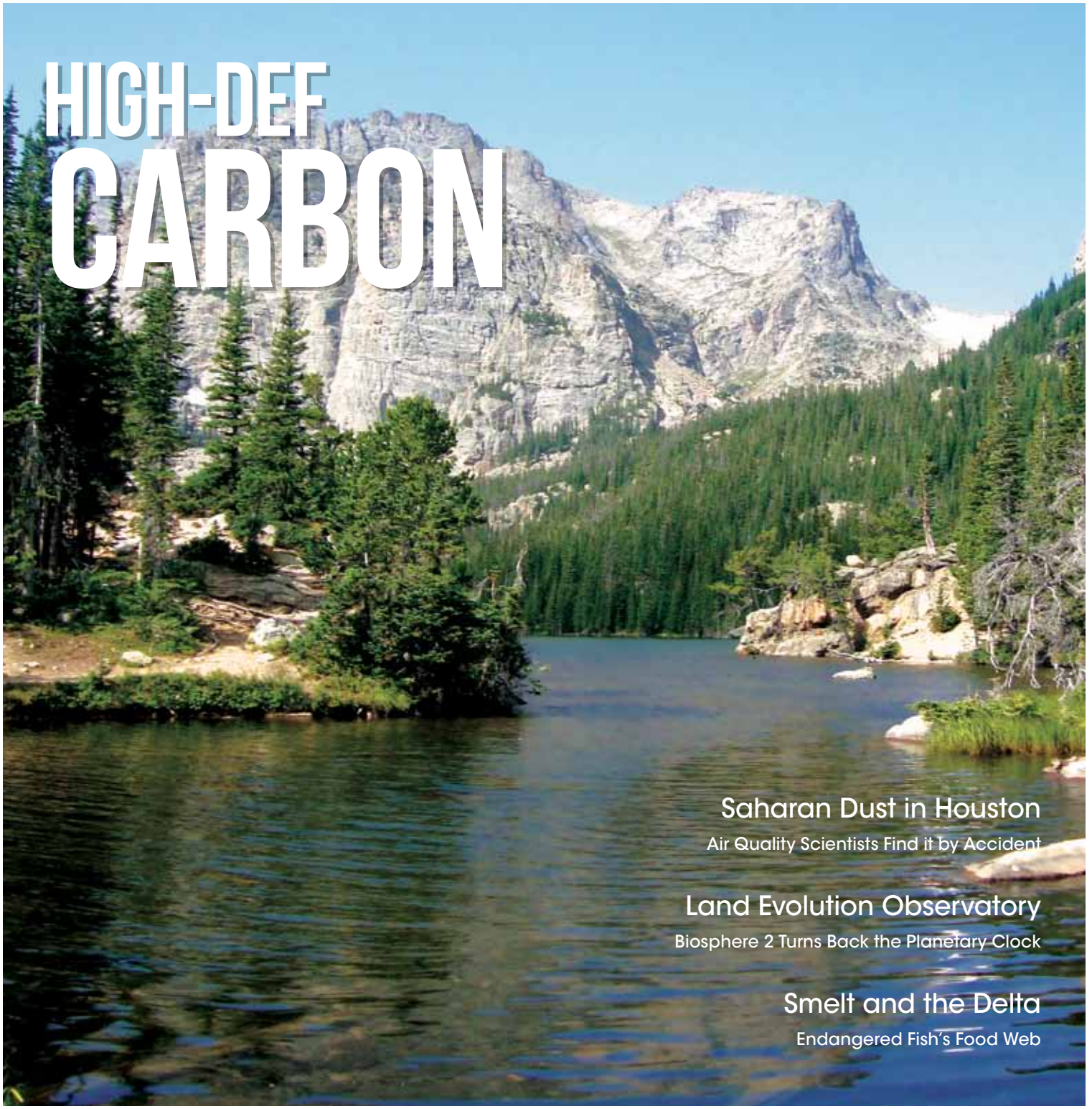
ENVIRONMENTAL
monitor
SPRING 2014
APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS



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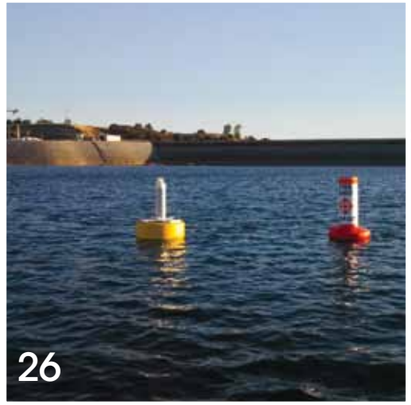

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IN THE NEXT EDITION

The Susquehanna River Basin Commission's remote water quality monitoring network tracks temperature, conductivity and more in dozens of headwater streams flowing amid Marcellus Shale drilling.

Cover Photo: National Park Service

WELCOME...

Welcome to the spring edition of the Environmental Monitor. At an expanded 58 pages, it's our biggest issue yet. We've filled that extra space with new features that bring you the most relevant and fascinating science, research and technology news possible. Turn to "In The News" for bite-sized updates from scientists across the globe. The "Web Exclusives" section has a quick look at just a few of the additional articles available only in the online edition. "In the Great Lakes" is a summary of research around the basin.

Meanwhile, we have more of the in-depth features our readers have come to expect. That includes a trip up the Rockies to Storm Peak, an atmospheric laboratory that spends 35 percent of the winter inside the clouds. We've also got the story on the OceanCube, an in-situ ocean observatory off the coast of Japan. From the cover story, we'll talk to a U.S. Geological Survey hydrologist that uses sensors to capture a high-definition picture of carbon transport in Rocky Mountain National Park.

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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Sensor data give early warnings of ecosystem tipping points

Big shifts in ecosystems — say, from a food web made up of native species to one dominated by invasives — can happen quickly and with relatively little warning. But a new study shows that intensive data provided by environmental sensors could help give managers a heads up for impending tipping points.

"The research is in a fairly early stage," said Ryan Batt, a graduate student at the University of Wisconsin-Madison's Center for Limnology and lead author of the study. "But I think in the long term we'd hope that it could contribute to being able to better anticipate these big changes and take action accordingly while the cost-to-benefit ratio for mitigating environmental impacts is still really low."

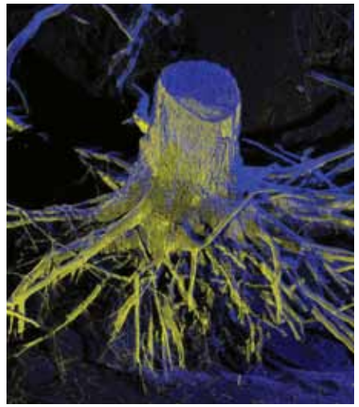
The method for predicting the approach of ecological thresholds has mostly been a focus of theoretical and laboratory research. This study, published recently in the Proceedings of the National Academy of Sciences, is an important step towards applying the tools in real ecosystems.

Grand Canyon temp studies seek humpback chub habitat

The deep, cool waters of Lake Powell feed the Colorado River below the Glen Canyon Dam in northern Arizona. Downstream, where the river flows through the Grand Canyon, water temperatures that once reached summertime highs of 86 degrees Fahrenheit before the dam was built are now capped at around 54 degrees.

The dam's effects on temperature, sediment and flow regimes have taken their toll on the native fish community that adapted to the conditions in the canyon, especially a peculiar looking chub with a fleshy lump behind its head.

"The humpback chub, being on the endangered species list, is a driver of a lot of the work in the Grand Canyon," said Robert Ross, a hydrologist with the U.S. Geological Survey's Grand Canyon Monitoring and Research Center. That work includes several temperature surveys in search of seasonal pockets of relatively warmer water that the humpback chub depends on for spawning and juvenile development.



A few Sierra Nevada firs give clues to fate of species

Somewhere in California's Sierra Nevada mountains, a single white fir tree is generating data that could help predict the species' fate as it responds to climate change.

The tree, dubbed Critical Zone Tree 1, is threaded with sensors measuring its sap flow and the volume of water sucked up by its roots and emitted from its canopy as vapor. It's named for the Southern Sierra Critical Zone Observatory, one of twelve such observatories across the country that peer into the thin layer of earth and atmosphere that sustains all life.

In the Sierra observatory, there's a particular interest in how the range's various tree species will respond to projected changes in temperature and precipitation. Before researchers can project the effects on an entire species, they need to zoom in on an individual member. Critical Zone Tree 1 will help measure the response of a single white fir.

Photo: (top) Ryan Batt; (center) Arizona Game and Fish Department; (bottom) Southern Sierra Critical Zone Observatory / UC Davis

IN THE NEWS

Buoy tracks great white sharks near North Florida beaches

University of North Florida researchers are tracking great white shark travel patterns near some northeastern Florida beaches, according to the Florida Times Union.

Many great white sharks have been tagged by scientific groups over the years. The researchers are monitoring the sharks with sensors that detect signals emitted from the tracking tags. Each sensor has a distinct signal which can be paired to a shark on record.

Sensors will be deployed off buoys in three areas near Jacksonville, Fla. and one area off the shore of St. Augustine, Fla. All the sensors will be placed within a half mile of the shore as many great white sharks pass near the shore during travel.

Last year Ocearch, a non-profit research group, detected a 16-foot great white shark traveling through the Jacksonville Beach surf zone.

Source of seemingly endless Arctic snow investigated

Researchers at Michigan Technological University are looking into extreme snow in the Arctic, according to a release from the school. Snowflakes require a speck of dust or another base to form around, but it's unclear why it continues to snow in pristine areas after dust particles have been cleared from the air.

To investigate, the researchers are using data on Arctic clouds to develop models of how snow forms. The clouds have been studied extensively and the Arctic is an area known for long periods of extreme snowfall. But instead of only considering dust particles for snow formation, the models allow for snowflakes to form around other particles.

With this modification, researchers say extreme, seemingly endless snowfall can be explained. They note that these other particles provide bases for larger snowflakes because they stay in the atmosphere longer, allowing for more ice crystal build up, before falling to Earth.

Massive canyon found under West Antarctica ice

Using imagery from NASA's MODIS satellite, researchers from the United Kingdom have discovered a new feature beneath West Antarctica's ice, according to National Public Radio: a valley larger than the Grand Canyon.

At first they didn't believe the data, but the explorers admit it was an exciting moment when the new ravine was confirmed. They say the valley will give clues to how the ice sheet performed in past climates.

Present-day ice sheets are changing extensively around coastal fringes. By studying the massive glacier-formed valley, the researchers say it may become easier to predict changes to come.

Great Lakes only U.S. region to gain wetlands

A federal report released in November 2013 indicates that the Great Lakes region was the only one to see an increase in its total area of coastal wetlands, according to the Associated Press. The results are likely due to restoration efforts in the region.

These efforts include new levees, canals and pumps to regulate water levels. Fish passageways are also being remediated in efforts to make better homes for wildlife and limit the spread of invasive species.

While the rest of the United States saw a loss of 360,720 acres of wetland area, the Great Lakes region saw an increase of 13,610 acres. The losses represent 1 percent of total wetland in the U.S. The greatest losses were seen along the Gulf of Mexico, where wetlands have been damaged by flood-control projects and over-development.

Seismometers capture crowd activity at Seattle Seahawks game

Seismologists at the University of Washington and the Pacific Northwest Seismic Network have installed earthquake sensors at the Seattle Seahawks' CenturyLink Field, according to a release.

The sensors captured seismic activity generated by the crowd during a playoff matchup between the home team and the New Orleans Saints on Jan. 11. Along with capturing some undulating wavelines, researchers installed the systems in less than a day, simulating a "fire-drill" procedure that is carried out following significant earthquakes.

Data recorded during the game have been posted online, along with analysis by the researchers. Installation of the two strong-motion seismometers added to an existing station at the stadium.

Greenhouse gas 7,100 times more potent than CO_2 discovered

Scientists at the University of Toronto and Ford Motor Company have discovered a new greenhouse gas, according to a study published in the journal Geophysical Research Letters. They say that the new gas is 7,100 times more powerful than carbon dioxide over a 100-year span.

The new gas, named perfluorotributylamine (PFTBA), does not occur in nature. Though it is much more scarce in the atmosphere than carbon dioxide, researchers say it takes a full 500 years or more to decompose, so each molecule has a compounded potency.

The researchers measured its concentration in the Toronto air and found it to be at 0.18 parts per trillion, far from the current atmospheric CO_2 concentration, which is near 400 parts per million. PFTBA is used in many electrical applications, such as making transistors and capacitors, according to The Guardian.

Mussel backpacks monitor mollusks' filtering capabilities

University of Iowa researchers are gluing electronic monitoring "backpacks" to the shells of river mussels to learn more about the creatures' filtration capabilities, The Gazette reported.

The backpack sensors measure gape, or the opening and closing of the shell. By measuring gape, the UI researchers can determine how much algae the mussels are filtering. Each backpack costs about $100.

Waterways with large mussel populations tend to be cleaner than those without, but pollution and dredging have severely affected the mollusks' numbers across Iowa and other states. The researchers plan to use their gathered data to gain support for habitat restoration in the state.

Landsat 8 satellite records coldest temperatures on Earth

The new Landsat 8 satellite, operated by the U.S. Geological Survey, has charted a temperature of minus 133.6 degrees Fahrenheit, according to a release from NASA. The temperature was recorded on the East Antarctic Plateau and is only a few degrees shy of the world's record low.

The coldest temperature ever recorded was minus 135.8 degrees Fahrenheit, recorded near Antarctica's Dome Argus in August 2010. The lowest temperature of 2013 was recorded at a location nearby, coming in at minus 135.3 degrees Fahrenheit.

NASA officials say the temperature data is an example of the new satellite's capabilities, including its thermal infrared sensor. The instrument was designed for measuring temperatures at the extremes and assembled at the Goddard Space Flight Center.

Wind-propelled sea drones complete 2,000-mile journey

An unmanned, wind-powered watercraft successfully navigated over 2,000 miles last month in a test of its seaworthiness, Businessweek reported.

Developed by Saildrone, the SD1 unmanned watercraft arrived in Kaneohe, Hawaii in early November. It left San Francisco 34 days before, traveling through gale winds and storms on its way across the Pacific.

The SD1 will eventually be used as a research platform and will monitor oceanographic conditions and marine life for the National Oceanic and Atmospheric Administration. The craft can be fitted with sensors and other instruments, and will use a two-way satellite to transmit data to and from Saildrone headquarters.

Saildrone has no immediate plans to market the SD1, and said the company is currently in the research and development phase.

Stained River

A band of stained water flowing out of the Caloosahatchee River into its estuary along the Florida Gulf Coast this summer was among the most visible signs of stress brought on by abundant controlled releases from Lake Okeechobee into the river. The releases from the lake, which feeds the Caloosahatchee, were a flood control measure during Florida's record rainfall in 2013. The colored dissolved organic matter shades out the estuary's seagrasses that shelter juvenile crabs and fish.

Photo: Sanibel-Captiva Conservation Foundation

The River Mile

In Central Washington, an initiative to introduce kids to bona fide scientific research has earned some students of Waterville Elementary a surprising honorary distinction.

"Their fourth grade students are the world's leading experts in the short-horned lizard of the Columbia Plateau," said Janice Elvidge, education specialist for the Lake Roosevelt National Recreation Area, a park in eastern Washington operated by the National Park Service. "They have GPS tagged those critters up on the plateau so they can locate and track them."

Elvidge is the "staff of one" behind The River Mile, an education program designed to get students participating in real-world scientific inquiry around the Columbia River Watershed. Student research efforts at Waterville served as a model for the fledgling River Mile program, which the school now participates in along with another 20 school districts across the state of Washington.

The goal is greater than just getting kids outside for the sake of being outside. Research has shown improved academic performance from students involved in field investigations, Elvidge said, whether it's as simple as habitat observation or something more advanced.

"We know that students doing even some of the basics of that, they're scoring 30 percent higher on state science testing," she said. "It's really important, that engagement in the field." JG

Place-based Learning Course

A geology course at Westfield State University in Massachusetts is looking beyond bedrock and soil profiles, asking its students to explore their personal connections to familiar landscapes. The course, titled "A Sense of Place," is taught by Tarin Weiss, an associate professor of chemical and physical sciences. Students pick a place that has been important to them that will be the focus of scientific and creative investigations.

Weiss prepares students — some science-majors, some not — for their scientific investigations by covering a wide variety of topics in class, from plant diversity to groundwater quality. Students also get hands-on-experience taking soil cores and temperature measurements as well as plot sampling for plant species. The course readings — along with guest speakers, artists, musicians and faculty from other departments — help students think about how they can creatively represent a sense of place around their location. Projects for this part of the course have included music, photography and poetry.

The course is part of a larger place-based education movement that emphasizes teaching students about where they live, not just far-flung places across the country or globe. Investigating the scientific and cultural aspects of places closer to home helps them engage as local citizens.

"Trying to plug them into issues within their communities where these places exist is another goal of the course," she said. JG

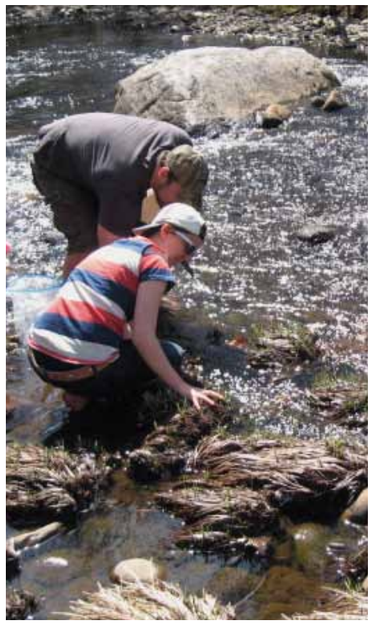


Photo: (top) National Park Service; (bottom) Tarin Weiss

Soil Remediation Class

Kansas State University professors transformed a plot of land from a problem to a classroom, teaching students on the fly to remediate nutrient pollution.

Saugata Datta, an associate professor of geology, and Nathan Nelson, an associate professor of agronomy, taught students to evaluate, sample and remediate land using Kansas Department of Health and Environment protocols.

Datta's geology students collected soil cores and contracted drillers to dig groundwater sampling wells based on land gradient and likely groundwater flow. They sampled wells for pH, salinity, dissolved oxygen and temperature with a water quality sonde. They found three out of four groundwater testing wells contained nitrate levels above the U.S. Environmental Protection Agency's drinking water standard.

Once all the groundwater data were collected, Nelson's team of students started analyzing soil quality to formulate a cleanup plan. Following in-depth analysis, they recommended a combination of excavation and planting trees to absorb contaminants.

Nelson said it will be several years before the phytoremediation process reaches its full potential. Future classes will be monitoring groundwater to keep an eye on the nitrate levels and the effectiveness of the phytoremediation.

The experience has been invaluable, Datta said. He mentioned that several students list the project on their resumes and bring it up with possible employers during interviews. AV

Drained Lake Study

With the help of a dried-up Pennsylvania lake and a slew of monitoring tools, university students are learning about the effects of damming on an understudied shale watershed.

Along with five researchers from Penn State University, Colorado School of Mines and Colorado State University, students in a PSU geochemistry class monitored water levels, stream discharge and water quality at the drained Lake Perez.

In 2008, problems with a nearby dam resulted in the draining of the man-made lake, leaving little more than a trickling stream and a ghost town of vacant docks and grounded watercraft. As part of the Susquehanna Shale Hills Critical Zone Observatory, students and faculty began researching watershed hydrodynamics in September 2013.

Sullivan and crew instrumented Lake Perez and its watershed to monitor groundwater levels, barometric pressure and streamflow. The students and faculty also collected water chemistry data. As might be expected in a geochemistry course, the study examined a number of soil factors, including gamma radiation, mineral composition and taxonomy.

The research will help determine the influence of damming on surface and groundwater. As the dam is expected to be repaired and the lake refilled later this year, the researchers will have a chance to obtain a before-and-after report of the lake and watershed. AC

Photo: (top) Jeanna Walters-Francella; (bottom) Penn State University

SALTY WATER, FRESH DATA

After historically sparse monitoring efforts on the Great Salt Lake, the USGS is helping to usher in a new era of intensive data collection

BY JEFF GILLIES

The fishless, hypersaline waters of the Great Salt Lake in Utah don't always engender the greatest enthusiasm for the system amongst the residents along the Wasatch Front.

"Joe Citizen is going to come up and say, 'It's a worthless system. There's no need to even care about Great Salt Lake," said David Naftz, a research hydrologist with the U.S. Geological Survey. "That's kind of the attitude you would get from 80 percent if you polled the people that lived around the lake and the Salt Lake Valley."

But the millions of migratory birds that stop to refuel on that lake's simple food web of flies and shrimp beg to differ.

"It's a bird resource of hemispheric importance," Naftz said. "They're stopping and they're getting energy on the Great Salt Lake by eating the brine flies and the brine shrimp that are relatively easy pickings for them."

The birds are fattening up on a lake with no outflow, a massive surface area that makes it the sixth largest in the United States and with a salinity three-to-five times saltier than seawater. Add to that a list of anthropogenic influences including mining waste and 90 percent of Utah's treated sewage effluent, and you've got a system that behaves unlike any other coping with an increasing contaminant load. To better understand how the lake functions and responds to human-caused stress, the USGS is coordinating monitoring efforts that will help equip managers with unprecedented data.

Though some of the agency's most advanced monitoring initiatives on the lake have gone into place within the last five years, they've operated a lake elevation gauge there since 1938. By taking observations documented by the region's early pioneers, USGS scientists have back-calculated lake levels to make a long-term record that goes back to the late 1800s.

Since it's a shallow lake with no natural outflow, water levels are particularly important there.

"The lake elevation just drives so many chemical processes in the lake," Naftz said. "Because the shoreline gradients are so low in that system, a one-foot drop in lake level can expose thousands of acres of sediment."

More recent monitoring stations are helping researchers understand how a dense layer of saline water moves across the lake bed and potentially distributes contaminants. Much of that is dependent on a railroad causeway built in the 1950s that splits the lake into north and south arms. Since 90 percent of the freshwater inflow enters the lake's south arm, the north arm is much saltier, saturated to the point that salt crystals fall out of solution.

Completing installation of the LakeESP platform.

> "...IT'S CREATED THIS KIND OF PERMANENTLY STRATIFIED LAYER THAT HAS SOME PRETTY INTERESTING CHEMISTRY GOING ON."
>
> **-David Naftz**
> U.S. Geological Survey

The difference in densities between the two arms causes water to flow through a constricted breach in the causeway, which has important effects on the structure of the water column in the south arm.

"You actually get this density-driven flow that's coming from the north arm that's diving under the less-saline part of the south arm, and it's created this kind of permanently stratified layer that has some pretty interesting chemistry going on," Naftz said.

That chemistry includes mercury concentrations in the lower layer that rank among the highest ever measured by the USGS lab where they were analyzed — a lab that sees samples from all over the country, Naftz said.

The USGS monitors the stratification with a Lake Environmental Sensing Platform first moored in the south arm in 2010. The platform supports a string of sensors that measures temperature at 15 depths and specific conductance at three depths. The conductance sensors are suspended near the bottom of the lake and along the interface of the deep brine layer, which tends to line up with the thermocline. That means the researchers can keep an eye on the brine layer by measuring the temperature profile every minute.

Watching the contaminated brine layer is particularly important during sustained wind events that can lead to mixing with the fresh layer, which has implications for how mercury moves through the system.

All Photos: U.S. Geological Survey

"It is a very dynamic system when you get some of these seiche events, and you can get some vertical mixing at that density boundary," Naftz said. "At least our hypothesis is it can move some of the methylated forms of mercury up into the more biologically available water in the lake where it's more available to the brine shrimp."

The USGS is also monitoring how water flows through a fault-related, spillway-like structure on the lake bottom south of the causeway. Naftz said high-density water moving through the breach builds up behind the 2-kilometer-wide spillway until a disturbance like high winds sends the dense water over the edge and farther south into the lake. A series of acoustic Doppler velocity meters installed along the structure in 2012 has captured flows of up to a half-meter per second.

"When it's a 2-kilometer wide structure, you're moving quite a bit of salinity and other nasty things across that spillway into the more southern portions of the lake," Naftz said.

The flow data at this spot is especially valuable for managers because the railroad company responsible for the causeway is considering building a second breach. The acoustic instruments will provide a before-and-after picture of how the dynamics of the system have changed.

In another study, the agency released dye into a tributary and tracked its spread with an AUV. The data showed that the inflow remained in a thin layer on the surface and moved across the lake quickly. Within an hour, Naftz said they had already detected dye more than a kilometer offshore. The results suggest how inflow from mine discharge could distribute contaminants across the lake.

The Great Salt Lake's unique water chemistry, geology and human influences have created a system where conventional limnological wisdom doesn't go very far. The sensing platform, spillway flow stations and other monitoring efforts across the lake are helping to foster a new era of scientific understanding.

"Until the last 10 years, there hasn't been much work on the lake with respect to limnology," Naftz said. "Just about anything you do or any monitors you put out has likely never been done before." JG

Seepage meters measure groundwater inflow.

Photo: Florida International University

WALL OF WIND

Florida International University's Wall of Wind generates 160-mph gusts to test hurricane-safe buildings

BY DANIEL KELLY

In 1992, Hurricane Andrew made landfall on South Florida with winds gusting up to 170 miles per hour. The storm inflicted $26.5 billion worth of damages in the state. Scientists responded by advocating for improved wind research to reveal what had happened and minimize such extensive damage in the future.

The key question: how can structures be designed to better survive hurricanes?

A team of engineers at Florida International University came together in the early 2000s to design a wind-generation system that could be used to study structure resiliency. Their initial prototype had two fans and propelled wind speed of 120 mph. Fast forward a decade and their original design has become the basis for what is today the Wall of Wind, a one-of-its-kind facility generating maximum wind speeds of 160 mph that is improving structure designs and answering other important questions in hurricane research.

The facility is similar to a wind tunnel in that flow conditions can be controlled and different wind profiles can be introduced.

"Natural winds have a profile and turbulence," said Peter Irwin, professor of practice for the Wall of Wind. "We want to make sure that we impact whatever we're testing with the right kind of wind."

So triangular segments at the front end of the wall help curve wind where it needs to go. Turntables downwind support test structures so scientists can consider different wind impact angles.

The Wall of Wind, which was built in 2012, has blasted trees, roof tiles, solar panels, silos and bridge segments since it began operating. A variety of other structures have been scaled down or tested at full scale depending on research needs.

"Anyone who's interested in the effects of wind, rain as well, to see how it infiltrates can use the Wall of Wind," said Irwin.

Their findings are aided by sensors that pinpoint wind effects and dynamics. Pitot-static tubes help measure the wind velocity. Holes drilled within the structures themselves are connected to pressure transducer systems that measure wind pressures. Strain gauges also help track the wind's toll.

"Load cells, which are kind of like little hockey pucks, are put on points in structures to measure the forces at that point," said Irwin.

Other sensors include cobra probes, which are small sensors that instantly measure rapidly fluctuating wind velocity and direction. Accelerometers help record the vibrations in structures, which Irwin calls "test specimens." Of course, there are video cameras to capture the destruction. The facility is also equipped with devices to measure displacement.

All the tech goes into making structures more efficient, Irwin says, and more likely to withstand a hurricane. Designing structures from the ground-up instead of retrofitting them makes them more stable and saves money over the long term.

"It's a well-equipped facility, probably the fastest facility of its type. It's open to testing to anybody," said Irwin. "Our only goal is to allow everyone — society — to build more resilient structures." DK

Digital FieldBook

BY PHILIP FLYNN

Though a digital revolution is changing the way scientists collect data, it's unlikely those advancements will ever completely supplant good old pen and paper. But anyone who spends some time with NexSens' new Digital FieldBook certainly won't miss the days of losing pens, running out of paper or making sense of an unkempt notebook.

The FieldBook's user-friendly interface lets users store observations, photos and manually-entered data alongside automated data from a web-enabled NexSens data logger. It's easy to organize and simplifies collaboration among members of research teams.

The FieldBook supports custom forms, which help tailor data logging and tracking to a particular monitoring project. Users can select from multiple fields including text, numbers, notes and customizable lists. The parameter field allows the user to specify what type of data is being entered along with the unit of measure. This allows the user to take samples with any sensor and manually enter them into the FieldBook.

This virtual notebook is a new feature of WQData LIVE, an advanced web datacenter designed by NexSens to accommodate any data monitoring application. WQData LIVE users can now manually enter data, notes or images while in the field. Because the FieldBook is tied into the web datacenter, manually entered data and automatic data streamed from a logger can be viewed, manipulated and compared side by side.

Each WQData LIVE project can support an unlimited number of FieldBooks. This means that every member of a research team can have his or her own virtual notebook for easy collaboration.

Other WQData LIVE features include web applets, public portals, site maps, data sharing and photo galleries. The datacenter's device-to-web integration makes it possible for a web-enabled data logger to stream data to the cloud, where it's accessible from any PC or mobile device with a web browser.

WQData LIVE's report feature gives the user many options for displaying data in a concise, easy-to-digest manner. A typical report contains a data table and an infographic generated using logged data or data from the FieldBook. Reports can also be customized to display multiple parameters, condensed data and information from preset time ranges.

NexSens provides a basic version of WQData LIVE for free. Professional and enterprise plans are also available. Learn more at www.WQDataLIVE.com. PF

OpenROV

An open-source project to produce affordable remotely operated vehicles is opening up underwater exploration and monitoring to scientists on a budget

BY AUSTEN VERRILLI

The OpenROV team tested a prototype in Hall City Cave — the site of a rumored stash of stolen gold.

Photo: OpenROV

Remotely operated vehicles are often used to explore hard-to-reach places underwater, but that doesn't mean the cost of an ROV is out of reach for would-be explorers.

OpenROV is an open-source project making ROVs available to almost anyone. "The intention of the project is to create an ROV that is low-cost and easy enough for anyone to build, but that is still capable of doing relevant scientific work and exploration," said OpenROV founder Eric Stackpole in the OpenROV KickStarter video.

OpenROVs come in user-assembled kits that cost less than $1,000. The body is made from laser-cut acrylic. All the components from the propulsion system to the internal electronics are off-the-shelf. "None of it was designed to go underwater," said OpenROV co-founder David Lang in an interview. "We just adapted it and made it work."

The project started when Stackpole, a NASA engineer working on small satellites, wanted to explore an underwater cave in Northern California. Hall City Cave is rumored to have gold stashed somewhere in its depths, hidden by Native Americans who were supposedly slain for stealing it.

Stackpole, Lang and a few other enthusiasts developed a prototype to explore the cave. The project gained a following as the team shared their progress online.

They started a KickStarter campaign to fund the project with the hope of creating a product many people could use. They asked for $20,000 over the course of a month in the summer of 2012. They promised donors of $775 or more an OpenROV kit. By the end of the donation period, the team had $111,622 in donations.

With new-found capital, the team continued to move forward. More programmers, engineers and enthusiasts came onboard to donate their expertise to the ROV's operating system code and system design.

"It's moving quickly," said Lang. "And the best part about it is it's really adaptable."

The OpenROV uses an Arduino Microprocessor, which has a large following in the world of open-sourced tech development. It's commanded by a tiny Beagle Bone Black Linux computer, which costs around $45.

Lang said programmers knew users would like to add their own computing functionality to the ROV. They left plenty of space on the Beagle Bone for users to program functions and add in hardware.

To pilot the ROV, users connect it to their computer via an Ethernet port. A web browser interfaces with the ROV via its IP address. The keyboard controls movement. A web camera allows users to navigate through the deep.

OpenROV was designed with payload space for sensors, samplers or additional attachments. Between the ROV's battery compartments, four threaded rods can be attached to hang sensors.

Dedicated users on the OpenROV website constantly share developments in wikis and a web forum. Discussions range from technical to outright fun. One can pick up a discussion on combating invasive lionfish or critique the latest code update for the communications system.

People have been using OpenROVs for everything from scientific instruments to toys. Its affordability allows researchers in impoverished nations to conduct habitat surveys and do underwater exploration.

The ROV is rated to dive up to 100 meters, though so far it has only been tested as deep as 20 meters. OpenROV is 30 centimeters long, 20 centimeters wide and 15 centimeters tall. It weighs approximately 2.5 kilograms and is neutrally buoyant once submerged.

It can move through the water at approximately 1 meter per second. Battery life lasts about an hour and a half.

The ROV typically takes a few days to assemble and is exploring soon after, though like any good project there's always some tinkering that has to be done.

Lang said now the OpenROV team is working to keep up supply and watching for user developments. "At this point, we're really just watching the community," Lang said. "We're going to watch and to learn and to listen because the users are the best indicators of what this technology will best be used for." AV

LANDSCAPE EVOLUTION OBSERVATORY

Biosphere 2 observatory turns planetary clock back to zero to study surface changes

BY AUSTEN VERRILLI

In early 1991, researchers were locked into Biosphere 2, a 3.14-acre experimental environment. They were left to survive within the indoor elements and successfully lived for two years with minimal outside intervention. By 1995 the indoor ecosystem could not sustain itself by recycling air and water within the facility. Biosphere opened its doors and windows to let in fresh air and new ecological research.

Biosphere's sealed earth experiment became extinct, but over the years the facility evolved into an indoor environment research station sealed under 7.5 million square feet of glass.

When the University of Arizona took over the massive indoor Earth in 2007 the science department wanted to optimize their unique resource. "We were challenged by the dean of science to come up with an idea and experiment that was totally new and could only be done at Biosphere 2," said Peter Troch, science director of Biosphere 2.

After much discussion among professors and researchers across disciplines, the department decided to use the Biosphere to look back at two fundamental components of the earth's landscape: soil and water. While many events have shaped the earth, much of the riverine landscape was sculpted and transformed by rain running over and through the soil. It forms landscapes called hillslopes leading into rivers.

The science team decided to add on to Biosphere 2, creating the Landscape Evolution Observatory, so they could simulate how hill slopes evolved from the beginning.

"What if we could go back to time zero?" Troch said.

Hydrologists have been studying and modeling the evolution of landscapes for years, but this will be the first controlled, large-scale, long-term experiment to look at the evolution of a hillslope.

All Photos: Paul M. Ingram / Biosphere 2

Three new additions in Biosphere 2 house massive troughs. Each sits on a 10 degree angle and is 11.25 meters wide and 29.60 meters long.

The troughs hold mineral-rich volcanic basalt that is one meter deep. The volcanic emission was chosen as researchers think it most closely resembles material that formed Earth's landscapes and eventually became soil as we know it.

Above the troughs, sprinkler systems simulate precipitation. Researchers will monitor infiltration of water into the soil and its movement beneath the surface. They expect that it will act as a catalyst for physical and chemical changes to the volcanic basalt. "We will see significant weathering and formation of clays," said Troch.

A wide variety of sensors are implanted in the soil to measure changes in soil chemistry and water flow characteristics.

Ten highly sensitive load cells beneath each giant trough continually track the weight of the soil and water inside.

Nearly 500 soil and water potential sensors are in each hillslope. "These measure the pressure of water at local points and are important for determining the direction and velocity of water movement and can indicate the onset of water-stress for plants," said Troch. "They measure pressures that are less than atmospheric pressure, indicative of water that is under suction due to capillary forces in the soil."

Each slope also contains about 500 soil water content sensors and water samplers. Vaisala carbon dioxide sensors will measure carbon dioxide shifts in the soil.

Other sensors include 34 vibrating piezometers in the soil, which measure water pressure greater than atmospheric pressure. "It basically allows us to see if there's a water table developing in the soil or not," said Troch.

Nearly 1,000 soil-temperature sensors monitor temperature gradients in each slope. Water and gas samplers give researchers the ability to grab samples on demand. Tipping bucket gauges track runoff from the slopes.

The entire experiment will run for about 10 years. It will begin by watching the weathering and development of soil. Then the researchers will add seeds to the hillslopes to see how plants affect water flow, retention and soil.

One hillslope is fully operational with sensors deployed in and above the soil. Researchers are using it as a starting point to determine how to finish preparing the other two for long-term experimentation. They plan to start long-term simultaneous experiments for all three this summer.

Troch said researchers spent a long time modeling and designing the experiment before building the slopes. Still, there is uncertainty as an experiment at this scale has never been performed.

He said one outcome he hopes to generate is interest and participation among the scientific community. AV

SAHARAN DUST

Scientists weren't aware of the impact of Saharan dust on Houston air quality until Shankar Chellam accidentally measured it

BY JEFF GILLIES

The petroleum refineries and other industries concentrated around Houston give air quality regulators there plenty of local pollution sources to keep track of. Meanwhile, scientists are helping them keep a closer eye on a surprising, far-flung source of particulate matter: dust from the Saharan Desert.

It's not news that dust from arid North Africa escapes into the atmosphere and is redistributed hundreds to thousands of miles away, but research on the phenomenon has focused mostly in its influence on geology and climate.

The effects of Saharan dust on urban air quality in other continents has been less understood until recently. One reason for the increased attention in Texas is a 2012 tightening of federal air quality standards that reduced the acceptable concentrations of airborne particulate matter. If states violating the standard can show that some portion of the pollution came from sources outside of their regulatory control, it won't count against them.

The stricter rules make parsing the sources of pollution and their relative contributions all the more important, according Shankar Chellam, professor of civil and environmental engineering at the University of Houston.

"Now the state is investing and is interested to know essentially all the sources," Chellam said. "Every speck of dust, they want to know where it came from."

Chellam and his colleagues have developed a method that not only detects Saharan dust in local air samples but also quantifies its contribution to total particulate matter levels. The results of their first attempt were recently published in the journal Environmental Science and Technology.

Their method should improve upon past efforts, which have mostly relied on satellite images of airborne plumes crossing the Atlantic. The problem with that approach is that it doesn't quantify the amount of dust in the areas that matter most. The images are limited to identifying dust high in the atmosphere and can only show whether the dust was present, not how much is there.

"That's where we come in, because our measurements are at ground level," Chellam said. "We sample the air that people actually breathe, not just the air that is 2 to 6 kilometers from the earth's surface."

Chellam came into Saharan dust research mostly by accident. His past research focused on identifying the chemical signatures for specific sources of air pollution like petroleum refineries and motor vehicles. By collecting samples and analyzing the levels of around 40 metals, he and his collaborators can develop an elemental profile for each source.

While collecting data on Houston's industrial pollution sources in 2008, they found certain days showed increased levels of particulate that couldn't be tied to any industrial sources. Their chemical analysis of the particles from those days seemed to signal it was from a natural source. They turned to satellite imagery and found a plume of Saharan dust had indeed made its way to Houston.

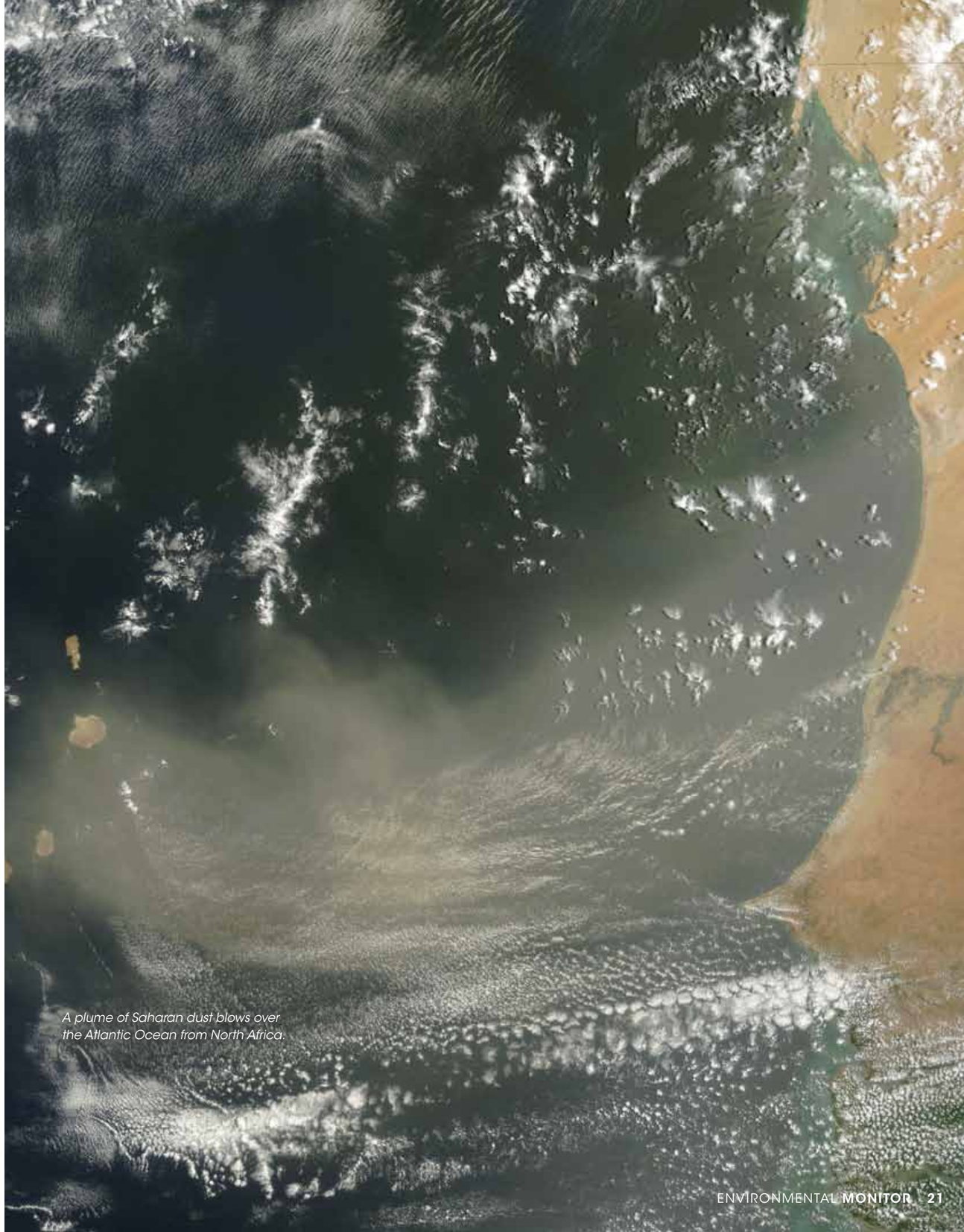
"Our sampling that was done in Houston was not at all based on the Saharan dust," Chellam said. "It was an accidental discovery that this impacts Houston at this great extent."

Once the researchers knew they were dealing with Saharan dust, they turned to an air sampling station on Barbados maintained by Joseph Prospero, emeritus professor of marine and atmospheric chemistry at the University of Miami. Prospero has used the station there to study the geologic and climatic effects of Saharan dust. It was an ideal place for Chellam's group to gather a sample that had crossed the Atlantic but hadn't yet mixed with the industrial and natural dust of the continental United States.

The researchers then developed an elemental fingerprint for the Saharan dust and plugged it into a model along with the signatures for refineries and other local sources. The results show that, for three days in July, sand transported to Houston from North Africa made up more than half of the particulate matter pollution at the sampling sites.

So far the researchers have only applied their method to the samples from the 2008 Saharan dust event, though the results were consistent across several sampling sites in Houston and two categories of particulate matter. Chellam said their next step is to secure funding to analyze more events and prove that the method is robust and can be applied universally.

"I believe that our method can separate the various sources carefully," he said. "We can provide that information to the regulator, and they can do what they need to do." JG



A plume of Saharan dust blows over the Atlantic Ocean from North Africa.

Photo: NASA

KING COUNTY

Spanning lakes and a sound, this county's monitoring program punches above its weight

BY JEFF GILLIES

MARINE

King County's water quality monitoring in Puget Sound began in the 1960s as an attempt to make sure the municipal wastewater discharges weren't degrading the habitat. It has since grown into a multifaceted and high-tech monitoring initiative that rivals the breadth of some state programs.

The county has collected near real-time, high-frequency data since 2008 when it partnered with the Seattle Aquarium to host two moored water quality sondes. The instruments, both YSI 6600 EDS, measure temperature, conductivity, pressure, dissolved oxygen, turbidity, pH and fluorescence every 15 minutes. A weighted pulley system keeps the sondes at relatively fixed depths, with one around 1 meter below the surface and the other 10 meters below.

The Point Williams buoy carries another sonde, and two more are installed in inner Quartermaster Harbor. These are mounted to pilings and remain stationary as depth changes with tides. This allowed their pressure sensors to detect a rise in the water's surface after the 2011 tsunami that devastated the Japanese coast. Kimberle Stark, a marine biologist with the county's Department of Natural Resources and Parks, was surprised to see an effect so far away.

"The water level rose about two to five centimeters. It doesn't sound like a lot, but it was actually quite large," she said. "The water was sloshing around for like three days, and that mooring picked it up, which was amazing."

It was also useful to scientists. Stark said the data will help efforts to predict the effects of future tsunamis on the sound.

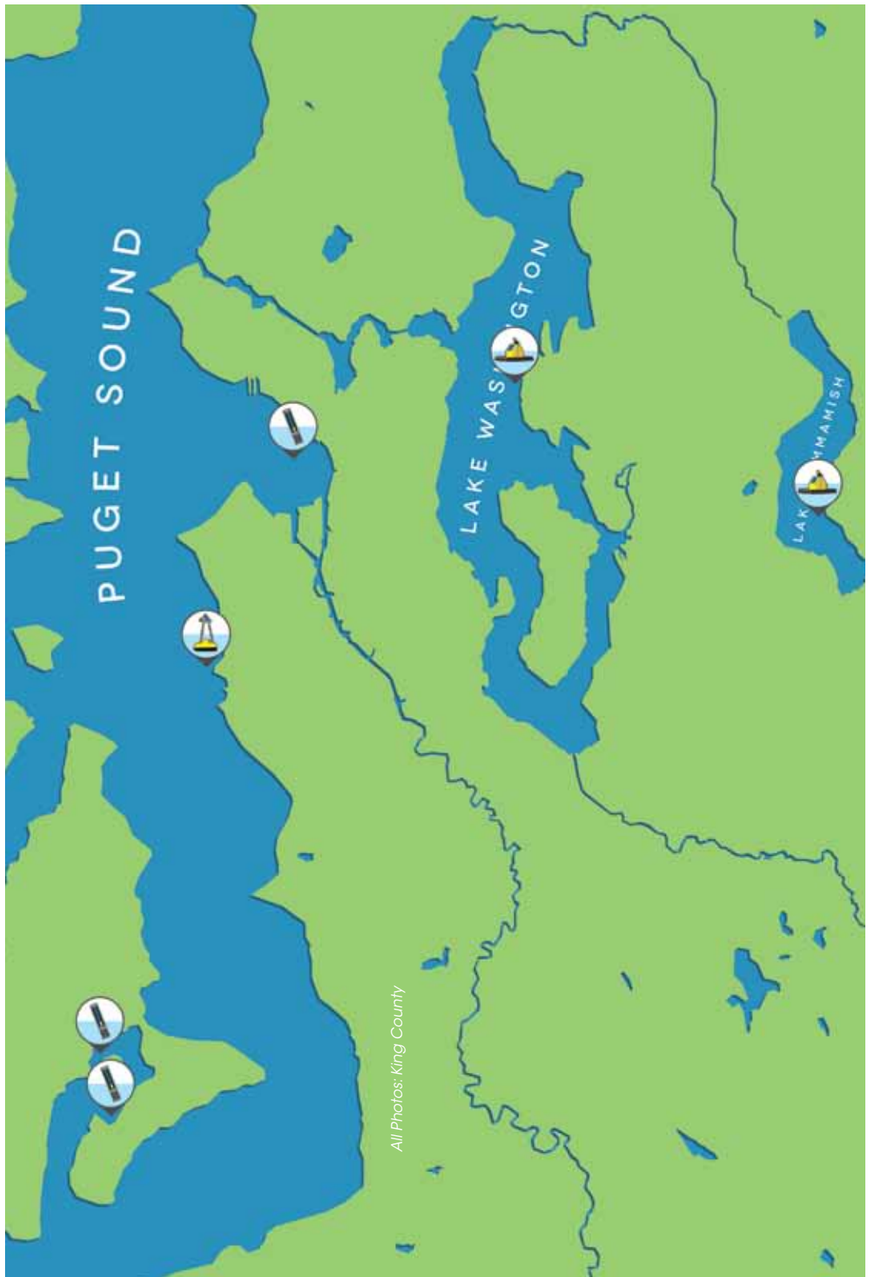
Intense biofouling on multi-parameter sensor.

While the monthly data are important, the high-frequency data from the moorings have helped the county take a closer look at processes that occur on a shorter time scale. For example, the instruments revealed dramatic 24-hour swings in dissolved oxygen that Stark said were unexpected. In the summer months, the sondes in Quartermaster Harbor were detecting DO levels above 20 milligrams per liter, which amounts to more than 200 percent saturation. At night, the levels would drop below 2 milligrams per liter, approaching hypoxia.

"Even though the sensor is very very good, I didn't believe the numbers," Stark said. "We actually had one of our lab guys go out and take a sample as early in the morning as possible, especially when we were having those high numbers. Sure enough, they were saying there were bubbles in the water it was so supersaturated."

The lows, meanwhile, only last around six hours.

"So at least mobile animals can move away if they need to go to areas with higher oxygen," she said. "But we are going to be paying attention to make sure those lows don't linger any longer than that." JC



All Photos: King County

LAKES

King County is home to some of the state's largest lakes and borders much of the central basin of Puget Sound.

"The story about Seattle is that we have a lot of traffic problems because we're squeezed in on all sides by water, practically," said Curtis DeGasperi, a hydrologist with the county. "The I-5 corridor skirts through between Lake Washington and the sound."

But traffic jams aren't the locals' only connection of the region's aquatic backdrop. And if the public's enthusiasm for the real-time data published by the county's water quality monitoring programs is any indication, the relationship is mostly positive.

The county operates profiling platforms on lakes Washington and Sammamish. The data is published live on the county's website. Program staff hear quickly whenever the data supply is cut off for maintenance or other downtime, whether it's from scuba divers on the sound or swimmers on the lakes.

"We have a group of triathletes that seem to rely on the information that's being put out there," DeGasperi said of the lake platforms. "So whenever it goes down, I end up getting emails from some of these swimmers that want to know when the system is going to be back up."

The YSI platforms measure a full suite of parameters at every meter along a vertical profile more than 50 meters deep on Lake Washington and 20 meters deep on Lake Sammamish.

The data from the platforms compliments a once- or twice-monthly sampling program that the county has conducted

Profiling platform on Lake Sammamish.

by boat since the early 1990s. Water quality monitoring on the lakes goes back another 50 years, when researchers at the University of Washington began collecting data on Lake Washington. Those long-term data showed that the lake has been warming and stratifying earlier and earlier in the year, which affects the development of a spring bloom that the ecosystem depends on for food for the rest of the year.

Even though the University of Washington data could show those effects, they were likely only sampling every two weeks, DeGasperi said. Now that the county has a system measuring temperature and fluorescence profiles every day, he said, they have a way to really pin down when the lake stratifies and the algae appear.

"These algae blooms can develop into large amounts of algae over the course of a few days, so when you're even sampling every two weeks you can miss the peak of these events," he said. "We can start to take a better look at the trends through time of the timing of the stratification and the effect on the spring algae bloom, and some of the other details that you don't as easily see if you're just going out every few weeks." JC

A HOME FOR THE WEDGEMUSSEL

High-resolution, fiber-optic temperature sensors detail Delaware River's endangered mussel habitat

BY JEFF GILLIES

A cutting-edge method for sensing water temperatures is helping the U.S. Geological Survey identify tucked-away cold water habitats in the dam-altered Delaware River that allow an endangered mussel to survive there.

Dams on the Upper Delaware River that create drinking water supply reservoirs for the New York City metro area also modify flows, sometimes leading to dramatic fluctuations in river level that can affect the species living there.

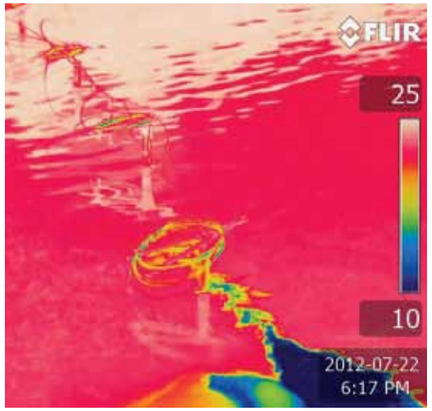
"The hydrologic regime is essentially the master ecologic variable that controls what's happening in the river," said Martin Briggs, research hydrologist with the USGS Office of Groundwater. Sometimes water levels drop low enough to expose the river bottom. "You have, essentially, a dry bed, which you can imagine is not a good situation for mussels."

The people who manage the dams want scientific information about the habitat of organisms affected by dam operation, especially for the dwarf wedgemussel, which is afforded legal protection as a federally listed endangered species. The USGS has counted the mussels — a species sensitive to water temperatures — in the Delaware since 2000. The scientists conducting those surveys have anecdotally reported colder water flowing over areas where they find mussel beds, as well as signs of groundwater seeps such as wet banks.

In an effort to confirm and quantify those groundwater inflows, Briggs and colleagues, in cooperation with the U.S. Fish and Wildlife Service, installed a high-resolution fiber-optic temperature sensing system in a place in the river where dwarf wedgemussel numbers were particularly strong. The results of the study — perhaps the first to use this setup in flowing water— identified a bankside groundwater seep that sent a plunging plume of cold water into the channel and along the stream bed where the mussels live.

Measuring temperature with fiber-optic cables was developed by the oil industry for keeping an eye on pipes, but has been adopted for environmental applications over the past eight to 10 years, Briggs said. The technology works by firing a laser pulse down the fiber, some of which is scattered back to a receiver. A portion of that backscatter is temperature dependent, which allows the researchers to back-calculate temperature measurements.

The highest spatial resolution this method can achieve is a temperature measurement at every meter of cable. That's fine for laying long lengths of cable along stretches of river, but isn't very useful for profiling temperatures in the 20- to 40-centimeter depths where the research team had identified the cold water plume.



Scientists snorkel in the river to find wedgemussels.

All Photos: Martin Briggs / U.S. Geological Survey

To get down to a finer resolution, they used a twist on the method — literally. They developed cables that could be coiled around a core, in this case a 5-centimeter-radius PVC pipe. A meter's worth of cable wrapped around the pipe placed two temperature-sensing points just 1.4 centimeters apart.

The researchers pounded five meter-long, cable-wrapped cores into the stream bed every two meters in a line perpendicular to the bank and extending out into the plume. That gave them a transect with more than 300 temperature-sensing points. Data collected at 4- and 10-minute intervals over several days revealed a plume of cold water that entered the stream and dived below the warmer surface waters.

"That was really controlling the stream bed temperatures in the upper horizon where the mussel lives," Briggs said. "Something about that inflow is likely influencing their survival."

That influence could be a matter of keeping water temperatures low enough — in this case, up to 9.5 degrees Celsius cooler than the surrounding water — to facilitate some part of the mussel's life process that is disrupted by warm water. Another hypothesis is that water trickling down from the seep could provide the mussels with crucial moisture when their beds are exposed during low flows.

Briggs said the centimeter-scale measurements made possible by the modified fiber-optic method was important for characterizing the mixing dynamics in the shallow water. It also provided the data needed by models that the researchers used to quantify just how much water was entering the stream through the seep.

The study, published in the journal Environmental Science and Technology, serves as a proof-of-concept for using fiber-optic cables for gathering high-resolution temperature data in rivers, which Briggs said hadn't been done before. It also provides quantitative data that helps cement the link between groundwater seeps and dwarf wedgemussel habitat.

"If we're going to protect this habitat, we have to know why the habitat exists," Briggs said. "That also helps us discover, potentially, more undiscovered habitat in the future." JG

DWARF WEDGEMUSSELS

With an average lifespan of around 12 years, this federally endangered species is a relatively short-lived mussel. Like most mussels, its larvae develop while parasitizing fish gills. Confirmed host species include the tessellated darter, Johnny darter, slimy sculpin, mottled sculpin and young Atlantic salmon.

FOLSOM DAM SPILLWAY

BY JEFF GILLIES

A computer rendering shows the Folsom Dam with a completed auxiliary spillway.

A construction project is underway on a Northern California dam to bolster flood protection for the Sacramento region, an area federal agencies say is among the most at risk for flood damage in the United States. An engineering firm's novel water quality monitoring strategy is helping to keep the operations on schedule while protecting the environment.

The Folsom Dam Auxiliary Spillway project is an approximately $900 million cooperative effort between the U.S. Army Corps of Engineers and the U.S. Department of the Interior's Bureau of Reclamation that will help the Sacramento region achieve a 200-year level of flood protection. Work on the project on the American River includes a new spillway that will give operators of the Folsom Dam more flexibility in controlling the Folsom Lake reservoir's level to make room for incoming flood waters ahead of storm events.

The project will involve removal and relocation of up to 1.2 million cubic yards of sediment and rock from the project area, including a significant amount of dredging and deposition of dredged material within Folsom Lake. Construction crews must meet state and federal environmental permit requirements, with a focus on water quality. Water clarity is a particular concern, and should turbidity levels outside of the project area rise above the project's Clean Water Act permit thresholds, a work stoppage would result.

Projects like this typically require manual spot sampling of water quality parameters like turbidity, dissolved oxygen, temperature and pH every four hours, according to John Spranza, senior consultant with Cardno ENTRIX, an environmental consulting firm. The firm is working on compliance issues for Kiewit Infrastructure West Co., the construction company contracted for the fourth of five phases of the spillway project.

Spot sampling is time-consuming and subject to error, both of which could be costly for a public safety project on a schedule. That's especially the case on subalpine, Western Sierra lakes like Folsom where turbidity is naturally very low to begin with, which usually makes for strict shut-down thresholds.

That could make for situations where a $235 million dollar project responsible for the flood protection of 40 linear miles downstream is held up by faulty measurements showing artificially high levels of turbidity, Spranza said.

"That could simply be a fish swimming by and kicking up some type of material, some piece of algae getting lodged in there, a cigarette butt — something that the meter picks up," he said. "It could be actual, or it could be an error."

To avoid that sort of hang-up while still keeping a close eye on the project's environmental effects, Cardno ENTRIX has pioneered what they call an "Active Adaptive Management Plan," a monitoring strategy that depends on "active" continuous water quality measurements and automated analysis of multiple instruments moored throughout the lake both upstream and downstream of the dredging site.

Three NexSens buoys moored in areas of Folsom Lake not affected by the job site carry YSI sondes that provide data on background conditions every 15 minutes. Another buoy and sonde downstream of the work area samples water under the influence of dredging operations. Under this setup, project managers can compare dredge-influenced water quality conditions against background levels to protect against false positives caused by equipment malfunctions or natural fluctuations brought on by storms or seasonal changes in lake conditions.

Data from the buoys are relayed back to a computer at the job site running NexSens iChart software, which calculates rolling averages and compiles reports every four hours and every 24 hours. The software will also send out alerts to project managers if a water quality constituent rises above a predetermined amount above background, triggering the "adaptive" elements of Cardno's management plan. Rather than immediately shutting down work, crews get a chance to check for anomalies in the data and modify project operations prior to triggering a shutdown.

"You send someone out in the field to calibrate the instruments and make sure you don't have a plastic trash bag wrapped around the monitor. We've seen little tiny fish that decided to take up residence inside of our instrument housing," Spranza said. "All sorts of stuff that's not project related but had we not had this system would have immediately stopped the project if a simple grab sample approach was used."

If the issue turns out not to be a fluke in the data, the crew gets a chance to take preliminary steps to address the problem. For example, they'll check that the sediment curtain around the dredge and deposition sites is working properly, or that there has not been a sudden change in background conditions. If they can't address the source of the water quality concern, and it is identified as coming from the project, then Spranza works with the Kiewit project team, regulatory agencies and project partners to determine if the issue can be resolved, or if the project needs to be temporarily shut down while a solution is worked out.

But that hasn't happened yet.

"When you have a robust dataset, it actually helps to keep the project moving," Spranza said. "So far we've lost zero days of work due to water quality on this project, and they're out there every day except for Sunday moving dirt."

The Folsom dam, built in the 1950s, is part of the federal Central Valley Project, a water management plan that moves water for municipal and agricultural uses from northern California to drier regions of the state through a system of pumps, canals, reservoirs and other feats of engineering. The new spillway's gates will sit 50 feet lower than those on the main dam, allowing flood-related drawdowns to begin earlier. The dam was originally built to pass up to 557,000 cubic feet of water per second. The new spillway will add the capacity to move another 300,000 cubic feet per second — more than three times the average flow rate of Niagara Falls. JG

ABOUT CARDNO ENTRIX

Cardno ENTRIX is an environmental consulting firm with 200 offices in North and South America and 300 offices worldwide. The firm offers services in water and natural resources management, liability management, permitting and compliance. Their Active Adaptive Management process was part of a Crane Valley Dam project that won an Engineering News-Record "Award of Merit" in 2013.

Rendering: U.S. Army Corps of Engineers

> "WHEN YOU HAVE A ROBUST DATASET, IT ACTUALLY HELPS TO KEEP THE PROJECT MOVING."
>
> **-John Spranza**
> Senior Consultant with Cardno ENTRIX

Photo: Mike Voellmecke

LIFE IN THE CLOUDS

BY JEFF GILLIES

Photo: Justin Broglio

At 10,500 feet above sea level, the Storm Peak Laboratory spends 35 percent of the winter inside the clouds– a great place to study their role in climate change

Perched on Mount Werner in the Park Range of the Rocky Mountains, the Storm Peak Laboratory near Steamboat Springs, Colo., is accessible to scientists in the winter via a gondola trip and two ski lifts, with stints on skis in between.

Those who have heavy equipment to haul or don't ski rely on snowmobiles or a snowcat. In the summer, it takes a ride up a rough Forest Service road in a high-clearance, four-wheel-drive vehicle.

Though the lab's remote, mountain-top location can make getting there a task, it's also part of what makes it "one the world's premier high-elevation atmospheric science laboratories," according to Gannet Hallar, Storm Peak's director since 2006.

"It really allows us, we always say, to have our head in the clouds," she said.

She means that literally. At 10,500 feet above sea level, the laboratory is inside of a cloud 35 percent of the time during the winter. That's crucial to the mission of the lab, which hosts research on particulate matter in the atmosphere, the formation of clouds and how the former affects the latter.

Operated by the Desert Research Institute, Storm Peak is unique worldwide for the breadth of monitoring equipment it houses and its accommodations for students and researchers, Hallar said. The lab has beds for up to nine scientists on extended stays to take advantage of its aerosol and cloud physics instruments.

Aerosol research is important because atmospheric particulate matter presents some of the greatest uncertainty when it comes to modeling and predicting future climate change. One dimension of that uncertainty is how aerosols interact with light in the atmosphere, Hallar said. While it's understood that dark particles absorb light and heat the atmosphere while white particles reflect and cool it, data from the lab will quantify that effect to integrate it into climate models.

Storm Peak scientists are also researching the role aerosols play in cloud formation. Water in the atmosphere needs an aerosol particle to condense around to form a cloud droplet, Hallar said.

"If you have more particles, you'll end up spreading that water amongst more particles, forming more, but smaller, cloud drops," she said. "That makes for more reflective clouds."

The lab investigates these and other issues with a lineup of monitoring equipment that includes an array of roof- and tower-mounted sensors measuring standard climatic variables like temperature, humidity, wind speed and direction, and solar radiation.

The instruments that really set the lab apart are the imaging probes, or "cloud probes." The probes capture an image of every single snowflake that passes through it, measuring their size, shape and number. The probes normally rely on airplanes to carry them through clouds, but the lab's spot in the sky allows them to run theirs on the roof.

"Storm Peak lab was the first place that ever did this on the ground," Hallar said. "In an airplane, you can cover a lot of distance, but you move through clouds very quickly. So we end up collecting a larger quantity of data about clouds because we stay in one place for a long time."

The lab also helped study the atmospheric effects produced by the mountain pine beetle infestations that have destroyed millions of acres of forests across the West. Their measurements found infested areas release significantly more volatile organic compounds, including a signature compound that mixes with ozone to produce aerosols. That can reduce visibility in the forest, though the cumulative effect of those aerosols' in the atmosphere could be wider than that.

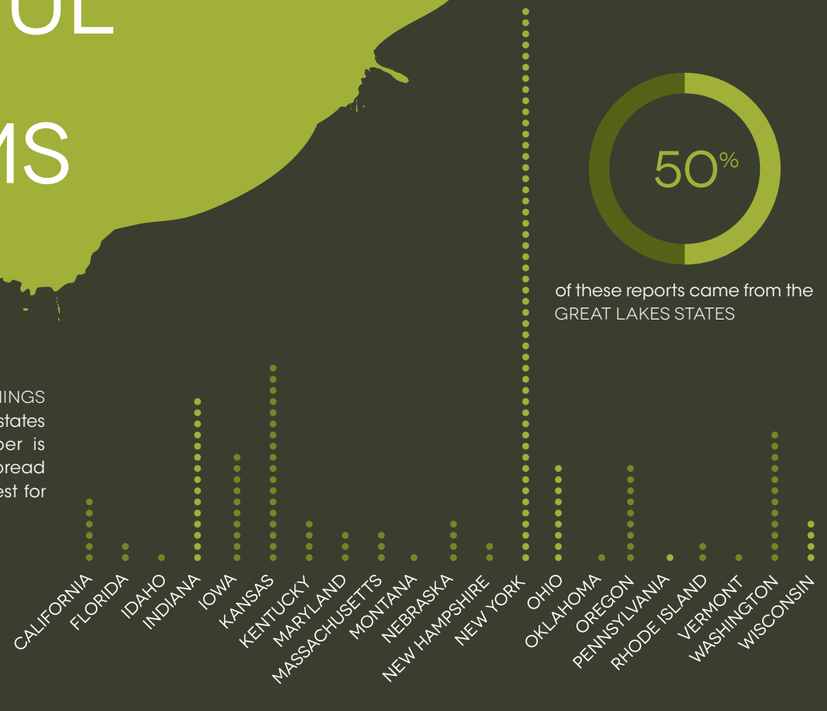
"Especially when you're considering these infestations that cover millions upon millions of acres," Hallar said. "Then it becomes more of a climate issue."

The lab has seen a series of facility upgrades, including perhaps the most important addition in 2009 when the lab gained flushing toilets. Before that it was incineration toilets that process waste by burning it up. Hallar, who spends many nights there, said it was "life-changing."

"And also science-changing," she said. "There was a lot of concern that those combustion toilets were actually contaminating our samples." JG

HARMFUL ALGAL BLOOMS

158 TOXIC ALGAE WARNINGS were reported by 21 states in 2013. This number is only an indication of how widespread HABs are, as some states don't test for algal toxins.



of these reports came from the GREAT LAKES STATES

2011 A RECORD YEAR

The year 2011 brought the most severe algal blooms that Lake Erie has ever experienced.

5,000 SQUARE KILOMETERS of Erie's Western Basin were covered in blooms fostered from excessive phosphorus loading.

Lake Erie's microcystis bloom was **2.5x** denser than in 2009, the previous record year.

Microcystins concentrations in Lake Erie rose to more than **1,000x** the World Health Organization's guidelines for drinking water.

TRACKING PROGRESS IN THE GREAT LAKES

1970 US forms the Environmental Protection Agency

1971 Canada forms Environment Canada

EARLY 1972 US Congress passes the Clean Water Act

1972 Great Lakes Water Quality Agreement between US and Canada to reduce phosphorus loads from point sources

1978 Revision to the Great Lakes Water Quality Agreement to include non-point sources

EARLY 1980s Target phosphorus load levels achieved by Lakes Ontario, Superior, Huron and Michigan

EARLY 1990s Lake Ontario reaches oligotrophic state

1992 Lake Erie shifts from eutrophy to meso-oligotrophy

EARLY 1990s Target phosphorus load levels achieved by Lake Erie in all three basins

1995 Lake Erie over target levels again

2005 Lake Erie forms a hypoxic "dead zone" with an area of about 10,000 square km

2007 Ohio EPA creates the Ohio Phosphorus Task Force

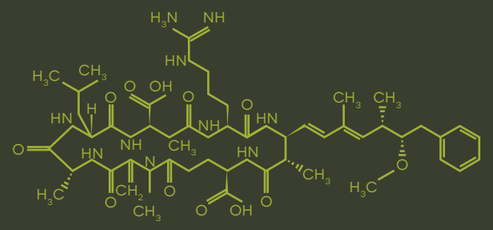
2009 Great Lakes Restoration Initiave is created

2013 Ohio Phosphorus Task Force says 40% reduction in phosphorus loading needed

ALGAE TOXINS

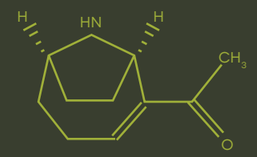
The two most common types of toxins found in algal blooms are Microcystin and Anatoxin-A.

MICROCYSTIN–LR
Type: Hepatoxin (affects liver)
Symptoms: stomach cramps, vomiting, diarrhea, fever, headaches, weakness
Algal Producers: Anabaena, Microcystis, Nostoc, Planktothrix
Amount that can be ingested: 0.000003 mg/kg body weight per day



All Graphics: Nate Christopher

ANATOXIN–A
Type: Neurotoxin (affects nervous system)
Symptoms: lethargy, muscle aches, confusion, impaired memory
Algal Producers: Anabaena, Aphanizomenon, Planktothrix
Amount that can be ingested: 0.0005 mg/kg body weight per day

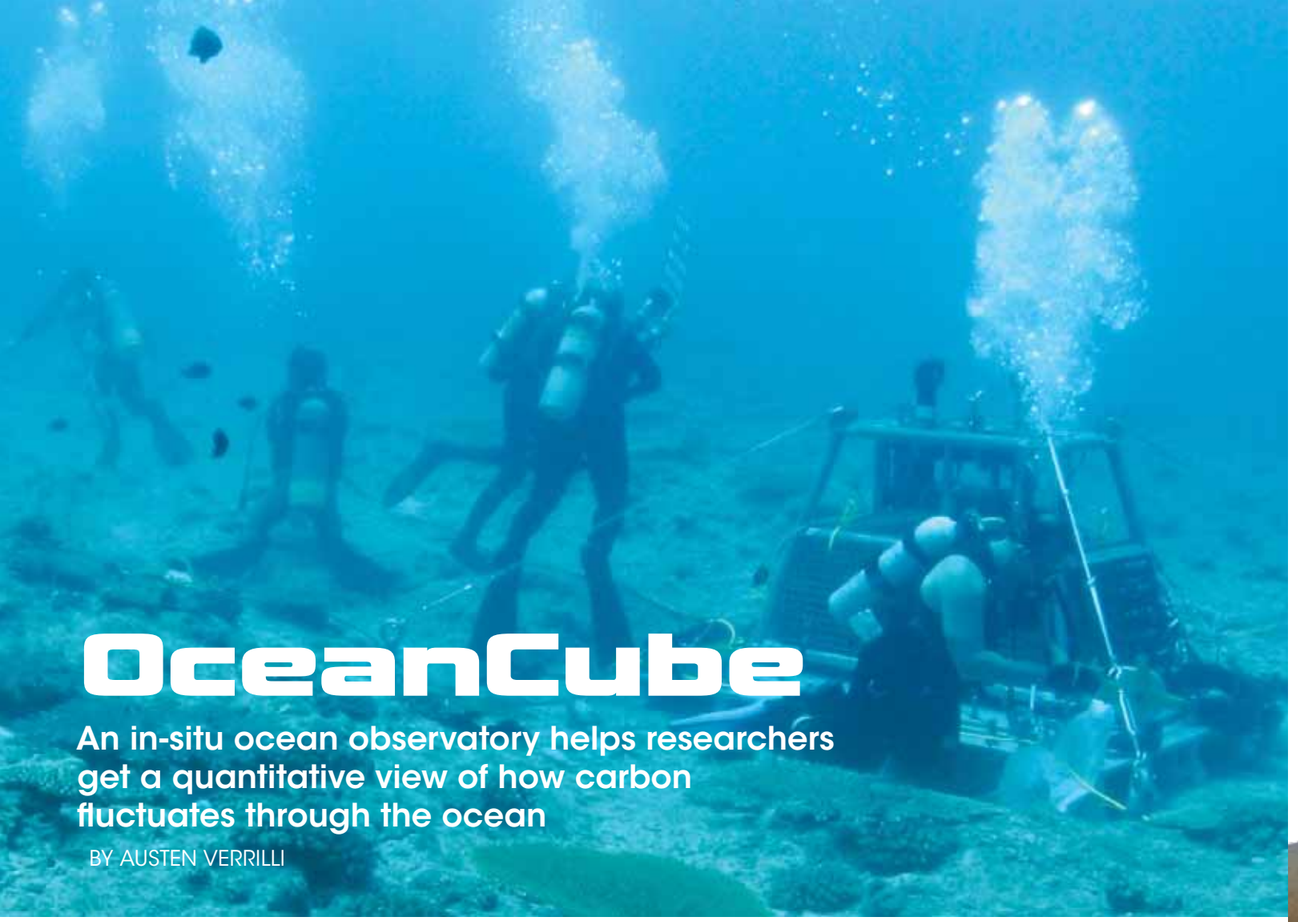


Information sourced from:
Toxic Algae News
toxicalgaenews.com

National Wildlife Federation
Feast and Famine in the Great Lakes

Ohio EPA Algae Information for Recreational Waters program
epa.ohio.gov/habalgae.aspx

TOXNET Toxicology Data Network
toxnet.nlm.nih.gov



OceanCube

An in-situ ocean observatory helps researchers get a quantitative view of how carbon fluctuates through the ocean

BY AUSTEN VERRILLI

The strong pull of the Kuroshio Current makes instrument deployment a challenge, as 50 million tons of water passes the southeast coast of Japan each second.

"Divers had to be careful not to be swept away," said Scott Gallager, Woods Hole Oceanographic Institution associate scientist and principal investigator for the newly installed OceanCube Observatory System.

Scientists from the United States and Japan built the observatory right in the middle of the powerful Kuroshio Current to monitor a 200,000 cubic meter volume of water. Data collected in the OceanCube will eventually be compared to another ocean observatory in the works down-current. "The design of the OceanCube is specific to understanding the flux of materials through a defined volume of water," Gallager said.

The team from Woods Hole Oceanographic Institution, Okinawa Institute of Science and Technology Graduate University and Okinawa Churaumi Aquarium weathered the current and a pair of typhoons to install their new observatory off Japan's Motobu Peninsula. It took three weeks and one diver was swept away. Luckily a fishing boat captain pulled him out down current.

OceanCube is the second iteration of an in-situ ocean observatory built to help researchers get a quantitative view of how carbon fluctuates through the ocean via biology and various current movements. The first undersea ocean observatory was built off a Panamanian Island in the Pacific Ocean.

The Kuroshio Current often carries cold upwelled water, which is rich in nutrients and low in oxygen and pH. Internal waves travel within the current, further stirring the water and increasing production as it hits Japan's narrow continental shelf.

Japan's OceanCube is located in a biologically rich section of the Pacific. The site is thriving with a multitude of marine species, said Amber York, a WHOI research associate who works on the project. Sea turtles are particularly prolific there, along with a vast number of fish she is working to identify and catalogue in a species count.

Gallager said the thriving ecosystem, living amidst low pH and low oxygen upwelled water, means that organisms must have developed strategies for dealing with acidified water well before ocean acidification became an issue. That makes the site a natural ground to study marine life's adaptability to ocean acidification.

Most species of coral in the area are recovering from a widespread bleaching event that occurred in the 1980s. Gallager said the observatory will be there to watch coral recover. "As the coral begins to rebound and grow back, the communities of fish and benthic organisms will change also," he said. "How the trajectory of these rebounding communities is impacted by climate change and ocean acidification is a major question we are addressing."

Carbon enters the water column as carbon dioxide diffusing through the air-sea interface. The carbon is transformed into calcium carbonate, most of which the researchers presume ends up on the seafloor. They hope to measure calcium carbonate flux with the new seafloor observatory and use the figures to gain a better understanding of carbon cycling in the ocean.

The OceanCube monitors a volume of water that spans 100 meters per side by 20 meters deep. The observatory includes a variety of habitats, such as open water, rocky seafloor and coral reefs. Gallager said the researchers were careful to build the cube with a fixed volume in mind so they could calculate carbon concentrations and flux to the seafloor.

Temperature strings are used on the corners of the OceanCube. Acoustic Doppler current profilers at each corner measure wave amplitude, period and velocity. ADCPs also measure magnitude and direction of the current.

At the center of the observatory, sensors measure the water's chemical and biological properties, such as temperature, salinity, pressure, pCO_2, pH, turbidity and chlorophyll. There are also sensors measuring organic and inorganic particulate in the water. Light sensors measure photosynthetically active radiation.

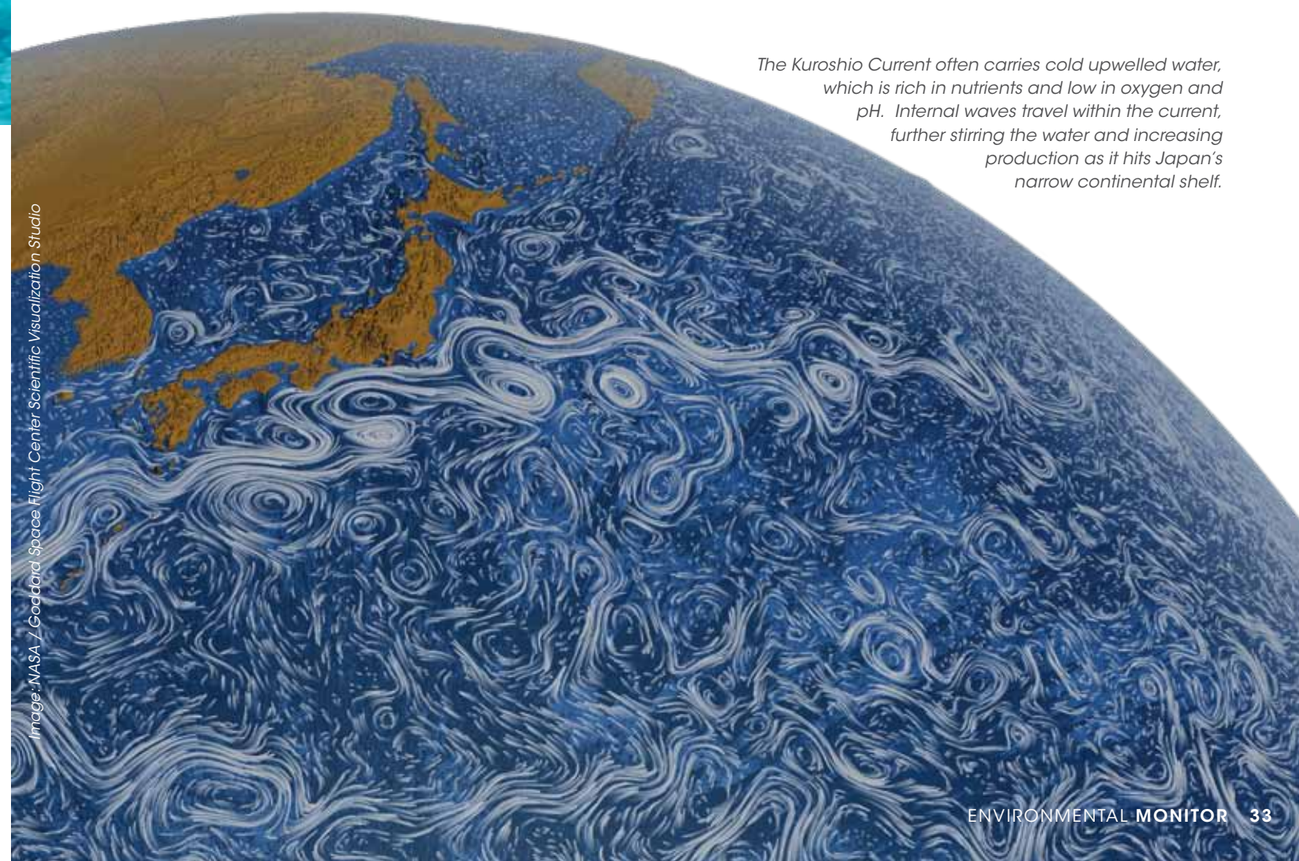
A special Continuous Plankton Imaging and Classification Sensor counts and classifies different species of plankton floating through the current. York said she is working on a similar setup for fish. "The next step is to develop automated machine vision classifiers to identify the fish automatically just as we do for the plankton. That will be a major advance in ocean observatories," she said.

Two fixed stereo cameras and a pan and tilt camera, controlled from the OceanCube website, show sea life in real time around the observatory. "We can look at the biology that happens at the site and correlate it with environmental parameters we are measuring," said York.

Data gathered by the OceanCube is logged in the Okinawa Churaumi Aquarium.

Now that the observatory is up and running, researchers look forward to sharing data with the scientific community.

The third ocean observatory will be built down-current at Oshima Island, 100 kilometers south of Tokyo. The researchers will then compare the two sites and measure transport of biological and inorganic carbon. AV



The Kuroshio Current often carries cold upwelled water, which is rich in nutrients and low in oxygen and pH. Internal waves travel within the current, further stirring the water and increasing production as it hits Japan's narrow continental shelf.

Photo: Okinawa Institute of Science and Technology

Image: NASA / Goddard Space Flight Center Scientific Visualization Studio

Photo: U.S. Geological Survey

HIGH-DEF CARBON

A sensor network in Rocky Mountain National Park is developing what one hydrologist calls a high-definition picture of carbon transport

BY JEFF GILLIES

In September 2013, historic flooding around Colorado's Front Range west of Denver destroyed homes, washed out roads and closed Rocky Mountain National Park for weeks. The closures cut off rescue workers and food aid from hard-hit mountain towns and separated scientists from streams and lakes within the park where they regularly collect water samples for long-term studies of water chemistry.

Though U.S. Geological Survey scientists couldn't make it to the Big Thompson River where it runs through the park for weeks, a network of in-stream sensors captured the creek's response to the flood in a way that wouldn't have been possible through grab samples alone, even if the scientists had been able to access it.

The sensors in the Big Thompson River and the Loch Vale basin in Rocky Mountain National Park are showing scientists how carbon moves through aquatic systems with unprecedented clarity.

"The sensors allow us to collect data at much higher frequency than we can usually do when we just go out and collect manual grab samples," said David Clow, a USGS research hydrologist in Denver. "We use those in-situ sensors to obtain a high-definition picture of carbon transport in streams."

Getting that picture is no idle scientific curiosity. In 2007, Congress passed the Energy Independence and Security Act, which directed the USGS to calculate fluxes of carbon coming from natural and managed landscapes across the country.

To do that right, hydrologists need to know how concentrations of various forms of carbon, such as dissolved organic carbon and carbon dioxide, change season-to-season and even hour-to-hour. They do that with sensor stations that produce measurements every 15 minutes. The USGS has had instruments in the Big Thompson and Loch Vale basin for two years, and the results are revealing for the first time how aquatic carbon responds to events like floods and daily cycles in drivers like solar radiation.

Take, for example, a station on the Big Thompson, which includes a water level sensor and a fluorometer measuring dissolved organic matter. By converting those measurements into estimates of discharge and dissolved organic carbon, the researchers can see that organic carbon concentrations ramped up in the spring of 2013 as snowmelt flushed the soil of what had accumulated through the winter. Organic carbon continued to spike whenever warming periods sent additional pulses of snowmelt into the stream and discharge rose. Later in the summer, the relationship wasn't as strong, as dissolved organic carbon levels stayed consistent despite daily fluctuations in flows. But when the water levels rose with the floods of September, the carbon concentrations went up with them.

The sensors have also revealed daily variations in dissolved carbon dioxide. The data shows a clear pattern of CO_2 levels spiking at night and dropping during the day as the solar cycle shifts the balance between respiration and photosynthesis. Pairing the CO_2 data with solar radiation data from another sensor shows the relationship is more complicated than just night and day. On Aug. 20, for example, one of the region's characteristic summertime afternoon storms blew in and solar radiation levels dropped. Sensor data show the CO_2 concentrations responded quickly with a quick bump as photosynthesis shut down.

In addition to events like floods and storms, the researchers are interested in the effects of the mountain pine beetle epidemic in the park. It's killed off millions of acres of ponderosa pines, creating a rich supply of decaying organic matter that should wash into streams.

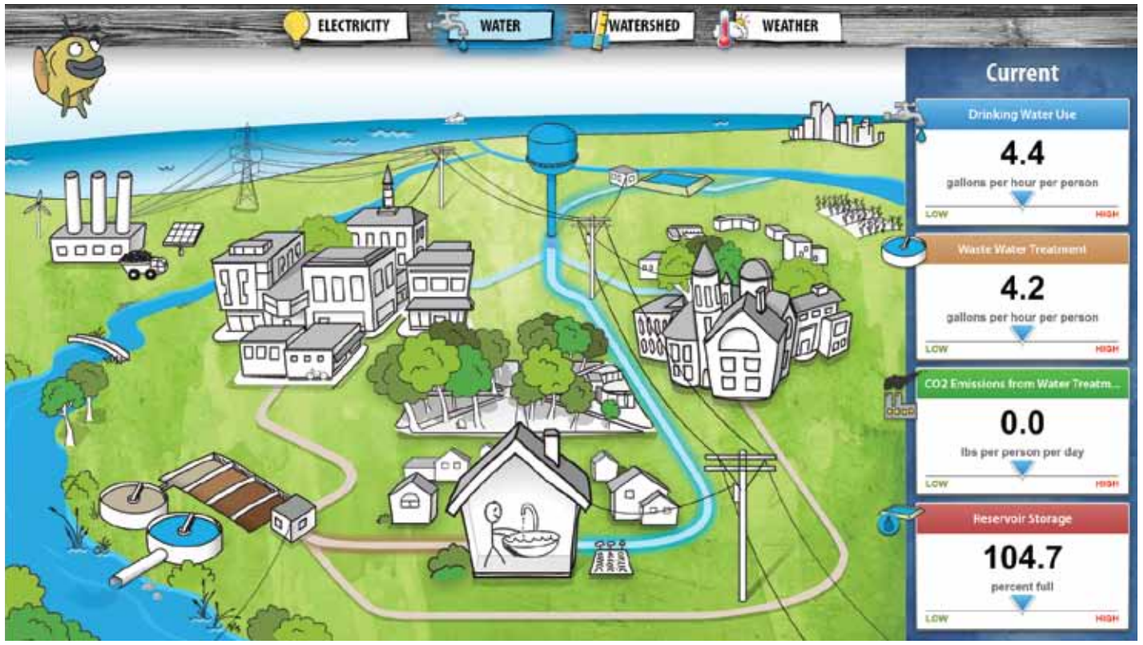
"A lot of our sites were installed to look at that specifically," Clow said. "How does all the decaying organic matter change the fluxes of carbon in the streams?"

Clow, who has been conducting this kind of research for the past 20 years, said he's only had the chance to work with these sensors for the past two years. They're still relatively new and scientists are just scratching the surface of what they can do with them, he said. Meanwhile, they've been essential in capturing the variability that must be accounted for if the agency's scientists are going to accurately calculate carbon fluxes. JG

Environmental Dashboard

A website and monitoring system helps an Ohio city understand how energy use and environmental quality affect the community

BY DANIEL KELLY



Most energy use is invisible, unless you're looking for it.

John Petersen, professor of environmental studies and biology at Oberlin College, wants to make it possible for everyone to see how much water and electricity is needed to run towns, buildings and homes.

For the past 13 years, he's developed technology that monitors and displays resource use. As he says, "the goal has been to engage, educate, motivate and empower a non-technical audience to change both thought and behavior in ways that benefit the environment."

His most recent project brings this together in the Environmental Dashboard, a system and website that shows how energy and water use and environmental quality within Oberlin, Ohio - a small town 35 miles west of Cleveland - affects the community.

But with the usefulness of the dashboard that Petersen helped develop with three former Oberlin students in 2004, it's no surprise that other towns are now considering adoption. The platform was the beginning of a business - Lucid Design Group - that has since moved to Oakland, Calif. The company's products have helped sustainability managers keep track of energy use on college and university campuses, in K-12 schools, in corporations and in green buildings nationwide.

"Our goal is to develop a technology that gets adopted in other communities across the country, but especially in the Great Lakes region," said Petersen.

Initial funding for the Oberlin project came from the EPA's P3 program, which helped develop the initial concept of monitoring in buildings. But work has now expanded to the Oberlin community and is taking a much broader approach.

Data from campus dormitories were the first to be incorporated into the monitoring system. Petersen and faculty, staff and student collaborators installed devices to track electricity use. Since that time, data have been added to track water use in all dormitories.

In 2008, the Great Lakes Protection Fund recognized the potential power of this monitoring approach with a substantial grant to expand the technology beyond individual buildings and campuses and into whole communities.

"This allowed for us to make a major transition in scale," says Petersen. "The goal shifted to designing an approach to monitoring and display that would help citizens contextualize the decisions that they make in buildings in the context of resource flows through whole communities. Ultimately we are seeking to create an approach that promotes what we call 'systems thinking' — it helps people to understand the ways their personal and collective choices about resource consumption are, in fact, acts of citizenship."

A critical part of creating this context is to monitor total community water and electricity use and to also include data on water quality in the stream that drains the community's watershed. This has meant working closely with the city's municipal utilities.

The display system taps into the utilities' supervisory control and data acquisition system to extract data on the drinking water treatment plant and Oberlin Municipal Light and Power. New sensors were installed at the wastewater treatment plant. YSI sondes added to the system measure dissolved oxygen, turbidity, pH and conductivity in Plum Creek water upstream from the plant and in the effluent.

"The director of the plant, Steve Hoffert, and personnel at the plant have collaborated with us throughout the process." said Petersen.

Once data are collected, they're pushed online to the Environmental Dashboard display where they are presented in a compelling way that makes environmental consequences apparent.

> "WE ARE CONCERNED WITH TRANSLATING DATA INTO SOMETHING THAT IS MEANINGFUL AND MOTIVATIONAL."
>
> -John Petersen
> Professor of environmental studies and biology at Oberlin College

For example, carbon dioxide emissions are displayed in parts per million and animated with a plume of smoke that gets broader if more is being emitted. Information on the building's energy usage is portrayed in dollars — something that everyone understands. And if a building has been retrofitted to produce energy, say with solar panels, a meter dial swings to green showing energy is being produced and to red when more energy is being consumed than generated.

"We're very much trying to translate quantitative measurements of consumption and environmental quality into a form that is engaging and accessible to a non-technical public," said Petersen. "We are concerned with translating data into something that is meaningful and motivational."

But software can only go so far. The Environmental Dashboard is a useful tool in cyberspace, but physical objects help tell the energy story in buildings around Oberlin. Digital signs are installed in buildings and dorms on campus. Hallways in student dormitories have "environmental orbs" — glowing glass bulbs that change colors depending on electricity and water consumption: a pulsing bright red color indicates that electricity use is high relative to what it normally is at a certain time of day. Yellow indicates intermediate use and a slow pulsing green indicates low use.

Petersen shows off the dashboard during a municipal utility tour.

Photo: Yvette Chin

"We see electronic signs that display the dashboard in public venues as key to the successful transmission of content in the community — to be crass, information needs to be in your face and in your space for you to experience it," said Petersen. "Dashboard provides you with a continuous sense of the implications of what you're doing, the larger system that these decisions are a part of."

That's where Aaron Kozloff comes in. As the community outreach coordinator for the Environmental Dashboard project, he connects the dashboard with the many initiatives in this community that are in one way or another connected with the environment. The most recent effort looks to expand the dashboard to four area high schools.

Another side to the Environmental Dashboard is the city-wide dashboard, which helps people understand how the community is using electricity and water and protecting water quality. The system is already set up in one elementary school and is expanding to the other four public schools.

"What we have termed 'empathetic gauges' — animated characters that appear on the dashboard and display different behaviors and different messages depending on resource use — are another key component of this project. Students will see Wally the walleye or Flash the energy squirrel cartoons depending on the animation," said Kozloff. "The character is happy if consumption is low and sad if it's high."

There is a third component in addition to the city-wide dashboard and the building dashboards, says Petersen. It's a forum designed to share the thoughts, ideas and actions of community members who are already moving the community forward on environmental sustainability.

"We want to use the technology to develop a pro-environmental attitude, to have people in the community understand how their own positive actions on the environment are part of a larger community-wide effort. We want them to feel like a connected part of a transition to greater environmental sustainability," said Petersen. DK

THE SMELT AND THE DELTA

A USGS nutrient monitoring network in the Sacramento-San Joaquin River Delta is illuminating an endemic, endangered fish's food web

BY JEFF GILLIES

The San Joaquin and Sacramento rivers converge in Northern California among a sprawling delta, a web of connecting channels that eventually flow into a system of bays and straits that form the open waters of the San Francisco Estuary.

Those waters are the only home of the delta smelt, a small, silver fish that hatches in the delta, migrates to the estuary to mature and returns upstream to spawn and die.

"The smelt is a peculiar little fish," said Bryan Downing, a research hydrologist with the U.S. Geological Survey in Sacramento.

It's also endangered, according to the state of California. And it's among several other fish species in the San Francisco Estuary whose population numbers are in the midst of an unexpected decline that scientists have been tracking since the early 2000s.

Some hypotheses tie the smelt's decline to intensive pumping operations that supply much of central and southern California with irrigation and drinking water. Scientists also question the status of the food web that supports the smelt, but that subject is poorly understood, Downing said.

To get a better grasp on the food web and the nutrients that fuel it, the USGS is building an advanced monitoring network in the delta. Data from the network will give scientists a better understanding of the foundation of the food web while demonstrating the capabilities of a pioneering branch of sensor technology.

"Is it flow, is it nutrients or is it a combination of those things that are affecting the food web? We are starting a backbone of a nutrient monitoring network to get at those questions," said John Franco Saraceno.

So far, the network consists of five stations within the Sacramento River portion of the delta. Each station is built on a USGS streamflow gauging site and supports a Satlantic SUNA nitrate sensor and WET Labs Cycle Phosphate sensor. A YSI EXO multi-parameter sonde at each site carries sensors for algal pigments, turbidity and dissolved organic matter. Measurements are collected every 15 minutes and transmitted online. The sensors are mounted on pilings channel markers. Where those structures aren't available, the sensors are supported by NexSens data buoys.

Photo: U.S. Fish and Wildlife Service

Many of the sensors, including those for nutrients and organic matter, are based on optical technology that has only recently been proven ready for "prime time," Downing said. That makes the delta one of the few places in the world with a real-time nutrient monitoring network. Coupled with the streamflow gauging network, the optical sensors will give scientists a new perspective on how nutrients fluctuate throughout this hydrologically complex system.

Continuous water quality measurements in the delta have provided a new window into gaps between discrete monthly measurements, continuous habitat quality information and linkages between nearby sites in the San Francisco Estuary. The measurements yield important information on the timing, drivers and mechanisms of food web component transport and processing that are often missed by the sparse frequency of traditional sampling methods.

The network is already providing insights into the system that scientists were missing with manual sampling. The station at Liberty Island has been especially revealing. Dikes in this section of the delta once kept the land dry and farmable. The land was ultimately inundated after a series of dike failures in the 1990s.

Today, the shallow reservoir is seen as a valuable rearing habitat for delta smelt and fish species. But scientists don't know much about how it functions. Data from the monitoring station are helping to change that.

"Since installing this system, we've learned that Liberty Island can be a source and also a sink of nitrogen that can then be used by the food web downstream or upstream," Saraceno said. "We actually see nitrogen retention in the summer as algae blooms."

Downing says the data could eventually help construct computer models of how the system functions. The data could also serve as a guide for the estuary's manual sampling programs, which remain important. Meanwhile, the USGS has received funding to expand the network further downstream into the estuary. Other research groups plan to install similar stations in the system.

"This is a first," Downing said. "And it's key to getting a better grip on what's happening in the delta and just how the whole system works." JG

Photos: Bryan Downing / U.S. Geological Survey

MONITORING GEAR

In-Situ Level TROLL 400

The In-Situ Level TROLL 400 is a self-contained absolute water level logger designed for unattended monitoring in freshwater, salt-water and contaminated waters. Sealed in a solid titanium housing, the logger is either suspended from a backshell hanger or secured to a direct-read cable with a twist-lock mechanism that ensures connections are not compromised. An internal memory records up to 130,000 data sets which easily export to a PC for further analysis. Standard communication protocols include Modbus, 4-20mA, SDI-12 and RS-485/232.

OTT Parsivel2

The OTT Parsivel2 is a laser-based optical system for complete and reliable measurements of precipitation. It captures both the size and speed of falling particles, sorting them into one of 32 separate size and velocity classes. Measurement intervals range from 10 seconds to 1 hour, offsetting the fast signal processor that calculates measurement data to determine the precipitation characteristics. Data are transferred to a data logger, automatic weather station or PC. The Parsivel2 is virtually maintenance-free and features a USB interface for simple setup and programming.

Proactive Mega-Monsoon XL

Capable of pumping fluids from 180 feet below the ground, the Proactive Mega-Monsoon XL is a reliable solution for continuous sampling or purging of groundwater wells. The replaceable motor module, motor housing top connector and the outside pump housing are all made of robust stainless steel parts. To power the unit, simply connect the pump to a Low Flow with Power Booster 3 XL LCD Controller and a 12 VDC battery. The LCD screen on top of the power booster displays and easily adjusts the discharge rate. With the addition of a low flow control valve, the pump can sample as low as 10 milliliters per minute from any depth.

Juniper Systems Archer 2

Built with a sleek and ergonomic design, the Archer 2 rugged handheld computer is packed full of features. Running a Microsoft Windows embedded software and a speedy 1.0 GHz processor, the handheld boosts productivity for professionals working in the field. The geotagging function marks a time stamp and GPS coordinates on a photo to keep track of the exact location where it was taken. Comprised of 512 MB of RAM and 8 gigabytes of flash storage, the memory provides plenty of room to store documents and images. Communication capabilities are enhanced via Bluetooth and Wi-Fi wireless technology. Additional options include a built-in barcode scanner, 3.75G GSM cell modem, 5 megapixel camera and a GPS receiver.

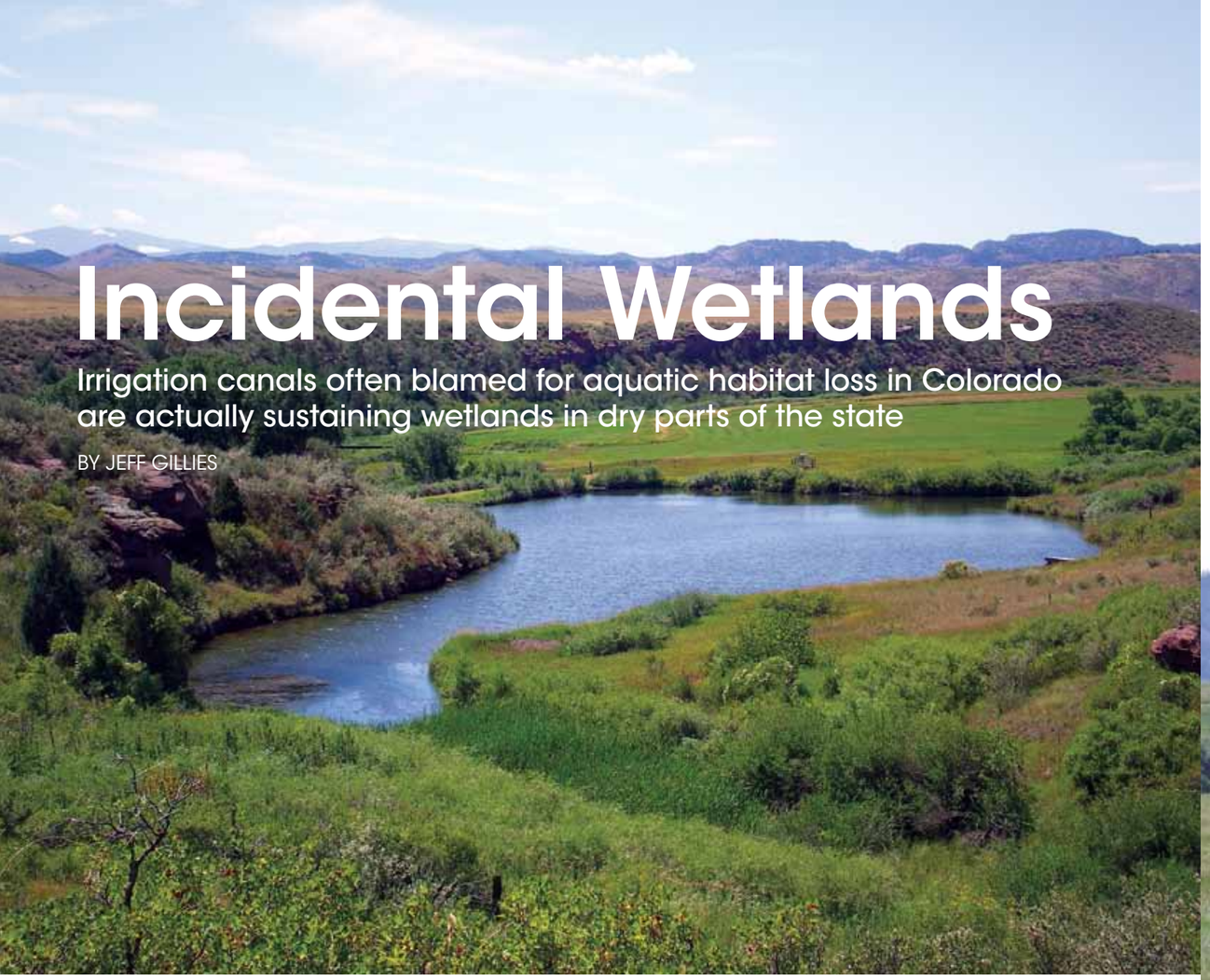
The rugged handheld computer produces a crisp image on its extra-large, sunlight readable display. An extensive battery life of 20 hours powers the unit through every work day. Carrying an IP68 rating and tested to MIL-STD-810G standards for water, humidity, sand, dust, vibration, altitude, shock and temperature, the Archer 2 is a reliable data-collecting machine.

Solinst Model 122

Determination of both light and dense non-aqueous phase liquids is quick and easy with the redesigned Solinst Model 122 oil/water meter. Factory-sealed and pressure proof up to 500 psi, the P8 probe is 5/8 inches in diameter and made of robust stainless steel. It can fit through tight spaces and into narrow wells. The laser-marked tape is available in lengths of 100 to 1,000 feet, or from 30 to 300 meters. Markings on the 3/8-inch PVDF flat tape are traceable to NIST and EU measurement standards. All Solinst Model 122 meters have been approved for use in explosive environments.

YSI Pro1020

YSI's new Pro1020 dissolved oxygen and pH/ORP meter is a true field meter, combining military grade connectors, an IP67 waterproof and rubber-overmolded case and a 1-meter drop test to complete its rugged design. A large, backlit display and glow-in-the-dark keypad make the readings visible in any lighting condition. Choose from polarographic or galvanic dissolved oxygen sensors, as well as a pH or ORP sensor that best fits the water quality application. Cables are interchangeable and range in lengths from 1 to 30 meters to increase the instrument's versatility. The unit stores 50 data sets in its memory with a number for later retrieval. The smart calibration function conveniently recalls the previous calibration values to simply walk through a step-by-step routine for re-calibration.



Incidental Wetlands

Irrigation canals often blamed for aquatic habitat loss in Colorado are actually sustaining wetlands in dry parts of the state

BY JEFF GILLIES

The extensive irrigation canals across Colorado that have made agriculture possible in dry parts of the state have also disrupted natural hydrology, drying up natural aquatic habitats like floodplain wetlands.

But in a surprising twist, a recently published study shows that the irrigation canals that carry water away from rivers are also creating and sustaining functional wetlands in areas that wouldn't otherwise support them.

"We've pretty much dried up a lot of our historic riparian wetlands (with irrigation), but what our research found was it created wetlands in places where you certainly wouldn't expect wetlands to be," said Jeremy Sueltenfuss, a wetland ecologist with the Colorado Natural Heritage Program and lead author of the study.

Documenting this connection is especially important in Colorado, where wetlands make up just 2 percent of the state's landscape but support 90 percent of the state's species at some point in their lifecycle. The findings could help ease conflicts between urban environmentalists and rural farmers over how much water ought to remain in the state's streams or be diverted for irrigation.

Though the diversions are unpopular with conservationists, some are the sole water supply to wetlands that appear to be as old as the canals themselves.

"In the particular area we worked in, that goes back to 1890. So they're over 100 years old," Sueltenfuss said. "If you stopped running the water, those wetlands are dry."

The irrigation has unintentionally supported wetlands through water that seeps out of canals through their earthen bottoms and sides. Irrigation companies keep close track of how much water they lose, but there hasn't been much study on where it goes, Sueltenfuss said.

With the hypothesis that the water was leaking into and sustaining nearby wetlands, Sueltenfuss set out to identify wetlands within the service area of the North Poudre Irrigation Company where canals appeared to be a potential water source. Using GIS data and aerial imagery, he and his collaborators selected 20 wetlands where they would collect hydrologic data in an attempt to match wetland water table fluctuations with daily canal flows provided by the irrigation company.

All Photos: Jeremy Sueltenfuss

Across the 20 study sites, the researchers dug 70 1-meter monitoring wells where they measured water levels every two weeks from May to November. Six wetlands each had one well equipped with an In-Situ Rugged TROLL 100 water level logger that measured the water table hourly.

Wetlands fed by groundwater typically have stable water tables, Sueltenfuss said. But the water tables they measured showed clear fluctuations that correlated with the canal flow data. When the irrigation was flowing, the water table would rise near the surface and recharge the wetland. When irrigators stanched the flow, the table would drop.

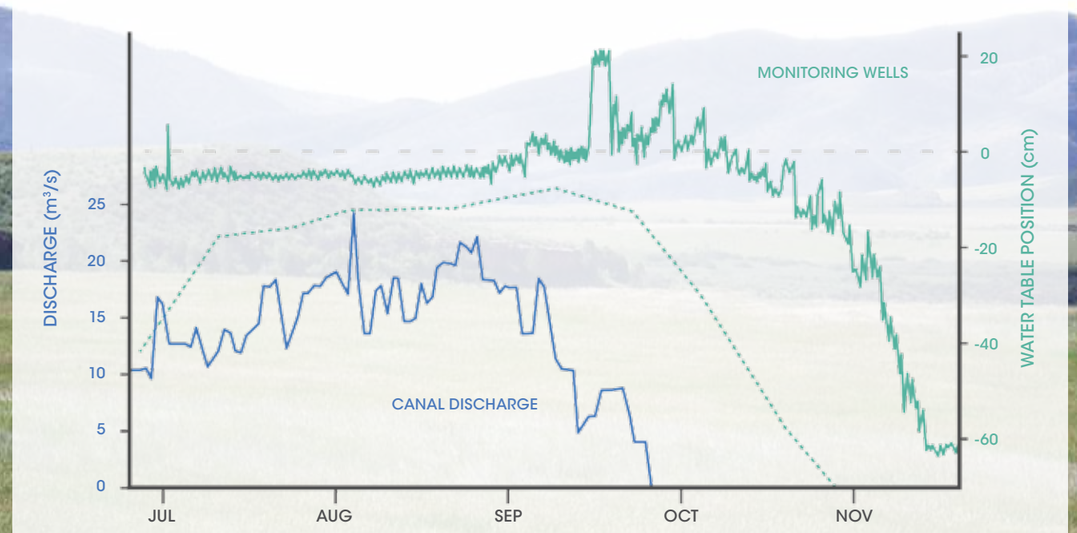
"Matching up water table position over time with canal flow over time, you could see how they overlapped really nicely," he said. "Much more clearly than I would have expected."

The researchers also conducted stable isotope analysis and found that the chemical signatures of the water of each wetland and its adjacent canal were generally identical.

The results of the study, published in the journal Wetlands, could lead to a new approach to wetland conservation in the state, Sueltenfuss said.

Urban environmentalists are often at odds with the agricultural sector, which they see as an outsized drain on the region's scarce water supply that ought to leave more water in the rivers. But these findings suggest that there might be important overlap in the seemingly conflicting goals of environmentalists and agriculturalists, one seeking to conserve important aquatic habitats and the other to divert water for crops and cattle.

"The most exciting piece of it is this novel way to approach wetland conservation in terms of getting people from both cities and agriculture at the same table and having a conversation," Sueltenfuss said. JG



After irrigation canal flows dropped, water tables at nearby wetlands fell at a similar rate after a month or two of lag time.

CHICAGO RIVER MICROBES

A federal lab is partnering with the Chicago sewer district to model and study the microbes of the Chicago River to detect benefits of infrastructure upgrades

BY ANDY McGLASHEN

All Photos: Metropolitan Water Reclamation District of Greater Chicago

An ambitious plan is underway to transform the Chicago River—essentially an open sewer engineered to carry waste away from Lake Michigan — into a destination where people can fish, paddle and play without fear of infection by harmful microbes.

To see if the plan works, federal researchers are helping the city's sewer utility study how microbial communities in the waterway change as the city overhauls its wastewater system. Scientists from the U.S. Department of Energy's Argonne National Laboratory have begun a seven-year project that involves analyzing microbes found in local water samples. The researchers are piggy-backing on routine sampling done by the Metropolitan Water Reclamation District of Greater Chicago, or MWRD, during the March-to-November recreational season.

"What we're going to do is extract the DNA from the samples, and with the computational power we have, sequence the genomes of the microbes," said Cristina Negri, an Argonne agronomist and project manager for the study. Comparing their findings with existing DNA libraries, the scientists can learn where the microbes originated.

The team also plans to create a hydrological model of the Chicago River system to better understand how microbes move throughout the waterway and how heavy rain events alter its microbial community, Negri said. That could help improve forecasting to warn residents of likely spikes in dangerous bacteria.

Chicago is the only major U.S. city that does not disinfect the effluent from its wastewater treatment plants to kill germs. The prevailing logic was that no one would want to have contact with the heavily polluted river anyway.

But in 2011 the U.S. Environmental Protection Agency ordered that portions of the Chicago River and connected waterways be made safe for swimming. To meet the new requirements, MWRD will begin disinfection at two of its treatment plants by 2016. The city also is in the midst of the so-called Deep Tunnel project, a decades-long effort to capture stormwater in tunnels and reservoirs to reduce flooding and combined sewer overflows.

The seven-year study will show what happens to the microbial community as disinfection begins and reservoirs are completed. But wastewater isn't the only source of microbes in the river, Negri noted.

"Chicago has this history as the meat packing capital of the U.S., and there actually was an area of the river called Bubbly Creek, because that's where all the carcasses and offal were thrown in the river," she said. "It was bubbly because of the gases from decomposing waste. So there has to be some microbial activity over there."

Agriculture, industry and waste from pets and wildlife also contribute microbes to the waterway, said Jack Gilbert, an Argonne environmental microbiologist involved in the study.

Argonne scientists are tapping into sampling the district already does through its ambient water quality monitoring program. MWRD scientists use surface grab sampling at 28 sites on 13 waterways and analyze the water not only for fecal indicator bacteria, but also for alkalinity, turbidity, dissolved metals, fats, radiochemistry and several other parameters.

The MWRD conducts regular sampling on the river.

The ambient water quality program is part of MWRD's broader monitoring of waterways in its service area. The district also conducts continuous dissolved oxygen monitoring in the Chicago, Calumet and Des Plaines rivers with 18 monitoring stations — both in shipping channels and shallow streams — that are mounted on bridge abutments and encased in stainless steel for protection. The stations take hourly measurements of dissolved oxygen, temperature and specific conductivity.

While the project's primary goal is measuring the success of MWRD's upgrades, it's also a chance to seek answers to fundamental questions about how microbes interact in the environment, Gilbert said.

"The most interesting thing from my perspective is that when a pathogen enters a natural ecosystem, it finds itself interacting with new organisms it's never encountered before," he said. "It finds itself in this light, cold and totally aerobic environment. If that doesn't kill it, it has the opportunity to start competing against these natural bacteria. We want to know what that interaction does to those organisms. Do they become more pathogenic? Less pathogenic? Shockingly, we know very little about that, primarily because we haven't had the tools to do it."

It may have taken Chicago officials a long time to see their waterways as much more than channels for moving ships and waste, but Gilbert said MWRD's partnership with Argonne is evidence that the city is awakening to the Chicago River's potential as a recreation asset.

"It's remarkable to see a public body taking such a far-sighted perspective of their system," he said. "They're investing in the future by allowing us to investigate this microbial world. Nowhere else in the world is this being done." AM

Environmental Measurements: Lessons Online

BY CHRISTINE DEMPSEY

For those interested in the principles behind environmental measurements, whether it be for water, air or soil, there is now a comprehensive online knowledge base: the Fundamentals of Environmental Measurements reference.

This online resource is designed for anyone who wants to know more about the what, why and how of studying the different elements that define environmental quality. The comprehensive library explains the science of a variety of environmental monitoring parameters while addressing the technology, methods and equipment used to study and measure them.

The Fundamentals of Environmental Measurements website is broken up into three categories: Parameters, Methods and Equipment, and Applications.

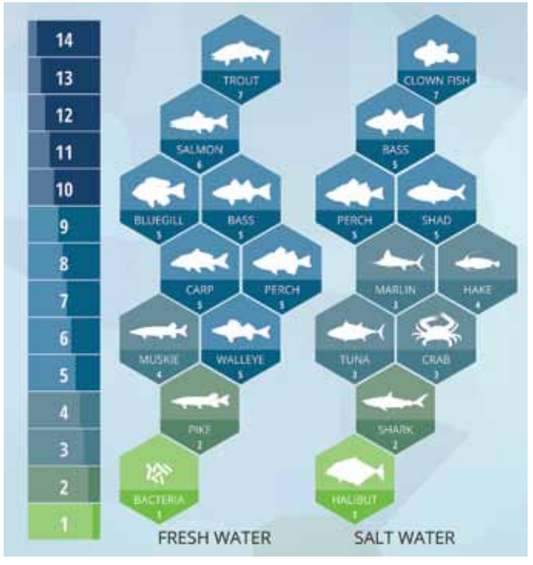
The first section explores the science behind environmental quality parameters in water, air and soil. Whether a project is measuring dissolved oxygen levels, conductivity, wind speed or temperature, this online resource has all the details.

The second category studies the methods available for measuring each parameter and explains the science behind the technology and equipment used. These sections compare the different methods and technologies available as well as exploring how the instruments work.

The final section offers example applications and typical monitoring systems in order to understand the importance of each parameter in a greater context. While these applications are presented as a starting point for tailoring a specific project, Fondriest Environmental offers its applications engineers to assist with any systems planning.

If additional information is needed or if a project requires assistance, the intuitive "Ask A Question" or "Live Chat" features are connected directly to an expert.

To learn more and receive parameter specific-discounts, visit www.fondriest.com/environmental-measurements.



Dissolved Oxygen Requirements

It goes without saying that most aquatic life needs oxygen to live. As dissolved oxygen levels vary between bodies of water, different species have adapted to different DO requirements.

Coldwater fish like trout and salmon are most affected by low dissolved oxygen concentrations and cannot tolerate them. Northern pike are among the most resilient, surviving at 1.5 mg/L DO for extended periods.

Most saltwater species have a higher tolerance for low DO levels than their freshwater counterparts. This is because saltwater cannot hold as much oxygen as freshwater; in general, dissolved oxygen levels are about 20 percent less in seawater than in freshwater at the same temperature.

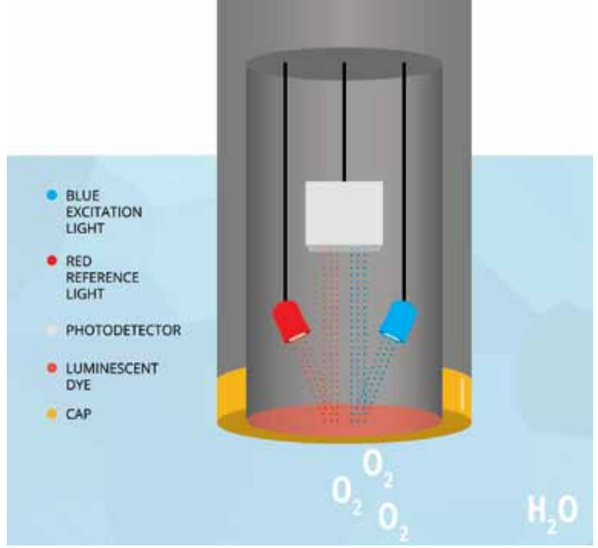
This does not mean that saltwater fish can live without dissolved oxygen completely. Many tropical saltwater fish require higher levels of DO, such as those surrounding coral reefs. However, benthic dwellers, such as halibut, can tolerate levels around 1 mg/L DO.

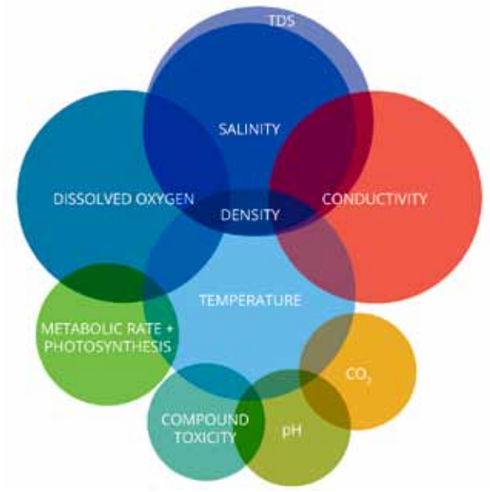
All graphics: Nate Christopher

Optical Dissolved Oxygen Sensors

Optical DO sensors measure the interaction between oxygen and certain luminescent dyes. When exposed to blue light, these dyes become excited and emit light. If dissolved oxygen is present, it can limit the intensity and lifetime of the luminescence. The measured effect is inversely proportional to the partial pressure of oxygen.

An optical sensor consists of a semi-permeable membrane, luminescent dye, LED and photodetector. As oxygen crosses the membrane, it interacts with the dye, limiting the luminescence produced. The altered luminescence is measured by a photodetector, and can be used to calculate the dissolved oxygen concentration. Some sensors include a red LED that does not cause luminescence as a reference.





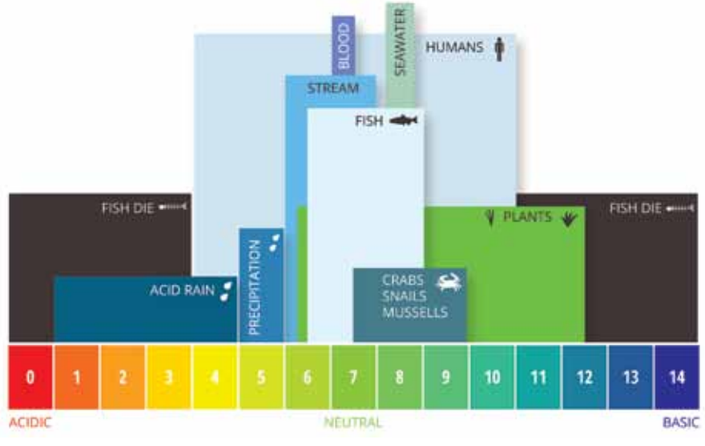
Water Temperature

Temperature is an important factor to consider when assessing water quality. In addition to its own effects, temperature influences several other water quality parameters and can alter the physical and chemical properties of water. In this regard, water temperature should be accounted for when determining:

- Metabolic rates and photosynthesis production
- Compound toxicity
- Dissolved oxygen and other dissolved gas concentrations
- Conductivity and salinity
- pH
- Water density

pH Tolerance

pH affects aquatic life by causing physiological effects, reducing $CaCO_3$ levels (needed for coral and shells) as well as increasing the solubility of toxic compounds. The majority of fish prefer a pH range of 6.5-9.0, though there are some unique exceptions. Angel fish and discus from the Amazon River Basin live happily in waters with a pH as low as 5.0. The Osorezan dace thrives in the acidic waters of Lake Osorezan, resting comfortably at a pH of 3.5, swimming into neutral pH waters only to spawn. On the opposite end of the spectrum, some african cichlids enjoy pH levels around 9.5 and alkaline tilapia flourish in Lake Natron, where pH levels reach 10.5.



IN THE GREAT LAKES

RESEARCH FROM AROUND THE BASIN

SUPERIOR

An array of thermistor strings that span the entire water column at several sites across Lake Superior is giving scientists new insight into the thermal structure of the lake, especially during the winter. A recent analysis by University of Minnesota researchers of temperature data from 2005-2012 shows that the strength of stratification varies from year to year and from site to site. The data also show the effects of ice cover. In 2009, a particularly icy winter, the ice cover trapped heat in the lake, warming the water column and resulting in weaker stratification. In the ice-free winter of 2012, stratification was much stronger.

Titze, Daniel J. "Observations of the winter thermal structure of Lake Superior" (2013). M.S. Thesis. University of Minnesota: U.S.

MICHIGAN

More than ten years of sampling at offshore stations in southeastern Lake Michigan before and after the invasion of quagga mussels has shown a significant change in summer chlorophyll-a dynamics, according to a study from the National Oceanic and Atmospheric Administration and the Great Lakes Research Center. Among recently published findings is average chlorophyll-a concentration across the water column in early summer has decreased by 50 percent between 1995-2000 and 2007-2011. The researchers attributed the changes to the mussels, which trap nutrients in nearshore regions and cut off the supply for offshore blooms.

Steven A. Pothoven, Gary L. Fahnenstiel, Recent change in summer chlorophyll a dynamics of southeastern Lake Michigan, Journal of Great Lakes Research, Volume 39, Issue 2, June 2013, Pages 287-294.

HURON

Lake Huron's population of alewife — once an important prey fish for the lake's Chinook salmon — collapsed in 2003. They haven't recovered and Lake Huron's ecosystem has since undergone a significant shift. An analysis from Ontario Ministry of Natural Resources and U.S. Geological Survey scientists of long-term climate data suggest that the harsh winter of 2003 likely contributed to the collapse. It was among the coldest years on record from 1973 and 2009, and supported the most extensive March ice cover.

Though that winter contributed to the decline, it doesn't explain why the alewife haven't bounced back. That's more likely the result of a lower abundance of their preferred prey organisms.

Erin S. Dunlop, Stephen C. Riley, The contribution of cold winter temperatures to the 2003 alewife population collapse in Lake Huron, Journal of Great Lakes Research, Volume 39, Issue 4, December 2013, Pages 682-689.

ONTARIO

The Charity Shoal structure on the bed of northeast Lake Ontario is a 1.5-kilometer-diameter depression surrounded by an elevated rim. Since its discovery in 1999, scientists have suspected it was a meteorite impact site but couldn't quite prove it. Marine magnetic surveys, seismic profiles and modeling conducted in 2012 took a first look at its subsurface structure, and the recently published results further suggest that the structure is an impact crater and not a volcanic intrusion or sinkhole. However, scientists won't know for certain until they drill into the sediment and bedrock for samples.

Suttak, Philip A., "High-resolution lake-based magnetic mapping and modelling of basement structures, with examples from Küçükçekmece Lagoon, Turkey and Charity Shoal, Lake Ontario" (2013). M.S. Thesis. McMaster University: Canada.

ERIE

A "robust community" of freshwater mussels was discovered in Lake Erie within a thermal plume created by power plant discharge on the shores of Oregon, Ohio. That's good news in the Great Lakes, where freshwater mussels are on the decline as a result of habitat loss and biofouling from invasive zebra and quagga mussels. A recent study from the University of Toledo found that the community within the plume was more diverse, denser and had larger mussels than others around the lake.

Nick J. Bryan, Christina V. Florence, Todd D. Crail, Daryl L. Moorhead, Freshwater mussel community response to warm water discharge in western Lake Erie, Journal of Great Lakes Research, Volume 39, Issue 3, September 2013, Pages 449-454

AT FAULT

As New Mexico snowpack shrinks, high-salinity groundwater bubbling up through faults looms as a water quality issue

BY JEFF GILLIES

Climate projections for the Southwest United States say the region should expect diminished snowpack. That's a concern for water managers as they prepare to supply a growing population with shrinking water resources. But scientists in New Mexico are hoping to learn more about what it could mean for water quality.

Melting snow contributes to the region's surface water flows, but so does deep groundwater bubbling up through faults. That groundwater can be low in oxygen and high in salinity and trace metals.

"In the arid Southwest, where we have things like relatively young volcanos and geothermal systems, you have the opportunity for waters to come from the subsurface and to mix with the surface water systems," said Laura Crossey, professor in the Department of Earth and Planetary Sciences at the University of New Mexico.

"It's not rocket science to say as we look into a future scenario where we might have less and less snowpack, then we'll see years where the water is more saline and has these other constituents in it on a more frequent basis than it does today."

To get a clearer picture of just how saline and metal-tainted the water might become, Crossey and her colleagues are monitoring water quality in streams and springs in a fault-crossed region of New Mexico.

By measuring ongoing variation in salinity and other chemical parameters in these waters and relating that to discharge, Crossey said they'll be able to forecast water quality changes under various climate scenarios.

"That's kind of where we're trying to head: finding ways that we can use monitoring to couple hydrochemical parameters to hydrologic parameters and then be able to work better with managers to think about water quality, not just water quantity," she said.

The group's study sites include streams on the Valles Caldera, a volcano that most recently erupted over a million years ago. That makes it a relatively young feature with active geothermal systems, Crossey said. Water sneaks up through those systems and enters streams as they cross faults, diminishing the surface water quality as it heads down the slope.

South of the caldera, Crossey and master's student Chris McGibbon have installed conductivity, temperature and depth sensors

Photo: Laura Crossey

A fissure along which springs are aligned near San Ysidro, N.M.

in a series of springs rising from the Nacimiento Fault. Data from this site give a clean look at water coming up from the fault before it mixes with surface water. The sensors are also giving researchers their first chance to understand what's driving slow changes in the water quality there. So far, they've detected slight seasonal temperature variations of 1 or 2 degrees Celsius. They've also seen more frequent salinity variations.

"There are many reasons that temperature might change. There are many reasons that conductance might change," Crossey said. "And if we monitor both of them, we can sometimes attribute how much of the change is from one process and how much is from another."

By advocating for this kind of monitoring, Crossey is hoping to emphasize the importance of water quality as managers begin to cope with approaching climate-driven water supply issues. Meanwhile, as part of the university system that works with students, she's also helping to train the next generation of environmental scientists to work with the sensors and high-resolution datasets that are becoming increasingly important in this kind of research.

"We're feeling the crunch of the new things that we need to be teaching students so that when they go out they're able to have the skills to take advantage of this monitoring," she said.

Q&A

Jeanette Schnars

Talking about buoys in Pennsylvania's Lake Erie waters

Jeanette Schnars is the executive director of the Regional Science Consortium, a collaborative non-profit based in Presque Isle, Penn., that coordinates educational and research projects for Lake Erie and the Ohio River Basin. The Consortium's members include colleges and universities, state and federal agencies, K-12 school districts and other non-profits. They work out of the Tom Ridge Environmental Center located at the gateway to Presque Isle State Park. The park's beaches and other recreational opportunities draw more than 4 million visitors a year, which is more than Yellowstone National Park. Schnars spoke to us about the consortium's mission and its water quality buoys.

Environmental Monitor: How does the Regional Science Consortium's coordinating role help improve research in the area?

Jeanette Schnars: We can put together a project and bring together researchers that might not normally interact. For one of our projects, we brought in a microbiologist from one university and a statistician from another university and another researcher from USGS. When research projects come up I usually have the ability to really bring scientists together to make a very strong team.

EM: Have you used data buoys in research applications in past?

JS: We do a lot of research on bacterial concentrations in the swimming water of our beaches. One of our projects is working to find more rapid techniques. How can we figure out the concentration more quickly? To do that, we operate two weather stations and two smaller buoys looking at only water quality parameters like temperature, pH, turbidity, dissolved oxygen and conductivity. We use that information to run several different predictive models.

EM: You're planning to deploy another buoy this spring. What will that add to your data collecting capabilities?

JS: This buoy we're looking at deploying in May is going to be a much larger buoy that will have the full weather station, a video camera, water quality parameters, as well as the wave sensor on it. So we'll have wave height, wave period and wave direction, which everybody is pretty excited about. This buoy will be feeding information into the predictive models for bacterial levels at swimming beaches. We're also working with members of the Consortium to integrate the data into their studies with fisheries, algal blooms and climate change.

EM: How will non-scientists benefit from the new buoy?

JS: A lot of people recreate on the water here. It's definitely an attraction. Many people from out of town visit, and sometimes when the weather is questionable they will still go out in unsafe conditions. We're hoping that this new buoy system will provide additional information on the water conditions on the nearshore Pennsylvania waters of Lake Erie and prevent anyone from being on the Lake during hazardous weather.

The data will be fed to our website, to the Great Lakes Observing system's website and NOAA's National Data Buoy Center. From there the information goes to the National Weather Service. Now, when the NWS reports the nearshore forecast for the Pennsylvania waters of Lake Erie, they will be using actual data that is coming from the new buoy system instead of predicting conditions like they do now. The NWS will provide the buoy information on their website, through the NOAA weather radio, and through their Dial-A-Buoy program where you can actually dial a phone number and get the information as well.

In addition to the weather station, wave sensor and water quality sensors, there will also be a video camera mounted on the buoy system taking 30-second clips of water conditions and updating to the website every hour. We wanted people to get visuals of what the conditions look like and how the waves are moving, so this will be important.

EM: Have you heard from people in the community looking forward to this kind of data?

JS: We've had a tremendous amount of community support for this project. People are very excited, and not just in Erie County. We get a lot of visitors from throughout the region and everybody has really wanted this for several years. So there will be a lot of excitement that this buoy system will be deployed off of Pennsylvania water of Lake Erie in our area.

Temperature String Evolved

NexSens' new rugged thermistor strings can hang in any environment

BY ALEX CARD

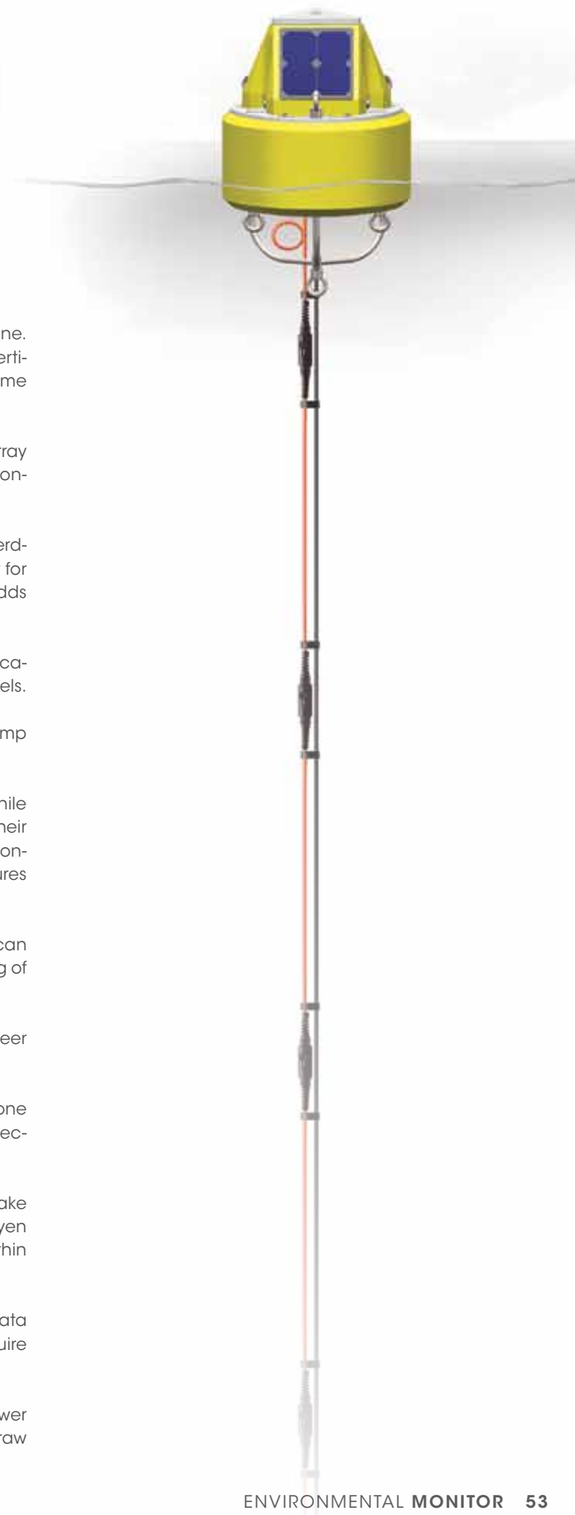


Photo courtesy of the Regional Science Consortium

The NexSens Technology TS210 thermistor string is the next evolution of the TS line. Featuring rugged integral construction, the TS210 is designed to measure vertical temperature profiles in the Great Lakes, coastal waters and other extreme environments.

TS210 strings combine the reliability of NexSens thermistor electronics with an array of new improvements, including reinforced cable design, exposed sensor configuration and an innovative clamp system.

"We now have a marine-grade cable that we use for the TS210," said Paul Nieberding, general manager of Fondriest Environmental, Inc., the master distributor for NexSens Technology in the United States. "It has a braided Kevlar core that adds an extra layer of strength to the cable."

A new clamping system attaches the load-bearing steel line to the communications cable directly, rather than connecting to the sensor as in other past models.

"The sensor is the main potential leak point," Nieberding said. "The new clamp takes more stress off of the sensor itself."

Additionally, the TS210's integral construction contributes to its durability. While modular thermistor systems such as the NexSens T-Node FR provide flexibility, their connectors can stress or bend over time, particularly in turbulent aquatic environments. Integrating the thermistor segment with the communication line ensures that the TS210 can gather data with minimized risk of damage in wave zones.

While thermistor strings are often limited to relatively short lengths, the TS210 can be custom-built up to 1,219 meters (4,000 feet) with 250 nodes. Precise spacing of individual nodes is also up to the customer's discretion.

A standard configuration will also be available, said Doug Nguyen, chief engineer for NexSens Technology.

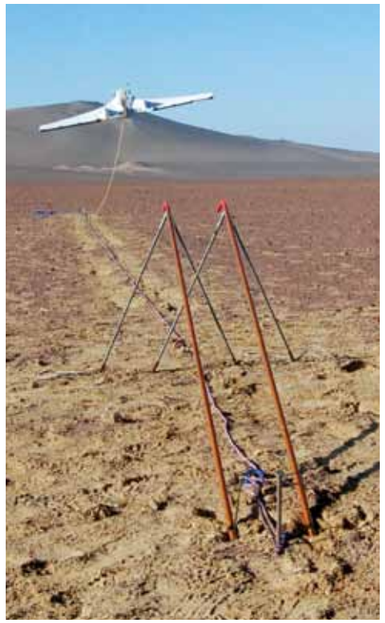
"Another option we have is a prebuilt section — 10 nodes, 10 meters, with one node per meter," Nguyen said. "Users could combine two or three of these sections into 20- or 30-meter chains."

As with the T-Node FR strings, the TS210 features exposed thermistors that make direct contact with water. This adds a serious boost to performance, Nguyen said. "Instead of taking 10 minutes to stabilize, it can take a measurement within a minute."

The TS210 uses industry-standard RS485 Modbus RTU output to interface with data loggers from NexSens and many other manufacturers. The sensor nodes require no calibration and only periodic cleaning and inspection.

A power requirement of 4-28 VDC allows the TS210 to run on a 12 or 24 volt power supply, depending on the application. Each node has a relatively low power draw of 1.5 mA when active and 0.35 mA when in sleep mode. AC

NEW TECHNOLOGY



Air-Deployed Temperature Buoys

In July and August, NASA's Marginal Ice Zone Observations and Processes Experiment brought scientists to Alaska's North Slope to study a region of annual ice freeze-and-thaw that is poorly understood.

The campaign gave scientists a chance to test two UAV-based instruments developed at the University of Colorado, Boulder that could help address those issues. One was the Air-Deployed MicroBuoy, a small buoy that supports a short string of temperature sensors designed to be launched from an unmanned aircraft.

"The whole package consists of a little battery, a microcontroller, a GPS and a little radio," said Scott Palo, who developed the buoy along with Dale Lawrence, both professors in the Aerospace Engineering Sciences Department at CU-Boulder. "And it fits into a physical package slightly larger than a roll of quarters."

During the campaign, the researchers deployed the buoys from ScanEagle UAVs operated by the University of Alaska, Fairbanks.

The researchers also tested the CU-Boulder-developed Self Deployed Surface Sonde, which consists of similar sensor equipment loaded into a small foam aircraft that can fly upwards of 20 kilometers offshore before landing and unfurling its 10-meter temperature string. Though this instrument's limited battery capacity can't carry its 18-inch wingspan as far offshore as a larger AUV with a micro buoy payload, it can achieve a more accurate placement than a buoy dropped from altitude. JG

In-Plant Moisture Sensor

Soil probes are commonly used in agriculture to measure soil moisture. But as it turns out, soil moisture sensors on the market today may not be ideal for all plants, especially ones with dense, meandering root systems like grape vines.

Using a standard soil probe only gives a moisture reading for a small section of soil, about the size of a baseball. That's a good sample, said Alan Lakso, professor of horticulture at Cornell University. But it's far from comprehensive. Researchers at the university say they've developed a better sensor, one that's as small as a fingernail and easily implanted into growing vegetation.

The sensor is constructed of two thin sheets of silicon on one side that bond with a layer of glass. In between the two halves is a small water-filled cavity encased by a porous membrane that exchanges moisture with its surroundings to maintain pressure balance, which is converted into a moisture measurement.

Not much power is required for the sensors, and they shouldn't cost much either. If a reliable mass-production method can be established, Lakso says the price for each might be around $5.

"Over an orchard or vineyard, one sensor gives you a very small sample. But if you could afford 10 to put in the same area," said Lakso. "It's much more inexpensive for researchers and hydrologists to take measurements, and lots of them." DK

Photo: (top) Scott Palo / University of Colorado, Boulder; (bottom) Alan Lasko

New pH Sensor for Ocean Acidity

A new generation of small, low-cost sensors for long-term monitoring of the pH of seawater is within reach, British researchers report.

Ocean acidification requires long-term monitoring, so researchers need instruments that can be deployed in remote areas and take repeated measurements over long periods. Most devices for in-situ pH measurements use electrodes, which are incapable of the precision needed to study ocean acidification, said Victoire Rérolle, a postdoctoral researcher at the National Oceanography Centre in Southampton, England.

"The more promising technology is spectrophotometry, but there is no off-the-shelf instrument currently available for that," Rérolle said. She and colleagues say they've made significant progress in addressing that challenge.

The micro sensor they developed took accurate measurements during more than a month aboard a research vessel, they report in the journal Analytica Chimica Acta.

The tool uses an indicator dye that changes color as pH changes — not unlike the litmus strips familiar to high school chemistry students — contained in a microfluidic chip. It also uses a spectrophotometer to measure light from an LED as it passes through the dyed water. Pumps and valves control the water sample.

The tool requires few inputs, so it could be deployed for a long time without maintenance. For example, it used less than 30 milliliters of dye during the test deployment. AM

CubeSensors

A small startup from Slovenia wants to build healthier households by making atmospheric monitoring technology accessible to homeowners.

The CubeSensor is a palm-sized monitoring system that evaluates atmospheric quality and provides users with relevant health and lifestyle suggestions through a companion web app. Seven sensors measure temperature, humidity, air quality, light, noise, barometric pressure and motion.

"We all have weather apps on our phones, but we know very little about what's going on in places where we spend on average 90 percent of our lives — our homes and offices," said Alja Isakovic of CubeSensors' outreach. "We decided it was time to find out how healthy the air we breathe is, and how little changes in our environment affect how we feel."

The CubeSensor differentiates itself from other household monitoring products by reading air quality through the detection of volatile organic compounds. This method produces accurate measurements that are unaffected by ventilation systems.

The device offers practical advice tailored to home and office through its web app. Shaking the CubeSensor gives instant air quality feedback: If the Cube glows blue, indoor atmospheric quality is good. If the Cube glows red, users know to consult the app for further recommendations. AC

Photo: (top) NOAA's National Ocean Service; (bottom) CubeSensors

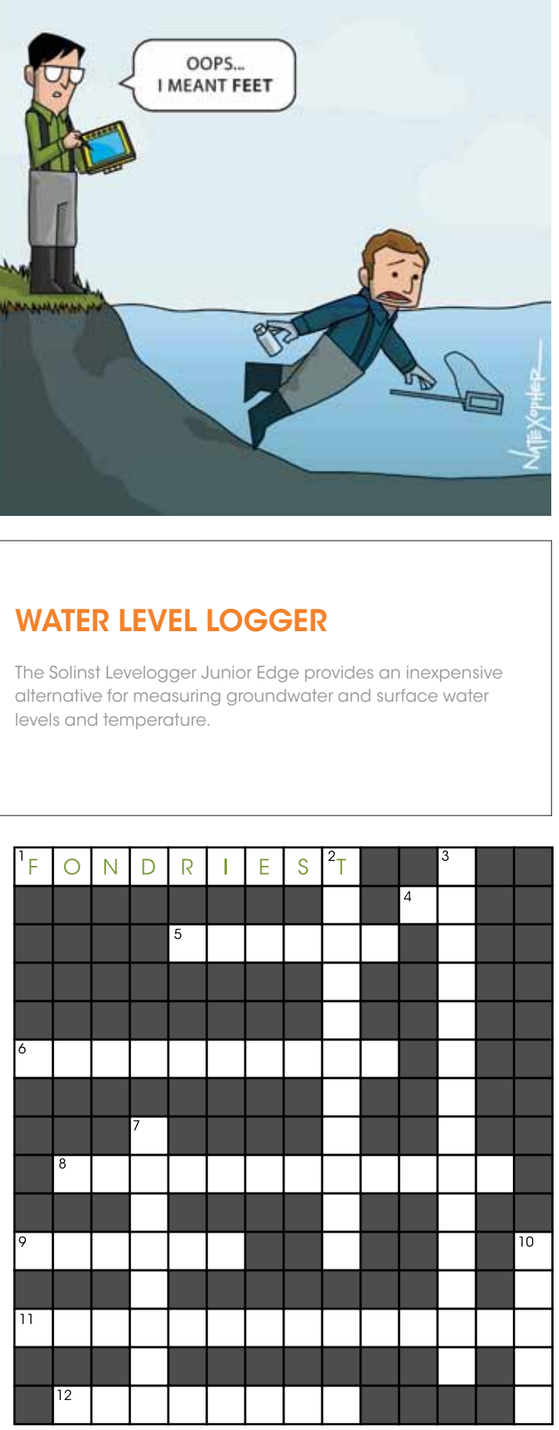
Water Temperature

Across

1. Your source for precision temperature sensors and strings
4. Le Chatelier's principle explains why _____ decreases as temperature increases
5. Dissolved _____ is less soluble in warm water than in cold water
6. The vertical cycling of warmer and cooler water in the ocean
8. Water temperature can affect ionic mobility and concentration, increasing _____
9. Temperature measures the average thermal _____ of a substance
11. The greatest source of heat transfer to lake water
12. Water freezes at lower temperatures under higher _____

Down

2. The thermal division in a lake
3. Cold water temperatures can inhibit _____ in plants
7. Salmonoids are particularly sensitive to an _____ in water temperature
10. Water is most _____ at 4 degrees Celsius



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NEXSENS technology