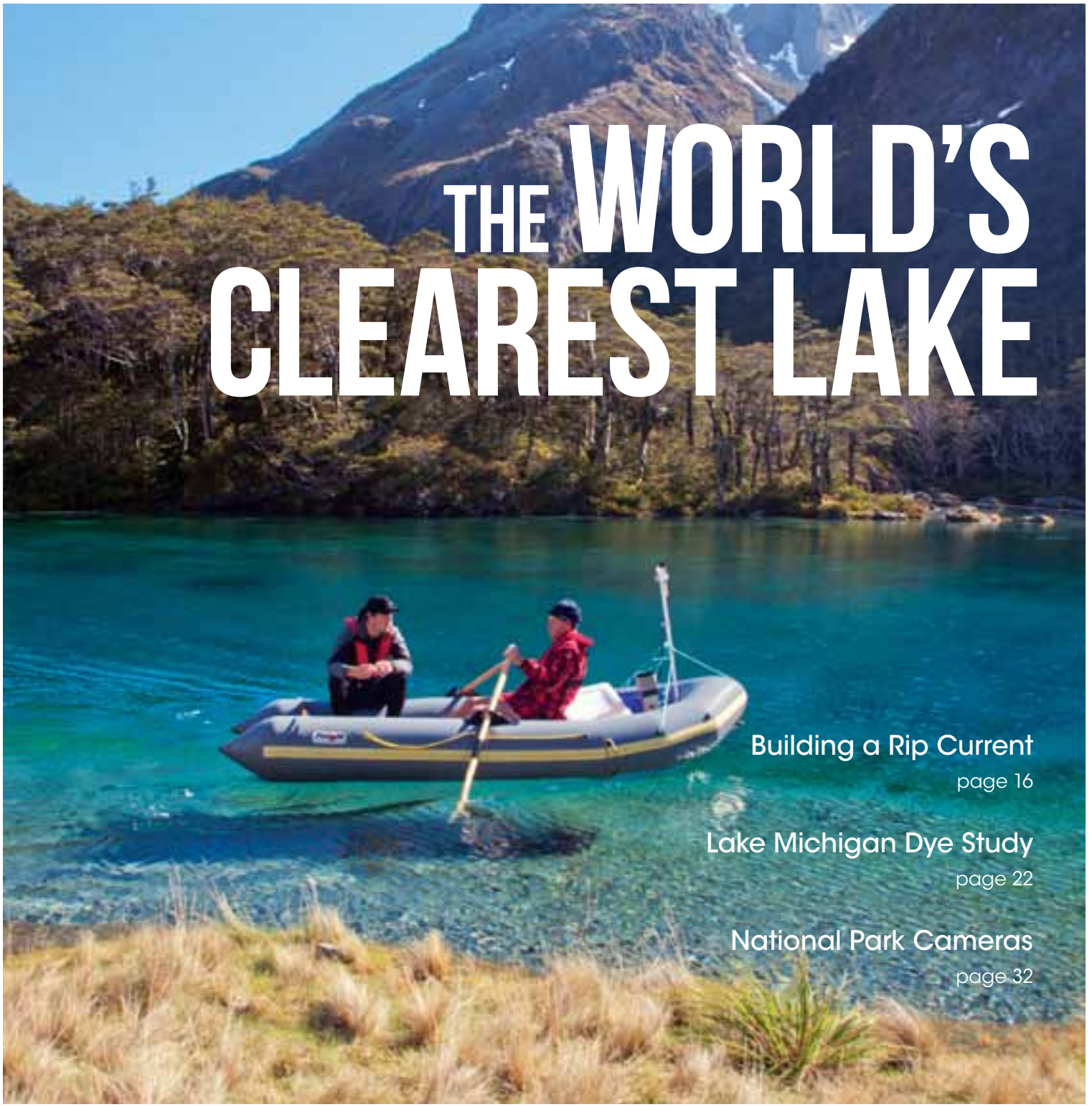
ENVIRONMENTAL
monitor
FALL 2013
APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS



THE WORLD'S CLEAREST LAKE

FONDRIEST
ENVIRONMENTAL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WELCOME…

Welcome to the Fall Edition of the Environmental Monitor. This issue spans the biosphere, from the soils on the slopes of the San Vicente volcano in El Salvador, to the crystal-clear waters of Blue Lake in New Zealand, to the aerosols and hydrocarbons in the atmosphere over the Southeast United States. Other highlights include a giant plume of red dye in Lake Michigan, a National Park Service webcam network, and rip current researchers who dug themselves an underwater trench with the propellers of a Vietnam War-era military landing vessel.

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.

Cover Photo: Mark Gall

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Rocky Mountain Tailed Frogs

A laboratory study of tailed frog tadpoles collected from small streams across Glacier National Park shows that animals from some streams are more likely to survive warmer temperatures than those from others. If one segment of the species is able to hold out against the warming temperatures that scientists predict, it could be a boon for the species' chances to adapt to climate change.

Photo: Joe Giersch

Antarctic Research Stations

Ronald Ross' work has taken him to Antarctica over a dozen times. He travels there once a year to install and service camera-equipped weather stations that track climate, icebergs and penguins. The engagement made possible by the cameras is important because federal funders of research are increasingly trying to reach out to the public and show them their tax dollars at work.

Photo: Ronald Ross

Stream Restoration Structures

Researchers at the State University of New York College of Environmental Science and Forestry and Syracuse University led a study of two streams in upstate New York that had undergone restoration. An intensive monitoring effort around man-made cross vanes and J-hooks found the in-stream structures effective. The results are important to future planning of stream restoration efforts.

Photo: Ted Endreny

Towers in Flux

Tracking carbon dioxide between forests and atmosphere

BY AUSTEN VERRILLI

Photo: Trevor Keenan

Determining exchange rates of carbon dioxide between the earth's forests and the atmosphere is turbulent business. Wind above forest canopies swirls as vortexes of air enter and exit stands of trees. Across the globe, towers stand among the landscape, with sensors monitoring these eddies for carbon dioxide, water vapor and other gasses.

These so-called "flux towers" collect data on carbon dioxide exchange rates between the earth and atmosphere. Information gathered plays into the debate on the measurable effects of climate change.

Flux towers give researchers the ability to watch as carbon dioxide concentrations vary between the earth and atmosphere, signalling the increase or decrease of the gas in forests. Fluctuations of carbon dioxide are clearly visible in long-running flux measurements, though researchers are not ready to point the finger at any one cause.

Harvard has the longest running flux tower measurement system on the globe, which offers unparalleled insights to the performance of ecosystem carbon cycles. Measurements indicate doubling of ecosystem carbon uptake over the past 20 years at their sites, which was entirely unanticipated in a forest of its developmental stage, said Asko Noormets, a forestry professor at North Carolina State University and lead principal investigator of NC State flux tower monitoring sites in the Ameriflux Network.

Researchers evaluate exchange between forests and the atmosphere through a method called eddy covariance. It explores century-old ideas with new technology to examine carbon fluctuations at fixed points. "The methodology is based on capturing the high-frequency information carried by wind," said Noormets.

By monitoring wind and gas concentrations at high frequency at a fixed point above vegetation, one can deduce exchange processes that occurred upwind.

Theoretical concepts underlying the eddy covariance technique date back to the 1895 work of Osborne Reynolds, a British physicist whose research is the foundation for principles of fluid dynamics relating to fluid turbulence.

The technologies that make continuous measurements of eddy flux possible have only recently come of age, said Noormets.

NOAA researchers started measuring flux exchanges in the 1970s. The instruments they built were complex and could only sample for a few days at most, due to sensor and data storage limitations, he said.

Early instruments needed more frequent calibration and repairs, requiring engineering expertise. Advancements in sensor technology, interface and reliability allow the operation of a typical instrument system by anyone, said Ge Sun, a hydrologist at the Eastern Forest Threats Assessment Center. "Nowadays, it seems much simpler because of computers and storage and technology," he said.

In the 1990s, instrument prices decreased and reliability of instruments increased, allowing university scientists to incorporate flux measurements into their research.

Two sensors are at the core of flux measurements: a water vapor-carbon dioxide sensor and a three-dimensional wind speed and direction sensor, or sonic anemometer.

Carbon dioxide and water vapor are usually combined into one sensor. "It so happens that the detection techniques for carbon dioxide and water vapor are similar and that fluctuations in both need to be known for carbon dioxide flux to be estimated," Noormets said.

Radiometers and infrared gas analyzers are also used on the towers. Methane concentrations have been a hot topic in flux measurement, as researchers think it will have a greater effect on the global climate in the short term.

Once data are collected by the tower, which typically samples continuously, the information is converted, processed and corrected, resulting in flux estimates. "We can then infer the exchange of that particular gas and the properties of the ecosystem where that exchange occurs," Noormets said. AV

Monitoring the Gunk

The Shawangunk Mountains–known locally as "The Gunks"–lend a scenic geological backdrop to the State University of New York at New Paltz. They also lend their name to a pond on campus that students and staff call "The Gunk."

While the name's origin may lie in the mountain range, the pond's appearance might have helped it stick.

"It's definitely gunky," said Alex Letourneau, a New Paltz senior studying computer science. "I wouldn't recommend swimming in it. I know people who have, but I'm not that brave."

Aesthetics aside, the pond has become a focal point for a water quality monitoring effort across campus. A monitoring buoy floating on the Gunk is part of a project to collect baseline data on the water passing through the pond before it eventually ends up in Saw Mill Brook, which flows into the Wallkill River, a tributary of the Hudson River.

The monitoring is backed by a collaboration between New Paltz, the New York Department of Environmental Conservation, the New York State Water Resources Institute at Cornell University and the Hudson River Estuary Fund. They're also supporting an initiative to outfit the campus with more green infrastructure like rain gardens, bioswales and permeable pavement. The data will help show whether those installations are benefiting water quality. Another aspect of the project will build elements of the monitoring and the infrastructure into education and outreach tools.

Though David Richardson, assistant professor of biology at New Paltz, is overseeing the monitoring, he said students are playing an important role in the investigation. This level of participation by undergraduate students is relatively rare, he said.

"There are a few exceptions, but most of the other people are working with graduate students or professionals or government agencies," Richardson said. "I think this is a pretty cool project because it involves mainly undergraduates that are driving the research."

David Richardson (right) and students deploy a data buoy on the SUNY New Paltz campus.

Letourneau, the senior studying computer science, is one of those students. Having taken a few biology classes and developed an interest in the field, he approached Richardson about working on a project that would combine biology with his major.

Before long, Letourneau was tasked with assembling and deploying a NexSens MB-100 buoy equipped with a YSI EXO2 multi-parameter water quality sonde measuring pH, temperature, conductivity, dissolved oxygen and turbidity.

"I was kind of diving in blind," Letourneau said. "It was pretty scary from my end of things. I was basically told I get to just figure out this really expensive, high-end piece of technology, and get it working for a purpose that I'm not the most familiar with."

Despite those initial misgivings, he got the buoy up and running. Though data collection began in June, it has already given researchers an idea of what's going on in the Gunk. For example, the data showed how the pond responded to June's wet weather.

"Conductivity went way down because there was dilution," Richardson said. "But turbidity went up because it was stirring up and eroding away some of the sediment. It was interesting to see that storms are positive in some impacts and perhaps negative in others."

In addition to getting the monitoring hardware going, Letourneau designed and developed the website that displays buoy data in near real-time. The design is clean and intuitive, which he and Richardson say should help in its outreach and education role for non-experts.

"You have to make a website appealing to someone who's not necessarily too familiar with, or maybe even interested in, science," Letourneau said. "You have to catch their attention a little bit and make it easy for them to take it all in and learn from it." JG

ABOUT DAVID RICHARDSON

David Richardson's other work includes research into the extent and causes behind an invasion of Didymosphenia geminata, or "rock snot," in New York. He's also investigating ongoing changes in Lake Minnewaska, an extremely clear, formerly fishless lake in the Shawangunks that has seen more algal blooms since golden shiner minnows were introduced.

Photo: Erich Stern

Practice in Research

When late-winter snow falls on a nature preserve near Washington, Pa., melted divots surround Eastern skunk cabbages. The cabbage's heat generation is among the topics Washington and Jefferson College students explore in a capstone ecology course.

Ecology students choose their own investigations. At the end of the semester, they draw their conclusions and share findings with students, professors and the public at a research symposium.

James March, an associate professor of biology, teaches the class. He said each student asks their own question and pursues an answer using environmental monitoring technology at the school and field station. The short time frame pushes students to be realistic with their questions and research expectations as the clock ticks toward presentation day. "It's kind of like a mini master's degree, but you only have three and a half months to do it," March said.

Students often use small iButton temperature loggers during their research. A student researcher placed a few inside flowering Eastern skunk cabbages and found the plant usually is 1-4 degrees Celsius warmer than ambient temperature.

In the end, March said, the course is as much about carefully planning each step of the project to completion as it is about the results. "It's the process that they learn from," he said. AV

Photo: (left) James March; (right) Carla Stanley

Iñupiat children seining in Kaktovik Lagoon.

Camp ANWR

As far as research trips go, getting to Kaktovik, Alaska, isn't bad. Commercial flights routinely fly there, but sometimes fog makes it difficult for planes to land. The delays are worth the wait for two University of Texas researchers who help run an annual marine science camp there.

Ken Dunton and Jim McClelland go to the small Alaska town, which has a population less than 300, for field work in April, June and August for several weeks each year. The camp they oversee takes place in August and is possible through a partnership between the University of Texas, U.S. Fish and Wildlife Service and Kaktovik's Kaveolook School.

"The main goal for the summer science program is to get kids excited about science," said McClelland, an associate professor of marine science. "The program also gives us an opportunity to share what we are learning about the local environment and connect with the Kaktovik community."

The camp is jam-packed with activities. Field trips let the children, native Iñupiat Eskimo, see firsthand the methods and sampling technology involved. There are dissections, beach walks that focus on coastal erosion and a geocaching scavenger hunt. The children also take educational boat rides.

"The research vessel we use for the camp is a 27-foot Boston Whaler. It's equipped with a sorting table that makes it easy to look at what comes up in our various sampling devices," said McClelland. "We also have sensors that measure temperature, salinity, pH and dissolved oxygen. The children learn how to deploy and operate those sensors."

The kids also run plankton tows. A beam trawl fishing net configuration runs along the bottom of the seabed to capture shellfish and other creatures that live there. In addition to the beam trawl, a PONAR grab sampler collects portions of the seabed for the young scientists to evaluate.

"The children get to see all of these sampling techniques and look at the samples that we collect," said McClelland.

The Iñupiat children see firsthand the techniques, equipment and samples collected, but the camp does more than increase their knowledge. It also fosters a connection with the local ecosystem, something that McClelland and Dunton say is already very strong within the Iñupiat community. More than 90 percent of Kaktovik residents fish and hunt to feed themselves. They see how they are part of the food chain every day. DK

GRAND CALUMET RIVER CLEANUP

BY JEFF GILLIES

Dredging is underway on the East Branch of the Grand Calumet River as part of an $80 million effort to remove contaminated sediment and restore habitat along the stream. Dredging began on Aug. 1 and is expected to remove approximately 350,000 cubic yards of polluted mud from the river and soil from adjacent degraded wetlands.

The Grand Calumet River system drains a heavily industrialized region between Chicago and Gary, Ind., before emptying into Lake Michigan through the Indiana Harbor and Ship Canal. Much of the system is listed by the U.S. Environmental Protection Agency as a Great Lakes Area of Concern for its legacy of pollution, including polychlorinated biphenyls, polycyclic aromatic hydrocarbons and heavy metals.

"It's very industrial," said Richard Weber, vice president and principal engineer with Natural Resource Technology, Inc., a partner firm on the dredging project. "Our upland support area is actually constructed in the area of a Superfund site."

The system has seen several sediment removal projects in recent years, including two on the river's West Branch funded by the Great Lakes Legacy Act. The Legacy Act is also contributing $52 million to the current dredging effort, which focuses on a 1.8-mile stretch of the East Branch near East Chicago, Ind. The state of Indiana contributed another $28 million that originated from an earlier settlement with area industry.

The East Branch project is being conducted by Great Lakes Sediment Remediation, LLC, a joint venture including Natural Resource Technology, Inc., J.F. Brennan Company, Inc., and Environmental Restoration, LLC.

Two hydraulic dredges on the river are pulling up sediment through 8-inch intake pipes, according to Weber. Because the contamination runs so deep into the sediment, complete removal would be cost prohibitive. The project's partners and their engineers have opted to partially dredge the tainted sediment and place a capping layer over the bed to isolate the remaining buried chemicals from the environment.

Four data buoys--one upstream and one downstream of each dredge--track turbidity in the river to make sure the operation stays within a compliance level for total suspended solids.

Each NexSens MB-300 data buoy sports a YSI 600OMS V2 sonde with a 6136 turbidity sensor that takes measurements every 15 minutes. The data is accessible in real-time through a NexSens WQData website.

Though the sensors measure turbidity, the compliance levels are established under total suspended solids. To make the surrogate turbidity readings useful, water samples from the river were recently analyzed for turbidity and TSS to develop a correlation between the two.

"We use that to monitor in real-time turbidity in the field to make sure that we're not exceeding that TSS standard," said Weber. The TSS standard is 50 milligrams per liter above background levels, which is determined by the buoy upstream of the dredge.

"If we do exceed that value above background and it is attributable to the dredging or capping operations, then we have to shut down activities and do something different such as applying best management practices to get back into compliance."

Photo: Natural Resource Technology

The sediment cap consists of a layer of sand and a commercial product called AquaGate, which is manufactured by Toledo-based AquaBlok, Ltd. The AquaGate product for this project is fine aggregate with an outer layer of organoclay to ensure long-term cap performance. Crews from J.F. Brennan apply the cap in thin layers over the remaining soft sediment with the company's patented broadcast spreading system.

Lower levels of contamination from the sediment have also infiltrated wetland soils along the river, and a large portion of the projected 350,000 cubic yards of material to be removed will actually come from the wetland excavation, Weber said. But the project's benefits reach beyond vacuuming and digging chemicals out of the marshes.

"Another reason for dredging of the wetlands besides the contamination is the fact that they've been overgrown with phragmites, which is an invasive species," Weber said. "And part of the money coming from the Legacy Act can be used for habitat restoration."

Once the invasive phragmites are scraped away, Cardno JFNew, a restoration specialist company working for Great Lakes Sediment Remediation, will restore the areas with ponds and swales and replant them with native vegetation.

This project, which is expected to take around three years, is one of several in the works to help the Grand Calumet River recover from decades of pollution.

"This is only one of many segments that have already been or are scheduled to be addressed through the Great Lakes Legacy Act," Weber said. JG

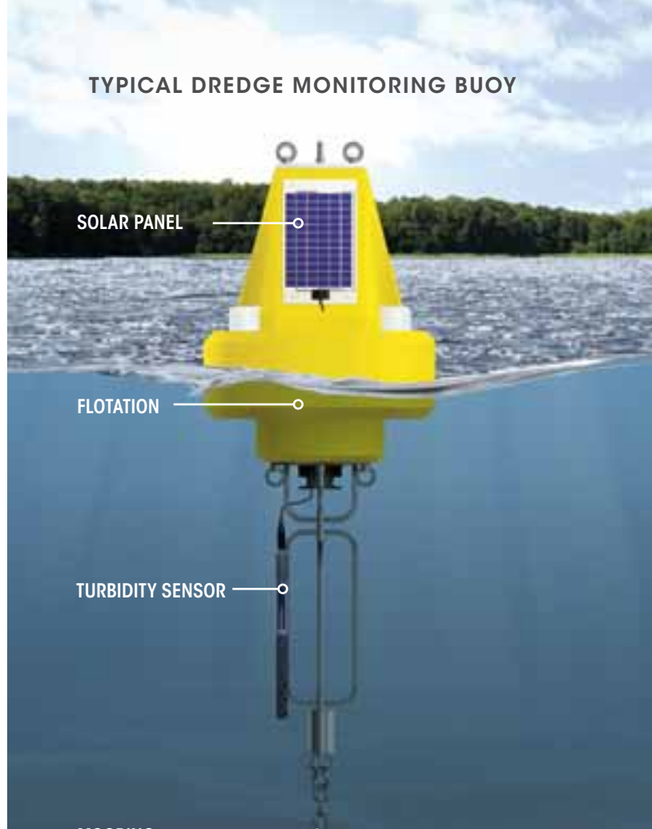
ABOUT GREAT LAKES SEDIMENT REMEDIATION, LLC

Great Lakes Sediment Remediation, LLC was awarded a $150 million contract under the U.S. Environmental Protection Agency's Great Lakes National Program Office Cleanup Services to work on cleanup projects in Area of Concern sites. The joint venture combines the expertise of its partners in dredging, capping and habitat restoration.

Natural Resource Technology, Inc., an environmental engineering and consulting firm based in Milwaukee, handles construction quality control and quality assurance, as well as technical documents.

J.F. Brennan Company, Inc., a marine services contractor based in LaCrosse, Wis., dredges sediments and marshes and applies its patented broadcast capping system to deliver layer of protective material over undredged sediments without disturbing the remaining contaminants.

Environmental Restoration, LLC, an emergency response contractor based in St. Louis, provides upland support, transports and disposes of dredged material and conducts other infrastructure activities.



While measuring total suspended solids directly is the ideal method to evaluate sediment re-suspension caused by dredging, it is not feasible for real-time applications given the available measurement technology. Thus, turbidity, a measurement of water cloudiness, is typically used to provide real-time data that represents approximate levels of resuspension and can indicate the likelihood of released toxins.

A typical dredge monitoring network consists of multiple buoys strategically stationed both upstream and downstream of the dredge operations to compare turbidity values. Within each buoy, a turbidity sensor is attached to a solar-charged data logger via communication cable. Turbidity sensors are available with self-cleaning wipers and other anti-fouling mechanisms to reduce maintenance and help ensure quality data over extended periods of time.

Turbidity data are collected at a user-defined interval and transmitted via radio, cellular or satellite telemetry to a project office. A web-based datacenter allows project personnel to access data from any remote location via a computer or smartphone.

Compliance requirements mandate that turbidity not exceed a certain level at downstream operations. This level can be a fixed value based on collected background measurements or a moving value compared with upstream turbidity data. Automated alarm notifications allow dredge operators and other personnel to receive immediate alerts when turbidity levels are too high so that corrective action can be taken.

Submersible Data Logger

BY DANIEL KELLY

NexSens Technology's SDL500 is designed to withstand harsh conditions. Fitting securely into NexSens' buoys, the fully submersible logger is an ideal choice for system deployments in lakes, streams or rivers. It features five sensor ports, multiple telemetry options and watertight reliability.

"The SDL500 is really the workhorse of the buoy-based systems that we offer," said Doug Nguyen, chief engineer for NexSens Technology. "It supports sensors, telemetry and data collection and can go down to 200 feet. Some SDLs have even been deployed under ice."

The logger was designed for deployment in NexSens' buoys, enhancing versatility in system design. The buoys are designed for years of service in lakes, rivers or coastal waters. Systems are available with up to 1500-pound net buoyancy and optional solar panels provide long-term power. Deployment pipes and instrument cages support and organize sensor configurations.

Sensors interface with the SDL500 through industry-standard communication protocols like SDI-12, RS-232, RS-485 and analog. Common sensors like water quality sondes, temperature strings and weather stations are a quick addition. NexSens connectorizes all sensor cables to use watertight plugs, making for a simple plug-and-play interface.

"A double o-ring seal protects the inner workings of the logger, but it's just as important that the sensor connections are watertight," said Nguyen. "So that's also a key advantage to our connectors."

The SDL500 logs data from various sensors based on user-defined intervals. All data are displayed in iChart software, which offers the industry's largest device library. The library contains drivers for YSI, Hach, Vaisala, Lufft and many other manufacturers.

Data are sent via cellular, radio or satellite telemetry. Cellular is the most common choice, says Nguyen, followed closely by radio. If needed, NexSens' iChart software can send alerts via email or text message when parameter levels exceed predefined thresholds.

The software can also push data to a NexSens WQData web datacenter, which allows project personnel to access data at any time from a web browser. The online datacenter makes it easier for multiple project managers to share and manage data, says Nguyen.

"We've found that different projects have different needs. The telemetry options make monitoring possible in even secluded locations. Customers have used the satellite option all over the world," said Nguyen. "And WQData is a popular option that makes it easier to share data publicly."

Nguyen has worked on many projects using SDL500 submersible data loggers and has seen them deployed for bridge scour monitoring, in flood alert systems and along rivers where dredging is taking place. DK

Quick pluggable sensor connectors with double o-ring seals

Powered with eight D-cell batteries

Fits in 6-inch deployment pipes

THE WORLD'S CLEAREST LAKE

A remote lake in New Zealand is the clearest freshwater lake ever reported

BY KEVIN ROSE

For decades, scientists have been fascinated by the color and clarity of water. Very high water clarity is extremely rare in nature. So it was with some surprise that a team of scientists from the National Institute of Water and the Atmosphere in New Zealand recently discovered that Blue Lake, in Nelson Lakes National Park on the country's South Island, is the visually clearest freshwater lake ever reported.

Mark Gall, a scientist at NIWA, said colleague Rob Merrilees had seen Blue Lake and thought it could be comparable to Pupu Springs, another South Island lake that was the clearest reported freshwater lake at the time.

"Beginning in 2009, we conducted an investigation working with optical instrumentation and techniques developed for the ocean and found that Blue Lake was actually visually clearer than Pupu Springs and clearer than we could have imagined," said Gall, lead author of a recent paper on Blue Lake.

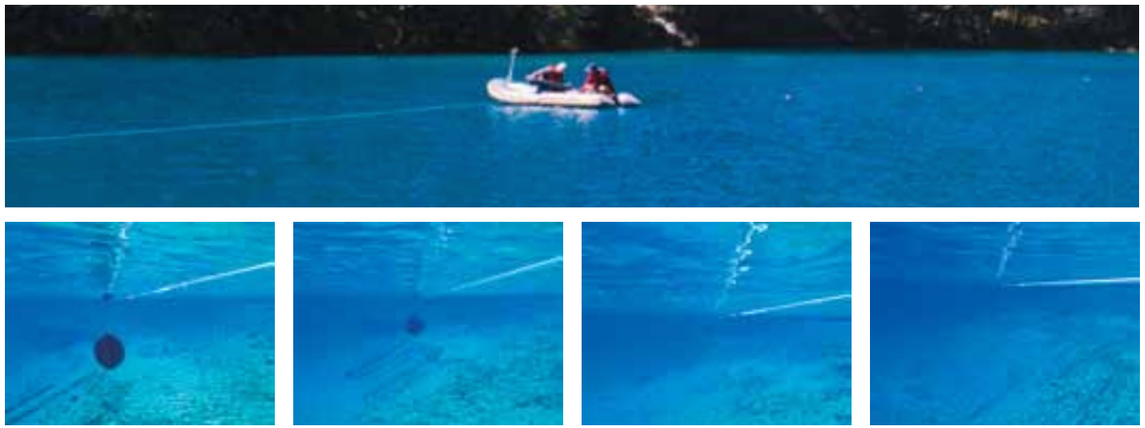
Water clarity can be assessed a variety of ways, including measuring the maximum distance that a black disk can be viewed horizontally underwater. This method "is a good index of visual ranges of practical importance for humans and aquatic animals," says study coauthor and NIWA scientist Rob Davies-Colley. The theoretical maximum for this method is about 83 meters (272 feet) in pure water. Blue Lake visibility, by comparison, ranged from 70-80 meters (230-262 feet). Even photos from days when the water is less clear (around 65 meters or 213 feet) reveal remarkable blue violet colors and outstanding clarity.

Because the lake is shallow, other methods like the Secchi disk that are common elsewhere can't be used. Gall and his colleagues visited the site several times by helicopter to collect water samples and measure water clarity with an underwater transmissometer from Martek Instruments. The crew also installed another transmissometer and instruments to measure temperature and depth at the bottom of the lake that recorded measurements at sub-hourly intervals. A Zebra-Tech brush wiper helped minimize biofouling on the sensors. Since the lake is difficult to access, the equipment included cellular telemetry for remote daily data access. Gall and his colleagues also gauged spring inflows with an OTT current meter.

The research team found that highly turbid water occasionally flushes into the lake from water and particles upstream, rapidly reducing the water clarity. However, these turbid episodes are short-lived and high clarity is restored within a few days as clear spring-flow flushes the injected particles.

High clarity is a rare feature in lakes due to landscape inputs of organic carbon, nutrients, and particles. Because of this, clarity is often a useful indicator of water quality, and clarity usually drops when human impacts increase.

Fortunately, "the remoteness of Blue Lake, the difficulty of access, and its location in a national park all contribute to the protection of this system," said Davies-Colley. "But climate change remains a threat." KR



Researchers gauge clarity by examining visibility of a black disk across a horizontal distance, pictured here at 7, 18, 35 and 50 meters.

All Photos: Mark Gall

LET IT RAIN

BY AUSTEN VERRILLI

Diagram: Nate Christopher

Cleveland Metroparks' natural resource managers are working with local citizens to improve the water quality of a Cuyahoga River tributary one yard at a time.

Environmentalists, engineers, the city of Parma, Ohio, and local citizens are collaborating to build a neighborhood full of rain gardens and rain barrels abutting a city park.

This summer, Cleveland Metroparks and West Creek Conservancy worked together to recruit homeowners to tend rain gardens. "We wanted the homeowners to adopt them," said Jennifer Grieser, a Cleveland Metroparks senior natural resource manager. "We wanted the homeowners to sign-off."

During the first round of installations, she said there were ten takers who ranged from first-time homeowners to lifelong residents. DCH Landscaping built 22 right-of-way rain gardens, one front-yard rain garden and installed 53 rain barrels in June 2013. URS Corporation provided final design services for the project.

Grieser said the main motivation for the rain gardens was to clean and reduce runoff entering West Creek through headwater streams that drain out of the neighborhood. "Stormwater gushes out of street outfalls and washes away anything living in these small streams," she said.

Workers from the Northeast Ohio Regional Sewer District installed Teledyne Isco flow meters so they can determine how the gardens impact runoff. Workers placed the flow meters before the outfall for the streets being measured.

Six streets now have flow-logging setups. Three are below treatment streets and three are beneath control streets. This arrangement should allow for pre- and post-installation comparison as well as treatment versus control comparison.

This fall the Cleveland Metroparks team will install 19 additional rain gardens. Neighborhood buzz spurred people from both treatment streets to request gardens.

When building a rain garden, a team of contractors from DCH Landscaping start by digging a hole. It has to be a bit deeper than the clay layer in Northern Ohio soil. "We would over-excavate the basin and then lay stone at the bottom," Grieser said.

Contractors install drains in the bottoms of the gardens to ensure they would not overflow or retain too much water.

Once the base of the garden is complete, the team backfills with sandy biosoil. Then they ensure their grading is correct so that water will flow into the rain garden. In some areas they cut a section of curb to create a channel for street runoff to enter the garden.

"After the soil is placed and the grade is correct, the key with the soil is that it doesn't get compacted," Grieser said.

Native perennial plants prevent the soil from getting too compacted and absorb nutrients in runoff.

Grieser said homeowners will need to maintain the rain gardens but the West Creek Conservancy will help with maintenance.

A Great Lakes Restoration Initiative grant has made the rain gardens possible. The Northeast Ohio Regional Sewer District and Northeast Ohio Areawide Coordinating Agency also contributed funds to the project. AV

MONITORING THE MUSSELSHELL

Volunteers track salinity in this crucial source of irrigation water

BY JEFF GILLIES

> "YOU'RE DEALING WITH SOME RESOURCES THAT ARE FEW AND FAR BETWEEN, BUT WITH INDIVIDUALS THAT REALLY DO CARE."
>
> **-David Stout**
> Big Sky Watershed Corps

The Musselshell River flows for 340 miles through Central Montana, passing over a landscape that still carries the chemical signature of its past as an ancient seabed.

Sediment washing into the river and groundwater moving through soils can both carry salts into the Musselshell and boost its salinity. That's an issue because agriculture dominates the land use along the river, which supplies crucial irrigation water in a near-desert climate.

"It's not like we have seawater levels of salinity, but there is a point at which excess salinity in your freshwater can really put crops into stress," said David Stout, a member of the Big Sky Watershed Corps posted at the Lower Musselshell Conservation District office in Roundup, Mont. Big Sky Watershed Corps is a partnership of Montana Conservation Corps, Montana Association of Conservation Districts and the Montana Watershed Coordination Council.

Stout sometimes walks the banks of the river with landowners and ranchers who have volunteered to help out with a salinity monitoring program conducted by the conservation district with funding from the state Department of Environmental Quality. The volunteers have come together through the Musselshell Watershed Coalition.

Stout and four volunteers from homes spread out over a 250-mile stretch of the river periodically measure conductivity (a salinity surrogate) with a handheld meter.

The program is new, but over time Stout says the monitoring will net long-term conductivity data that hydrologists can pair with U.S. Geological Survey flow data and build statistical relationships between the two. The goal is to use those correlations as the basis for an online tool that farmers can check before irrigating. If they find low flows and high salinity, for example, they might want to hold off.

"If we can get people to start thinking about these chemical changes in the river that are going on all the time, I think that forms this really interesting relationship with the river–this shared resource–that we haven't really had before," he said. "It's those kind of real solutions that we hope to achieve through this monitoring program."

Stout's visits with the monitoring volunteers draw out another sort of data–local knowledge from ranchers who spend their lives in close connection with the land.

Photo: David Stout

On a recent sampling trip, Stout said he was on the water with a rancher and their meter wasn't showing them what they expected. They tested the water above the confluence with a creek and again below it, where conductivity suddenly spiked.

Stout said they weren't sure what was going on. Then the rancher mentioned that his flood irrigation, which pumps water into fields to flow alongside crops, was running at the time.

"He starts working out the problem in his head, and he tells me, `Could it be that I've got my flood going and it could be water moving through the ground and feeding the river?'"

That was likely the case, Stout said. Irrigation can draw more groundwater through the salt-laden soils and into the river.

After that, the rancher started picking out more places to sample. Their readings were jumping around, and he wanted to know how far downstream the numbers stabilized. And he wanted to know what the numbers were in the creek.

When they found the creek water had much lower salinity levels, the rancher recalled to Stout that the soil in the creek's drainage doesn't have quite as many salts as the rest of the Musselshell River watershed.

"It's these kinds of relationships with the land that you get out of a monitoring program like this that really get us excited," Stout said. "It just makes you happy that you drove 100 miles to drop an electrical conductivity meter in some stream somewhere."

The information from volunteers is especially valuable for Stout and the groups he works for because they're working with relatively few resources for environmental monitoring and restoration. Eastern and Central Montana have fewer people than the western part of the state. Stout works in two counties with a combined population of around 4,000 people. And a prairie river like the Musselshell lacks the conservation draw of the state's high-profile trout streams.

"It's one of those places in Montana that feels forgotten or left out of the whole game because with so much environmental restoration and water quality monitoring, a lot of the focus is on other parts of the state," Stout said.

"You're dealing with some resources that are few and far between, but with individuals that really do care." JG

South by Southeast

Scientists dive into region's cooling climate

BY DANIEL KELLY

While much of the world has experienced a warmer climate in recent years, the U.S. Southeast has cooled. Scientists want to know why, because the answer could reveal keys to improving air quality and understanding climate change.

To study the cooling Southeast, scientists at several institutions have joined forces to conduct the Southern Atmosphere Study, the largest study on southeastern U.S. air quality since the 1990s. These include the U.S. Environmental Protection Agency, National Center for Atmospheric Research, National Science Foundation, National Oceanic and Atmospheric Administration and the Electric Power Research Institute.

Five air quality studies fall under the Southern Atmosphere Study umbrella. One of them, called Southeast Nexus, is looking at the source of aerosols and hydrocarbons in the area and their contributions to haziness and poor air quality. Natural hydrocarbon emissions from forests in the Southeast are the highest in the country, and scientists expect the results will yield insights important to understanding the atmosphere in the rest of the nation.

"Trees emit a lot of hydrocarbons in the atmosphere. It's what you smell when you walk through a forest," said Joost de Gouw, a research scientist with NOAA and the Cooperative Institute for Research in Environmental Sciences at University of Colorado Boulder. "These are much larger than the man-made emissions."

Hydrocarbon emissions, human-caused or not, are important because they react with nitrogen oxide in polluted air to form ozone and other heat-trapping particles in the atmosphere. In the Southeast, however, the same types of emissions and aerosols could play a role in the area's cooler climate. That is precisely the hypothesis de Gouw and others are testing, but analysis can't begin until all the data are collected.

De Gouw, who has served on multiple NOAA air quality research missions, is highly familiar with the plane and instruments used for data collection. And the long flights.

"It's seven hours. We fly down low for five of those hours. The air is very turbulent down there, very bumpy," said de Gouw. "It's a physically demanding thing to do."

One reason they fly low is to collect discrete air samples, just one of the many samples they collect. The NOAA WP-3D is a prime research airplane, equipped to collect roughly 20 to 25 different kinds of measurements. De Gouw says there are many mass spectrometers aboard and instruments to take optical measurements like light absorption and scattering rates. Probes stick out of the aircraft and pump air in to be analyzed.

Five scientists aboard the flights look after the instruments, though many operate autonomously without a human manager. A scientist in the back of the plane watches as the data come in and may change the flight plan in an instant to inspect a scientifically interesting region more closely.

Those in-air measurements combine with others taken on the ground to give a more complete profile of air in the Southeast. The Electric Power Research Institute facilitates ground measurements because it has been tracking air quality for many years and already has sites running at or near power plants, de Gouw said.

Some of the instruments at the ground sites are gas spectrometers and other chromatography instruments that separate air samples to measure the concentrations of hydrocarbons they contain. Anywhere from 60 to 100 hydrocarbons can be measured from sensors on the ground.

"The ground sites can carry a lot more instruments and record around the clock. It's very detailed data," said de Gouw. "By combining the two (data from the air and ground), it gives us a very detailed picture. It's a very powerful combination." DK

Photo: David Oonk

RIPPED CURRENT

Tired of searching for elusive rip currents, a group of researchers made their own

BY AUSTEN VERRILLI

It's easy to get caught in a rip current during a day at the beach. But scientists find the currents difficult to monitor. That's why, last summer, a group of researchers from the Woods Hole Oceanographic Institution built their own.

Steve Elgar, senior scientist at the Woods Hole Oceanographic Institution who led the experiment, said the currents are hard to find. What's more, they occur in places where it's hard to collect data, like near a wave-battered pier.

Rip currents result from a combination of inbound waves and underwater channels in the sand, which create an avenue for strong outbound currents.

Elgar said it's still not clear which element of the currents is the initiator, though he suspects that it varies. Melissa Moulton, a graduate student at the Massachusetts Institute of Technology has been working with Elgar to figure that question out.

The bigger picture for the researchers is creating a model that will give people the opportunity to incorporate rip currents into research from a desk, instead of a trip to the beach. "I'm trying to put myself out of business, in a sense," said Elgar. "Our goal is to figure out the physics so you don't need us anymore."

It's a noble goal, but it won't come easy. Elgar described measuring rip currents among the constant rumbling surf with words like "turbulent, non-linear and chaotic."

To create a rip current, the team traveled to the U.S. Army Corps of Engineers Field Research Facility in Duck, N.C. There the researchers dug a large trench in the surf zone, measuring 30 meters wide by 100 meters long by 2 to 3 meters deep. The idea was to funnel water away from shore, creating a giant rip current.

The team used a Vietnam War-era military landing craft to dig the massive trenches. They created the channel with the 75-foot-long aquatic vehicle's guarded 3-foot propellers. "We just drove it right on the beach and wiggled its butt back and forth to make a trench," Elgar said.

The team tried to hire a dredge rig to dig the trench, but no dredging company would consider getting their crafts that close to shore. The landing craft ended up being a more economical option anyway, as a free military surplus vehicle.

It took three attempts to successfully create the current. "We dug one of the trenches and the waves were just small," Elgar said. "It filled in and we never made a rip current."

The second try ended the same way. The third attempt worked. The team created a rip current flowing an average speed of 2 knots out to sea, which lasted for nearly 36 hours.

Once the current was in motion, the team started collecting data. They wanted to understand how sea floor sand, waves, currents and the beach all interact during a rip current to determine its physical properties.

Elgar said he expected the trench to fill quickly, like a sand castle moat after one wave passes over. He hurried to deploy their array of sensors, but he found the current and trench were relatively stable with average sized waves passing over.

A host of sensors were used during the experiment to determine current movement and trench depth. Acoustic current meters tracked wave and rip velocities. A GPS-guided jet ski driver took bathymetric surveys of the trench below with a sonar mapping instrument. WHOI-designed altimeters gave depth readings at fixed points during the experiment.

The result of the research team's rip currents, they hope, will be an equation. "We would like to be able to understand what's going on in a sense that a physicist can write an equation on what's going on," said Elgar.

He said their rip current makes for a great test for their developing model. "The rip current and the subsequent filling in of the trench is providing a wonderful test bed for model development, model calibration and model verification," Elgar said. "The extreme perturbations to the seafloor and the corresponding strong changes in the waves and currents are a challenge for models, and thus a nice testbed."

The research, which is ongoing, has many potential benefits. Elgar said an accurate rip current model could be used when planning new beach structures like piers. It may help municipalities keep beaches safer. The model would also lessen the cost of related research.

The research team's rip current was funded by a National Security, Science and Engineering Faculty Fellowship. People from WHOI, the U.S. Army Corps of Engineers and MIT all contributed to the project. AV

Elgar and his team clear a 100 meter long by 30 meter wide trench with a Vietnam War-era military landing craft.

Photo: (top) William Birkeimeier; (bottm) David Clark

RUNNING THE GAMUT

The GAMUT climate and water monitoring network will help scientists and managers prepare for coming challenges to Utah's water sustainability

BY JEFF GILLIES

A growing population and a shrinking snowpack could complicate water supply issues for Utah, which is already the second-driest state in the country. Fortunately for the state's managers, construction is underway on a monitoring network to better characterize water as it flows down the mountains and into urban areas.

Data from the climate and water monitoring network could fill a gap in scientific understanding of Utah's water systems, said Joe Crawford, a research technician at Brigham Young University who is helping develop the network.

"There hasn't been, in my opinion, nearly the amount of research that's necessary to understand how population increase, land use and climate change are going to impact water sustainability in Utah," Crawford said. "That's one of the overarching questions that we're focusing on."

The network is called GAMUT, which stands for Gradients Along Mountain to Urban Transitions. The network falls under the iUTAH program, a larger interdisciplinary effort to study and protect the state's water sustainability. The iUTAH program was funded by a $20 million grant from the National Science Foundation's Experimental Program to Stimulate Competitive Research.

The GAMUT network is a collaborative initiative between Brigham Young University, the University of Utah and Utah State University. Each university will oversee a branch of the network that will follow a single stream from its origins in the mountains down into the valleys where humans begin to play a larger role in the fate of the water quality and quantity.

"We get all the data and the measurements and find out what's going on in the headwaters up above anthropogenic influences as much as we possibly can," Crawford said. "And then as we start coming down into the valley, we measure the same parameters that we were measuring up high, but now we're taking into consideration anthropogenic influences as well as natural influences."

The universities are at various stages in the process of installing multiple climate and water quality sensors along the course of their target streams. The climate stations will measure barometric pressure, wind speed and direction, air temperature, relative humidity, precipitation, snow depth, soil temperature and moisture, and solar radiation.

Photo: Dave Eiriksson

GAMUT climate stations measure wind, precipitation and soil parameters.

Photo: (top) Dave Eiriksson; (bottom) Chris Cox

The aquatic stations in the mountain stretches of the streams will measure stream stage, water temperature, electrical conductivity, pH, dissolved oxygen, and turbidity. The stream stations in the urban stretches will also include sensors for total algae (chlorophyll a plus phycocyanin), fDOM and nitrate. All stream stations will feature YSI EXO2 multi-parameter sondes.

The three streams are in watersheds at different stages of transition from rural and agricultural land uses into more urban and industrial development. The University of Utah will focus on Red Butte Creek, which flows down into the urbanized Salt Lake City. Utah State will look at the Logan River, which flows into the still-highly agricultural Cache Valley. BYU will handle the Provo River, which flows from the Uinta Mountains down into the Heber Valley. Development there falls somewhere between the other two watersheds.

"The Heber Valley is transitioning. It still has quite a bit of agricultural land, but at the same time it's quickly undergoing a rapid transition," Crawford said. "People are selling their farms. It's being transformed over to a more urban and industrialized area."

By trying to answer similar questions in watersheds of varying states of development, the researchers hope to gain additional insights into the effects of land use on Utah's water supply.

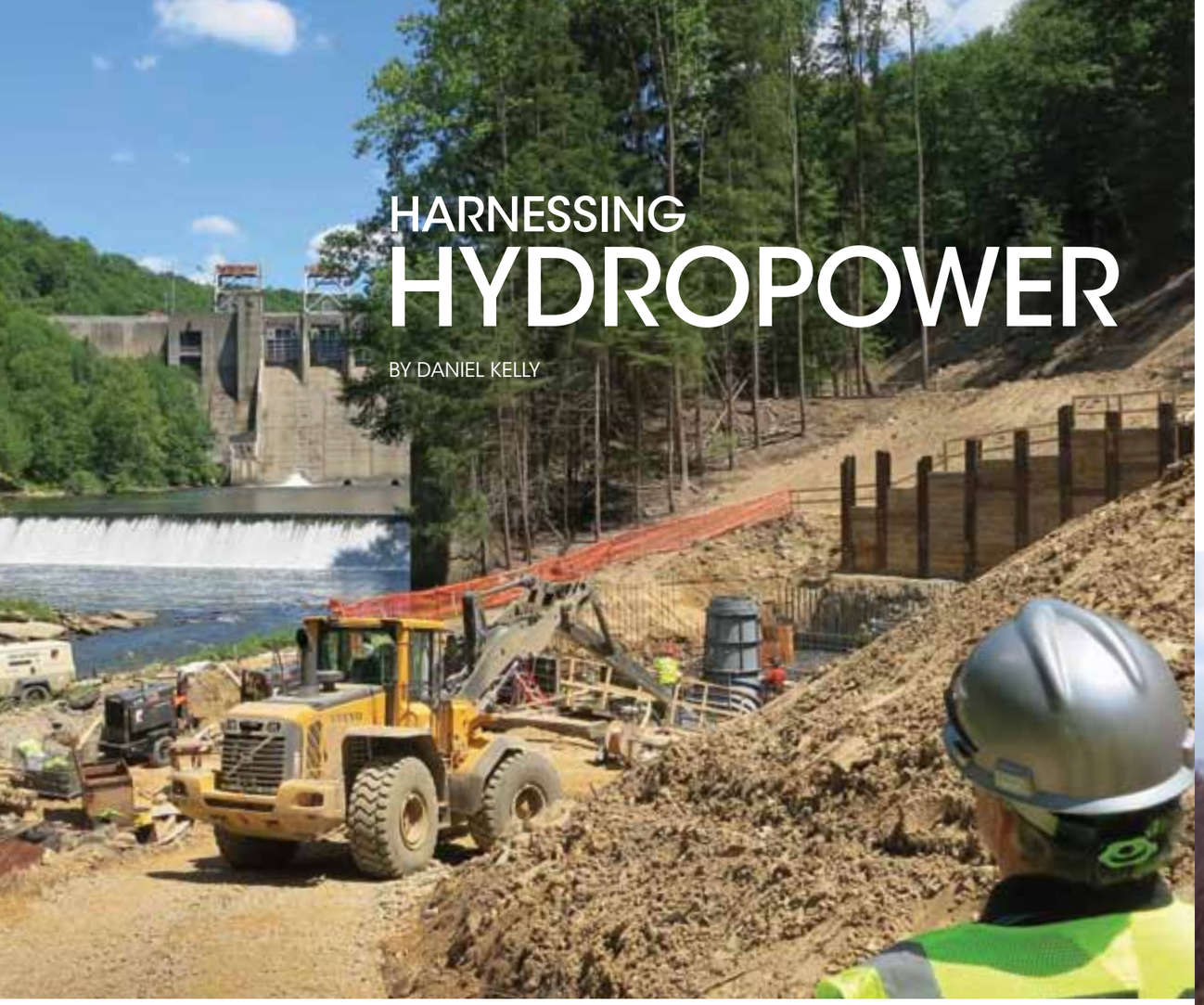
The GAMUT network will supply valuable climate and water quality and quantity data in an understudied region that will help scientists and managers better understand and prepare for the growing demands on Utah's water supply. But the network's designers hope its influence will reach beyond scientists and government officials.

"I think it will be a really good educational tool that will help educate the public and let them know what we're doing," Crawford said. "I've had professors come to me and say, 'When you have it set up, let me know. I want to take my class out.'"

Water quality stations will track changes in chemistry as the streams flow down the mountains.

HARNESSING HYDROPOWER

BY DANIEL KELLY



In 1938, as part of an effort to develop flood controls in the Allegheny River basin in Western Pennsylvania, the U.S. Army Corps of Engineers broke ground on the Mahoning Creek Dam. By 1941, the project was complete.

Although initial plans to equip the dam for hydropower were scrapped due to steel shortages associated with the nation's accelerating war mobilization efforts, project engineers included a hydropower conduit in the final design so the dam could later be retrofitted for energy production.

Seven decades later, Enduring Hydro, LLC, a Maryland-based hydropower developer, is implementing the vision of those early engineers. In partnership with the U.S. Army Corps of Engineers Pittsburgh District, the company is constructing a 6-megawatt, environmentally responsible hydroelectric facility on the Mahoning Creek Dam.

The project is scheduled to come online in late 2013. Enduring Hydro expects that the facility will generate 20,000 megawatt-hours of clean, carbon-free electricity annually for the next 50 to 100 years. That is enough electricity to power 1,800 homes, and is equivalent to planting 1,000,000 trees as it replaces 10,000 tons of carbon dioxide from fossil fuel electricity.

"There are over 75,000 unpowered dams in the United States," said Kristina Johnson, Enduring Hydro's founder and CEO. "We think Mahoning Creek is a perfect example of the common-sense energy solutions our country needs in order to build a clean and vibrant 21st century economy."

To succeed, the project must accommodate the interests of a variety of stakeholders. "One of our goals going into this was to figure out how to produce the maximum amount of energy possible, while not negatively impacting the natural resource we are utilizing," said David Fox, the project's chief environmental manager.

Once the project is up and running, water from the upstream reservoir will flow into a 10-foot diameter steel conduit, travel 1,000 feet downstream and enter a powerhouse containing two specially designed hydropower turbines. The reservoir stratifies in the summer, and the deeper zone can have fairly low oxygen levels. "If we are not careful, this oxygen depleted water could negatively affect conditions downstream of the hydropower facility," Fox said.

> "WE THINK MAHONING CREEK IS A PERFECT EXAMPLE OF THE COMMON-SENSE ENERGY SOLUTIONS OUR COUNTRY NEEDS IN ORDER TO BUILD A CLEAN AND VIBRANT 21ST CENTURY ECONOMY."
>
> **-Kristina Johnson**
> Enduring Hydro founder and CEO

To mitigate this risk, Enduring Hydro, in coordination with the Army Corps and the Pennsylvania Department of Environmental Protection, has studied the system and evaluated how the project could impact water quality. Based on this work, Enduring Hydro and the Army Corps collaboratively developed an Adaptive Management Plan which specifies how the facility will be operated.

To implement this plan, a network of NexSens data loggers and YSI water quality sensors will monitor water quality at the reservoir intake, in the stilling basin just downstream of the dam and at the hydropower outfall. The data will be posted on a website in real time, and will also feed directly into the power plant control system.

The entire system will be automated. If water quality standards drop below agreed upon levels, the control system will reduce flow to the powerhouse, and oxygen-rich water flowing through a bypass valve at the dam will be increased. "We are confident this solution will enable us to maintain the environmental integrity of Mahoning Creek while meeting our energy generation goals," Fox said. DK

SYSTEM DESCRIPTION

Enduring Hydro, a company that modernizes hydroelectric facilities, is working with the U.S. Army Corps of Engineers to build a hydroelectric plant into Pennsylvania's Mahoning Creek Dam. The dam was built in 1941 and Enduring Hydro has opened its hydro conduit, making way for generation of hydroelectric power.

The monitoring network consists of three sites. The first site is located on the top of the dam to monitor the intake waters from the reservoir (intake site). Located downstream of the dam are the stilling basin and downstream sites. These sites each have a solar-charged NexSens 4100-MAST radio telemetry system with YSI 6-Series sonde for monitoring of temperature, specific conductance, dissolved oxygen and turbidity during construction.

The stilling basin and downstream sites transmit data via 900 MHz spread spectrum radio to the NexSens 3200-AVSS system located at the intake site. The 3200-AVSS acts as a data logger for monitoring water level and quality in the reservoir and as a radio-to-cellular bridge for transmitting data through the Verizon cellular network.

Data are downloaded through NexSens iChart 6 software, which is hosted remotely on the NexSens server. The data are then pushed to the NexSens WQData web datacenter for 24/7 access for project personnel from any Internet browser. Data are collected and posted on the datacenter on a 30-minute interval.

Once the plant is in operation, the water quality data will be combined with other operating parameters into the plant's SCADA system to control plant operations. In turn, the SCADA system will also provide non-water quality data to the 3200-AVSS system, so that all data (water quality and plant control) can ultimately be viewed together on the WQData web datacenter.

Photo: Mike Voellmecke

Photo: David Fox

LAKE MICHIGAN DYE STUDY

A Rhodamine dye study in Lake Michigan helps Purdue University researchers better understand currents in the Great Lakes

BY ADAM REDLING

Researchers at Purdue University are seeking to gain a better understanding of the role that Great Lakes currents play in dispersing material such as invasive species.

On July 14, a five-member team led by Cary Troy, an assistant professor in Purdue's School of Civil Engineering, boarded a research vessel for a week-long study aimed at tracking currents in the middle of Lake Michigan.

Through funding from the National Science Foundation, researchers gained access to the Blue Heron, a research vessel from the University of Minnesota Duluth, to conduct their experiment on the lake's currents.

"The general idea is to get a better understanding of where stuff is going in Lake Michigan. That is the broadest definition of what we're doing," Troy said. "You could be thinking about if you introduce an invasive species, and you have the larvae of the invasive species floating around the lake. Where are they likely to be transported? You could be thinking about phytoplankton, or anything that is a passive particle that essentially goes with the flow. Our experiment is designed to get that kind of data to improve the models that predict where these substances go."

The university's study is one of the largest-scale examinations of Great Lakes' dispersion in the past 30 years. Tracking current patterns can prove complicated, because unlike oceans, the Great Lakes flow in unpredictable ways due to variables such as water temperature and wind velocity.

To track water dispersion in Lake Michigan, the researchers injected the non-toxic fluorescent dye Rhodamine WT into the surface water behind the Blue Heron. The researchers then used a WETStar fluorometer to map the concentrations of the dye as it diffused into the lake.

The researchers also used an instrument known as a TRIAXUS. The TRIAXUS is a towable instrument package that was pulled behind the vessel to measure dye concentration, water temperature and turbidity, in addition to other parameters.

By employing a technique known as tow-yoing, researchers moved the TRIAXUS up and down through the water to attain two- and three-dimensional maps of dye concentrations in the water.

While the researchers don't have specific numbers to quantify their expedition just yet, the experiment provided some surprising initial results.

"The unexpected thing for us was how quickly that dye patch grew into this massive blob of dye. Within 5 or 10 minutes, it was already 100 meters to a side and growing rapidly," Troy said. "The reason we think that the dye patch exploded so quickly is that you have sort of a conveyer belt mechanism where the water at the top is moving very quickly away from the slower moving fluid down below. And once that dye gets mixed down through those layers, you have an effective dispersion mechanism where the difference in the velocity from the water at the surface and the water a little bit below the surface really serves to spread out the water and the dye to a very big patch."

That water disperses so easily in Lake Michigan could be either beneficial or detrimental to the Great Lakes depending on the circumstance. Having water disperse easily could mitigate some of the damage done in the event of an oil spill or other contamination incident. However, the free-flowing nature of the lake could be a disadvantage in trying to corral an invasive species.

The research conducted aboard the Blue Heron is just one facet of the study, however.

University researchers also placed monitoring buoys in the middle of Lake Michigan to help measure the currents' movement throughout the water column over longer periods of time. They plan on retrieving these monitors at the end of the summer to download the gathered data to study over the winter.

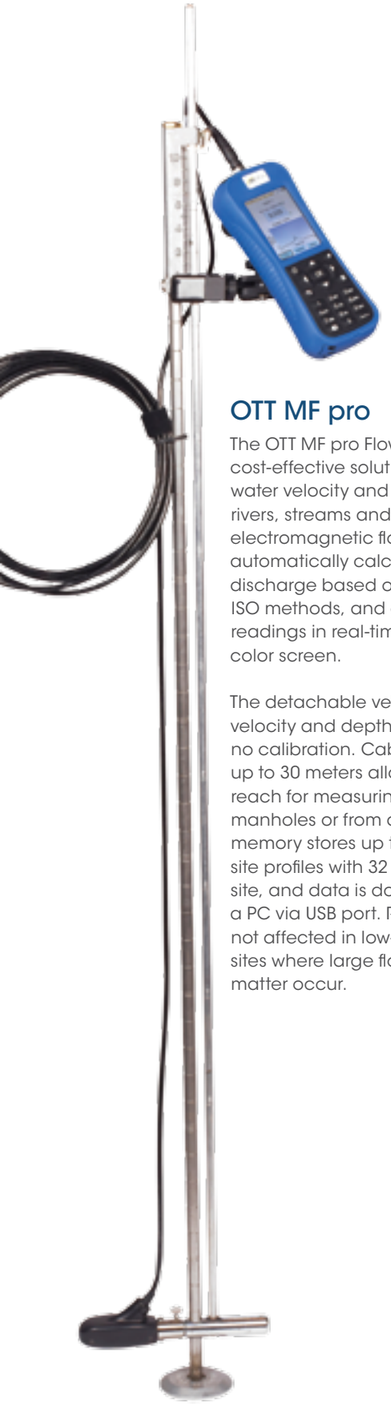
Facilitated by funding from the National Science Foundation's Physical Oceanography Program, the monitoring of Lake Michigan's currents will continue to be a point of emphasis for Purdue University over the course of the next two years. AR

Researchers launched a zodiac to better survey the Rhodamine dye plume.

The TRIAXUS towed vehicle measured dye concentrations.

All Photos: Cary Troy

MONITORING GEAR



OTT MF pro

The OTT MF pro Flow Meter is a cost-effective solution to measure water velocity and depth in rivers, streams and canals. The electromagnetic flow meter automatically calculates total discharge based on USGS and ISO methods, and graphs velocity readings in real-time on a full color screen.

The detachable velocity or velocity and depth sensors require no calibration. Cable lengths up to 30 meters allow for greater reach for measuring water flow in manholes or from a bridge. The memory stores up to 10 metering site profiles with 32 stations per site, and data is downloadable to a PC via USB port. Readings are not affected in low-flow areas or in sites where large flows of organic matter occur.

YSI Pro1030

The YSI Pro1030 pH and Conductivity Meter measures temperature, conductivity, salinity, specific conductance, total dissolved solids as well as a selection of pH or ORP. Cables come in lengths from 1 to 30 meters, and the built-in 4-electrode conductivity cell holds interchangeable pH and ORP sensors.

A simple walk-through of the calibration process is accessible by pressing the Cal button. Up to 50 data points can be stored in the meter's memory. The graphic backlit display and glow in the dark keypad provide visibility in any weather condition. Military spec connectors, an IP67 rating and 1-meter drop tests add extra protection and waterproof resistance for the most demanding field applications.

Hydrological Services TB3

Collect precipitation and rainfall measurements in calibrated bucket sizes of 0.01 in, 0.2 mm, 0.5 mm and 1.0 mm per tip. The HSA TB3 Tipping Bucket Rain Gauge features an integrated syphon mechanism for the highest accuracy, even in cases of hard rainfall and debris. As rainfall is accumulated, the bucket tips based on its calibrated capacity and passes the encapsulated dual reed switch. The switch can transmit these events to a data logger, telemetry system or HSA's Total Rainfall Display.

The long-term stable calibration makes this instrument ideal for remote locations where servicing may be limited. An optional data logger with no external power requirement can date- and time-stamp up to 100,000 events. Bucket assemblies come in brass or chrome-plated plastic.

Laser Tech 200X

Calculate horizontal distance, slope distance, vertical distance and inclination between two remote points with the Laser Tech Rangefinder TruPulse 200X. The infrared technology emits energy pulses to determine distance by measuring the time it takes for each pulse to travel from the device to the target and back. The in-scope field-of-view is 100 meters at 915 meters away. The powerful LED display adjusts to any lighting condition.

Wirelessly transfer data to a PC with Bluetooth or the RS-232 communication port. The 200X is also iOS compatible. The rugged, IP56-rated rangefinder is ideal for site surveying and inspection in construction, telecommunication and public works.

Sentek EnviroSCAN

Designed to reach depths down to 40 meters, the Sentek EnviroSCAN Soil Moisture Sensor measures volumetric water content in any soil type from saturated to dry. The probe can include up to 16 moisture or moisture/salinity sensors at 10 centimeter depth increments.

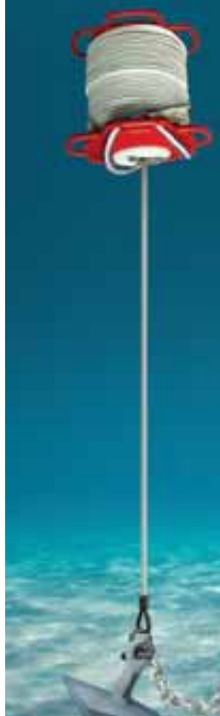
Installed in a customized access tube for long-term operation, the capacitance-based technology sensor creates a high-frequency electrical field around itself to measure changes in dielectric constant over a period of time. The sensor gives an output in volumetric water content in millimeters of water per 100 mm of soil measured. To increase accuracy, each sensor is assigned a specific calibration equation based on the soil texture. Real-time data transfer to NexSens datalogger and telemetry systems is possible through SDI-12, Modbus-485 and RS-232 interface protocols. Additional temperature and humidity options are available.

Fiomarine Fiobuoy

Protect your data with the Fiobuoy. This efficient, all-in-one underwater retrieval system is concealed with the equipment on the seafloor to avoid entanglements with passing vessels and other surface concerns. When it's time to retrieve the equipment, the submersible buoy unwinds to the surface, making recovery fast and easy.

The Fiobuoy can be programmed with a time and date for release or triggered with an on-demand acoustic release from up to 500 m away. Encoded with a six-digit security code, the Fiobuoy is protected from unauthorized use.

Incorporating an acoustic release, marker, reel and retrieval line, the Fiobuoy is ready for quick deployment. Unlike a traditional acoustic release, this system remains tethered to both the equipment and anchor. The Fiobuoy can be redeployed within minutes of its recovery.



Growing Algae

BY AUSTEN VERRILLI

The word "algae" can strike thoughts of low dissolved oxygen into the minds of limnologists and aquaculturalists alike. The most common problem-species of the autotrophic microorganisms, microcystis, has caused enough issues in the world's waterways to earn a scummy reputation.

Still, not all algae are bad. Alltech Inc., a Nicholasville, Ky.-based company that develops natural feed supplements for agriculture and aquaculture, has put algae to work, and it's definitely for the fishes.

Inside the feed-prep room at Alltech's aquaculture center, Vaun Cummins, a senior aquaculture technician, holds a scoop of fine, fishy-smelling powder. The substance resembles talcum powder with its fine consistency and smooth feel. The pungent substance is Alltech's production Schizochytrium SP1 Algae.

Cummins said the algae can be used to reduce or replace fish oil in the diet of farmed fish. Fish oil comes mainly from wild caught menhaden anchovy, a small filter feeding fish. It typically takes two pounds of marine-caught fish to make enough fish meal and fish oil for a farmed fish to gain one pound of weight. "Aquaculture can't rely on that for very long," Cummins said.

Using marine-caught fish to grow farm-raised fish may become a greater problem as aquaculture continues to advance as the fastest growing sector in world agriculture. Cummins said the average yearly growth of the global industry is around 6 percent.

The fish grow even faster. Cummins can raise a batch of tilapia on diets formulated with algae from fingerlings the size of a pinky finger to a harvest size of nearly 2 pounds in approximately eight months.

Algae are added to fish diets during trial runs. Cummins watches as the fish grow and react as they consume different mixtures of feed. Typical trials run nine to 12 weeks.

The trick is feeding six times per day and keeping the fish in healthy water. He keeps water quality in check with his YSI 556 handheld meter. "In aquaculture, you're farming the water," Cummins said. "You're making sure those water quality parameters are where they need to be to have healthy fish and optimal growth."

Alltech's state-of-the-art aquaculture research center is an indoor operation where recirculating water flows through a variety of blue tanks ranging from 100 to 1,500 gallons.

All Photos: Alltech, Inc.

Alltech produces 20 tons of Schizochytrium algae per run in their Winchester, Ky. plant (below right) for use in animal feed supplements. They test algae feed supplements on fish in their aquaculture lab (below left).

In the larger 1,500-gallon tanks, fattened fish school in circles. In smaller 250-gallon tanks, catfish and bass hover near the shadowy bottom. Some tanks sit idle, awaiting the growth of fingerlings or incoming test subjects.

Northeast of the aquaculture facility, Alltech's algae plant in Winchester, Ky. towers above adjacent Kentucky Highway 64. Inside, gleaming stainless steel fermenters and dryer chambers stand four stories tall.

Kevin Welsh, operations manager for the plant, said the fermenters on site have a combined capacity of more than one million liters. A maze of piping winds throughout the plant, recirculating sterilized raw materials used in algae production. A central control room regulates and monitors the plant's automated processes.

Here Alltech produces heterotrophic microalgae grown in a closed system. Alltech workers control the entire process, ensuring traceability, sustainability and consistency.

Michelle Stevens, quality assurance manager at the plant, said her team can produce 20 tons of algae from a single 1.5 milliliter vial of algae. It takes 11 days, stepping up to larger and larger batches. "We take this (algae) and inoculate the broth and nine days later we're harvesting the main fermenter, our biggest fermenter," she said. "Our output from that is about 20 tons of biomass."

The algae are only for animal consumption. Stevens said the algae can take the place of soybean meal in livestock feed or fish oil in aquaculture. The biggest difference is algae grows much faster and has more fatty acids than soybeans.

"We can still get the same growth responses," Cummins said. "We can still get the same feed conversion ratios that we would get if we were just using a commercial diet that had fish oil in it. And not only that, this is very high in DHA (docosahexaenoic acid), the heart healthy omega-3."

The algae then pass omega-3 fatty acids onto to the dinner table. "What we can safely say, with the research that we've done, is that we are able to increase that DHA level in the filet and, yes, it does make it to the consumer," said Cummins. AV

Acidification Experiments

BY ALEX CARD

Scripps Institution of Oceanography students farmed seaweed and wrangled baby red abalone to study the effects of growing ocean acidity

All photos: Scripps Institution of Oceanography

For student teams from two California-based research labs, custom-built bubblers, seaweed harvests and baby sea snails are all providing answers about ocean acidification.

With the help of Jennifer Smith, assistant professor in marine ecology and conservation at Scripps Institution of Oceanography, the students performed experiments to study the impact of ocean acidification on coastal organisms.

One experiment studied seaweed growth, while another looked at the effects of acidification on invertebrate sensory capacity. For the third experiment, the researchers "farmed" seaweeds and invertebrates on undersea tiles.

The students involved were from the Smith Lab at Scripps and the Hamilton Lab at Moss Landing Marine Labs. Each experiment was performed in the Smith Lab, though the single-species and tile collection processes were performed in San Diego and Monterey Bay, Calif.

The first team, led by oceanography masters student Susan Kram, explored the reaction of California's dominant seaweed species to ocean acidification.

"An experiment begins by collecting algae and placing them in the state-of-the-art flow-through seawater bubbling system," Kram said. For 30 days, a student examined the specimens and gathered pH and temperature data from the seawater -- a process that sometimes takes more than two hours. The final step in each experiment involved measuring the growth of the algae.

Another experiment examined the effects of ocean acidification on invertebrate larvae, organisms that often rely on certain environmental cues to know when to settle and metamorphose into their juvenile stage. Scripps masters student Molly Gleason and her team studied the behavior of red abalone larvae -- a type of edible sea snail -- in acidified and normal conditions to determine if the detection of these cues was hindered by abnormal aquatic conditions.

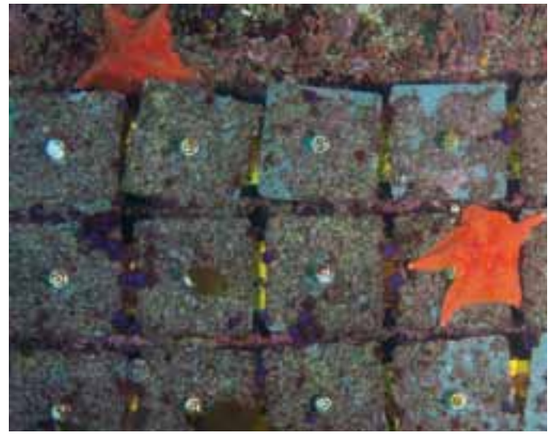
"We expose [the abalone larvae] to the cue-producing calcified algae and then count the number of larvae that successfully settle. We can then determine if [ocean acidification] affects the ability of baby abalone to successfully settle onto the benthos prior to developing into adults," Gleason said.

The third experiment, carried out by oceanography masters student Emily Donham and her team, sought to determine which species in a competitive community would fare best in acidic conditions. PVC settlement tiles were placed on reefs in Monterey Bay and La Jolla, San Diego. For one year, the researchers left the tiles alone, allowing for natural recruitment of seaweed and invertebrate species to occur. The tiles were collected by divers and inserted into the Smith Lab's seawater bubbling system -- the same one used by Kram's team -- for five weeks.

"This state-of-the-art bubbling system allows us to simulate [ocean acidification] in the near future as accurately as possible so we can make realistic predictions about which species will (or won't) cope with lowering seawater pH," Donham said.

Postdoctoral researcher Nichole Price designed the seawater bubbling system specially for work at the Smith Lab. Most experiments that use stagnant seawater are limited to relatively short durations due to lack of available nutrients. Price's system solves this by cycling out used seawater and bubbling a gas blend into the specimen's aquarium at a rate constant to water exchange. In doing so, the specimen is never nutrient-limited, and the pH of the seawater in the system is allowed to fluctuate as it would in real coastal environments.

"We use up to 40 replicated experimental aquaria (with controlled temperature and light conditions) to attain adequate sample size so our results represent multiple independent species reactions to treatment conditions with sufficient confidence that our results are unbiased," Price said. Using high-precision mass flow controllers, the researchers simulated the expected atmospheric conditions of 2100, according to predictions by the International Panel for Climate Change.



"Farmed" seaweeds and invertebrates on undersea tiles.

Other monitoring instruments used in the Smith Lab and at collection sites include pH and temperature sensors such as the SeaFET, Honeywell's Durafet Non-Glass pH electrodes, and handheld HQ40d Hach meters with glass electrode PHC201 pH probes. A LI-COR sensor measured photosynthetically active radiation, and HOBO Pendant UA-002-64 data loggers monitored temperature and light intensity.

As it turns out, the study found that the carbon dioxide-enriching effects of ocean acidification do compromise the ability of red abalone to detect settlement cues. Other invertebrates, Smith said, are likely at equal risk: "Our results suggest that many calcified seaweed species are negatively affected by [ocean acidification], including the species most known for providing settlement cues for invertebrates."

Many invertebrate larvae are also sensitive to the warming effects associated with climate change and may have difficulty surviving in a warmer, more acidic marine environment. Scientists like Jennifer Smith and the students at the Smith Lab continue to examine these problems and others through experimentation and research.

"Many of the experiments are still ongoing and the students have been busily working throughout the summer," Smith said. AC

VOLCANO'S EDGE

An international partnership pairs environmental and social research to protect a town from devastating landslides

BY DANIEL KELLY

Soil around San Vicente volcano in El Salvador has always been rich, leading farmers to plant coffee, beans and sugar cane on its slopes. In times of heavy rain, the loose soil and volcanic rock on the steep slopes washes down, covering the villages nearby in heavy mud. Small downpours typically aren't a big deal, but hurricanes and tropical storms can bring disaster.

When Hurricane Ida hit San Vicente in November 2009, nearly 300 people died from volcanic debris flows in the communities in and around the town. An international aid effort followed. One of the responders was Luke Bowman, a doctoral candidate in Michigan Technological University's geology program, who went to San Vicente as a member of the Peace Corps Response program and later continued his time there as a Fulbright Scholar.

Over 15 months, Bowman looked at the cultural and sociological aspects of the San Vicente region that make its people vulnerable to the extreme events, and worked with others to minimize their impacts in the future. Doing that requires a lot of effort and multiple initiatives.

Michigan Tech began collaborating with the University of El Salvador through the Partnerships for Enhancing Engagement in Research (PEER) program, led by the U.S. Agency for International Development and the National Science Foundation. Bowman, along with John Gierke, a professor of geological and mining engineering and science at Michigan Tech, worked with Fredy Cruz, an agronomy professor at the University of El Salvador.

They looked at 40 years of satellite imagery and continue to review images, trying to chart land-use practices that could make slopes less stable and residents more vulnerable to landslides. The U.S. Geological Survey's Earth Explorer program makes Landsat imagery publicly available and makes it possible to collect images for analysis. They're using the agency's LaharZ flow-modeling program to simulate a range of potential debris-flow paths that originate on the volcano's slopes and map the inundation areas for use by local authorities and decision-makers.

Five municipalities on the north side of the volcano host most of the population that farms the steep slopes. Many farmers agreed to permit Solinst Leveloggers in their wells to monitor water table depth throughout the watershed. The leveloggers were purchased with funds from the PEER program. Farmers protect the equipment from vandals, and the University of El Salvador sends technicians out to collect the data. The university representatives share data with the farmers so that they can use it in their planting preparations.

Photo: Luke Bowman

Lahar aftermath and deposit after the November 2009 Hurricane Ida disaster on the north flank of San Vicente Volcano.

Photo: (left) Fredy Cruz; (right) Rutilio Parada

"Most of the wells that we're monitoring are three to four meters deep, all in alluvial sands and lahar deposits. Water can travel pretty efficiently through the deposits," said Bowman. "We're going back in October to see whether there are in fact perched water tables on the steep slope that could be a factor in the formation of shallow landslides."

Predicting rainfall is also important to crop preparations, especially for planning for flooding and drought scenarios. Bowman and colleagues worked closely with the Centro de Proteccion para Desastres (CEPRODE; The Center for Disaster Protection), a Salvadoran NGO, to set up tipping bucket rain gauges along the volcano, where knowing the rainfall rate is closely linked to landslides.

CEPRODE's San Vicente-based project was vital to organizing efforts in the area, as well as planning logistics for university researchers.

"Five municipalities make up the northern plank of the volcano, and CEPRODE acquired funding for five weather stations at government buildings providing near real-time data on the web, the most important of which is rainfall rates," said Bowman. "They provided four-wheel drive transportation on field campaigns and were there to install the rain gauges."

Bowman says other parameters are collected at the municipal weather stations, including solar radiation, temperature and wind, which can all go into creating a hydrologic model for the region. In times of crisis, the rainfall rate is the most important to know. It's a first-response tool for landslide forecasting when extreme weather strikes. But CEPRODE and local Civil Protection committee members also helped set up a longer term monitoring tool for slides, one that georeferences open cracks on the volcanic slopes and uses cement markers to measure changes that might indicate a slide-vulnerable area.

Five local observers based out of coffee plantations along the volcano's slopes track rainfall using staff gauges. They write values on worksheets that are collected monthly, though some observers send data sets at the end of each day via two-way radios provided by CEPRODE.

The cement markers and local rain observers are important to maintain awareness of the slides and improving response efforts. So is cooperation. Part of Bowman's time in San Vicente also included designing a certificate program geared toward reducing risk from disasters.

The program was free and open to the public and met every Saturday for nearly five months. Representatives from the municipal government, University of El Salvador, Red Cross, Civil Protection, police force, fire department and others came to the class to learn more about disaster response and crisis management. The time together paid off when an extreme rain event–Tropical Depression 12E–hit in 2011.

"It turned out that most of the people who managed the 2011 crisis were a part of the certificate program. It was great that they already knew each other," said Bowman. "There hadn't been another disaster to test strategies, but it cemented relationships started in the program. They were really tested by fire."

The mission to hone disaster-response strategies in San Vicente is continuing in an ongoing effort to make them more effective and prevent unnecessary damages and loss. The PEER program, or the "marriage between NSF and USAID" as Bowman calls it, makes sense, he says. Researchers from the National Science Foundation are doing work in many different areas of the world and USAID already has support networks set up in many of the countries where research is taking place.

In El Salvador, there are social aspects that contribute to disasters. These include a colonial history, poverty, a brutal civil conflict, population density, recurrent disasters and food security. Even though technically it's illegal to live near the volcano's drainages deemed high risk, those laws aren't enforced, Bowman says.

"People have no other option. There's no place to go. Social factors come into play," Bowman said. "Better technology is good for improving our understanding of the hazard phenomena, but it won't have any impact if it's not put into a social context." DK

Informal concrete benchmarks are installed to monitor slope movements at a surface crack following Tropical Depression 12E, November 2011.

Park Panoramas

National Park Service webcams connect faraway park lovers to nature's beauty

BY DANIEL KELLY

Since the U.S. National Park Service was established in 1916, part of the agency's mission has been to increase Americans' appreciation of nature's wonder. Key to that effort–and also abiding by environmental regulations–is clean air and high visibility.

To achieve cleaner air, many national parks have air monitoring systems in compliance with the Clean Air Act. But only 18 are part of the National Park Service's air quality webcam network. Each camera updates every 15 minutes, often providing breathtaking panoramas. As the weather sensors collect data on a variety of parameters, the webcams simultaneously give a unique view of those figures. "The idea initially was to take long range, qualitative views of visibility over a long distance," said Melanie Peters, natural resource specialist for the National Park Service.

Among the parks covered by the webcam network are Yosemite, Grand Canyon and Theodore Roosevelt. The network of webcams grants 24/7 access to online visitors. Great Smoky Mountains National Park has two webcams, both of which were in the top three for views in 2012. The cameras at Purchase Knob and Look Rock each had over a million views that year.

"We want to engage people," said Peters. "To keep people connected remotely. If they can't get there in person, to stay connected to the parks they love."

Jim Renfro, an air quality specialist at Great Smoky Mountains National Park, notes that the National Park Service is an adviser to the states, helping them abide by relevant mandates that exist to improve water and air quality in their jurisdictions. "Our mission is to preserve and protect our heritage, natural resources, unimpaired for future generations," said Renfro.

Monitoring is key to that undertaking, so Renfro's station of weather sensors and webcams makes an important contribution. Parameters collected there include ozone, particulate matter, temperature, humidity, wind and precipitation. But the park is over 520,000 acres, and his team can't measure everywhere all the time. That's where the webcams come in.

"The cameras have captured wildfires at Yosemite, smoke from fires at Grand Canyon, rainbows, dust clouds," said Peters. "We make sure to catch the dust on our filters. It's not a park by park decision. It's all done as part of national monitoring."

The data collected must undergo quality control checks before they can be added to any network. The process can be long, with the most recent report for air quality in national parks spanning from 2000 to 2009. The findings?

"Visibility has been improving, but there are still some areas of significant concern," said Peters. "Of those, most are getting better." DK

All Photos: National Park Service

EXIT SURVEY

Ten years of data from the ChesMMAP survey show some demersal fish flee areas of low dissolved oxygen

BY AUSTEN VERRILLI

Photo: Eric Brasseur

In the Chesapeake Bay, one of America's most productive and stressed fisheries, marine organisms have to be dynamic to keep on swimming.

A study from the Virginia Institute of Marine Science analyzing 10 years of data found many demersal, or near-bottom dwelling, fish are sensitive to water quality and environmental conditions, which seem to dictate where they live and when they leave.

Andre Buchheister, a VIMS graduate student who led the study, wanted to understand how demersal fish distribution over time and space relates to water temperature, dissolved oxygen, salinity and depth. He and a group of VIMS researchers aggregated and synthesized data to see if they could spot any trends.

They found that water quality in the bay, which is often stricken with low-oxygen dead zones, can greatly impact the distribution of fish in the Chesapeake Bay's mainstem. "Dissolved oxygen was definitely one of the largest and strongest variables that affect the fish community," he said.

Once dissolved oxygen in the mainstem dipped below hypoxic levels of 2 milligrams per liter, the variety of species caught quickly declined to zero, according to study data.

Buchheister said many near-bottom fish move north or south away from the mainstem due to physiological stress and lack of food when dissolved oxygen becomes hypoxic. "There's evidence that the foraging grounds are compromised due to these hypoxia events," he said.

Salinity of the bay's waters also divides near-bottom fish species latitudinally. Fish tend to live in regions where the salinity matches their preferred conditions. For example, the researchers observed that white perch and striped bass live mainly in the upper bay, which has stronger fresh water influence. Summer flounder, spot and Atlantic croaker reside more often in high-salinity waters in the lower bay.

According to the study, the middle of the bay had a high turnover of fish species moving in and out, as the brackish salinity conditions make it stressful for many fish.

Data for the study came from the ongoing VIMS Chesapeake Bay Multispecies Monitoring and Assessment Program. Researchers analyzed 10 years of data from 3,640 sampling stations during 48 cruises, from 2002 to 2011. The study was conducted aboard VIMS' R/V Bay Eagle, where 45-foot bottom trawls are dragged for 20 minutes to collect fish. Researchers use a Hach Hydrolab sonde to collect water quality data.

Researchers sample the bay mainstem by dividing it up and tackling it section by section. At each station the team takes an inventory of the fish they've caught. A few are dissected to determine their age and stomach contents. Environmental data, including water temperature, salinity and dissolved oxygen levels are recorded. The team also notes sea and weather conditions.

Species assessment program researchers sample in March, May, July, September and November. "We sample on these different months to really capture the dynamic nature of the fish in the Chesapeake Bay," said Buchheister.

Buchheister hopes the study will make it easier for water managers to understand the health of fish populations, which will help them determine fishing regulations and quotas.

The study was published in the Marine Ecology Progress Series. Buchheister, Chris Bonzek, Jim Gartland and Rob Latour all contributed to the paper. AV

Microbe ESP

The Environmental Sample Processor will help Columbia River Estuary scientists better understand microbial processes in the waterway

BY JEFF GILLIES

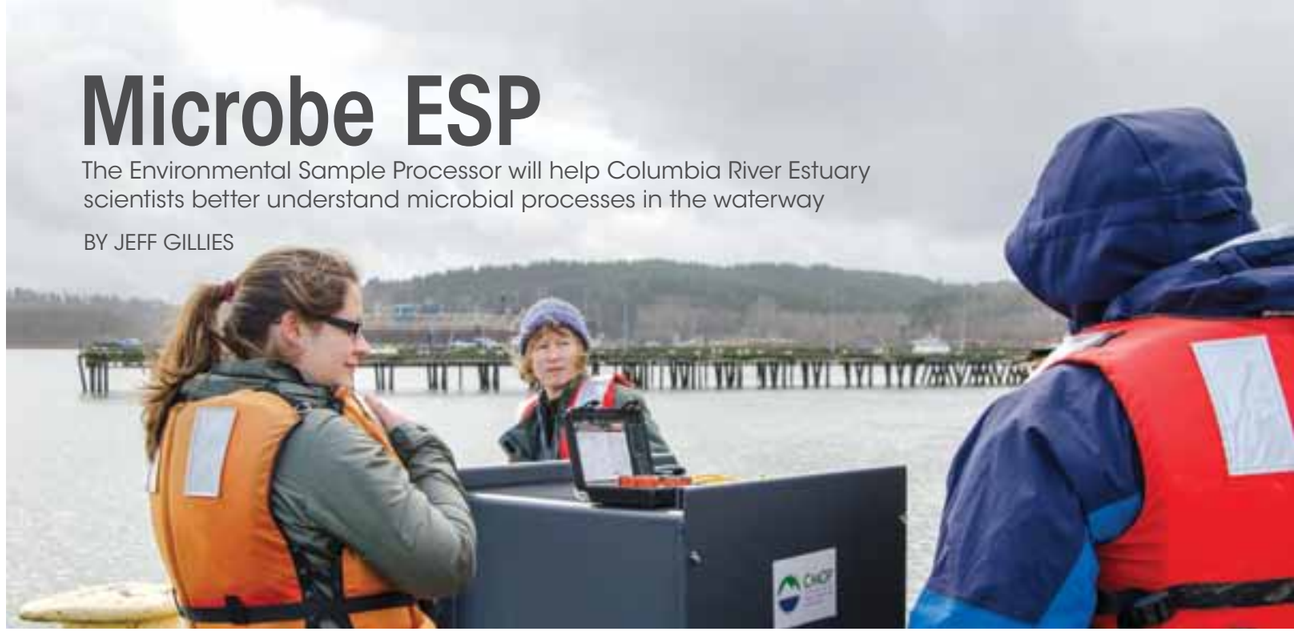


Photo: Jeff Schilling / Center for Coastal Margin Observation and Prediction

For the water flowing off much of the lands of the Pacific Northwest, the Columbia River Estuary is the last stop on the way to the ocean. But it's no rest stop: The estuary is an active factory of chemical and biological processes that influence the character of the water that eventually flows into the Pacific Ocean.

"We think of the estuary as a bioreactor that effectively removes, or filters organic matter and pollutants from the water," said Holly Simon, an associate professor in the Oregon Health and Science University's Institute of Environmental Health. "And so we're interested in understanding how that filtration processor works and what factors impact it."

Microbes are the workers in the filtering factory, and an important part of describing their function involves determining the types of microbes present in biological "hot spots" in the estuary and how their activities vary over time. With the help of a pioneering piece of environmental monitoring equipment that has seen only a handful of applications across the country, scientists like Simon can begin painting a clearer picture of how the activities of microbial populations relate to the filtration process in the estuary.

The instrument is the Environmental Sample Processor, or ESP, developed by Chris Scholin and colleagues at the Monterey Bay Aquarium Research Institute. The ESP has been recruited to help the efforts of the Beaverton, Ore.-based Center for Coastal Margin Observation and Prediction, or CMOP, where Simon is an affiliate scientist.

The ESP collects water samples from below the water's surface, either drawing samples at specific time intervals or whenever associated water quality sensors detect certain conditions. CMOP scientists have integrated the ESP into SATURN, the center's long-term monitoring network of physical and biogeochemical sensor stations throughout the estuary.

Beyond just taking samples, the instrument can perform automated genetic identification tests that previously required water samples to be brought back to the lab. Once the ESP is fully up and running in the estuary, information about the abundance and activities of specific microbial species will be sent back to shore through wireless communications.

That kind of power will be especially useful for the estuary, as its many inputs–the river, ocean water, and productive peripheral bays–can make for dramatically variable water quality conditions. Those water quality shifts provide opportunities to capture important ephemeral microbial processes, but they're difficult to capture if you're relying on a boat and an armful of sample bottles.

"Interesting things happen in microbial community composition and activities in response to changes in this dynamic environment," Simon said. "The ESP allows us to target those changes, which is really hard to do if you're just out there on any given day trying to sample."

CMOP researchers first had to make sure the instrument could sample the estuary's turbid waters without clogging. CMOP performed a round of tests earlier this summer and the ESP worked fine.

That those tests happened at all is largely thanks to the efforts of Lydie Herfort, a CMOP senior research associate in the Simon group, who worked closely with CMOP modeler and communications specialist Charles Seaton, and Michael Wilkin and his team from the Astoria field station.

"It takes a small army to get this thing deployed, with the sensors all functioning correctly and the communications working," Simon said. "And she orchestrated it all." JG

INDUSTRY PROFILE

Q&A

Justin CHAFFIN

Taking samples and advising students on Lake Erie

Justin Chaffin has been working as the research coordinator of the Ohio State University's Stone Laboratory for about a year. He was appointed to the job while still a doctoral candidate at the University of Toledo where he studied algae and Lake Erie.

Since being appointed to the position, Chaffin hasn't just been sitting behind a desk giving orders. He's frequently out on the water taking samples, managing the lab's lake monitoring technology and working with students.

He also has been a key player in coordinating water quality monitoring practices between state regulators, researchers and charter boat captains in an effort to understand and compare data collection practices occurring across Lake Erie's Western Basin.

Chaffin answered a few questions on his background, current work and efforts to coordinate monitoring during a media event at Stone Lab in historic Stone Cottage on Lake Erie's Gibraltar Island.

Environmental Monitor: How did you land the job of research coordinator for Stone Lab?

Justin Chaffin: Well, the job description was pretty much to a tee of what my graduate research was. They asked for someone that studied harmful algal blooms and knew about nutrient dynamics, knew about cyanobacteria dynamics, knew about toxin production. I did all that for my Ph.D. research and I did it all in Lake Erie. So, I was a pretty good candidate and I knew about Stone Laboratory to begin with.

EM: We've heard a lot about the need for an increased amount of monitoring around Lake Erie. Why do you think that is?

JC: Well, we need to judge whether or not changes in land use are having an impact on the lake. We can use a satellite to see where a bloom is, but we can't use a satellite to determine if it's toxic or not. We can't use a satellite to determine nutrient concentrations. So, if you don't have your boots on the ground and boats on the water getting a water sample, there are a lot of unknowns regarding that.

The satellite is great to tell you when a bloom is occurring and where it's at. We use the satellite to give a prediction of where that bloom will be in a couple days, but if you don't have a water sample you are missing a lot of the: "Why is that there?" It's just: "That's where the bloom is."

EM: You have been working to examine data collection methods of different government entities and charter boat captains in Lake Erie, how is that process going?

JC: I think that the steps we made this winter just learning who's out there, what, when and how they are sampling was a great first step. Then the next step is to see if the data is comparable. If it is, it is. If it's not, it's not. Then we need to try to standardize and coordinate methods better. But, without this initial analysis–understanding if this data comparable–you can't necessarily take the next step.

EM: You work with a lot of students on a regular basis. How do they affect or help you with your research?

JC: At Toledo I had one honors student that worked closely with me, and here at Stone Lab I had two research students this summer. It's always good to get a different perspective on how the data's analyzed, especially coming from a more raw form.They might not be able to connect all the dots that I as an advisor might think are obvious. So, when they hand me the first draft of a paper, it's like, "Ok, here's something I didn't explain well enough," or "I'm not conveying this message well enough," so I can go back and reassess myself through them.

Monitoring Mariculture

Water quality matters to the first shellfish farm in U.S. waters

BY JEFF GILLIES

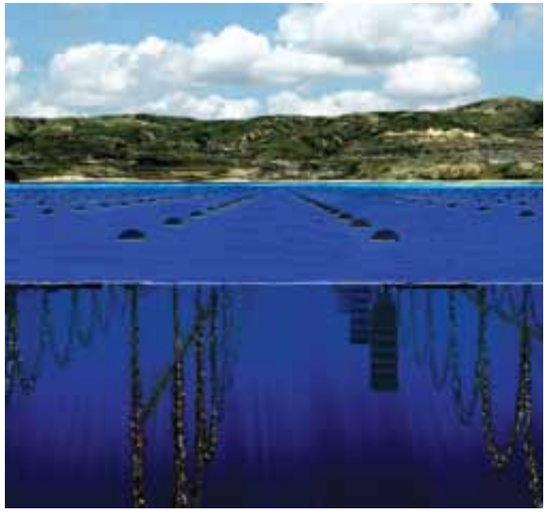


Photo: Daniel Kelly

Image: Catalina Sea Farm

Miles off the coast of southern California, marine life fueled by upwelled, nutrient-rich water grows so thick on the legs of oil rigs that divers occasionally scrape them clean to maintain the structures' integrity.

Phil Cruver, a "social entrepreneur" with six startup companies to his name, is banking on that oceanic conveyor belt of nutrients to fuel a unique aquaculture venture that he says could ultimately cut into the millions of dollars that the U.S. spends each year to import mussels.

Cruver is the CEO of the Catalina Sea Ranch, which he intends to be a 100-acre oyster and mussel farm anchored 5.5 miles offshore from Huntington Beach and Long Beach. The project has already been granted a provisional permit from the U.S. Army Corps of Engineers and now awaits approval from the California Coastal Commission.

Once approved and constructed, the operation will be the first shellfish farm in U.S. federal waters. Cruver said the offshore waters are ideal for shellfish production because the animals can feed on the naturally abundant phytoplankton and won't depend on food pellets like farmed finfish. The ranch will produce oysters, which will be housed in suspended cages, and mussels, which will be seeded on 689-foot long lines.

Leading the ranch's "Offshore Mariculture Monitoring Program" is Dale Kiefer, a professor of biological sciences at the University of Southern California. Kiefer's expertise is in plankton dynamics and remote satellite sensing of the oceans, but has turned to aquaculture and fisheries issues in the past five years.

The preliminary monitoring included a survey of the benthos conducted through a series of grab samples that were tested for organic carbon levels, macroinvertebrate populations, sediment grain size and heavy metal concentrations. The tests didn't find anything out of the ordinary and will provide a baseline dataset in later years to determine whether the operations are having an impact on the benthic conditions.

The ranch's monitoring program hasn't yet surveyed the water quality in the column, Kiefer said, because this part of the ocean has been consistently well studied. Research on the effects of a sewage treatment plant with an outfall pipe in the area has lead to a long time series of information on water quality.

"It's probably one of the most heavily sampled coastal areas in the world," he said. "So we know chlorophyll concentrations, we know water temperature, oxygen concentrations. There are simulation models of current velocity and there is lots of satellite imagery."

But once the ranch is up and running, instruments will continuously record water quality data.

"We'll have a fluorometer and water temperature, salinity and dissolved oxygen probes built right into the long-line support system," he said.

The monitoring program will couple real-time data with simulations from a software program called AquaModel, which predicts the effects of aquaculture operations on benthic conditions and water quality. The model, which Kiefer co-developed, is calibrated to each fish farm it simulates with data on variables including current velocity, the number of fish, growth rates, oxygen consumption and feed rates, among others. Once those numbers are plugged in, the model projects the farm's impacts, including the deposition of organic carbon.

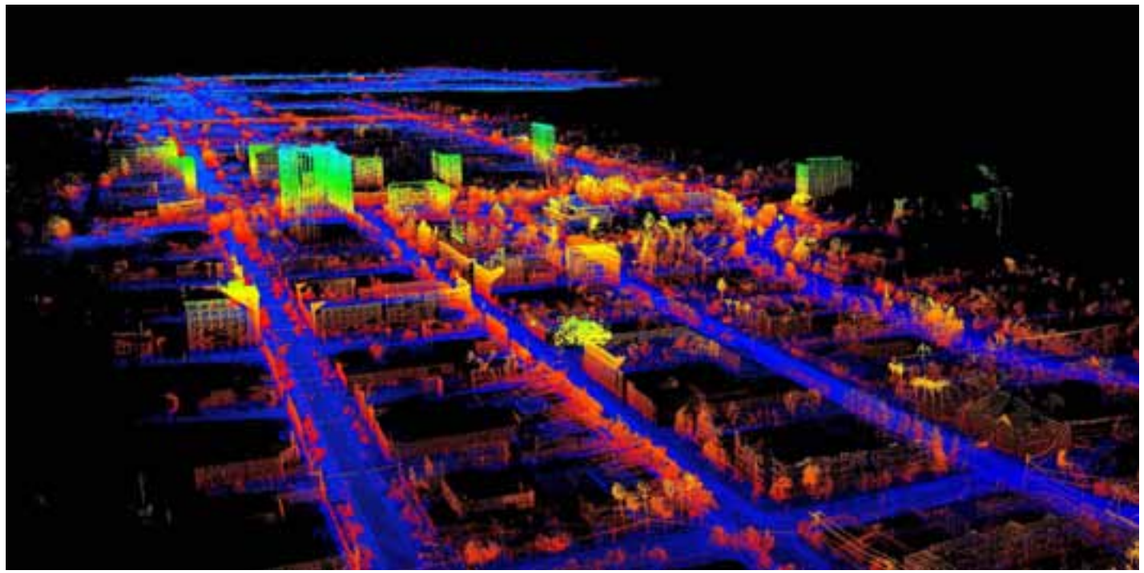
Though the shellfish will use up some oxygen and produce nutrients, Kiefer said the animals are relatively benign compared with a traditional fish farm. That's especially the case because the shellfish feed on naturally occurring phytoplankton rather than artificial food pellets fed to fish.

"Of course, everything is relative, but they'll probably be a source of water quality improvement," he said.

That could be good news for the waters over the San Pedro Shelf. But it's also good news for Cruver.

"You save 60 percent of your operating costs because you don't have to feed these babies," Cruver said. "You put them out there and they consume the phytoplankton naturally." JC

NEW TECHNOLOGY



Mobile Lidar

Light detection and ranging, or lidar, is a laser technology commonly used in aerial applications to map the earth. Now it has a new application on the back of a pickup truck.

Michael Olsen, a professor of geomatics at Oregon State University, said vehicle-mounted lidar came about inadvertently when engineers were testing a lidar application for helicopters in 2006. They had the system mounted to a pickup truck to mimic the way helicopters travel over land. Once mounted and working, they decided to leave the system in place.

Ground-based mobile lidar systems change the capabilities of the light ranging and mapping system. The technology looks down on the land from a different perspective, which enhances its view in the short-range but limits long-range resolution.

That means within 100 meters of clear land the system can accurately map the Earth's surface with hundreds or thousands of points per square meter. Aerial lidar images, Olsen said, usually have a resolution of only 8 to 60 points per square meter.

Mobile lidar works with a similar principle as plane-based lidar. As the vehicle travels across land, the imaging system collects data points that all form a point cloud. All the points add up to an image of the landscape.

For smaller areas with vehicle accessibility, Olsen said, mobile lidar is the best and cheapest method for mapping land. It provides a very detailed picture of buildings, trees and even the lines painted on a street.

Olsen said mobile lidar can be used in environmental applications to map changes in habitat and land cover. "You can pick up some really subtle changes," he said. "You can get accuracy down to a few centimeters."

Researchers studying habitat delineation typically make several passes at regular time intervals, comparing each subsequent lidar image to a baseline image. Olsen said researchers used mobile lidar to analyze changes to the San Diego coastline from erosion and tides.

Mobile lidar was also used to covertly map the travel path used to transport the Endeavor Space Shuttle through Los Angeles to the California Science Center.

The David Evans and Associates Titan mobile lidar system used to map Los Angeles is anything but subtle. A hydraulically raised platform fills the truck's bed. Once raised, the lidar system on the platform scans from high above the cab.

Simulations of the shuttle's movement through the streets, incorporating the mapping from the system, show incredible detail in three dimensions.

Still, Olsen said mobile lidar is a new technology and takes a skilled user to get the best images possible. "It's a very steep learning curve if you are the one to collect the data and process the data and do some analysis with the data," he said.

Two Transportation Research Board reports explain more detail on mobile lidar applications to transportation projects. Links to the full reports are available online at www.fondriest.com/news/mobile-lidar.htm. AV

Photo: David Evans and Associates

Chemometer

Colorado State University researchers are developing a device that looks like a thermometer and has appropriately been dubbed the "chemometer" for its abilities to test for chemicals quickly and easily.

At four cents a piece, the wax paper chemometer tests for dozens of chemicals and will be useful for quick readings and in minimizing site visits. Samples applied to the paper react with printed reagents, travel up a track and change colors. A ruler shows the concentration by indicating how far the sample has traveled.

The current model can measure chemicals important for occupational health like cadmium, copper or chromium. There are also tests for herbicides, pesticides and flame retardants.

The device can measure so much while costing so little because the materials are inexpensive. "Filter paper, printing, inexpensive reagents--these things are inexpensive from the beginning. And the price should go down further in mass production," said Chuck Henry, professor of chemistry at Colorado State.

Quick training and low initial cost make the device good for organizations managing multiple monitoring stations. Since they're made of paper, a ream of them in a backpack could constitute thousands of tests.

"You could visit 100 sites, take samples, and find that only 25 of them need servicing," said Henry. "That's a lot of savings." DK

Photo: (left) David M. Cate, John Volckens and Charles S. Henry; (right) Andrew Thaler

Open CTD

Environmental scientists use CTD sensors (conductivity, temperature and depth) to get a basic view of the ocean's characteristics. The sensors are normally configured in large bundles and cost thousands of dollars, limiting who can afford their use.

Two researchers are trying to bring the cost down and make it easier for oceanography enthusiasts to take measurements on their own. Kersey Sturdivant and Andrew Thaler, post-doctoral researchers at Duke University, have begun work to design a personal CTD that will be smaller and more affordable. Their work could bring down barriers for citizen scientists and ultimately result in more usable data with wider use.

"I've always said the goal is not to compete or replace the typical CTD, but provide an avenue through which interested parties can get involved," said Sturdivant.

One way citizens have already gotten involved was through fundraising contributions. The pair posted the OpenCTD project on crowdfunding site RocketHub to cover materials, testing and final designs.

The blueprints in development will be available for free and the researchers hope to develop a manual that can be downloaded on popular e-book reading devices. Once the project is complete, their personal CTD sensors should cost a few hundred dollars in materials.

OpenCTD will have a PVC body, a copper thermistor and an electrode that uses two stainless steel washers to take conductivity measurements using Ohm's law. The design uses an Arduino micro-controller and looks to hit 5 percent disparity in readings from YSI's Castaway sonde.

Sturdivant says their CTD can be packaged into small devices because only three sensors are needed. Many sondes, on the other hand, have multiple sensors.

A prototype looks to integrate all the sensors on a single circuit board, weighing around three to four pounds with a single SD memory card. Thaler says the temperature and depth probes are finalized, while work on the conductivity probe's accuracy and resolution is ongoing. Water and pressure tests are still underway and the calibration process will then be developed.

"What we're trying to do is make one for about $200 that won't inhibit a layperson, general enthusiast or scientist," said Sturdivant.

Crowdsourced funding piqued early interest and total funds raised hit $5,800. DK

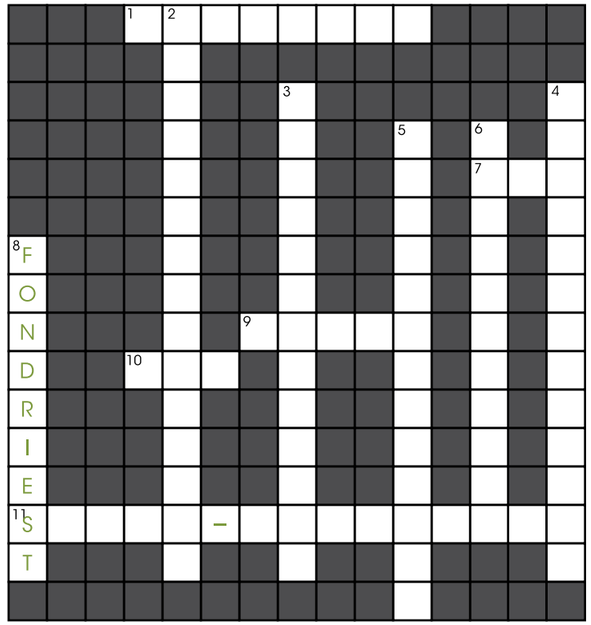
Measurement Methods

Across

1. Measure with refractometer or calculate from conductivity
7. Measure of the reducing or oxidizing potential with platinum electrode
9. Multi-parameter water quality instrument
10. 5-day test to determine the effectiveness of wastewater treatment
11. Measure flow from level

Down

2. Velocity measurement from sound
3. Method of turbidity measurement by light intensity
4. Measure rain by counting tips
5. Used to measure dissolved oxygen by titration
6. Measures concentration proportional to light absorbance
8. Where to buy water quality measurement equipment



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