen availability, may shape toxicity of Lake Erie cyanobacterial blooms. Retrieved from <http://ns.umich.edu/new/releases/23030-multiple-factors-including-nitrogen-availability-may-shape-toxicity-of-lake-erie-cyanobacterial-blooms>*

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# Wayward Weather Balloon

After a test flight goes awry, Montana Space Grant Scientists chase a weather balloon launched in Big Timber, Montana, to an island on Lake Winnipeg.

BY DANIEL KELLY

Following the test launch of a weather balloon to prepare for a nationwide project to study the 2017 solar eclipse, officials at the Montana Space Grant Consortium learned that what goes up doesn't always come down. Sometimes, what goes up stays airborne for 32 hours and travels more than 1,100 miles before crash landing on an island in Lake Winnipeg.

Berk Knighton, flight director at the space grant, says the test launch began like many others have. But there was one exception, as the satellite modem typically used was swapped out for a newer model shortly before launch from Big Timber, Montana. The change shifted things just enough that a razor blade configured to cut the line that would bring the balloon down didn't go through its intended slot, and got stuck instead.

The weather balloon was also carrying a raspberry pi controller, 5.8 gigahertz modem and a camera for sending back live video. Knighton says this gear is being used to work on long-range video transmission capabilities that will be employed during the upcoming nationwide eclipse tracking event. There was also a GPS tracker and an Iridium satellite modem for receiving commands. "Like for the line termination which didn't happen," Knighton joked.

That malfunction, which occurred around four hours after the initial morning launch, was the beginning of a busy and demanding 32 hours for Knighton.

"By about 12:30 (p.m.), we realized that all the systems we had to possibly terminate the flight weren't going to work," said Knighton. "Then I called the folks in Salt Lake." That's where a Federal Aviation Administration outpost is located, and Knighton let officials there know that the balloon was "derelict" — that there was no way of bringing it down. But it did transmit long enough to tip him off that it would soon enter Canadian airspace.

The next day, he was getting ready to contact Canadian authorities in Edmonton to give them an update on the weather balloon's location. But he checked the Space Grant's tracking website first. There were two trackable devices onboard. "The second one reported it was right in Lake Winnipeg," said Knighton.

Satellite images revealed that it had landed on Nut Island. The question, then, was how to go about retrieving it. Thankfully, some contacts at Google were there to talk Knighton through dynamics and connect him with folks in Manitoba who helped him find places to stay and charter a boat.


Once he got to the lake, it took two hours to cross and reach the island, where the balloon was draped around the branches of a cottonwood tree. "The fact that I recovered the balloon and could do defective work to see what did or did not work, I consider to be like the MasterCard commercial," Knighton said. "You know — priceless." 

Photo: Berk Knighton / BOREALIS





INDUSTRY  
PROFILE

# Q&A Ryan McEwan

Ryan McEwan, associate professor of ecology at the University of Dayton, is leading several projects in his lab (mcewanlab.org). One is uncovering effects of an invasive shrub on streams, while another is in the works to tackle the city's stormwater outfalls. He answered a few questions on these ongoing efforts.



lection of biofilms from in-stream substrates to understand biology of streams. We measure stream abiotic and chemical parameters in a variety of ways including field-based probes and lab-based digestion/reagent approaches. We also measure terrestrial conditions using basic forestry techniques and equipment.

**EM: How are your projects useful in educating students?**

**RM:** Students are a key part of all projects that happen in my laboratory. Undergraduates participate in projects in a variety of ways including very basic tasks like sorting leaves, and more leadership-focused activities. It is normal for advanced undergraduates in my lab to lead projects and become authors on scientific papers. Graduate students are also highly engaged in my projects at both the MS and PhD level. Currently, I have 2 PhD students and 1 MS student working on various projects. These graduate students lead projects but also train undergraduates. Students use the training to propel themselves into environmental careers.

**EM: Do you have any results so far that you can share?**

**RM:** One interesting thing we have found is that Amur honeysuckle has effects, both biotic and abiotic, and streams and "restoration" activities that remove honeysuckle, even at small scales, have measurable effects on the stream. Given that the water is flowing, one might expect that if the stream is invaded upstream, then removing honeysuckle in a downstream reach would not have an effect. We found that, actually, even a removal of 200 meters of honeysuckle in the forests along a flowing stream has measurable effects on the aquatic system. There has been a lot of work on "BMPs" for "streamside management zones" in eastern North America, but what our results suggest is that species composition of the riparian forest matters — maybe matters a lot. A big surprise came during one of our Amur honeysuckle removal efforts when we found a considerable volume of woody debris was hanging in the honeysuckle canopy. This debris is a crucial part of stream biology — the idea that an invasive would alter inputs could be a key find.

**EM: What sort of studies would you like to embark on in the future?**

**RM:** One exciting idea we have is to treat "outfalls" in the City of Dayton as mini-watersheds and ask questions about how green infrastructure can alter what enters waterways from an urban environment. I was surprised to learn that the City of Dayton (and presumably other cities) have great maps of their outfalls, the pipes where stormwater flowing through the streets enters the river system. Those maps set up nicely for an experimental approach that might mirror something like Coweeta or other hydrological labs where the influence of management practices on stream chemistry and biology are measured at weirs. I am excited to test the influence of green infrastructure in urban environments by taking a "small watershed" approach using these outfalls.

Photo: McEwan Lab

# Oldest Oak On Campus

BY CASSIE KELLY

When you walk through the center of the University of California - Riverside's campus, you will see two large oak trees, often referred to as sister trees. They were planted around the same time that the campus was being developed, some 60 years ago, and have grown into large, shady trees.

But one of them has been experiencing some difficulty and was showing signs of sickness. So with the help of an arborist, Toshio Ishida, assistant director of Landscape and Refuse Services at UCR, took on the challenge of helping the tree before it was too late.

They began by looking at many possible causes of the tree's decline, including a soil test to see if nematodes might have been a factor, but came up short. The biggest indicator of the tree's sickness was the north side of the tree. It started to wither around five years ago, and it looked split right down the center up until recently when the other side began to decline as well.

One of the biggest factors in the tree's decline was construction happening on campus. With all of the traffic and a change in the draining system, the tree had been through a lot. After further testing, Ishida and others found that the soil around the roots was extremely compacted; they had no room to grow.

"We dug holes and did compaction tests and found that from all the traffic and stuff, the soil was very compacted under the root zone of the tree," said Ishida. "That's when we started to realize that was part of the problem."

To fix this, they dug eight trenches from the center of the tree out with an air spade system, a technique that doesn't damage the roots. The trenches were 2 feet deep and 12 to 18 inches wide. They then filled them with a fertilizer and mulch mix to give the roots nice, airy space to grow.

They also removed all grass growing under the tree so that the roots don't have to compete for nutrients and water. And now that there is a layer of mulch surrounding it, people tend to avoid stepping on it.

Ishida said he won't know for at least two growing seasons if the measures they took will help the tree. "Oak trees are very slow, they take a long time to show stress and to show healing," he said.

But, Ishida said they are hopeful that the tree will return to its former glory.

"Students and faculty have said they are happy to see us try to save it because it is the center of campus," Ishida said. "It's a good thing for us to do." ☺

Photo: University of California, Riverside







NEW  
TECHNOLOGY



## 3D-Printed Weather Stations

Since 3D printing became possible, the technology has been lauded for all the potential it holds to make things. Virtually anything conceivable, including figurines, car parts and even prosthetics, can now be made with the right design and the push of a button.

Scientists at the University Corporation for Atmospheric Research are looking to leverage some of that potential in a project to build weather stations with 3D printers. Not just a pet project, the researchers are being funded by the U.S. Agency for International Development with plans to scale up the work to provide weather stations in remote areas of the world that lack them.

Their efforts are utilizing 3D-printed parts, off-the-shelf sensors and raspberry pi microcontrollers to support a system that can be easily replicated and maintained wherever it's stationed. Much of the work is in the beginning stages at this point.

"The idea came from the twisted mind of my colleague, Kelly Sponberg. He's been involved with these issues for some time," said Martin Steinson, a project manager at UCAR. Sponberg is a technologist with the organization. "He explained the issues in Africa where the stations break and nobody is there to fix them. And he told me about the idea and I thought he was a nut."

Sponberg, who has worked extensively in Zambia, has seen firsthand the need for such a system in parts of the world, like Africa, where funding for weather monitoring is scarce and expertise for maintaining the stations is lacking. Steinson points out other regions of the world, where weather data are sparse, that could benefit from the systems. These include the rest of Africa, many areas in the Caribbean and the developing world overall.

"We would be working with the weather service of the country — in Zambia, it would be the Zambia Meteorological Department. They'll be the makers and owners of the things," said Steinson. "This is one of the biggest advantages we see on this setup. They can just make the components they need and take them out there with them. It's a real advantage to this idea."


In explaining how the stations would work, Steinson says that sensors would send data to the raspberry pi controller. The controller would collect the data and do some of the post processing to turn the readings into something easily understood by meteorologists. From that point, data would be transmitted via some form of telemetry, depending on the area. Some stations would use cell signals, radio, or even Wi-Fi if it's available. For the most-secluded locations, a memory card would serve to gather the data directly. 

Photo: Martin Steinson / University Corporation for Atmospheric Research



NEW  
TECHNOLOGY



## Drone River Project

Monitoring the health of a river requires many types of tasks: visiting sites, gathering samples, fielding calls, evaluating data, determining corrective actions when problems arise and deciding whether changes in monitoring are needed, among others. In many cases, there simply aren't enough people to do all these tasks effectively. And some tasks, especially repetitive ones, might be done more reliably if they were not being performed by humans, but by intelligent machines.

Alberto Camacho, a PhD candidate in artificial intelligence at the University of Toronto and Patricio Córdova, a master's student studying applied computing at the same university, took up the challenge of automating many river monitoring tasks to improve efficiency in a prototype system they refer to as the Drone River project. The Drone River project system consists of an automated call center, sensors placed systematically along a river and a series of drones powered by solar energy that can perform a variety of monitoring tasks. The Ottawa River was used as a theoretical test case.

The Drone River monitoring system response starts with a variety of sensors placed along the river of interest. The sensors would monitor the river in real time, looking for readings outside normal parameters to detect problems. An automated call center, which Camacho and Córdova have already developed, would attend to phone calls and text messages and perform lan-

guage processing to understand problems reported by civilians. A unique feature of the Drone River project is that, in addition to phone calls or sensors reporting problems, a social media search can also be automatically performed to see if anyone is talking about problems in the river, which would trigger a system alert.

As Camacho mentions, "Once the system detects an anomaly using either method or both, the system automatically responds. A drone will be sent to inspect the affected area, taking pictures, recording videos or even deploying extra sensors. This makes it possible to have a complete report that will be sent to the authorities in the required format, thus speeding up the process to solve the problem and preventing its extension."

Some of the river characteristics the Drone River sensors could continuously monitor for are pH, dissolved oxygen, oxidation-reduction potential, conductivity (salinity), turbidity, temperature and dissolved ions.


Córdova adds that, "Since the sensors that take these measurements are connected to the cloud, we can perform the analysis of the water on the cloud and trigger further actions." As a part of routine monitoring or in response to sensor information, the drones could also be trained to do routine tasks such as taking samples from the river. 

Photo: Alberto Camacho & Patricio Córdova



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