ENVIRONMENTAL
# monitor
SUMMER 2015
APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS

# OHIO RIVER RESEARCH

## Lake Erie HAB Network
More sensors for algal blooms coming

## Ash Borer on the Move
Destructive invasive jumps to new tree species

## 10 Years of GLEON
Linking lakes and people for a decade

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# CONTENTS

ENVIRONMENTAL MONITOR | SUMMER 2015



## IN THE NEXT EDITION

The Iowa Lakeside Lab provides science classes and research opportunities for university students as well as outreach programs and services through Iowa's state universities.

*Cover Photo: Gary Birge / USACE*



## WELCOME...

Welcome to the Summer 2015 edition of the Environmental Monitor, a quarterly collection of the best of our online news publication. A series of stories in this issue follows research and science on the Ohio River, a waterway that has been incredibly important to the country's history yet ranks among the nation's most polluted. Stories include a look at ORSANCO, the interstate agency that monitors water quality on the river, and an effort to estimate chlorophyll concentrations with Landsat 8 satellite data.

You'll also read about the tenth anniversary of the Global Lakes Ecological Observatory Network, which links instrumented lakes and the scientists who study them. This issue's system description lays out the data buoy system that the Niagara Region of Ontario is using to pursue swimming advisories based on real-time data.

Located in Fairborn, Ohio, Fondriest Environmental is the trusted partner you can turn to for help with environmental monitoring projects. We can assist in everything from planning and monitoring to systems integration, equipment calibration and even staff training. Our applications engineers assemble, integrate, and calibrate all equipment – when you get it, it's ready to use. Our specialists have years of experience developing and deploying remote systems and working with leading suppliers such as YSI, Hach, Thermo Scientific, In-Situ, Solinst, NexSens, and many more.

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# WEB EXCLUSIVES

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## Scripps Study Could Lead To Better Coral Bleaching Forecasts

Scientists at the Scripps Institution of Oceanography studying the Heron Island coral reef near Australia's Great Barrier Reef are zeroing in on stressors affecting the shallow-water flat. Their results could help incorporate multiple stressors into bleaching forecasts to improve its accuracy in a high-carbon-dioxide future.

"Coral reef flats in general are very understudied with respect to climate change," said David Kline, associate project scientist at Scripps and lead author of the investigation. "Conditions are too shallow to put a mooring buoy and they're challenging environments with large swings in environmental conditions."

To get around those issues, he and others built a custom monitoring platform to take measurements around the reef flat. It was equipped with sensors to track pH, conductivity, temperature, depth, water flow, tidal salinity and light levels. The sensors interfaced with a data logger with integrated radio telemetry to broadcast findings to scientists in real time.

## Idaho State Grad Student Lives In Wilderness For Transpiration Study

To get the data he needed for his graduate research project, John Whiting had to do a little camping. But this was no weekend research project – he spent more than three months collecting measurements in a wilderness area near Idaho's Frank Church River.

The goal of his research was to measure the impacts that snowpack had on water availability for Douglas fir trees, the most wide-ranging tree in central Idaho. Data collected would also help answer questions relating to the health of streams and fish in the Pioneer Creek Watershed.

"We wanted to test the hypothesis: Does snow matter?" said Whiting, a research assistant and graduate student of geoscience at Idaho State. In the No Return wilderness, where the study took place, there have been concerns that streams could dry out after other investigations looking at stream ecology and fish health. "We were mapping where flow exists and fluctuates, and where flow is continuous, to see how it affects ecology in the immediate area and downstream."

*Photo: (top) David Kline; (center) Chris Connors; (bottom) Zaki Moustafa / SFWMD*

## SFWMD Tracks Wind, Impacts To Wetland Nutrients

Scientists at the South Florida Water Management District are investigating how cattails and other types of emergent aquatic vegetation impact nutrient transport in large constructed wetlands.

To test the hypothesis that emergent aquatic vegetation can reduce wind stress and, as a result, lower nutrient transport, researchers are conducting an experiment to quantify the effects that aquatic plants have on wind-generated stress in constructed wetlands. Results of the study could help improve management of the district's stormwater treatment areas and the reduction of nutrient concentrations, mainly phosphorus.

"The main reason is to determine and quantify the impact of wind stress on nutrient transport in open and vegetated areas in large, constructed wetlands," said Zaki Moustafa, principal scientist at the district and leader of the research. The effort is aimed at answering one question, he says: What role does wind-generated stress play in transporting nutrients in large subtropical wetlands?

# IN THE NEWS

## NASA Releases Satellite Image of 'Garua' Fog Over the Coast of Peru

An image captured by a NASA satellite on June 7 depicts the recent fog hovering over the coast of Peru, near the capital, Lima. The fog is caused by a combination of upwelling currents and the Humboldt Current, according to NASA's Earth Observatory.

The process occurs because the Humboldt Current pushes cold water towards the coast which is then pulled to the surface by strong upwelling currents. The cold waters are then evaporated into the atmosphere leading water vapor to condense into fog that fills the valleys along the coast.

The phenomenon creates unique cloud formations over the desert-like landscape.The Earth Observatory said the two formations visible in the image, both stratocumulus clouds, are open- and closed-cell formations and are usually quite dense, oftentimes blocking sunlight.

The fog usually persists from June to November and is commonly known as 'garua' by locals.

## With Groundwater Pumping, California Sinks At Unseen Rate

In the summer of 2014, U.S. Geological Survey scientists studying soil levels in California found that the state was sinking at its most extreme rate in 50 years, according to Grist. The cause, they say, is the depletion of groundwater supplies as the state grapples with long-term drought.

That type of massive sinkage has not been seen since the 1970s, which was around the time that groundwater depletion was first discovered as the reason for sinking California farmland. But as groundwater has come to supply nearly 60 percent of the state's water in the current drought, the extreme sinking has made a comeback.

The USGS researchers have reached out to government agencies, as well as private businesses, to inform them of the sinkage and see how they are dealing with it. Many simply haven't been aware of the subsidence and few track repairs associated with it. Managing the issue is further complicated by a lack of restrictions on groundwater amounts that farmers can pump, as well as current regulations that keep information private on those pumping it.

## EPA: No Broad-Scale Drinking Water Pollution From Fracking

After a long-term look into the effects of hydraulic fracturing, or "fracking," officials at the U.S. Environmental Protection Agency have found the practice is likely not polluting drinking water supplies, according to National Public Radio. They say the number of documented impacts from the practice has been low when compared to the number of fracking wells in the country.

Scientists at the agency analyzed more than 950 different sources of information on hydraulic fracturing to make the find. The in-depth review involved scientific papers, technical reports and interviews with stakeholders. It was completed at the request of Congress.

Though EPA scientists say there is likely not a widespread drinking water pollution problem related to fracking, they did find some vulnerabilities related to the practice. These include amounts of water required for fracking in dry areas and the unstable constructions of some wells.

## Wind storm over dry lake bed caused milky rain in Pacific NW

Last February, an unusual rain descended upon parts of the Pacific Northwest, coating affected regions with a milky residue. A team of researchers from Washington State University say that dust from a dry lake bed nearly 500 miles away caused the off-color precipitation, Reuters reported.

Initially believed to be the product of a volcanic eruption in Japan, ash from wildfires or a Nevada dust storm, the source of the rain was clarified when WSU researchers tested its chemical composition and studied wind pattern data from the event.

Testing connected sodium levels in the rainwater samples with saline from a dry lake bed. Further analysis suggested — and eventually proved — that Oregon's Summer Lake was the source.

The milky rain affected about 200 miles of Oregon and Washington, and mirrored a similar 2008 rainfall event in New Mexico.

*Photo: (left) Jeff Schmaltz / LANCE/EOSDIS Rapid Response; (right) Laura Stevens / Woods Hole Oceanographic Institution*

*Photo: fishermansdaughter/CC BY 2.0*

## New study explains mysteriously fast draining of glacial lakes

Scientists from the Woods Hole Oceanographic Institution and the University of Washington have revealed how cracks form in glacial lakes, leading to the intense drainage of billions of gallons of water in very short amounts of time.

According to a WHOI press release, the researchers went to the south of Greenland to record a series of massive draining events over three years. They used GPS technology to understand how the water in the lakes shifted over time, just before they burst.

They found that water finds its way into moulins, pathways that cut through from the surface of the ice sheet to the floor. If the moulins become clogged by the influx of water, they create a bulge below the surface. The bulge then increases in tension until the pathway cracks, causing massive glacial slips. This process is called a hydrofracture.

Lead author of the study, Laura Stevens, said hydrofractures can only occur if there is both tension and an influx of water flow. This finding will help future scientists understand why hydrofractures occur in some lakes and not others.

## NOAA predicts Gulf of Mexico Dead Zone the size of Connecticut

The Gulf of Mexico dead zone is predicted to be about 5,483 square miles this year, according to a recent press release from the National Oceanic and Atmospheric Administration. Also known as the hypoxic zone, the dead zone is the area of water in the Gulf with the lowest oxygen and relatively little marine life. Although the dead zone for 2015 may seem quite large, the area has been stable in size for several years, researchers say.

For the first time, results of four models were combined to give the estimate. Combined results from several models are also referred to as an ensemble forecast. Nutrient runoff and stream data from United States Geological Survey was used for model input. USGS data used for the ensemble forecast included information from thousands of real-time stream gauges, real-time nitrate level sensors and monitoring information from long-term stations.

The latest nitrogen levels were found to be somewhat higher than the long-term average while phosphorus levels were somewhat lower.

The long-term environmental monitoring techniques used in the current study should help researchers to continue improving river management practices, improve ensemble forecasts and improve understanding of how nutrients move through the Mississippi River and the Atchafalaya River, ultimately flowing into the Gulf of Mexico.

# Buffalo River Cleanup

New York's Buffalo River has a legacy of industrial contamination, like a lot of other Great Lakes rivers and harbors. But its past of sustaining large influxes of industrial effluent netted it the distinction of being named a Great Lakes Area of Concern.

Sevenson Environmental was awarded a contract to dredge the Buffalo River in 2014, as part of the second phase of a plan to remove contaminated sediment from its bed. In addition to dredging the water body, Sevenson was also tasked with managing turbidity levels around dredging operations to minimize negative effects to aquatic life and water quality. Project engineers sourced the monitoring equipment needed from Fondriest Environmental's rental program.

Two NexSens Technology CB-450 Data Buoys were deployed upstream of the dredging, while one was deployed closer to it. Each supported a YSI 600OMS Optical Monitoring Sonde with an optical turbidity sensor. Once data were collected by the sondes and recorded by NexSens data loggers within the buoys, cellular modems transmitted them back to project managers who viewed them online through a NexSens WQData LIVE Web Datacenter in real time.

As the project went on, Sevenson engineers moved the buoys to maintain consistent monitoring around dredging operations. They also used another YSI 600OMS Optical Monitoring Sonde to spot-check and validate turbidity levels using a handheld YSI 650 MDS Multi-Parameter Display System.

*Photo: Doug Nguyen*

# Green Roof

When Muhlenberg College's capital projects manager David Rabold talked to students about what they wanted to see from a sustainable redesign of their beloved student union building, their message was clear. They saw the need for an update, but they also liked Seegers Union the way it was. So, as one student put it: Don't mess it up.

"I like working with the students," Rabold said. "It's very refreshing."

They were also an ideal partner on the building's new green roof, playing a central role in the project from installation of the vegetation itself to wiring the roof with environmental sensors that will drive future student research. Rabold said putting the students on the project saved some money and helped stretch a grant from PPL Corporation that funded the roof work. More importantly, it followed the small Pennsylvania liberal arts college's preference of giving students hands-on experience with live projects on campus.

A group of eight to 10 students in the College's interdisciplinary program in Sustainability Studies got the 2-foot-by-4-foot, pre-planted trays arranged and growing on the roof. After that, Rabold and Richard Niesenbaum, professor of biology and director of the Sustainability Studies program, left it up to the students in a project-based, problem solving course, Sustainable Solutions, to design and implement a monitoring system.

The student who picked out the sensors was given little other guidance than the direction to select equipment that could show whether the green roof was having its intended benefits. After some back-and-forth with Rabold over what would fit their budget, they ended up with a system that will track the roof's carbon dioxide uptake, moisture retention and cooling abilities.

Erin Murphy, a junior environmental science major at Muhlenberg, was in the fall 2014 Sustainability Solutions class that was tasked with installing the equipment. She was surprised to find herself more or less learning to be an electrician, saying Rabold "gave us the equipment and showed us the wires and said, 'Well, make a wiring diagram, put it together and we'll see if it works.'"

It didn't always work, but the team worked together to troubleshoot issues with tech support, especially when reading the manual wasn't enough.

"One of the issues was the manual changed in the middle of our buying and installing the rain gauge," Rabold said.

The students picked the locations for carbon dioxide sensors, one over the green roof and another over a non-vegetated area

Photo: David Rabold

to show the difference in gas uptake. They also placed moisture sensors to show how long the soil retains water, and temperature sensors over the green roof, and black and white areas of the roof to detect any cooling effects.

Once the sensors were in place, Rabold did his part to take care of the data connection. It was a challenge to get the logger linked into the campus network, which was "buttoned up tight," he said. Barring a few last kinks to work out after the winter weather lets up, the monitoring network is up and running, ready to collect data that will be used by students in the college's sustainability class.

Murphy said she's ready to get back up on the roof this spring to keep an eye on the monitoring equipment she had a hand in installing, even though the work is no longer tied to college credit.

"I'm just interested in keeping that legacy running so that in the future other students can use it," she said. JC

# MIT Tracks 'Vog'

"Vog" is a word that few know and use. But for people living near Hawaii's Kilauea, it's the perfect mashup to describe what they deal with everyday: volcanic smog. Much of the vog that comes out of the volcano is comprised of sulfur dioxide, a compound toxic to humans and plants. It can react with components in the atmosphere to form sulfuric acid, a common component of acid rain.

In a recent investigation conducted by students at the Massachusetts Institute of Technology, sulfur dioxide monitors and other sensors were used to characterize the plumes coming out of one of the volcano's newest craters. The investigation was carried out by students in MIT's Traveling Research Environmental eXperience program that involves a trip each year to give students experience in environmental field work.

"Field work is a part of environmental science and engineering, but it's not a big part of the curriculum," said Jesse Kroll, associate professor in the Department of Civil and Environmental Engineering at MIT. "Students get experience with modeling and lab work, but often not with going out in the field. TREX was set up to give students a chance to explore that side."

For the past three years, the trip has let students study Kilauea's emissions. In 2012, students set out to figure out how best to collect vog data. The following year, they carried out real-time measurements of the chemicals belching out of the volcano. For the 2014 field work, students set up monitoring equipment near Halemaumau crater, a newly opened vent on Kilauea. DK

Photo: (top) Massachusetts Institute of Technology; (bottom) Danielle Walquist Lynch/CC BY 2.0

# Marathon Monitoring

Students at the University of Massachusetts – Lowell took to the pavement to measure air quality during the 2015 Boston Marathon, according to a release from the school. The running event is the fourth in a row that students from the school have studied.

Monitoring came at the request of officials with the Boston Athletic Association, which organizes the event each year. Students were asked to monitor conditions at five locations along the marathon route. They were spread out across the race's route, including spots at its start in Hopkinton and end in Boston, to get a representative data set.

Using a host of different sensors, including handheld anemometers, undergraduates collected measurements on air temperature, humidity and wind speed and direction during the race. From their locations along the route, students then shared the data with others at the Athletic Association's media center.

"Our students … gain an appreciation for the art and science of taking good observations," said Frank Colby, professor of environmental, earth and atmospheric sciences, in the release. "Participating in this activity is a way for them to support a high-

profile event in our own region, and is an opportunity for all of us to demonstrate the quality of UMass Lowell and its students."

Air quality measurements were also shared with the press and through social media. The data will likely be used for organizing future races, as officials can use them to better judge air quality conditions. From there, the data will be used in efforts to find the effects of air quality changes on runners' performance. DK

Photo: Tom Archer / Michigan Sea Grant

# AFTER TOLEDO

**The Toledo water crisis has treatment plants and researchers around Lake Erie joining forces to create a harmful algal bloom monitoring network.**

BY JEFF GILLIES

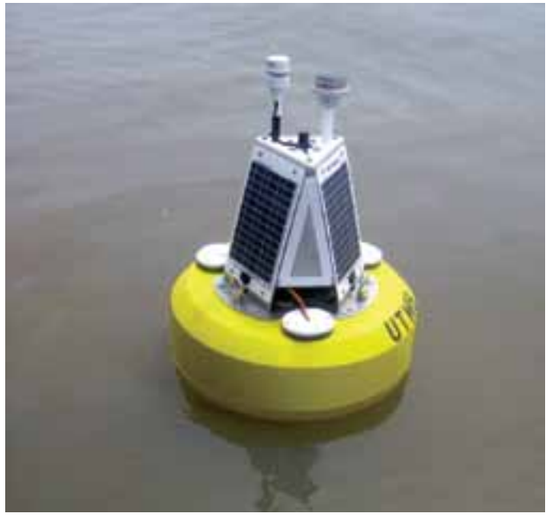
Talk long enough to anyone in the Lake Erie environmental science or policy world and two words will likely come up: "after Toledo," referring to the summer 2014 water crisis that cut off 500,000 residents from their water supply following a toxic algae bloom.

For Ed Verhamme, project engineer with water research firm LimnoTech, "after Toledo" meant fast-tracking a project to get water quality sensors out to the City of Toledo's offshore water intake crib. Now when a potentially toxic bloom moves in, the continuous algae data from those sensors give treatment plant operators a few hours' warning to ramp up treatment procedures to ensure the water is safe to use.

The data have been useful enough that the state is helping treatment plants around the bloom-prone western basin purchase their own sensors. By summer 2016, data from the treatment plants could be bundled into an online database with algae measurements from university and government monitoring projects, creating an unprecedented Lake Erie harmful algal bloom, or HAB, monitoring network.

"To me it seems simple, but it just hasn't been done before," Verhamme said. "There are so many individuals concerned about HABs, but how do you really get them coordinated and how do you really start sharing all this data?"

The first step will be to get everyone producing the data in the first place. Verhamme and LimnoTech will work with treatment plants this summer to get the sensors up and running somewhere along their intake systems that draw water from Lake Erie. They'll integrate the sensors into the plants' data management and process control systems. Without sensors like these, treatment plant operators are blind to the quality of the water they're drawing into their intakes, Verhamme said. With more timely information, they can fine-tune their treatment procedures to keep the water clean while saving money.



*University of Toledo's new water quality buoy floats in Maumee Bay.*

Photo: Josephine Johnson


Map: Nate Christopher

For example, Toledo spent $2 million on activated carbon in 2014 to treat algae. With more information, they could turn on and off the treatment or change the dosage by knowing what's happening in the lake.

"One of the real advantages for them is they know they can handle the bad water when it comes in, but they're really trying to save money on the additional treatment that they have to do," Verhamme said.

They'll set up a system to pipe the numbers to the data-sharing specialists at the Great Lakes Observing System. GLOS Executive Director Kelli Paige said the nonprofit group had its own "after Toledo" experience at its annual meeting in November, where everyone in the room agreed that if more monitoring projects come online as a result of the crisis, the data had to be accessible and usable for anyone who needed it.

"We came away from that meeting with a pretty clear directive that we should be doing more to help coordinate all the data that's coming out of these various monitoring projects," Paige said.

GLOS already does some of that work through its online data portal, which lets users access data from real-time monitoring stations across the Great Lakes. They also host archived datasets. The organization recently funded a project to share decades' worth of data from Heidelberg University's nutrient monitoring efforts in Lake Erie tributaries.

When it comes to sharing data from the treatment plants and other sensors around Lake Erie, GLOS is already hosting a HABs data portal (http://habs.glos.us/map/). Paige said it will also be a good opportunity to pilot their next big idea: My GLOS. That service will allow users to create accounts and customize easy access to whatever data they're most interested in, whether it's related to algae, climate, temperature or beyond.

Verhamme estimates that as many as seven treatment plants along the Ohio lakeshore could come online with algae sensors this summer, from Oregon to Avon Lake in the central basin. They'll be joining Lake Erie monitoring stations from NOAA's Great Lakes Environmental Research Laboratory, University of Toledo, Ohio State University and Bowling Green State University.

The University of Toledo's buoy is the first operated by their Lake Erie Center, which recently acquired a new boat with the capacity to deploy and maintain the platform. The station floats in Maumee Bay, a shallow, nutrient-rich area where the blooms tend to ramp up, according to Tom Bridgeman, associate professor of environmental sciences at the university. They've located their buoy around 8 miles from Toledo's offshore intake, giving them even more warning of an approaching bloom. The sensors at the intake that the city began using last summer give Toledo plant operators a few hours' notice to tweak their treatment, but the new buoy could give them even more time.

"If high toxin levels are developing in Maumee Bay, then we can give the water treatment plants some advanced warning," Bridgeman said. They'll be able to say that "there may not be any toxin right next to your plant, but a couple miles away high toxin levels are developing, and that water could be circulated over to your plant within half a day if the wind and currents change."

Elsewhere in the lake, a new buoy operated by Bowling Green is planned for Sandusky Bay. NOAA will deploy several continuous monitoring stations in western Lake Erie, contributing to a growing network that will also include Ohio State's sensors on South Bass Island and a few more stations offshore of Cleveland. It will likely take a year or so before all of the university and treatment plant sensor stations are running together as a cohesive network and all of the data-sharing kinks are worked out by GLOS. But once everything is running smoothly, the nascent harmful algal bloom monitoring network could prove to be an important tool in making sure there won't be another "after Toledo" on Lake Erie.

"It is thoroughly monitored compared to other lakes, but not thoroughly monitored enough to prevent a water crisis," Bridgeman said. "That's what we're aiming for." JG

# Hach AS950

## Automatic Samplers

BY DANIEL KELLY

Hach's new AS950 water samplers build on the company's history of making quality samplers by adding more intuitive programming, operation and data transfer. Some of the new features they boast include an improved status screen, a full color display and USB capability.

The AS950 samplers replace the Hach Sigma SD900 samplers and are available in all-weather, portable and refrigerated varieties. The enhancements they've undergone help make them some of the most robust automatic samplers on the market today.

"Hach AS950 automatic samplers collect and store unbiased, representative water samples for laboratory analysis," said Jamie English, product manager at Hach Company. All are compatible with sampling bottle sets of different size and quantity, and are easily configurable to meet changing sampling needs, she says.

What really sets the AS950 samplers apart is the ease of use that has been worked into their design. An example of this is the new programming they incorporate that presents important project information on just one screen.

"In a single view, the user knows immediately if there were any missed samples, knows if alarms have been activated, and knows where the sampler is in the program," said English. "The user now has much more confidence as to where the sampler is in the program — when's the next sample being taken, how many samples have been taken, what type of sample — as well as if they need to take further actions due to any alarms or events."

The programming updates are made more effective by a one-quarter VGA full color display that is new on the AS950 and features a graphical user interface. "Other samplers are monochrome and limit the program view," said English. The new display makes it easier to see project alarms and alerts.

From there, the AS950 samplers bring another practical update to users: the ability to transfer data through USB.

"It's the only sampler that allows the user to upload and download data via a USB so that there's no need for a laptop in the field," said English. "In the past, the need to take the laptop was inconvenient — imagine a stormwater application when data needs to be downloaded during a storm event — or in some cases causes the user to be a target of theft."

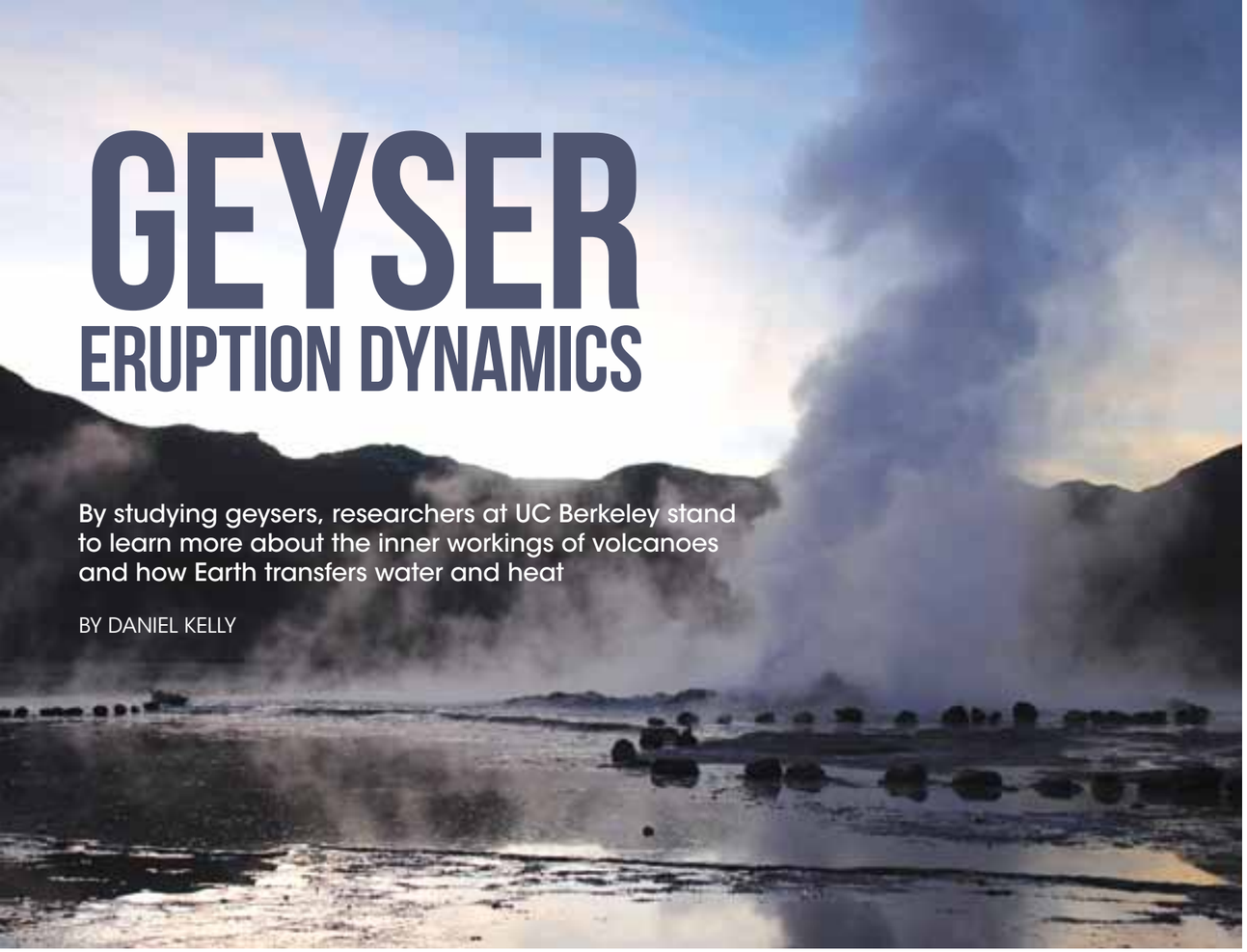
Other new features that the AS950 samplers bring to the table include compatibility with existing Hach sensors when users add the sensor port option. The option allows them to connect two sensor ports to trigger and log measurements. Some common parameters that customers measure include pH and flow.

"With this (sensor port) option, the customer can do both with one sampler and no need to move up to a sonde for multiple parameters," said English.

And for users with special data logging concerns, there is the IO9000 module option that allows them to use digital or analog to communicate with their logger of choice.

Maintenance concerns are similarly minimal just like with the SD900, says English. Pump tubing has a long life, around 20,000 cycles, thanks to spring-loaded pump rollers that cushion and users can see if tubes need changed by looking through the pump's clear cover. The only thing that needs to be swapped regularly is the desiccant, which is installed as easily as a light bulb, says English. And users should make sure to download FSData Desktop software, available at hach.com, to manage firmware updates, logging, sensor diagnostics and reports. DK

# GEYSER
## ERUPTION DYNAMICS



**By studying geysers, researchers at UC Berkeley stand to learn more about the inner workings of volcanoes and how Earth transfers water and heat**

BY DANIEL KELLY

Geysers are mysterious things. Locked underground in a series of loops and heated chambers, they hold water and steam that shoot out of the ground on their own. And beyond seeing that they yield such explosions, scientists have long wondered why erupting geysers exist in the first place. Why doesn't a geyser simply run out of steam and bubble up into a hot spring instead?

Clearly some questions are harder to answer than others, and the one asking why geysers exist isn't one that can be solved yet. But there are others that can be measured by scientific investigation, and researchers at the University of California, Berkeley have set out to answer them.

Around half of the world's geysers can be found in Yellowstone National Park, and that's where the UC Berkeley team surveyed. Investigations there relied on non-intrusive methods and equipment because Yellowstone is a protected area. To fill gaps in understanding left by the restrictions, they also traveled to a site near Chile's Atacama Desert where it's permitted to deploy instruments within geysers.

"Geysers are fascinating and millions of people watch them in Yellowstone each year," said Michael Manga, professor of earth and planetary science at UC Berkeley. "They're windows into how Earth transfers water and heat and we can study them at the surface."

He and others at the university studied Yellowstone with aboveground instruments like seismometers, tiltmeters and infrared cameras. In Chile, they strung temperature sensors and pressure transducers down geysers to study their internal dynamics. They also dropped GoPro cameras down into the spewing tubes to record the action.

Along the way, they uncovered some key finds about geysers that Manga says could help in understanding other types of eruptions, such as volcanoes that are much too large and dangerous to instrument in similar ways.

"We're interested in why and how volcanoes erupt. And for us, geysers are small versions of volcanoes," said Manga. "We put a range of instruments inside. Those geysers we picked had holes big enough for cameras and probes. But we also took water samples."

The water samples helped show what minerals are dissolved in geysers' water, and researchers also tried out lidar and radar

*UC Berkeley scientists study Chilean geysers with temperature and pressure sensors to learn how Earth transfers water and heat.*

*All Photos: University of California, Berkeley*

to measure how the ground around geysers deforms as they erupt. The real key measurements were pressure and temperature, says Manga, because the water boiling within is most controlled by heat and pressure.

Overall, the efforts helped scientists get a good look at heat and water transfer across a wide range of geyser types, yielding information that advances understanding of geysers but also adds to what is known about volcanoes.

"Geysers are just erupting water. Volcanoes are more complicated because they erupt liquid rock with water in it," said Manga. "But by measuring the eruption physics of geysers and combining those with what volcanoes do using geothermal technology, we can use the insights we gain on volcanoes."

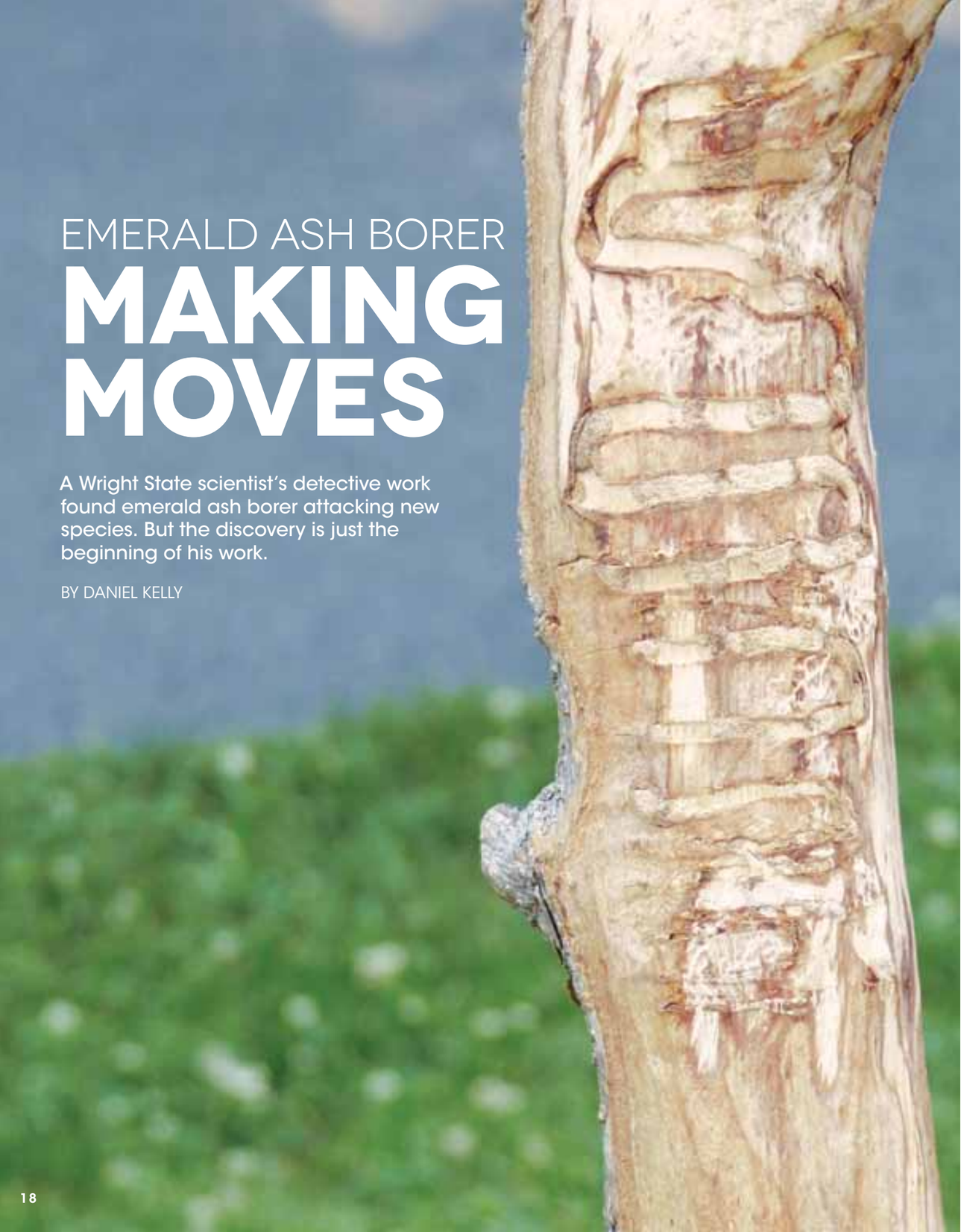
In addition to those insights, Manga and others uncovered new details into the inner workings of geysers and added to their understanding. At one site, they found that steam can escape a geyser at the speed of sound. At another, they measured how the ground deforms inside and outside of a geyser, leading them to conclude that there must be something special about the substrate that allows a geyser to exist.

They even found what causes a geyser to stop erupting: It runs out of steam, or cold groundwater rushes into it, causing its water to cease boiling. Geysers that are more exposed to the external environment — those that reside in open pools instead of cones — are more vulnerable to those types of disturbances, says Manga.

But perhaps the most striking find revealed how truly interconnected and regular geysers naturally are. In one test, researchers discovered a set of three geysers that erupted one after another in a well-timed sequence. In other tests, they saw how small eruptions steadily occurred as they built up to yield bigger ones.

In a similar vein, they found a geyser in Chile that erupted at exactly the same time interval over 3,600 eruptions, a regularity that is more precise than the eruptions of Yellowstone's Old Faithful.

"We have a lab model that we can't make as regular," said Manga. "It's a very simple model, while the real world is complicated and messy." OK



# EMERALD ASH BORER
# MAKING MOVES

**A Wright State scientist's detective work found emerald ash borer attacking new species. But the discovery is just the beginning of his work.**

BY DANIEL KELLY

In 2002, Detroit was ground zero for the emerald ash borer invasion, as the shiny green beetle pushed its way in on poorly treated wood packing material that carried goods from eastern Europe and Asia. The bugs were probably dormant larvae at that time, resting until conditions were right to chew their way out.

And when they did, it wasn't long before they found ash trees like those they loved in Asia right here in the United States. They preyed on the trees near Detroit first, and from there expanded into untouched territories including Illinois, Indiana and Ohio. Within a decade, emerald ash borers were found in much of the U.S. Midwest and Northeast, all the way from Kansas to New Hampshire.

That the emerald ash borer can spread quickly isn't surprising. What is, however, is the way they do it. The beetles can't expand that rapidly on their own, and only extend their range by about a kilometer per year naturally. But when people don't treat wood by spraying it with pesticides or drying it out, emerald ash borers can make huge geographic leaps, like their emergence in Denver that came out of nowhere and other sightings in Arkansas and Louisiana.

Unfortunately for those trying to stop the expansion of this resourceful invasive species, emerald ash borers have been found in a new tree: white fringetree, a close relative of ash. That discovery was made by Don Cipollini, professor of biological sciences at Wright State University.

"They had tested the leaves of this tree early on for suitability of the adults because adults feed on the leaves. But that's not a big issue; it's what the larvae feed on that's really damaging," said Cipollini during an interview in his lab. "For some reason, that step was never examined back then. And that lingered in my mind, this question about white fringetree."

Luckily for Cipollini, who lives near Yellow Springs, Ohio, one of the trees was growing right in his backyard. From there, he started to look around the Dayton area in 2014 to find where other white fringetrees were planted. There were about 10 in public areas around Yellow Springs, as well as a few others in private yards.

"So I just said, 'This summer, this is the summer I'm going to go out and address that question: Is emerald ash borer using this species in the field?'" said Cipollini. "I just simply went out, starting from one end of the Little Miami Bike Trail in Yellow Springs examining the trees, just visually, and inspecting the trees for evidence of an attack."

The telltale signs of an emerald ash borer attack include dried and shrunken stems with D-shaped holes where adults have chewed their way out. Cipollini also noted cracked bark and signs that trees were dying back, like epicormic sprouting: new stems sprouting at points below the attack sites to compensate.

The first few white fringetrees that he checked looked unattacked.

"So I'm three trees in, thinking maybe there's nothing to this," said Cipollini. "Then I walked up to the fourth tree."

That white fringetree, hiding in plain sight beside a popular public bike path, was harboring emerald ash borer. Cipollini began collecting evidence to prove his find, and would go on to survey 16 more white fringetrees near Dayton. A total of five of those were found to show signs of emerald ash borer attack, but

*Don Cipollini walks along the Little Miami Bike Trail in Yellow Springs, Ohio, where he first discovered emerald ash borer attacking white fringetree.*

*All Photos: Nate Christopher*

the very first one was special: It carried a dead adult male that was key to proving the insect was what Cipollini thought it was.

"As this thing dried after I'd collected it, six weeks later I went to look for it, and right in here was a trapped adult," said Cipollini, pointing to the winding, larvae-chewed feeding gallery where the adult once lay. "I could see it in there. I dug it out and that led to the positive identification of the beetle as emerald ash borer."

Scientists with the U.S. Department of Agriculture's Animal and Plant Health Inspection Service gave their official stamp of approval on Cipollini's findings. It was the beginning of a whirlwind of additional study, traveling, presentations and conferences to discuss his findings, in addition to publishing his results in the Journal of Economic Entomology.

"I don't think people were looking, frankly. It could have been anybody that decided to do this," he said. "It just happened to be me." Another factor that may have slowed the discovery is the fact that many trees don't show visible signs of attack until it's too late.

Cipollini's hypothesis is that white fringetrees are a good target for emerald ash borers because they share similar chemical signatures that ash borers can key in on. The trees are among the most closely related trees to ash in North America even though they don't look like them.

The similarities between the two trees brings up another question: Could emerald ash borers spread to other closely related trees? After all, both ash and white fringetree are members of the olive family, says Cipollini.

Unfortunately, the answer could be yes. If white fringetree is susceptible, then other trees in the olive family that look and smell just like it may be too. Trees like the pygmy fringetree, swamp privet, cultivated olive and devilwood.

"So this type of understanding helps guide what to pay attention to," said Cipollini, pointing to the closeness of each species on a chart showing similarities between their evolutionary paths. "What's next on the menu? That's the reason for the focus on these species over here. If this one can be attacked, then it's quite possible that this one and this one, and so forth, can be too."

Cultivated olives are important economically for fledgling olive industries in Florida and well-established ones in California. And, of course, olives aren't just grown in the U.S. Growers in Europe may have to be on the lookout for ash borers in the future.

Cipollini believes the emerald ash borer will make it to Europe eventually (it is in Moscow right now), much the same way it made landfall in Detroit. And as the insect's effects have already been felt here in the U.S., Europe will have to deal with them too.

The ecological damage is also important. If borers attack and kill white fringetree like they do ash, they're removing another tree that pollinators visit. "Bees and other insects service these flowers and obviously they make these olive-like fruits in the fall that birds eat, mammals eat," said Cipollini. "So there's this wildlife value to the plant that would be affected if it gets killed back."

But before that scenario plays out, Cipollini says more investigation needs to be done to understand how the beetle is making its moves. Uncovering that will help regulators like those at the USDA Animal and Plant Health Inspection Service plan for minimizing the damage.

To get at the question, Cipollini's lab is equipped with rearing barrels that hold borer-besieged white fringetrees he found during his studies. By simply bringing the infested trees into his room-temperature lab, he is speeding up the ash borer development process and can see if live adults emerge from them or not. There is also an incubator that holds branches from several tree species believed to be at risk, each bound with small strips of ash borer eggs. In a work related to the initial discovery, he's monitoring which tree species ultimately provide livable environments by checking for feeding galleries that hatching larvae leave behind.

So far, he has confirmed white fringetree is an acceptable host for emerald ash borer larvae. And so is devilwood, which supported the development of a few larvae. In green ash, he found that larvae appeared to grow faster than in white fringetree, but with similar numbers of surviving larvae. The results were different for a species of Chinese fringetree, which did not support larvae growth. Cipollini says that the tree may have a shared evolutionary history with the emerald ash borer in Asia and possess effective defenses against it. And more work is planned on olive trees, with Cipollini sourcing stems from California for study.

He has also continued his legwork around Yellow Springs, uncovering four more white fringetrees that have been affected. And he conducted similar surveys at the Morton Arboretum outside Cincinnati, where he's found about half of 20 white fringetrees there have been attacked.

The full results of his second investigation are slated to be published soon in the journal Environmental Entomology.

"What I've learned is that, more or less, these trees (white fringetrees), they'll all get attacked when beetle densities get high enough," said Cipollini, while walking along the bike trail in Yellow Springs. "It doesn't mean they'll die of it, but I think they're all going to get tested." OK

*Don Cipollini inspects white fringetrees for signs of ash borers, including D-shaped exit holes and feeding galleries*

*Scientists are still testing related trees to see which species the ash borers can live in.*

*Photo: Nate Christopher*

*Photo: (bottom left) Nate Christopher; (others) Daniel Kelly*

# MERCURY IN BATS

**Bats near acidic lakes and rivers were found with higher mercury levels, illuminating the paths this global contaminant follows through aquatic ecosystems.**

BY JEFF GILLIES

A new study of mercury levels in bats links higher concentrations in some colonies to the acidity of nearby lakes and rivers, further illuminating the paths this global atmospheric contaminant follows through aquatic and terrestrial ecosystems.

Previous research has shown that fish and other organisms in lakes with higher acidity tend to have higher mercury concentrations. This study from Nova Scotia shows the effect appears to extend to little brown bats, which feed on adult insects that live in aquatic habitats as juveniles.

"What we found was that the average water acidity in surrounding freshwater systems may be an important factor in increasing bioavailability of mercury in aquatic food chains leading to little brown bats," wrote Linda Campbell, study co-author and a senior research fellow in environmental science at Saint Mary's University, in an email.

The study, published online in the journal Environmental Science and Technology, came about after a bird ecotoxicologist, a bat biologist and a limnologist got together.

"While we didn't all walk into a bar, our interests and expertise overlapped nicely," said Campbell, the limnologist of the group.

She and Neil Burgess, a bird ecotoxicologist with Environment Canada, had worked together on a study that mapped mercury in sportfish and loons. That experience showed them the potential of developing geographical mercury studies out of large databases. They saw that potential in an archive of bat fur samples collected from across Atlantic Canada over 15 years or so by bat biologist Hugh Broders, also of Saint Mary's University.

The bat fur archive was especially valuable because the samples were collected before any Nova Scotia colonies were afflicted with white-nose syndrome, a widespread fungal epidemic that has killed millions of bats across North America. The disease has since spread to mainland Nova Scotia, leading to restricted research access to those colonies.

The team chose to look at little brown bats for the females' tendency to forage near their maternal colonies during pregnancy. That helps tighten the link between any diet-related effects and

*Photo: U.S. Fish and Wildlife Service*

*The study measured mercury in little brown bats.*

*Photo: Ann Froschauer / USFWS*

the local geographic area. Though some colonies sampled were in provincial and national parks, most were found in attics.

Given her expertise in aquatic ecosystems health, Campbell said she was surprised to find herself working with archived bat fur. But environmental contaminants rarely respect the boundaries between ecosystems or scientific disciplines, so that sort of academic tourism comes with the territory.

"Our environment is so interconnected such that if I follow one strand, I will inevitably find myself going to new areas and working with new people, which is one of my favorite aspects about my job," Campbell wrote.

After analyzing the bat fur samples for mercury concentrations, the researchers saw that the geographical variations in concentrations matched up with acidity patterns in previously published water quality maps of the same region. But employee turnover at Environment Canada meant only the raw data behind those maps was still available. The research team, including the study's lead author, Megan Little, spent months reworking it into a usable dataset. A comparison of that dataset with the mercury fur concentrations dataset showed that female little brown bats eating aquatic insects from regions with more acidic lakes and rivers had higher mercury concentrations.

Campbell said a lack of exposure and toxicology research on bats makes it impossible to say for certain whether the colonies with higher mercury levels are suffering from the higher contaminant load. Some research has suggested that bats could be more tolerant of elevated mercury levels, but the concentrations the study found in colonies in southern Nova Scotia still warrant concern, she said. The research team would like to pursue some follow-up studies using similar methods to see if elevated concentrations are leading to increased stress or health issues.

The study highlights the ways mercury — from its global primary sources of coal burning, forest fires and gold mining — can infiltrate both aquatic and terrestrial ecosystems, accumulating and magnifying as it passes through their linked food chains.

Since aquatic ecosystems are especially susceptible to mercury accumulation, "every living thing which depends on freshwater resources can be impacted," Campbell wrote.

"What we are seeing for bats (is) not limited to just those little animals, but also can apply to other wildlife and even humans. What we are seeing shows we need to be more cautious about what contaminants we release into the environment." JG

# OHIO RIVER

It's hard to overstate the importance of the Ohio River to the United States. Its main stem defines borders of five states, while its watershed stretches to touch nine more. Its 981 miles have served as a transportation and trade route for thousands of years, supporting the economic activity that has fueled iconic cities of the region like Pittsburgh, Cincinnati and Louisville.

But those uses have come at a cost. Since 2001, industries have discharged a greater volume of pollutants into the Ohio River than any other waterway in the country. This series shows scientists tracking pollution in the river, learning more about how it breathes, tackling the basin's nutrient runoff, and studying its algal blooms with satellites.

## LOCKS AND DAMS

Because of its length, the Ohio River has always served as a popular transportation route. Now a series of locks and dams accommodate commercial navigation.

- HYDROELECTRIC DAM
- CURRENTLY BEING REPLACED
- UNDER CONSTRUCTION


## POOL LEVELS

Normal pool elevation above mean sea level for the navigational dams represented in feet.




## RIVER FACTS

Starting in Pittsburgh, PA and ending in Cairo, IL, the Ohio River is the largest tributary for the Mississippi.

**981** MILES LONG

**0.5** MILES WIDE (AVERAGE)

**24** FEET DEEP (AVERAGE)

## BASIN

The Ohio flows through or borders six states, while its drainage basin includes eight more.

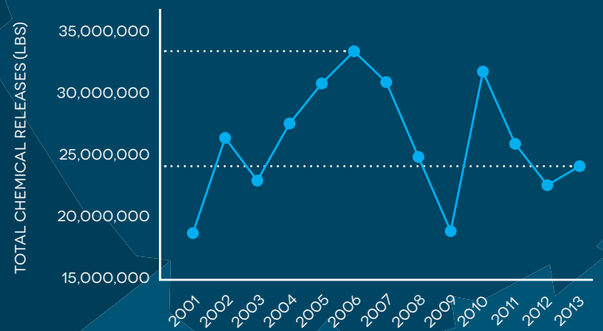

## POLLUTION

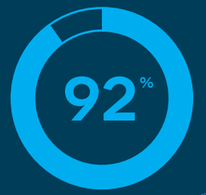
Since 2001, the Ohio has been the most polluted river in the United States. While the latest Toxic Release Inventory reports show

**24,180,571** LBS

of chemicals released into the river in 2013, it is still a large improvement over the TRI of 2006 which reported a total of

**33,457,120** LBS




of total chemical releases in 2013 were from nitrate compounds


of total chemical releases in 2013 were from the AK Steel Corp. plant in Rockport, IN

*All Graphics: Nate Christopher*

*Information from:*

*ORSANCO — orsanco.org*

*Ohio River Toxic Release Inventory Analysis 2013 — orsanco.org/images/stories/files/pollutionControlStandards/2013%20TRI%20Report%20rev3.pdf*

*USACE — lrd.usace.army.mil/Missions/CivilWorks/Navigation/OhioRiver.aspx*

# LIVING RIVER


**Researchers at Marshall University use dissolved oxygen, temperature and solar radiation levels to model the Ohio River's metabolism.**

BY DANIEL KELLY

Few scientists have tried to gauge the metabolism of large, winding ecosystems like the Ohio River. Instead, many have chosen to zero in on lakes or smaller streams where their results can be more easily understood.

Metabolism in an organism is easily described: It's a measure of all the catabolic and anabolic reactions inside its body. These would include chemical reactions involved in biological processes. For the Ohio River and other large systems like it, metabolism is defined a little differently. Its metabolism is linked to changes in dissolved oxygen levels, influenced by the consumption of oxygen by creatures living in its waters. While some take the oxygen in to live, including fish and other aquatic animals, others produce oxygen as a byproduct of making their own food. This segment typically includes aquatic plants and algae.

Luckily, measuring dissolved oxygen is fairly straightforward these days, as scientists have a variety of sensors out there to choose from. Jeff Kovatch, an associate professor of biological sciences at Marshall University, uses YSI 6600 V2-2 Multi-Parameter Water Quality Sondes to measure DO levels at two different points in the Greenup Pool of the Ohio River. He combines the data they collect with information on water temperature and solar radiation to estimate the metabolism of the Ohio River in an ongoing work.

"When you get the large, lotic systems like the Ohio, it's something people have not looked at," said Kovatch. "It involves new concepts and the metabolic theory of ecology. Combining those two things provides a way to study the main stem as a whole entity instead of fish and algae as individual units."

The 10-year-old theory looks at the metabolic rates of organisms in an area to observe how they add to processes in their environments. Looking at the Ohio River from that standpoint is valuable because few others have done so in the past. The work is also revealing more about the river, including the makeup of its trophic structure and it may also help advance understanding of how other large rivers function around the world.

In addition to dissolved oxygen, the sondes collect information on the Ohio River's temperature, turbidity, pH, conductivity and chlorophyll. Data on the extra parameters help with other investigations. The temperature and DO pieces to Kovatch's model are easily added, but there is a little post-processing.

"With the data sonde technology, we measure the dissolved oxygen levels every 15 minutes," said Kovatch. "Over a known geographic distance, we can do a volumetric extrapolation to get an idea of the total oxygen flux."

Kovatch calculates the solar radiation data using time-tested methods that rely on latitude and longitude, light attenuation in the water and time of day. He and others in his lab collect the light data by going out to different sites on the river using boats. They drop sensors to a known depth and confirm how the light behaves in the water.

*All Photos: Marshall University*

*Jeff Kovatch (left) prepares to dive to retrieve a data sonde with the help of students Steve Phelps and Thaddaeus Tuggle.*



"By taking the radiation and the temperature, what I do is model changes over the day and night cycle to extrapolate what the physiologically active biomass in the Ohio might be," said Kovatch. "Some of the estimates I came up with, the biomass is quite large."

The results aren't very surprising, says Kovatch, because of the sheer magnitude of the Ohio River. After all, its average discharge is around 8 cubic meters, which is quite large over its nearly one-thousand-mile length. In addition, his model doesn't divide up organisms into consumers or producers of oxygen. It captures a glimpse of all the organisms in the river combined.

"It doesn't tell you if it's an autotroph or heterotroph," said Kovatch. "It wouldn't tell you if it was dominated by bacteria, fish or bivalve mollusks." DK

# ALL MIXED UP

BY DANIEL KELLY

Studying algal blooms in lakes, oceans or marine systems is relatively simple since blooms tend to concentrate at the surface. But studying the blooms in a river is much different. Flowing water tends to mix the algae from top to bottom.

That's the case in the Ohio River, where Marshall University researchers are studying chlorophyll concentrations as a surrogate for algae. Key to their effort are images from the Landsat 8 satellite that can capture large sections of the river in a single snap. Scientists then ground-truth what the satellite finds with water samples. By combining the two approaches, researchers hope to develop a reliable way of estimating chlorophyll levels within the river using satellite images alone.

"When you have a long river, and the Ohio's close to 1000 miles long, typical sampling would take a liter of water every 80 miles or so and you do that about every two weeks," said Jeff Kovatch, associate professor of biological sciences at Marshall University. He is completing the work with Thaddaeus Tuggle, a graduate student in his lab. "Well, the river doesn't sit still to capture the concentrations."

The advantage that satellite technology provides is the capability to capture hundreds of miles of river in just one image, he says. That lets researchers see changes in chlorophyll concentrations over a much broader area than typical sampling.

After the satellite collects its images, the values for light reflectance and absorption that it picks up are matched to the ground-truth data collected by Kovatch and others in the Ohio River's Greenup pool. They go about 30 meters offshore, where the river is well mixed, and collect samples using grab samplers. Collection takes place at three different locations at the same time on a given day. Different types of chlorophyll, a and b, are monitored by YSI sondes deployed along the pool while chlorophyll c is calculated in the lab.

"That involves us going out, collecting the water samples and doing a chlorophyll extraction," said Kovatch. "We use that to fit a model of the different band values to different concentrations of chlorophyll."

When comparing the model that he's helped develop with Tuggle, Kovatch says that it predicts chlorophyll concentrations really well. He declined to share an estimate of the model's accuracy until after the final paper detailing the research is published, but he did have some plans for future studies that might use the model.

"We would be able, from the comfort of one's computer, be able to sample chlorophyll concentrations across the entire Ohio River," said Kovatch. "In terms of time and money, we could collect a lot of detailed data quickly."

In addition, by using historical images from NASA, Kovatch says it could be possible to extract the Ohio River's past concentrations.

"If we can do that, we can get a 30-year data set, a temporal and spatial data set relating to the Ohio River," said Kovatch. DK

*The Ohio River near the J.T. Myers Lock and Dam as captured by Landsat 5 satellite in 2010.*

*Photo: NASA*



# BENEATH THE BASIN

BY DANIEL KELLY

*A grassed waterway in Cherokee County, northwest Iowa.*

Dealing with nutrient runoff is no easy task. Lots of methods to mitigate it have to do with what's going on at the surface, like the application of fertilizers or disturbance of soils. But looking at what is happening beneath the surface is just as important.

With that in mind, scientists at the Iowa Department of Natural Resources and the Iowa Geological Survey used GIS data to make a framework that could ease decisions for state agencies, non-governmental organizations and other entities working to manage water resources in the Upper Mississippi and Ohio River basins.

"We were looking at the water flux associated with the basin," said Keith Schilling, research engineer at the Iowa Geological Survey and lead author of the work. "Our study is unique in that it looks at the conditions beneath the fields, the agricultural-hydrological connection."

Pre-existing data were used for the work, so there was no field component. Instead, scientists analyzed GIS databases to find ideal spatial maps relating to soil coverage, land slope, permeability and other factors. The tool was made by overlaying and intersecting the different maps.

Using soil maps, researchers could identify what was under the crop fields to look at the range of permeability from sandy to clay. That's a built-in classification, says Schilling. Others in the framework include high, low, flat and glaciated slopes, as well as what's growing on a watershed's cropland.

"There are ways to relate permeability to slope," said Schilling. "They drive water and nutrient movement over land, so it gives you an idea of infiltration versus runoff."

The tool is most useful for those people who deal with managing multiple watersheds. Farmers are already going to be familiar with what's happening in their local watersheds, he says. Still, the concepts used at the larger-scale are translatable at local levels.

So practices like building terraces or planting grass along waterways can be used to reduce overland flow. Other methods, more geared toward managing nitrate levels, involve things like loss-controlled wetlands or bioreactors.

The framework covers more than 11,000 watersheds around the Mississippi and Ohio River basins. It currently exists in a format mostly useful to researchers, but there are plans to scale it up for broader use.

"We'll be providing a web interface for this study, not just an abstract one," said Schilling. "It'll be a web application that people can use, and launches hopefully in the next few weeks." DK

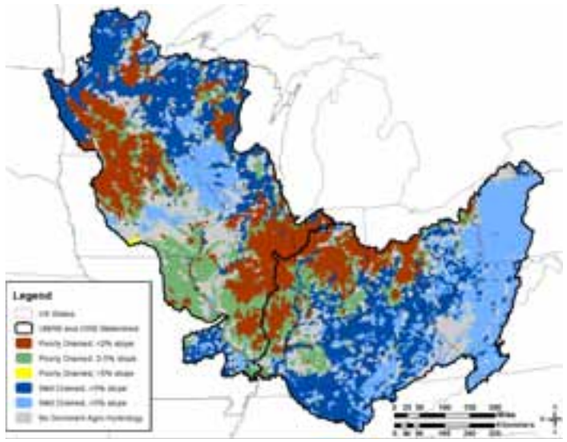



*Photo: (top) Lynn Betts / USDA Natural Resources Conservation Service; (bottom) Schilling, et al.*

# EYES ON THE OHIO RIVER

*All Photos: Greg Youngstrom / ORSANCO*

**An update on the Ohio River Valley Water Sanitation Commission's (ORSANCO) work to monitor the health of the Ohio River using a variety of technologies and techniques.**

BY DANIEL KELLY

The most recent U.S. EPA Toxic Release Inventory National Analysis, published in 2013, names the Ohio River as the most polluted river in the United States. It reports that twenty-three million pounds of chemicals were discharged into the river during that year. The discharge number is big, but easy to explain: The Ohio River is a working river, charged with transporting barges around the clock; turning generators at hydropower installations along its length; and absorbing inputs and runoff from agriculture, urban areas, wastewater treatment plants and industry.

Another way to put it in context is to consider the volume of the Ohio River. At some twenty-five trillion gallons, its chemical content is highly diluted, meaning it is safe for aquatic life, recreation and as a source for drinking water. Making sure that the river maintains those beneficial uses is the work of the Ohio River Valley Water Sanitation Commission, or ORSANCO, an interstate agency representing eight states near the waterway.

"We have a very efficient staff and work really hard to locate the monitors we use and to complete the processes for tracking the complexities of a 981-mile river," said Richard Harrison, executive director at ORSANCO. "We do a very good job of doing that with close coordination of eight states and federal partners."

As part of that monitoring work, the agency has many initiatives to keep an eye on a large number of things in the river, including nutrients, dissolved oxygen levels, metals, bacteria and other water quality parameters.

The Toxic Release Inventory identified nitrates as the biggest contributor to the Ohio River's pollution — 92 percent of the discharge total. But that is just one of the pollutants that ORSANCO monitors as part of a bimonthly program that involves sampling at 15 dams along the river and another 14 sites along its major tributaries. The manual sampling effort involves going out with sampling bottles, gathering discrete water samples and then sending them to labs for analysis.

"We have routine monitoring as part of a program where we sample every other month," said Greg Youngstrom, an environmental specialist with the agency. "We track 31 different parameters. Those include metals, major nutrients and ions, like chlorides." Chlorides are indicative of road salt runoff.

The nutrient monitoring is increasingly important, as the U.S. EPA has asked states to develop limits for nutrient concentrations in lakes and rivers nationwide. The requirements cover inorganic and organic sources of nitrates and phosphorus. Much of the reason for the increased focus is the effects that high nutrient levels can have on the ecosystems of waterways.

"When you increase nutrients, you increase algae, which causes an algal problem that affects macroinvertebrates," said Youngstrom. To complement exploring the issue even further, the agency has dissolved oxygen data loggers at 60 sites along the river, with each reporting measurements every 30 minutes. If levels come back anywhere below 5 milligrams per liter, agency officials go out and inspect the river's pool where they were taken. "That information will also be used in developing the numeric nutrient criteria."

The agency conducts some monitoring on an as-needed basis. During the contact recreation season, from April through October each year, ORSANCO tracks bacteria levels at six sites near major urban areas once a week to make sure conditions are safe for swimmers. Environmental specialists with the agency collect water samples near Cincinnati that are later analyzed for fecal coliform and E. coli bacteria. The agency's partners near Pittsburgh, as well as some wastewater treatment plants, send them data as well.

ORSANCO is also adding new stations equipped with remote telemetry capabilities, including a NexSens 3100-iSIC Data Logger that was recently deployed at the Newburgh Locks and Dam with a YSI 6600 V2-2 Multi-Parameter Water Quality Sonde and a Turner Cyclops CDOM sensor. It joins another 3100-iSIC the agency has at Smithland Locks and Dam.

"Right now, we have three stations on the Ohio equipped with data sondes that measure pH, temperature, conductivity, turbidity and chlorophyll-a," said Youngstrom. The third is located at John T. Myers Locks and Dam near Uniontown, Kentucky. "We're starting to get more use of telemetry systems."

Data from the Turner CDOM sensor are aiding another project looking at mercury in the Ohio River. Since CDOM measurements are a good surrogate for methylation — the process that makes mercury bioavailable to organisms in the river — ORSANCO scientists can use them to model where fish and other aquatic animals are more likely to absorb mercury. The work depends on levels of mercury found through the routine, discrete sampling efforts.

"By collecting mercury samples from one day to the next, we are building a relationship between the CDOM and mercury levels," said Youngstrom.

Moving forward, the agency will continue its work tracking and maintaining the health of the Ohio River, and may even add a few new monitoring initiatives. Coming out of its June commission meeting, one of three annually, ORSANCO officials say they have lots of things in the works, including new dissolved oxygen monitors, remote telemetry stations and efforts to support setting nutrient limits requested by the EPA. DK

# REAL-TIME BEACH MONITORING

With more water to worry about than just its famous waterfalls, the Niagara Region is shifting to real-time beach monitoring to keep swimmers safe.

BY JEFF GILLIES

The Niagara Region of Ontario has more water going for it than its famous falls. Between Lake Erie to the south and Lake Ontario to the north, the regional government tests more than 25 public beaches to ensure the water is safe for swimmers.

But when public health officials learned that gaps in the standard testing protocols could lead to unsafe beaches being left open or safe beaches kept closed, they put a plan in motion to join the shift in beach science towards more timely predictions based on real-time water quality data.

The Niagara Region's issues were part of a growing recognition that the "persistence model" of monitoring for E. coli — an indicator of harmful pathogens in swimming water — isn't always adequate.

Photo: Doug Nguyen

"We sample today and kind of assume that whatever the result is going to persist the next day or for future days," said Glen Hudgin, environmental health manager with Niagara Region. "If we get a good result on yesterday's sample, that means the water quality is going to be good for another week until we sample again. And certainly that's not the case."

The regional government gets its beach testing mandate from the province of Ontario, which has a minimum standard of testing beaches using that model just once a week. Hudgin said they tried testing some beaches every day to see how E. coli levels fluctuated, and the results suggested they weren't providing the best service to beach-goers.

"We discovered that there were lots of days where there would be spikes in E. coli that we didn't catch in time because of the lag in getting reports back from the lab," Hudgin said. And those spikes would lead to closures the following day even though E. coli levels had fallen back.

The Region may have a solution in predictive modeling, a beach monitoring method that's catching on in the United States and has been recommended by the U.S. Environmental Protection Agency. It relies on real-time water quality and weather data collected by sensors that are sometimes installed directly on the beach and in the water. Customized computer models take in those data and generate a prediction of E. coli levels.

A "Nowcast" system in use across several U.S. Great Lakes cities is a prominent example of predictive model beach advisories at work. In 2013, the U.S. Geological Survey reported progress on models for dozens of beaches in Ohio, Wisconsin and Illinois. The City of Chicago expanded a predictive model pilot program to all 24 of its beaches shortly after that.

Like the Chicago system, the Niagara Region's predictive models use data from weather stations and water quality buoys installed at the beaches. The buoys are equipped with YSI 6600 multi-parameter water quality sondes collecting data on water temperature, turbidity, total dissolved solids and wave heights. Hudgin said they experimented last summer with SonTek Argonaut-XR current meters for velocity measurements but found that their location within the surf zone led to them getting turned over in bad weather or buried in sand.

The data collected by the buoys every fifteen minutes is radioed to weather stations on shore. Sensors there measure wind speed and direction, rainfall, relative humidity and solar radiation. Both the water quality and weather data are transmitted from there via satellite to an online data management system.

So far, the agency has buoys and weather stations in Lake Ontario at Lakeside Park in Port Dalhousie, and Lake Erie at Long Beach in Wainfleet and Crystal Beach in Fort Erie. They chose those beaches based on how prone they are to E. coli fluctuations and their popularity. Fort Erie beaches are especially popular, Hudgin said, attracting both Canadian and American tourists.

The models for the Niagara Region beaches were originally based on data from other locations as they waited for information from their own sensors to accumulate. The models are still under development and aren't yet accurate enough for the agency to base their beach closures on, but they plan to post results from both the persistence model and the predictive model on their website this summer, Hudgin said.

"We're collecting a tremendous amount of data," he said. "We haven't nailed it all down yet, but as we continue from year to year to collect this data, we feel that we're going to get better and better at understanding what's going on." JG

**THE NOWCAST SYSTEM** *is a predictive beach monitoring method that relies on real-time water quality and weather data from equipment installed directly on the beach and in the water. The modeling system is catching on in the U.S. and is currently used across several Great Lakes cities.*

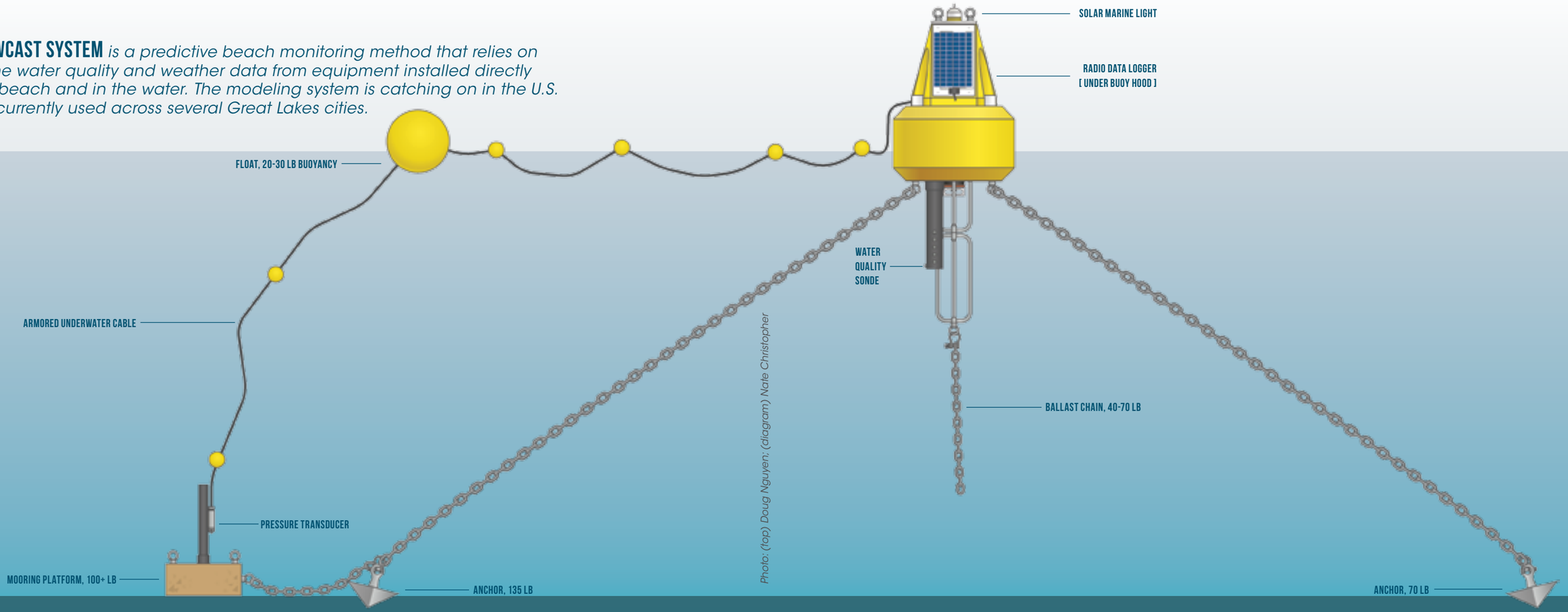



Photo: (top) Doug Nguyen; (diagram) Nate Christopher

# SCALING MOUNT EVEREST'S WATER WOES

**Trash, human waste left by Mount Everest tourists dirties water downstream. Ball State scientists measure the impacts and try to clean things up.**

BY DANIEL KELLY

Nepal's Mount Everest is a wonder to behold. Sitting at more than 29,000 feet, many attempt to summit it each year. And though some climbers don't make it to the top, all of them have an effect on the mountain's ecosystem.

What's more, say scientists at Ball State University, the quantities of trash and human waste they leave behind are having disgusting effects on water quality downstream. At the bottom of Mount Everest, there are Sherpa communities too poor to afford water treatment plants and their members often drink untreated water straight off the mountain.

"You can find almost every kind of waste. Everything from water bottles, batteries, cans, toilet paper," said Kirsten Nicholson, professor of geological sciences at Ball State. To ease the problem, she notes that the Nepalese government has built rubbish bins, facilities to hold waste and even sponsors trash pick-up drives.

But the efforts have yielded little for communities who have to drink the runoff. And the Sherpa's response to poor water quality at one source does little, as they simply move higher up the mountain to find water. New water treatment plants could help, but so could limiting the number of visitors that the mountain gets each year. But that is unlikely because of the economic impact their tourism yields.

"The local people would be fine — there's fewer than 3,000 people living in the whole region — using their existing system. And that's to use human waste on their fields," said Nicholson. "But we probably have 50,000 people visiting every year and there's no proper waste disposal. For example, there's one toilet where it drops within 10 meters of a stream."

The water quality in that waterway isn't good, says Nicholson, who is leading scientific efforts to chart the effects that visitors' waste has on the health of other streams nearby. She is working with Klaus Neumann and Carolyn Dowling, both professors of geological sciences with Ball State, as well as collaborators in Nepal. These include Subodh Sharma, a professor of environmental science at Kathmandu University; Nurbu Sherpa, a community leader in Namche Bazaar village; Pemu Sherpa, a community leader in Khumjung; and a youth group from Namche whose members will help collect water samples and have found lab space for scientists to use.


*Photo: (left page) Adrienne McGrane; (right page) Kirsten Nicholson*

*A collected water sample, with its source in the background.*

*A Sherpa woman washes cloths using a town water supply near Lausasa township.*

The work involves collecting groundwater samples, taking them back to a lab and analyzing their E. coli concentrations. Researchers would like to do more investigations using DNA research techniques, but this year Nicholson and others will zero in on bacteria, pH, temperature, total dissolved solids and conductivity. They will also analyze for arsenic and other chemicals to see if they meet World Health Organization standards.
The goal is to figure out the extent of the impacts that waste from tourists has on water quality and then use those results to solve the dirty water problem, which is better or worse for some.

"Some communities have the capability to source clean, uncontaminated groundwater," said Nicholson, referring to relatively cleaner waters found deep underground. But for those who don't, getting the water they need is tough. "There are no roads, and they get their water by running hoses to springs."

The management choice comes down to drilling wells or treating the water that runs off the mountain, and the local population can't afford to do either. But the Ball State team hopes to change that, and is working to secure funding to bring in drilling equipment that would let them open up wells near the town of Kunde.

That will hopefully come after modeling work the group is looking to do that would span groundwater resources in the area. Drilling a few wells for potable drinking water could solve all of the town's water problems, says Nicholson.

"We want people to have access to clean groundwater," said Nicholson. "And the info we collect should be used as a base level to see if cleanup programs in the area are actually working. It will give the (Nepalese) government good baseline data to judge how effective its efforts are." DK

# 10 YEARS OF GLEON

The Global Lake Ecological Observatory Network is celebrating ten years of linking lakes, and more importantly, the people who study them.

BY JEFF GILLIES

In October 2005, five scientists were marooned on a mountain near Yuan Yang Lake in Taiwan. Dead-set on installing a new batch of water quality sensors, the group had ignored an incoming typhoon that washed out the only road behind them, knocking chunks of pavement the size of a garage down the cypress-covered slopes.

The scientists, some of which would go on to co-found the Global Lake Ecological Observatory Network, hiked and hitched rides until they made it back to their hotel two days later than planned. That's a simplified version of the journey, but know that it was impressive enough for one of them to write a two-and-a-half-minute song about it.

It's a symbolic story in GLEON's history for two reasons. First, they succeeded: They managed to install the sensors at one of the sites (along with others in Wisconsin) that would make up the first-ever global lake monitoring network. A network that has for 10 years now enabled internationally collaborative limnology research that repeatedly covers new ground in the discipline.

Second, the story is more about the people than the data.

"GLEON, more than everything, is people," said Cayelan Carey, assistant professor in Virginia Tech's Department of Biological Sciences. "And I think the people part is by far the most important part."

Carey wasn't on that mountain, but the network has likely influenced her career as much as any other member. As she put it, "GLEON has changed my life in a really amazing way."

As an undergrad in 2006, she helped launch the data buoy on New Hampshire's Lake Sunapee, now a prominent site in the network. She spent a year at Uppsala University in Sweden while researchers there where coincidentally installing a GLEON buoy in Lake Erken. From Sweden she could easily attend the observatory network's fourth official meeting held in Finland that year. There, a car ride with current co-chairs Paul Hanson and Kathleen Weathers led her to found the GLEON Student Association. Though the association's original aim was to improve the student experience, she said it has gone on to benefit the network's culture for students and senior professors alike.

Now Carey has her own lake station in Virginia's Falling Creek Reservoir, qualifying her for another GLEON benefit, something she called buoy therapy.

"Buoy therapy is what happens when your buoy isn't behaving," Carey said. "Buoys break and sensors get lost and computers fall to the bottom of lakes." A GLEON listserv gives them resources for both troubleshooting and commiserating. She also has her own students in the network's student association.

GLEON was right at the front of a trend in ecology towards broadly collaborative research, said co-founder Peter Arzberger. And the student association pushed researchers to think about how collaborations can be more effective.

"This was a wonderful opportunity to immerse graduate students right into this nascent organization," he said. "If science is becoming more collaborative, then scientists ought to be exposed during their graduate careers to this sort of networking."

*A team from the UW-Madison Center for Limnology deploys "David Buoy" in Lake Mendota.*

*All Photos: UW Center for Limnology*

Arzberger was among those stranded by the typhoon, the group's fifth man who stood on the lakeshore while the others took their four-person boat out to install the sensors. Those early stations let the researchers compare lakes in Taiwan and Wisconsin, leaving them to wonder: Why stop there? So he and fellow co-founders Tim Kratz, Fang-Pang Lin and David Hamilton reached out to other scientists that might be interested in sharing information about lakes gathered through emerging sensor and wireless data technologies.

The result was their first workshop in 2005 — the event that makes this year GLEON's 10th anniversary. The first meeting generated enough interest to have second and third meetings, and suddenly the group had to think about things like funding, governance and how all these international scientists could go about working together.

Funding came from the Gordon and Betty Moore Foundation and the National Science Foundation. And the system for working together that GLEON uses is one Arzberger says he hasn't seen anywhere else. It's a three-light system that assigns a green light to projects with an idea that still need collaborators and direction, a yellow light when the group is converging on who is going to do what, and a red light when the data is collected and ready for publication.

That strategy has eased the way for the network of 500 scientists and 150 lake stations to link up and conduct cross-site studies, which often produce findings that wouldn't be possible with a single-lake study. For example, a 2012 study looked at dozens of temperate lakes to show that surface area influences the relative roles of convection and wind shear for mixing within the surface mixed layer and inducing gas exchange. The smaller the lake, the more influence convection has on the mixed layer.

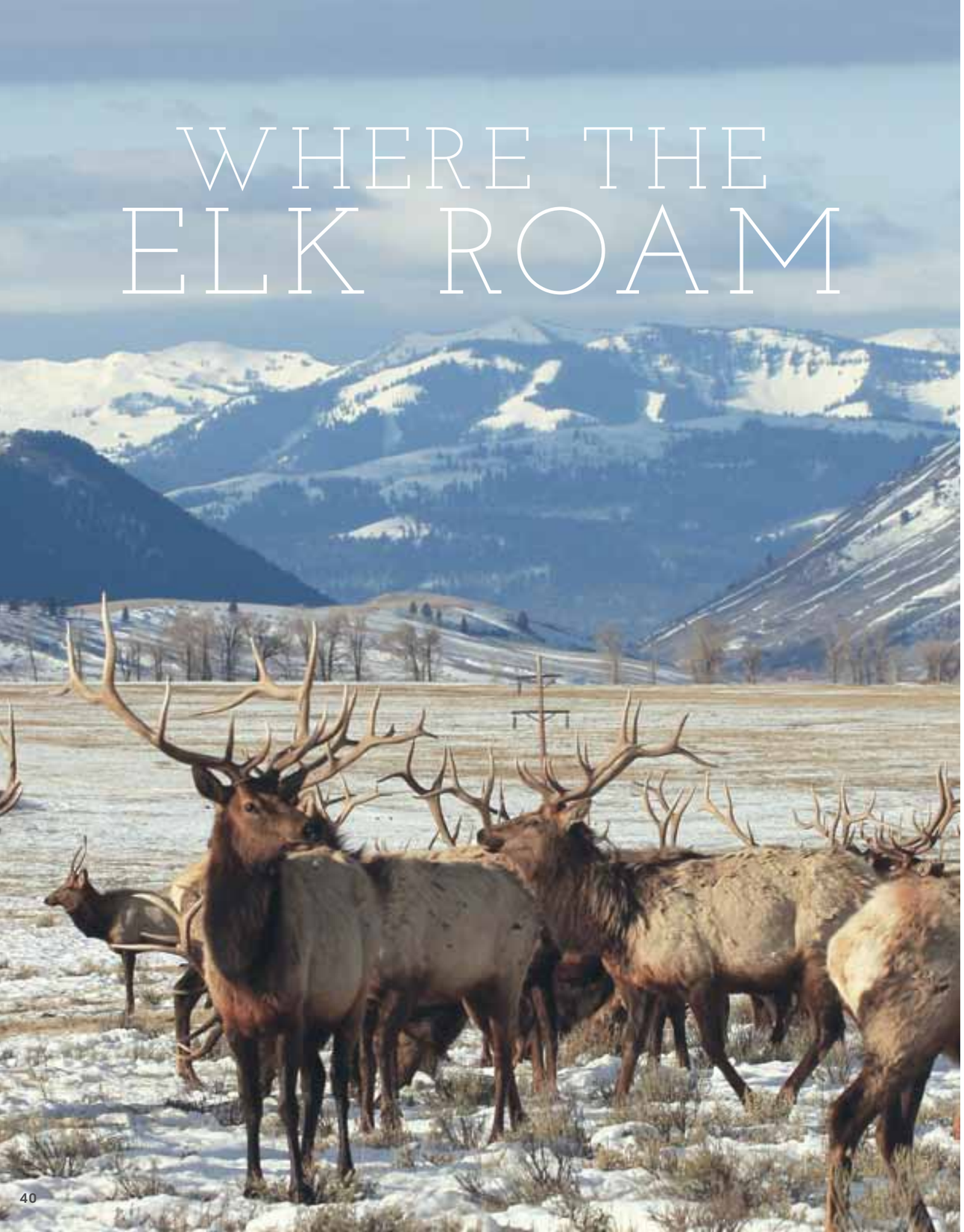
"The only way they could get to this was they had 40 different lakes with different sizes," Arzberger said. "It was one of those things that you get by pooling data. That's really where the value is, along with this open collaborative framework for working together."

GLEON still has issues to overcome, Arzberger said. Scientists still share data through spreadsheet files that have to be cleaned up so the numbers are comparable between lakes. Requiring a unified scheme for data collection isn't feasible with a grassroots network of member sites that are collecting data under different funding environments with their own data regimes. Another concern is tracking the use of shared data. Members are usually happy to share data from their sites, but their funding agencies often want to know who's using it. That could be helped by developing digital object identifiers for datasets and building an ethic among members to cite those identifiers when they use someone's data.

Social matters like that are important to GLEON, and the network's social culture will be in full swing at its 17th meeting in South Korea this October.

"Like many things in life, you start something not knowing quite where it's going to go," Arzberger said. JG

# WHERE THE ELK ROAM



**Using advanced GPS technology, researchers collared and tracked elk herds as they migrate through Wyoming's Yellowstone National Park.**

BY ALEX CARD & JEFF GILLIES

Arthur Middleton has studied migrating populations since his grad school days, but he knows it doesn't take a PhD to recognize why Wyoming attracts a certain kind of person. They're nature-lovers, he says, outdoor enthusiasts who value unspoiled wilderness — and want to live next door to the ineffable Yellowstone National Park.

But the elk that roam Wyoming are a little harder to pin down. That's why Middleton, an ecologist at the Yale School of Forestry and Environmental Science, helped lead a study to map the migration patterns of nine major elk herds throughout Yellowstone and across the state. Using GPS technology, Middleton and University of Wyoming researchers collared and tracked elk to determine how their movements impact the surrounding ecosystem.

"We've known about Yellowstone and these animals for 130 years or so, but only in the past decade and a half have we been able to actually map their seasonal migrations," Middleton said.

This capability is largely permitted by technological trends toward miniaturization. In the past, Middleton says, limited battery life prevented GPS collars from measuring more than one location per day. Without built-in telemetry, data could only be collected from the collars by physical retrieval once the collar fell off the animal.

The collars used in Middleton's study mark an elk's location once every half an hour, and transmit those data via satellite for near real-time monitoring. These advancements allow for "very, very, very detailed" migration tracking, Middleton says. When combined with historical migration information from previous research, the data paint a more comprehensive picture of how these herds' movements fit into the larger ecosystem in and around Yellowstone.

"That ability to migrate is what makes them abundant," Middleton said. "And their abundance is what sustains the big predators and the hunting economy outside of the park."

Middleton helped collar three of the nine major herds tracked in the study. The process was simple enough: Researchers meet in the morning with a game warden and helicopter pilot to establish the day's itinerary. Once a capture point is picked, Middleton helps guide the helicopter and its crew to the location. With a target in sight, a crewmember uses a net gun to immobilize it, while another jumps out and hobbles the animal before collaring it. The collared elk is then released, and the crew heads to the next capture point. The whole process happens quickly, and on a good day the crew can capture an elk every 20 or 30 minutes.

*Photo: (left) Tony Hough / USFWS; (right) Arthur Middleton*

*Researchers recaptured collared elk, analyzing nutrition and checking for pregnancy.*

Occasionally, capture points were set on or near private land, making capture and collaring a little trickier, Middleton said.

"We need to be careful about where and how we capture animals," he said. "We don't want to knock down fences, or cause any undue stir."

It took no more than a couple of days to collar a sample for a given population. Due to the elk's migratory habits, it isn't uncommon to lose a collared individual or two to a hunter if the herd strays from the park's boundaries, but Middleton says he and the other researchers see this as a routine part of the job rather than a complication.

## DISAPPEARING CALVES

Middleton has already seen the fruit that GPS collar studies can bear. He led a 2013 study of long-term climate data and GPS-collared animals that helped tease out the relative effects of drought, grizzlies and wolves on the elks' reproductive slump.

Up to 20,000 elk migrate from Yellowstone's edges and spend the summer in the park, according to the U.S. National Park Service. The strategy gives the migrators access to additional food sources over the nonmigratory populations, Middleton said.

"Each spring, they follow the green grass behind the melting snow up into their summer ranges, which are mostly inside Yellowstone National Park," he said. The tender emergent grass is easier to digest and has more nutrients. Migration is also thought to help the elk avoid predators, which tend to stick close to their den sites near the home ranges.

Not all elk migrate, but those that do are more abundant than their resident counterparts, which suggests that it's been a historically successful strategy, Middleton said. But the migrators are returning from the park with half as many calves as they did 20 years ago. In the mid-1990s, there were 30 to 40 calves per 100 cows in the Clarks Fork herd, a group of around 4,000 that Middleton followed for the 2013 study. Now the herd is down to 10 to 15 calves per 100 cows.

In an effort to better understand what's limiting reproduction in the migratory portion of the herd, Middleton and collaborators from state and federal agencies embarked on a study of climate data and the abundance of predatory grizzlies and wolves in the area. The researchers also used GPS collars to track the movements of around 100 elk and several wolves from packs that hunt the herd. They recaptured many collared elk twice a year and used ultrasound-based methods to analyze the animals' body fat and check for pregnancy.

The climate data showed that warmer temperatures have sped up the spring green-up period, cutting the time that the elk have access to nutritious emergent grass. Drought conditions in the region have also degraded habitat. Meanwhile, the grizzly population has rebounded in the park, and the bears have emerged as the primary predator of elk calves.

"We know that grizzly bears have increased by more than threefold in numbers in the summer range of our migratory elk," Middleton said. "What that added up to was fewer elk being born due to basically drought effects and forage quality on their summer range. Of those calves that did come into the world, they had much higher predation rates, particularly by bears that were removing calves soon after their birth in June."

Though the increase in bear numbers is the main contributor to the grizzlies' growing elk predation, Middleton's study found that the invasion of lake trout in Yellowstone Lake may have also played a role. Lake trout, a non-native species discovered in the lake in 1994, have taken a toll on the lake's population of native cutthroat trout. Cutthroat are an important food source to predators in the park, and lake trout are no substitute.

"Cutthroat trout used to spawn heavily in these really shallow tributary streams to Yellowstone Lake and were readily available to predators like bears that would scoop them up and feed on them," Middleton said. "Lake trout spawn down in the depths of the lake, so they're not an ecological replacement for cutthroat trout."

*Photo: Diane Renkin*

*Photo: Neal Herbert*

Bears are increasingly seeking out elk calves as an alternative meal, he said. Though the growing bear population is a bigger factor than the lake trout invasion, Middleton said its contribution is striking because it was brought on by people in the core of the Yellowstone system but has consequences for animals dozens of miles away.

"Because of migration, we can be observing some of the effects of that lake trout invasion when we look at elk that are 20 or 30 or 60 miles away from the lake in their winter ranges," he said.

The researchers used data from the GPS-collared animals to try to figure out whether wolves are affecting elk beyond the individuals that they hunt and kill. For example, some biologists have suspected that elk that spend time avoiding and looking out for wolves may do so to the detriment of their health.

Between the GPS data and field observations, Middleton said they found that behavioral responses of elk to wolves were just too small and too infrequent to seem to accumulate in a way that impacted their fat or their pregnancy.

"You turn on National Geographic or the Discovery Channel and you watch lots of predators chasing and eating lots of prey, and so we think that that's happening all the time," he said. "But how long did the photographer have to sit there and wait for that to capture that moment?"

## YELLOWSTONE'S MIGRATORY LANDSCAPE

The new elk migration tracking study is part of a larger project conducted by UW, the Wyoming Game and Fish Department and the U.S. Geological Survey. In addition to elk, the project examines population movements among moose, bighorn sheep and mule deer. Public outreach is a big goal of the project, and while some scientists are turning to social media to accomplish that, Middleton is focused on creating a traveling museum exhibit and short film about the elk's migrations. He sees "both a need and opportunity to connect with people" to better inform them about the role these populations play in the park's overall health.

While it's still far too soon to draw meaningful conclusions from the ongoing tracking project, Middleton says the studies it comprises should help answer some vital questions about the park and the animals that live there: What species sustain the Yellowstone ecosystem? Where do they go? And what ecological and landscape changes are shaping them and their migrations into the future?

"The big thrust of the project is kind of rethinking the Yellowstone as a migratory landscape," he said. "It's about the creatures that make the landscape tick." JG

# MONITORING GEAR

## Eos Arrow

Eos Arrow receivers provide quick, precise data in mapping, surveying and other GIS applications. Arrow receivers can communicate with multiple satellite constellations; offer real-time 60cm, 10cm, or 1cm accuracy; and connect to any Bluetooth-equipped iOS, Android, or Windows device. By interfacing with GPS, GLONASS and other regional satellite constellations, Arrow receivers can be used anywhere in the world. Real-time submeter accuracy eliminates the need for post-processing data and broad connectivity with nearly any Bluetooth-enabled device means no extra hardware is needed.


## In-Situ RDO PRO-X

The In-Situ RDO PRO-X Optical Dissolved Oxygen Sensor is a stable dissolved oxygen sensor designed for long-term environmental monitoring. It uses the latest technology to offer stir-independent readings and low sensitivity to interference from common water compounds. A sensor cap preloaded with calibration coefficients is easily replaced by the user, providing low-maintenance and reliable operation. The sensor easily connects to common data loggers for applications such as monitoring dam discharge or dissolved oxygen profiling.


## Thermo Dual Star

The Thermo Orion DUAL STAR benchtop meter has two input channels, making it easy to measure two things at once. The meter displays readings on each channel simultaneously and is ideal for labs with high throughput of pH and ion analysis. It features software to automatically compensate for measurement conditions, meaning the meter displays more accurate results faster. Simple adjustments to the stirrer probe can be made directly from the meter and each channel supports ten stored methods, including calibration data and password protection. The DUAL STAR's memory supports up to 1000 data points.


## Airmar WX

Airmar WX WeatherStation Instruments are compact weather sensors that collect measurements of apparent and true wind, barometric pressure, air temperature and more. Different models are available for stable and moving platforms, such as buoys or boats, as well as for taking measurements of relative humidity, wind chill and GPS location. Their simple design has proven better at avoiding interference from birds or spider webs than some anemometers, in large part because of their streamlined construction with no moving parts.


## Eno Scientific Well Sounder 2010 PRO

The Eno Scientific Well Sounder 2010 PRO Water Level Meter is a portable sonic meter ideal for measuring static water levels in wells. It uses sound waves to measure water level from the top of wells, removing the need for direct measurements that can lead to contamination. The Well Sounder 2010 PRO automatically filters out waves bouncing off anything but the water, ensuring accurate level data. It has a built-in data logger to record up to 13,000 readings and can even be set up for automatic logging as quick as once per minute.


## Solinst DataGrabber

The Solinst DataGrabber Data Transfer Device connects directly to Direct Read Cables or Optical Adapters to download data from Solinst Leveloggers. It comes with a 512 MB USB flash drive and is compatible with other USB drives. The DataGrabber features a button to start data downloads and light indicators showing when the device is connected, transferring data and finished with a transmission. It runs on 9-volt alkaline or lithium batteries and is a valuable accessory for simplifying field data management.


## LI-COR Terrestrial Light Sensors

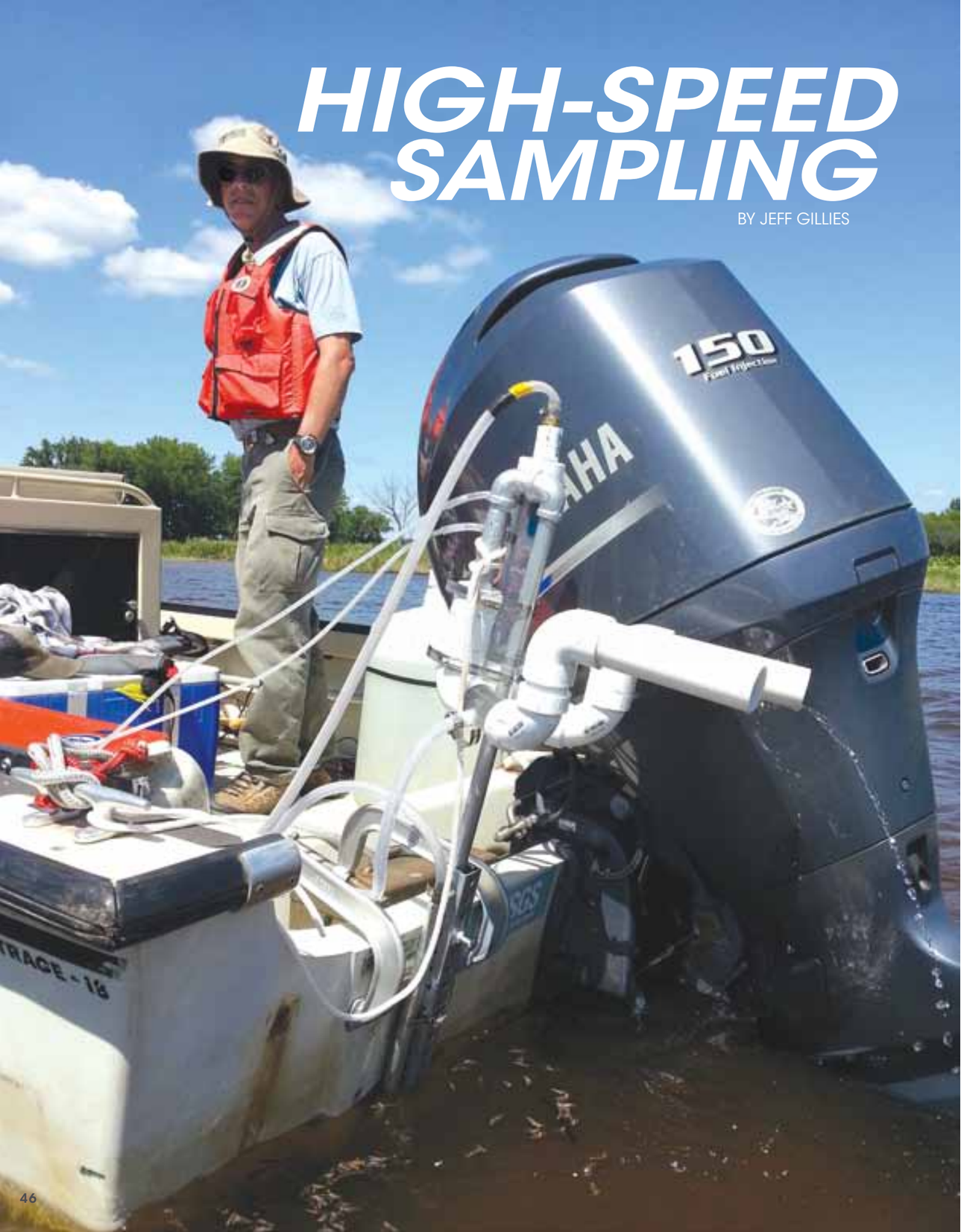
With a new modular design, LI-COR terrestrial light sensors incorporate detachable sensor heads and interchangeable cable and base assemblies. The new sensor heads are not only removable, but also feature a water-shedding design to wick moisture away from the sensing eye itself and ensure reading accuracy. The new design minimizes maintenance concerns, as it is easy to swap in new components as needed. And cost of ownership is considerably reduced because it's now possible to use multiple LI-COR sensor heads with just one base and cable assembly.


## NexSens CB-150

The NexSens CB-150 Data Buoy offers a compact and stable monitoring platform for applications in freshwater and marine bodies. The 70-pound buoy can be deployed by one person and is ideal for smaller bodies of water and short-term deployments. It features an instrument well to accommodate data loggers and batteries, and three 6-watt solar panels are integrated for charging. Pass-through holes support deployment pipes and subsurface instruments like water quality sensors and thermistor strings.

# HIGH-SPEED SAMPLING

BY JEFF GILLIES






While limnologists are well-versed in tracking how a lake or river changes at a single point over time, a new homespun, high-speed sampling rig could soon help scientists capture a snapshot of how water quality varies across a water body's entire surface.

The Fast Limnology Automated Measurement platform, or FLAMe, is a boat-mounted water intake system that analyzes surface water quality with advanced sensors while traveling "as fast as your boat can go, essentially," said John Crawford, a USGS research ecologist.

Crawford started working on the FLAMe platform while a graduate student at the University of Wisconsin's Center for Limnology, where he said his supervisors first scoffed at the concept before coming around.

"Going fast is not just because we were grad students having fun in the summer," Crawford said. "It actually serves a pretty important purpose with some of these questions that we're interested in."

Those are questions of how a lake or stream's surface water varies in chemistry or hydrology at a single moment in time. Speed matters here because the sensors need to cover as much water as possible before time becomes a factor. Daily photosynthesis cycles, for example, could significantly influence dissolved oxygen levels within a matter of hours.

By syncing the sensor data with timestamped location coordinates from an onboard GPS unit, Crawford and his collaborators have generated water quality maps for systems as small as a bog pond and as large as a Mississippi River pool. The intake is largely made up of a few hundred dollars' worth of pumps, PVC pipes, hoses and clamps, but it draws water over the same advanced instruments that limnologists have used for years in more stationary applications.

Crawford said the spatial angle is an understudied one in freshwater research, which tends to focus more on how water quality at one spot varies with depth or passing time. That's especially the case when it comes to using recent sensor technology.

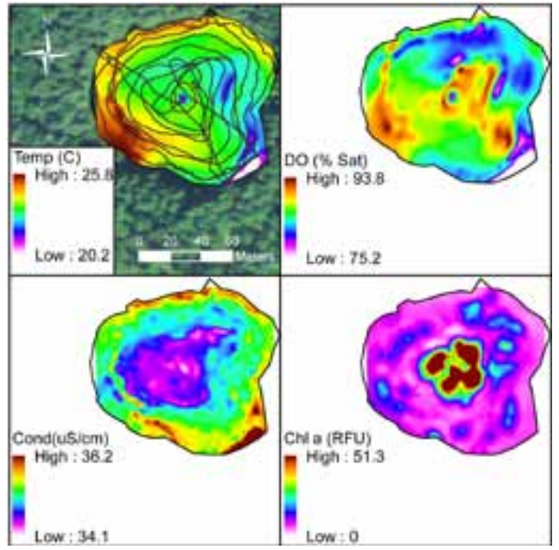
"What we're arguing is you can leverage those to go after spatial patterns as well, with a really small investment," Crawford said. "We made most of this with stuff you can pick up in the plumbing aisle of a hardware store."

A full list of components, CAD drawings and other instructional material is freely available along with a study of a few FLAMe field applications that was recently published in the journal Environmental Science and Technology. Crawford — the lead author — and his collaborators are also working with a manufacturing group to get them into the hands of more researchers.

The FLAMe system includes a low-speed setting that uses a pump to draw water to the sensors, which are housed safely on the boat. Keeping the instruments onboard and bringing the water to them felt like a safer alternative to towing them outside the boat, which Crawford said others have tried in the past.

"That's a frightening prospect in my mind, when you have such expensive equipment that you want to take care of," he said.

*All Photos Courtesy of John Crawford*




*Maps of various water quality parameters collected on Trout Bog.*

That can also keep the instrument from doing its job well. The FLAMe flow-through system, for example, is engineered to virtually eliminate bubbles that can interfere with optical sensors.

The high-speed setting uses a separate intake that relies on the velocity of the boat to force water into the system. The pump then pulls sub-samples of that water to the sensors, so the sampling rate is still controlled. The FLAMe developers have tested it with instruments including the YSI EXO2 multi-parameter sonde and Ultraportable Greenhouse Gas Analyzer from Los Gatos Research.

The study of FLAMe applications reports dissolved carbon dioxide data from Allequash Creek in northern Wisconsin, a small stream where the high-speed setting wasn't likely to get much use. They floated the creek in a johnboat Crawford said was barely big enough for the equipment and a person, who likely had to get out and push. Still, the variety in the data from the trip was impressive.

"In one day, sampling from the head to the outlet, we see as much variability in $CO_2$ concentrations that we might see at one site over the course of a year," Crawford said.

They also produced maps of nine different water quality parameters across the surface of Trout Bog, a small lake surrounded by a peat wetland. Though some of his colleagues doubted the lake would show much variability, they were surprised by distinct patterns in conductivity, temperature and dissolved oxygen. Beyond those low-speed tests, the researchers also mapped the larger Lake Mendota and Pool 8 of the Mississippi River while traveling at speeds approaching 30 mph.

"This concept and this general setup is functional for the smallest of headwater streams the smallest of lakes, all the way up to large lakes and one of the biggest rivers in the country," Crawford said.

# LITTLE BEETLE, BIG IMPACTS

**Vast swaths of dead trees killed by tiny bark beetles are leaving behind groundwater that is increasingly finding its way into mountain streams.**

BY JEFF GILLIES

The largest-ever outbreak of destructive mountain pine beetles across western North America isn't just turning mountainsides from green to red to grey as millions of lodgepole pines die off. The effects are cascading through the water cycle, as trees that once took up and transpired shallow groundwater now leave it below the surface where it eventually flows into mountain headwater streams.

Two recent studies of forested mountain watersheds have yielded new findings on mountain pine beetle effects on hydrology. One of those is a study of two watersheds in Rocky Mountain National Park, where beetles have killed millions of trees since 1996.

The beetles' recent success appears to be related to climate change. Cold temperatures once served as an important control on their populations, but the low of 30 degrees Fahrenheit generally understood to kill the beetles has become more rare, according to Reed Maxwell, professor in the Colorado School of Mines' Department of Geology and Geological Engineering.

"In a lot of places in the Rocky Mountains, if you look at any weather station you'll see that the number of years with that cold of a temperature are fewer and fewer," said Reed, co-author of the watershed study. "In fact, a lot of the stations in the areas we work in — Grand Lake on the west side of Rocky Mountain National Park — they don't have a minus-30 reading between, say, '92 and last year."

Combined with a persistent low-level drought that may be reducing the trees' ability to produce enough sap to eject burrowing beetles, Reed said the net result is a "perfect storm" in affected areas where "basically all the mature lodgepole pines are dead."

And dead trees don't use water. The study from Maxwell and lead author Lindsay Bearup, a doctoral student in the Colorado School of Mines' Hydrological Science and Engineering Program, found that shallow groundwater that would have otherwise been taken up by trees in late summer is left behind and ultimately contributes to streamflows in beetle-infested watersheds.

The fraction of streamflows made up of groundwater was 30 percent greater in a watershed with a more recent and intense infestation than a similar nearby watershed with an older and milder infestation.

"This would suggest that there's more water available in streams. This would also suggest that there's going to be more water

*Rainfall samples collected in watershed with trees killed by mountain pine beetles helped parse out streamflow sources.*

*Photo: (top left) Ward Strong / B.C. Ministry of Forests, Lands, and Natural Resource Operations; (others) Lindsay Bearup*

*Photo: Lindsay Bearup*

available in storage," Reed said. "But I wouldn't say that it's going to be a boon for water availability because it's a pretty complicated system and this is just one piece of it."

The system's complexity has made it difficult to assess the hydrologic impacts of beetle infection, he said. Studies using sap flow meters have helped resolve effects on single trees, but scaling that up to the watershed level is more complicated. This study is the first attempt to do so, according to Reed.

The researchers identified the share of streamflows made up of groundwater by first sampling rain gauges, snow pits and shallow groundwater wells across both watersheds in the summer of 2012. By using stable isotope analysis and conductivity measurements to identify each source by a chemical fingerprint, they could apportion out the contribution of each source in samples taken from the streams flowing through each watershed.

In addition to comparing two similar watersheds over the course of the same summer, the researchers were also able to look at how flows in one of the watersheds — the Big Thompson — changed throughout the course of the beetle infestation. A similar study had been conducted there in the '90s, which provided pre-beetle baseline data.

That was lucky, Reed said. Control data have been hard to come by for beetle impact studies because it's difficult to predict where the beetles will hit next. Researchers have focused on one particular research forest in Colorado for their "before" picture, but the infestation still hasn't come.

"Everybody assumed that this would be the control and have been taking tons of baseline data waiting for it to get hit by beetles, and it's not been hit," Reed said. "Other places got hit so quickly that before they could even become baseline, they were already impacted."

The study, published in the journal Nature Climate Change, follows up on previous studies that have shown an increase of organic carbon in the receiving waters of watersheds with beetle impacts.

Organic carbon is affiliated with drinking water contaminants, which treatment plants have procedures for removing. But those procedures also produce carcinogens known as disinfectant byproducts, and treatment plants are always balancing between the immediate contaminant risk with the long-term cancer risk.

A better understanding of beetle impacts on the route that water takes through the watershed could prove to be important for

*Lindsay Bearup collected water samples in the Big Thompson River.*

how water managers deal with the water quality effects of the outbreak.

"How these systems respond hydrologically has a lot to do with how carbon moves through the system," Reed said. "And so tying the hydrologic changes to the water quality changes is really important. I think that's going to be another big component."

## WATER YIELD UP SLIGHTLY

A second recently published study adds to the evidence that it's changing the way water moves across the landscape and eventually into people's homes.

"The bark beetle has a important impact on water yield. It's not just an aesthetic phenomenon," said Ben Livneh, lead author of the study and a research scientist with the Cooperative Institute for Research in Environmental Science.

The study of forested mountain catchments within the Colorado River basin suggests that around 10 percent more water flowed out of catchments with lots of beetle-killed trees compared to those with intact canopies.

Though the estimate of 10 percent is significant, it's a fairly small number weighed against the year-to-year flow variability that can be as great as 300 percent. The research also found that particularly heavy accumulation of dust on the mountain snowpacks can hasten spring melting, causing peak runoff to hit two to three weeks earlier than normal.

"From a management standpoint, those are the two big features managed for," Livneh said. "How much is coming and the timing of the big pulse coming through."

Livneh's research on the bark beetle's effects on water was a project of the Western Water Assessment, a research program designed to produce practical, usable scientific information for the West's water managers. Part of the genesis of the project was a surprising year for managers in 2010, when predictive tools told them to expect a normal amount of runoff and they ended up with much more.

Beetles and dust were both suspected causes.

"There was also a general sense in the region that the forests were changing and interest in what that portends for our water," Livneh said.

*Photo: (top left) Lindsay Bearup; (bottom left) Thomas Cooper; (right) Lance Cheung / USDA*

*Ben Livneh and Dominik Schneider make albedo measurements with an albedometer*

*Photo: Ben Livneh*

Livneh and his colleagues turned to a computer model to create a picture of what was happening in watersheds where beetles have taken out forests. He thought the complex interactions between water and the landscape were too nuanced for scientists to draw meaningful conclusions based purely on streamflow and precipitation measurements.

The researchers plugged information into the model including data from meteorological stations in each catchment, topography, vegetation and soil texture. They also used leaf area measurements from satellites as well as annual beetle damage surveys conducted by the U.S. Forest Service. The results showed the effect of the bark beetle contributed to an 8 percent to 13 percent increase in the annual water yield.

The increase in water is thought to be the result of dying trees' effects on sublimation and transpiration. When snow falls on a healthy canopy, much of it sticks to needles and branches before it can fall to the ground. The snow held aloft is more susceptible to the high winds that sublimate it into water vapor. In areas where swaths of trees have lost their needles after dying from bark beetle infestations, more snow falls to the ground where it's more likely to stick around until it melts and becomes part of the runoff. And while healthy trees take up water and transpire some through their leaves and needles as vapor during summer, beetle infestations quickly shut down transpiration in the host tree, leaving more water behind that eventually makes its way to streams.

Even if the increase in water yield produced by the model is accurate, it isn't permanent. Forests do recover from beetle infestations. With the canopy gone, more light makes it to the forest floor and saplings grow much more quickly. Livneh said that when he ran the model under a regrowth scenario, the water yield still increased, but only by about half as much. But the 10 percent yield increase is still a viable number in the early years of an infestation before regrowth picks up steam.

Livneh said a century of fire suppression has contributed to the bark beetle epidemic. Without natural fires to occasionally knock back patches of forest, trees across the West have grown old together. Stands of trees are uninterrupted by the dead or early growth areas that would otherwise serve as a natural barrier to the advancing outbreak.

"We've sort of created a condition where there are these huge expanses of mature forest that are just ripe for a big outbreak of some kind — whether it be fire or bark beetle — to rip through." JG


# Finding Offshore Bass

Fresh off a Top-10 finish at BASSfest, Bassmaster Elite Series angler Brandon Card shares his approach for finding big offshore bass.

BY BRANDON CARD

Advancements in fishing technology have more anglers searching deep water for bigger bass, and for me there are times when the only way to win a tournament is to head offshore. My approach to fishing away from the bank begins with less casting and more reliance on technology to locate fish before I even make a cast. By using my electronics, mapping technology and FishSens underwater camera, I can develop a gameplan to catch big bass in offshore-dominated tournaments.

## PRACTICE

Once I launch my boat and begin official practice during an offshore tournament, I have the mindset that I will be idling my boat and watching my electronics for nearly the whole practice. In the Elite Series, we're given two full days and a shorter day to practice. During a good offshore tournament, I'll probably spend two to three hours during the whole practice period fishing and the rest of the time behind the wheel of my boat. If I plan on fishing offshore exclusively, that means spending 12 to 13 hours just slowly driving my boat. It's tedious work, but that's the best way to cover ground and find the schools of fish that it takes to do well.

## OBVIOUS SPOTS VS. SLEEPER SPOTS

So many of the most obvious spots are community holes and just about everyone can find them. This is a double-edged sword because there will be other people fishing these places, but at the same time these obvious spots are good for a reason: They attract fish. During practice I like to idle across these spots that I know have fish just so I can see how they're positioning and then try to look for that in other areas of the lake. I keep these areas as part of my spot rotation, but also look for the less obvious — the sleeper spots.

These sleeper spots are usually ones that do not look great at first glance. The bank or bottom may be bare, or the differences on the contour changes may not be as obvious. They take more work to find, but they are an important part of my strategy to make sure I have enough fish to last for a multiple-day tournament.

## ELECTRONICS

I run three Lowrance HDS 12s: one up front and two at the console. It has definitely made a difference and allowed me to use all of the technology and view it at once.

Above the wheel I have one unit that I use for charting, 2D sonar and video with my FishSens camera. On the side I have a unit mounted on a RAM mount that is always a split screen showing SideScan and DownScan. DownScan works great for deeper schools of fish and I prefer the SideScan for shallower schools. One thing I have noticed in shallow water is that you will often spook fish as you idle over them, but if you watch closely you can see them swimming off to the sides on your SideScan as you go past them. It is very similar to the spawn, where a fish will swim away from a bed if you get too close, but they usually go right back to where they were after you move away.

## ARE THEY EVEN BASS?

There is nothing more exciting than seeing schools of fish on your graph, but what kind of fish are they? With some experience you can begin to tell what they are based on how they look and are acting, but nobody knows for sure every time. The best way I have found to see if they are bass, crappie, white bass, drum or something else is to use an underwater camera.

The FishSens SondeCAM is what I use to see for sure what fish they are because it is easy to use, is really clear and it easily plugs into the video port on my Lowrance HDS units. This is the best way to tell exactly what kind of fish they are so you are not wasting your time fishing for something you don't want to catch.

*Photo: Rob Newell*

# AFRICAN RIVER
# LIFE FORCE

**Researchers with UC Santa Barbara and Princeton University used chemical analysis techniques to find the importance of hippo dung to African river ecosystems.**

BY DANIEL KELLY

Few studies have looked at the effects hippos have on the water quality of streams. And the reason is simple: Studying near hippos isn't safe.

"It's an ornery animal to work with," said Doug McCauley, assistant professor of ecology, evolution and marine biology at the University of California, Santa Barbara, who just completed a study measuring the effects of hippo dung on the ecosystem of an African river. "When you're sampling in a stream with salmon, there's no threat that a salmon would bite you in half."

But for studies near gigantic hippos, the threat of danger is very real. So McCauley and other scientists from UC Berkeley and Princeton University were extra cautious during their time sampling in the Ewaso Ng'iro River, doing things like adjusting their sampling times to avoid hippo herds or traveling with escorts from the Kenya Wildlife Service.

Researchers' efforts charted the impacts of hippo dung by looking at its usefulness to fish and insects in the waterway. Their results are some of the few that tell of hippos' effects on ecosystems and underscore the need to protect hippo populations in decline.

Researchers began by feeding ground hippo dung to Trinidad guppies in lab tanks. This allowed them to see if the dung could serve as a food source for fish. As many aquarium enthusiasts know, guppies will eat most anything and they took no exception to the hippo waste.

"We used that information to interpret what it looked like in the wild," said McCauley. "As it turns out, hippo dung is wonderful guppy food."

The next step from there was collecting data in the field. Much of this relied on water samples from the Ewaso Ng'iro River that scientists analyzed for hippo nutrients. Combined with this were tissue studies of barbel fish, the most common in the river, as well as those from dragonfly larvae.

Chemical analysis showed that the tissues of those fish and insects were made up mostly of hippo dung. McCauley says that the findings make sense, but he was still intrigued to see the evidence encoded in the chemistry of fish and insect blood.

"What we see is this really important food that fish eat and take up biomass from," said McCauley. "Hippo dung may be an important food source for fueling productive fisheries. There is solid evidence that fish use resources derived from hippos."

Another neat find, which is part of a related research project, was the effects that water flow has on the usefulness of hippo resources. They become more or less available to creatures in the river ecosystem based almost solely on flow.

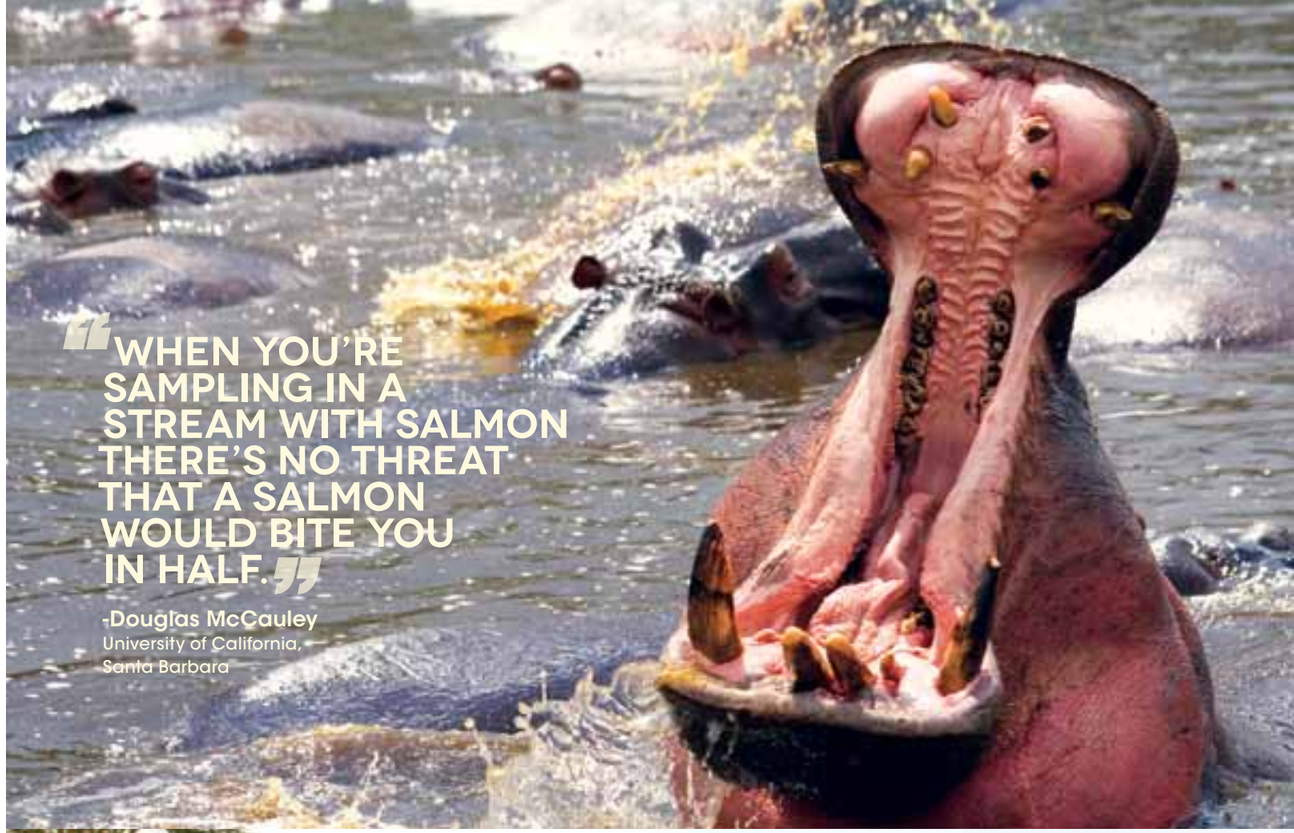
The Ewaso Ng'iro River runs perennially, McCauley says, but dries out as it moves toward Somalia. So the hippo matter can be extra food in some places, but too highly concentrated in others. Human actions, he says, are largely to blame for the river's diminished flows.

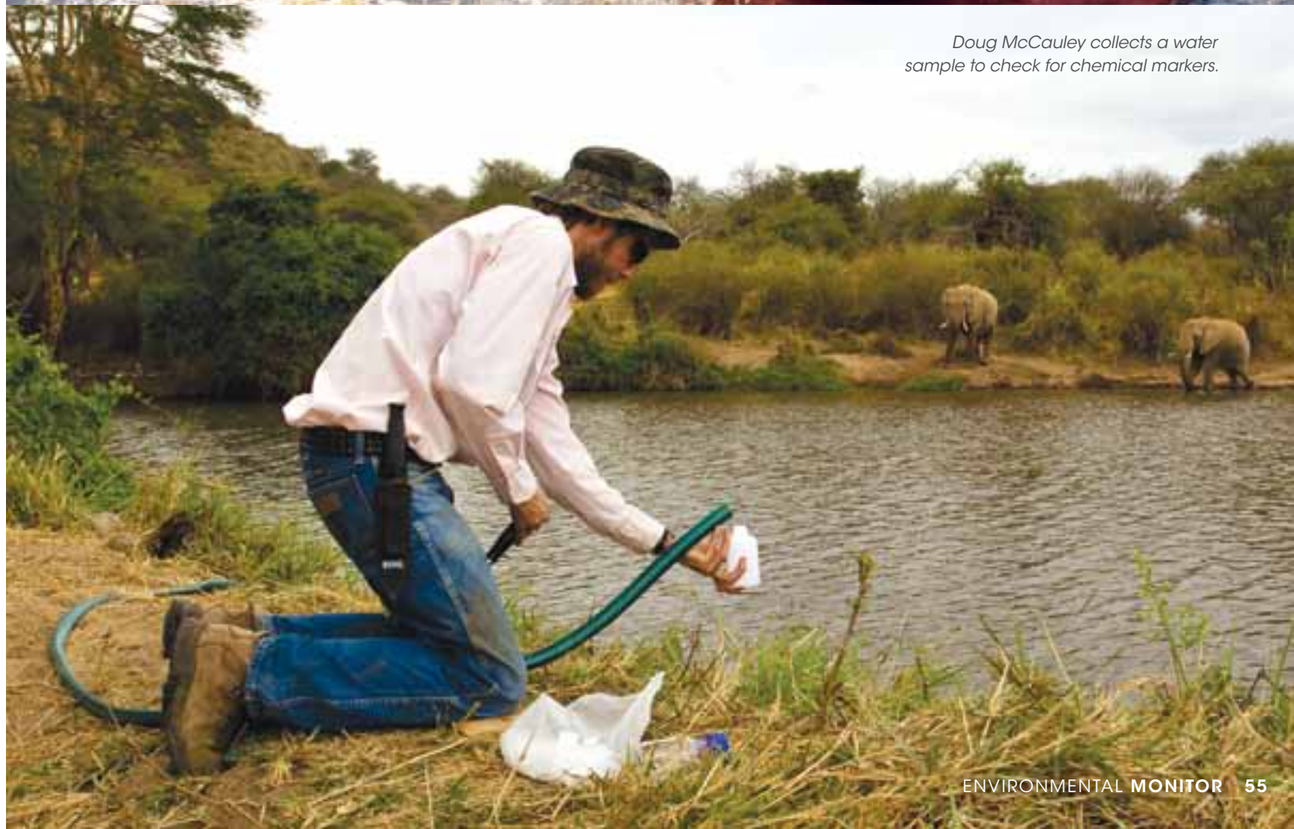
"When rivers dry up, there can be isolated pools that have too much nutrient input, the result of not enough water and too many hippos," said McCauley.

In addition to the finds on water flow and how creatures use hippo waste, McCauley says the research brings attention to a larger issue not getting a lot of scrutiny these days: declining hippo populations. Like lots of large-animal populations, hippos have been losing habitat range in recent decades. And conservationists have noted 10 to 20 percent declines in hippo numbers.

Those declines are forecast to continue, which is a huge loss to nature's biodiversity portfolio, he says.

"Beyond the obvious loss of a wonderful animal, we're losing an important biological force," said McCauley. "They fuel life in these rivers that would be lost without hippos. It raises the stakes on their declines." DK



*Doug McCauley collects a water sample to check for chemical markers.*

*All Photos: UC Santa Barbara*

# IN THE GREAT LAKES

## RESEARCH FROM AROUND THE BASIN

### SUPERIOR

Waves are a defining environmental factor in the Apostle Islands, an archipelago in western Lake Superior. The waves affect recreational boaters and ecological processes like lake trout spawning. To characterize the wave climatology of the region, scientist from the University of Wisconsin-Madison and University of Michigan hindcasted wave statistics over a 35-year period beginning in 1979. The model was validated with data from offshore NOAA buoys and Nortek Acoustic Wave and Current instruments. The model showed that significant wave heights increased within the interior of the Apostle Islands, likely a result of decreasing ice cover and a clockwise shift in wind direction. The analysis found a trend of wave heights increasing by 2 percent per year, an order of magnitude greater than an increasing trend found in a similar study of areas of the global ocean that aren't affected by ice.

*Anderson, J. D., Wu, C. H. and Schwab, D. J. (2015), Wave climatology in the Apostle Islands, Lake Superior. J. Geophys. Res. Oceans. Accepted Author Manuscript.*

### MICHIGAN

Mussel invasions have changed the distribution of primary productivity in Lake Michigan, tying up nutrients in nearshore expanses of the filamentous algae cladophora. A new study from the University of Wisconsin-Madison and the U.S. Geological Survey shows that those nearshore areas have also become a place of intensified mercury accumulation. The researchers collected water samples along a transect from the Manitwoc River's mouth out to the Lake Michigan waters overlying cladophora-quagga assemblages. The samples showed increasing concentrations of methylmercury, the bioavailable form of the toxic metal, despite the diluting effect of the incoming river water. The mercury methylation occurring in these nearshore zones was previously undocumented and could have a profound impact on bioaccumulation across these areas.

*Ryan F. Lepak, David P. Krabbenhoft, Jacob M. Ogorek, Michael T. Tate, Harvey A. Bootsma, and James P. Hurley (2015). Influence of Cladophora–Quagga Mussel Assemblages on Nearshore Methylmercury Production in Lake Michigan. Environmental Science & Technology.*

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### HURON

Thanks to an expansion of the National Oceanic and Atmospheric Administration's Thunder Bay National Marine Sanctuary in Lake Huron, scientists are gearing up for expanded work to explore the lake's shipwrecks, according to the Associated Press. Much of their work will rely on advancements in side-scan sonar. The sanctuary was recently expanded to 4,300 square miles, up from 450 in years past. The new sanctuary is nearly ten times what the old one was, and contains a lot more shipwrecks. Many of the wrecks have already been studied, but scientists estimate that there are nearly 100 out there left to be found. For those, high-definition mapping capabilities of side-scan sonar will make things a lot easier to navigate. New types of side-scan sonar have improved images of the lakebed to near photo quality.

*Associated Press. (2015, June 4). Sunken treasure: Marine sanctuary's expansion has researchers ready to explore more shipwrecks. U.S. News and World Report. Retrieved from http://www.usnews.com/news/us/articles/2015/06/04/marine-sanctuary-researchers-gain-access-to-more-shipwrecks*

### ONTARIO

During the summer, the Greater Toronto Area suffers from poor air quality driven by high ozone concentrations. Given recent research that found elevated ozone levels over lakes Erie, Michigan and St. Clair, scientists from University of Toronto and Environment Canada sought to uncover a connection between high-ozone days and the "lake breezes" set up by cooler temperatures over the lake and warmer temperatures over land. Their 3-year study found lake breezes blew into the city 74 percent of days in the May-to-September warm season, and peak daytime ozone concentrations were 42-49 percent higher at five monitoring stations on lake breeze days. On a few days selected as case studies, only monitoring sites within the lake breeze circulation pattern showed higher ozone levels, showing the relationship isn't a coincidence and the high ozone days are caused by the breezes.

*G.R. Wentworth, J.G. Murphy, D.M.L. Sills, Impact of lake breezes on ozone and nitrogen oxides in the Greater Toronto Area, Atmospheric Environment, Volume 109, May 2015, Pages 52-60*

### ERIE

Under future climates, agricultural best management practices will become more necessary to help reduce the nutrient inputs to Lake Erie. But according to a study led by scientists at Grace College, those BMPs will likely become less effective. Researchers made the find after generating simulations with the Soil and Water Assessment Tool, a modeling apparatus supported by the U.S. Department of Agriculture and Texas A&M University. The efforts focused on prominent Lake Erie watersheds because those areas had plenty of quality data to yield reliable models. For the effects of climate, scientists modeled for moderate and pronounced effects. The research shows differences in how watersheds respond to future climate changes. And different management strategies will have to be implemented across watersheds to account for that.

*Nathan S. Bosch, Mary Anne Evans, Donald Scavia, J. David Allan, Interacting effects of climate change and agricultural BMPs on nutrient runoff entering Lake Erie, Journal of Great Lakes Research, Volume 40, Issue 3, September 2014, Pages 581-589*

# Climate Insights from Caves

**Researchers found clues in stalagmites in a cave south of the Himalayas that could help better predict Central Pacific El Niño events and monsoons.**

BY CASSIE KELLY

Researchers have uncovered clues in stalagmites in a cave just south of the Himalayas that could help better predict Central Pacific El Niño events and monsoons as the planet's climate changes.

Jessica Oster, assistant professor of Earth and Environmental Sciences at Vanderbilt University, and her research group stumbled upon the findings back in February 2013. They were in Mawmluh Cave in Meghalaya, India, studying seismic activity in the region. While exploring there, they found young stalagmites which had formed in rich, "beautiful" layers over the past 50 to 100 years, Oster said. They had high concentrations of uranium, an essential element for dating the layers.

The team made a record of the Mawmluh stalagmites to help them decipher average rainfall records from Central Pacific El Niño events, which occur when there is abnormally strong warming in the Central Pacific and cooling in the Eastern and Western Pacific. By looking at the composition of the layers that make up the stalagmites, the team could determine that when El Niño events occurred, the monsoon rainfall was restricted to directly above the cave, leading to a different chemical makeup in the layer. If it was a non-El Niño rainfall, the water would find it's way in through other avenues, which they could also determine from the layers.

According to Oster and her team, data was consistent with historical information for the area. But one question still remains for the team and for the locals who depend on accurate rainfall predictions.

"What will El Niño do with global warming and the impacts on the monsoon?" Oster said. "Looking at warmer periods in the past, with this information that we have from recent past, could inform our understanding of what might happen in the future."

Monsoon prediction is critical to agriculture in India, so Oster and her team are hopeful that their research will be helpful for those who are trying to predict changes. They plan to expand on the research in many ways. Oster is currently in Berkeley, California, studying the uranium and thorium samples and has plans to look at different chemicals as well. She wants to look farther back into the past using the samples collected at Mawmluh. They also have to complete their research on earthquakes in the region.

"Having these samples in the first place was surprising and it's interesting to see where it will take us."

The research has been funded by the National Science Foundation, the Vanderbilt International Office, the Cave Research Foundation, the Geological Society of America and the Swiss National Science Foundation. CK

*Photo: Life-Of-Pix*

INDUSTRY PROFILE

Q&A

# Kathleen Weathers

Kathleen Weathers, a biogeochemist with the Cary Institute of Ecosystem Studies and co-chair of the Global Lakes Ecological Observatory Network, got involved with GLEON on the ground floor. She was working with the Lake Sunapee Protective Association when she learned about GLEON in 2005 from co-founder Tim Kratz. She helped find funding for a buoy on the lake and registered the LSPA as the first GLEON site. She answered a few questions on the occasion of GLEON's tenth anniversary.

**Environmental Monitor: In a few sentences, how would you describe GLEON to someone who hadn't heard of it?**

Kathleen Weathers: GLEON is an ever-growing group of scientists and citizen scientists who are passionate about understanding how lakes and reservoirs "work" and how they respond to change. GLEONites are enthusiastic about working collaboratively across cultures, career stages and different perspectives. Importantly, GLEON is grassroots. It is a network of people first and foremost, who are united by a mission to carry out networked lake science, education, and outreach through a process that encourages diverse leadership and initiative.

**EM: How does being a grassroots effort benefit GLEON compared to top-down observing networks?**

KW: Everyone who is involved in GLEON is engaged because they wish to be, which turns out to be a very powerful motivator for doing — and platform from which to do — innovative science, outreach, as well as for developing technologies and models. We have taken great care to structure GLEON to empower people to take leadership, to grow within the network, and to embrace diversity of all kinds — to collaborate with integrity. Ideas, data and personal connections are what power the network and its products.

**EM: What issues are you navigating as co-chair of the steering committee?**

KW: First, GLEON has achieved successes beyond our (the whole GLEON community, I believe) wildest dreams. One of the biggest challenges is to retain the nimble, dynamic and personal nature of the network as we grow. In 10 years, we are more than 500-members strong, and our all-hands meeting size has grown from 20-30 to almost 200. The second is how to maintain financial support for face-to-face meetings that are crucial to carrying out truly innovative science and generating new ideas and initiatives. This funding is some of the hardest to obtain, and underpins our success. It also is what allows us to support participation of early career scientists and colleagues (whether citizens or scientists) from developing countries. The third is the issue of accessing and supporting tools and technologies — the cyberinfrastructure — for data exploration, visualization, and sharing that is at the core of GLEON collaborations. Data and information are at the core of GLEON, yet we lack the cyberinfrastructure to readily, easily share data around the world, or visualize those data. Finally, how do we position GLEON (GLEON's people, data, and lake networks) as the go-to place for knowledge, information, innovation, and leadership about lakes and reservoirs?

**EM: Lake Sunapee was one of the sites in a multi-lake study showing the effects of Irene across North American lakes. Can you describe what that study found and how a single-lake study would have missed that result?**

KW: Not all lakes and reservoirs respond to and recover from major disturbances similarly. Major storms such as hurricane Irene, which are predicted to increase in the future, had huge legacy effects on some systems (such as the Ashokan Reservoir, Catskill Mountains, NY), that were not nearly as evident in Lake Sunapee. Lakes with large watersheds located far from the storm's path were more affected than lakes with small watersheds located close to the storm's path.

**EM: What excites you about the future of lake observation?**

KW: The ability to visualize, hear, and predict how lakes breathe and function, 24/7 365 days a year, using new tools and technologies — and to compare lakes around the world (locally based, globally relevant) is truly exciting. And, to use that information as a common language—to display and interact with the data in real time and in ways that resonate and inspire us, collectively (citizens and scientists together), to make management decisions, or create art, music, or new policy offers a remarkable opportunity.



# Lake Methane Emissions

BY ALEX CARD

Of all the heat-trapping gases in the Earth's atmosphere, none has drawn the attention of the public and policy makers like carbon dioxide. But new research enabled by advanced greenhouse gas detectors suggests that the scientific community should keep a closer eye on methane released from a seemingly unlikely source — clean oligotrophic lakes.

Using an ultraportable greenhouse gas detector, researchers from the University of Geneva conducted a study to see just how much methane oligotrophic lakes emit. According to Daniel McGinnis, author of the new paper and assistant professor at University of Geneva, aquatic systems in general have been excluded from many models that attempt to quantify methane release into the atmosphere.

McGinnis hypothesized that methane travels from lake sediment to the water's surface in plumes of microbubbles, particularly during periods of lake turnover. Although his hypothesis was deemed controversial by some of his peers, he planned a 36-hour experiment to quantify methane flux at a lake's surface.

Choosing a site at Lake Stechlin, just north of Berlin, McGinnis and his team constructed a small, floating test chamber. Tubes connected the chamber to greenhouse gas detectors onboard a small boat. Dissolved methane and carbon dioxide sensors hung off the side of the boat to monitor ambient surface levels of the gases.

The researchers used the chamber to measure gaseous flux between the lake surface and the atmosphere, and in turn the mass transfer rate of the gases. This, McGinnis said, led to a surprising find.

"What's interesting about that is you can standardize these rates and they should be the same for every sparingly soluble gas," he said. "But what we found was that the mass transfer rate for methane was significantly elevated than that of $CO_2$."

This means that not only is methane far more potent a greenhouse gas than carbon dioxide, but it's also capable of entering the atmosphere from the water at a faster rate. McGinnis ran calculations to explain the results, and found that 145 liters of gas per square meter of lake surface area would have to exchange daily to verify his observations — "and that's a lot," he said.

McGinnis and his team plan to install a research platform on Lake Geneva and establish a yearly monitoring program there. They also hope to develop an imaging system that accurately detects the microbubbles that McGinnis hypothesizes are at the root of methane exchange in lakes.

"Once we have a better understanding of what exactly is driving it, we can have a better idea of when and where this might be significant," McGinnis said. AC

*Photo: Sabine Flury*

*Photo: M.L. Ferraro*

# Millennium Falcon ROV

A new remotely operated vehicle and sensor package combination in development at the University of Washington is looking to ease operations for the offshore energy industry. Built to deliver complex monitoring equipment to the seafloor, the ROV bears the name of another famous smuggler: the Millennium Falcon.

But the ROV isn't the biggest achievement of the effort. As those involved say, the Millennium Falcon is a "dumb system" because it really just does one thing, deliver packages. The real value of the ROV is the complex box of sensing devices it can deliver to the seafloor for hooking up with energy-supplying conduits there. UW scientists are developing that too, and call it the Adaptable Monitoring Package because it holds a slew of environmental monitoring tech useful for those studying the effects of offshore energy generation on marine life.

"We were using a Saab Falcon ROV," said Brian Polagye, assistant professor of mechanical engineering at U. Washington, in explaining the ROV's out-there moniker. "And so we had to customize it. We needed a name."

One of his grad students suggested the name on a whim and it stuck. He admits that the package the ROV carries looks similar to the Rebel Alliance's X-Wing starfighters. "And we all probably like Star Wars a little too much," he quipped.

The effort began back in 2012, and scientists at the school didn't have a prototype monitoring package until the following year. Construction of the devices began the next year, and testing of the whole system got underway in 2015.

The real need for an ROV-monitoring package combo was realized even before that though, says Polagye. Difficulty of development, as well as the expenses and scientific heft needed, kept others from jumping at the opportunity to be the first to put something like it together.

"It's one of those things where now that we have it developed everybody's saying, 'That's a great idea, can we get one?'" said Polagye.

Now that the combination has been developed, this "great idea" holds huge promise for ocean monitoring efforts and offshore energy work. This is because having the ability to deploy and retrieve complex sensing devices or equipment from the seafloor means that only one underwater power conduit needs to be placed, netting huge savings for a green energy industry in its infancy.

The capability also helps researchers looking to maintain sensor performance and data accuracy because they can use it to retrieve and deploy monitoring packages more regularly. Those are big advancements over research projects of today that often send long mooring lines down to the ocean floor and then attach vertical profilers for data collection.

Photo: Applied Physics Lab, U. Washington

"My hope is that it gets used in the marine energy industry to learn more about how marine life interacts with tidal wave converters, which could make it easier to service offshore energy installations," said Polagye. "But for ocean observatories as well, just general environmental monitoring in coastal areas where it's hard to put instruments down and get them back."

The system is still in its first stage of development, but quite capable. Future versions look to incorporate cross-communication between the ROV and the monitoring package and then hopefully complete automation of the ROV by adding a computer onboard.

For now, the AMP includes an array of hydrophones for tidal and wave study; cameras that capture depth of field and width; two active sonars; and a click detector for studying marine mammals. This coordinates to turn on the cameras when a mammal is close. Researchers are also working on a Doppler profiler to measure waves. DK

# Wearable Air Sensor

Scientists studying the health effects of airborne particles around one thousandth the width of a human hair are closing in on their holy grail: wearable sensors that capture what individuals are truly exposed to.

A new study led by Patrick Ryan, an epidemiologist at the Cincinnati Children's Hospital Medical Center suggests the field is getting closer to that. The researchers tested a recently developed ultrafine particle sensor on school children, asking 20 students to wear the device for 2 to 5 hours.

"We took it out of the laboratory for the first time and actually put it on some kids that had asthma," said Ryan, who is also an associate professor of pediatrics and environmental health at the University of Cincinnati.

The Enmont personal ultrafine particle sensor, or PUFP, measures ultrafine particle concentrations once per second, along with GPS location that allows the data to be mapped. It could stand to be a little smaller and quieter, according to feedback from the participants. Though the device isn't perfect, the results show that it can capture a variety of personal exposures while holding up against the rigors of being strapped to a kid's backpack.

Photo: (top) Enmont, LLC; (bottom) Francesca Cappa/CC BY 2.0

Prior to the PUFP, the standard devices for measuring ultrafine particles were the size of a shoebox or bigger and couldn't be spun around or turned upside down. Sang Young Son, study co-author, associate professor of mechanical and materials engineering at the University of Cincinnati, and the engineer behind the PUFP, managed to shrink it down while making a measurement mechanism that isn't as sensitive to jostling. JC

# Cyberwood

Using tobacco plant cells grown in a culture containing carbon nanotubes, researchers at a Swiss engineering and technology institute have created an electronic sensor module that is at least 100 times more sensitive than the most advanced temperature sensors available today.

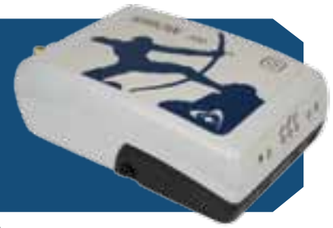
"In the past, materials scientists and engineers looked at biological materials and Nature as a source of inspiration, since many natural materials, even today, present properties not achievable by synthetic counterparts," wrote Chiara Daraio, professor of mechanics and materials at Eidgenössische Technische Hochschule Zürich, in an email. "In our work, instead of being 'inspired' by Nature, we exploit properties found in biological systems."

Study lead author Di Giacomo had examined plant and fungal cells cultivated with nanostructures, resulting in a highly conductive woody material he calls "cyberwood." New research builds upon that work, paying special attention to cyberwood's thermal properties.

"Plants are known to be very sensitive to temperature variations," Daraio wrote. "We decided to try to create materials that would 'immortalize' these properties, allowing them to persist after the plant cells died."

The "most obvious application" for cyberwood, Daraio said, is in thermal sensors of unparalleled sensitivity. These could be produced at very low costs for use in consumer electronics, such as touchscreen devices, or in advanced thermal cameras. Cyberwood also has some potential as a building material — it can be worked like wood, but is also more readily molded. AC


# Arrow



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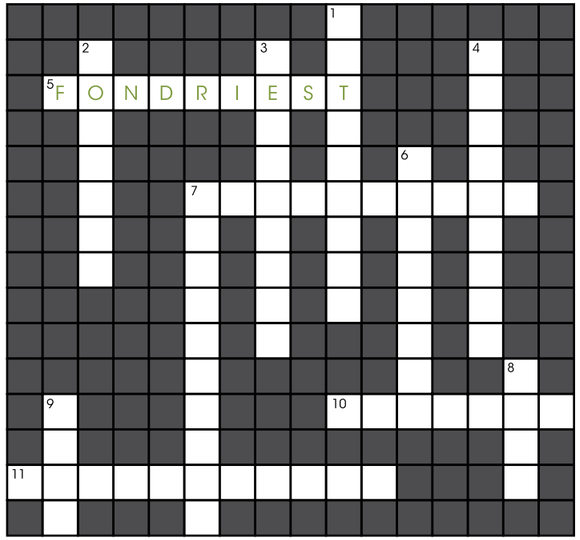
## Ohio River

**Across**

5. Where to buy river monitoring equipment
7. The Ohio River originates in _____ Pennsylvania
10. The _____ 8 satellite is used to measure the river's chlorophyll
11. The river is the largest tributary of the _____ River

**Down**

1. The river's _____ includes parts of 14 states
2. The river shapes the _____ of five states
3. Thomas Jefferson called it "The most _____ river on earth."
4. The river starts where the Monongahela meets the _____
6. Robert de La Salle was the first _____ to explore the river
7. The river's _____ feature a large rostrum
8. The USACE operates 20 _____ along the river
9. _____ mine drainage is a water quality problem in the river

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