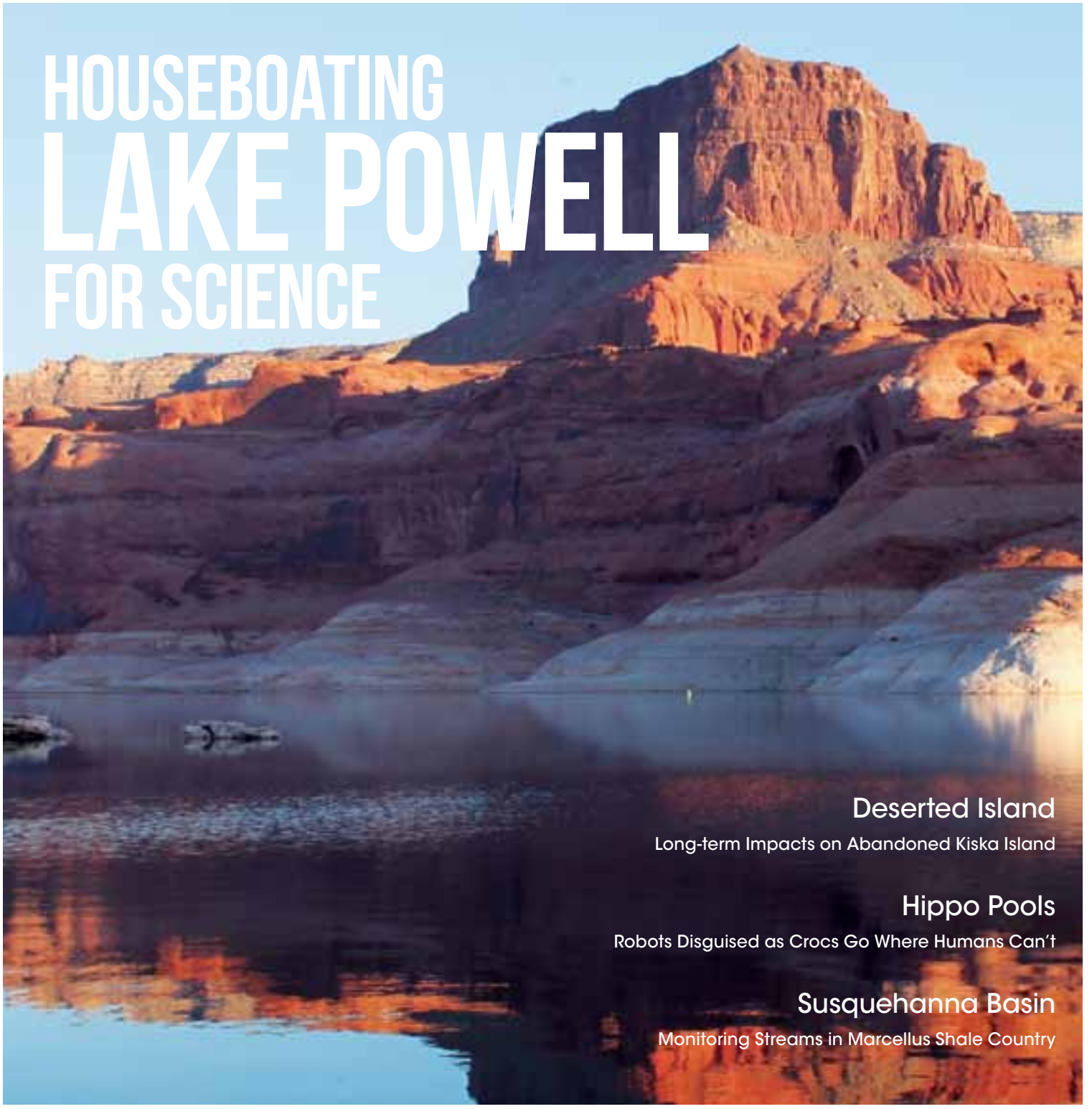
ENVIRONMENTAL
monitor
SUMMER 2014
APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS



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FONDRIEST
ENVIRONMENTAL

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Earlier this year, the Regional Science Consortium deployed a data buoy on Lake Erie off Presque Isle State Park, which draws more than 4 million visitors a year. We check in on the first season of data collection.

Cover Photo: David Naftz

WELCOME...

Welcome to the Summer 2014 edition of the Environmental Monitor. It's the season when thousands of vacationers flock to the bright, blue waters and red rock canyons of Lake Powell, where the houseboat is the vessel of choice for discerning leisure-seekers and environmental scientists alike. Our cover story reports on a crew of USGS scientists who set one up as a mobile lab for a two-week water quality survey to learn more about the reservoir's mercury contamination problem.

We've also got a look at the Susquehanna River Basin Commission's extensive stream monitoring network that tracks water quality in dozens of headwaters that flow amid drilling sites in the Marcellus shale region of Pennsylvania. Outside the lower 48, we have reports on scientists using robots to survey dangerous hippo pools in Kenya, an interdisciplinary study of a long-abandoned Aleutian island, and a year-long study of wetlands in the Mekong River Basin.

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WEB EXCLUSIVES

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Sensor-equipped ferry to monitor Admiralty Inlet

Newly installed acoustic sensors on two Washington ferries will help monitor water circulation in Puget Sound. The ships sail back and forth over the Admiralty Inlet, a three-mile span that is the gateway between the Sound and the Pacific Ocean.

Scientists with the Applied Physics Laboratory at the University of Washington will manage the monitoring effort that relies on acoustic doppler current profilers to measure a host of environmental parameters. They expect their work will yield new insights into the events taking place beneath the water's surface every day.

"We hope to quantify the sub-tidal exchange flow through Admiralty Inlet, especially the intrusion of dense ocean water into Puget Sound," said Jim Thomson, associate professor of environmental fluid mechanics at the university.

The devices will collect measurements on Admiralty Inlet's depth, water velocity and flow, the exchange of saltwater and freshwater in the channel and the volume of water passing through.

Mount Washington Observatory

The fastest winds ever measured by humans in the western hemisphere didn't blow across the barren lands of the Yukon or an Antarctic ice sheet. The 231-mph gust recorded in April 1934 whipped over Mount Washington, a New Hampshire peak about a three-hour drive from Boston.

A crew at the Mount Washington Observatory, a private, non-profit research institution, recorded the gust — which stood as a world record for 60 years until an Australian cyclone beat it by 22 mph in 1996. It was just two years after the facility opened, and since then weather has been recorded around the clock at the observatory, which styles itself as the "Home of the World's Worst Weather."

"The 82 years of the observatory's existence and recording the weather every hour, 24 hours a day, 365 days a year really backs up that statement," said Eric Kelsey, director of research at the observatory.

Photo: (top) Washington State Ferries; (center) Mount Washington Observatory; (bottom) NASA

Ocean currents may have doubled ice age length

For millions of years, ice ages ran like clockwork in 41,000-year cycles. But around a million years ago, an unknown force lengthened the cycle to 100,000 years and caused colder glacial periods.

"The whole climatic system of our planet changed completely," said Leopoldo Pena, paleoceanographer and assistant research professor at Columbia University. "This has been a puzzle in our profession for the past couple of decades."

The solution for that puzzle may be soon at hand, as a new study suggests deep ocean currents might be responsible for the shift. The currents move warm, shallow water and cold, deep water between the Atlantic and Pacific oceans in a 1,000-year cycle.

The researchers sampled fossilized plankton off the South African coast to measure isotopes of neodymium, an element that reflects the unique composition of continental crusts and reveals signs of North Atlantic seawater.

IN THE NEWS

Invasive water snakes pose threat to California species

Invasive water snakes making their way into California waterways pose a threat to native and endangered species there, according to a release from the University of California, Davis.

While scientists don't know how many of the invasive snakes are in California, estimates place the number at 300. The two most widespread species are the southern water snake and the common water snake. A new study from UC Davis researchers shows that suitable habitat for the invasive snakes overlaps with the current ranges of the giant garter snake and the California tiger salamander. The watersnakes could prey upon or compete with those species, both federally threatened.

With such low numbers, ecologists say that the issue is not yet out of control. Action should be taken now, they say, to control emerging populations of invasive water snakes to protect species native to California.

NASA tries again with Orbiting Carbon Observatory satellite launch

Two was NASA's lucky number on July 1 as they made a second attempt to launch their first carbon-monitoring satellite, Nature reported.

The Orbiting Carbon Observatory-2 will map carbon dioxide sinks and sources across the world using a high-resolution spectrometer. The satellite, which cost $465 million, is almost identical to its predecessor that went down in 2009 without reaching orbit.

The OCO-2 won't be the first satellite to monitor CO_2, but it will do so in unparalleled detail, sampling the atmospheric column every 3 square kilometers. In comparison, the Japanese Greenhouse Gases Observing Satellite takes measurements every 85 square kilometers.

Gas industry, watchdogs urge homeowner water quality testing

The oil and gas industry and energy watchdog groups alike are pressing New Mexico's domestic well owners to test water quality in their wells before and after drilling, the Santa Fe New Mexican reported.

The New Mexico Oil and Gas Association is encouraging the tests to prove that hydraulic fracturing operations are safe. The organization has launched a campaign to promote voluntary cooperation between industry professionals and domestic well owners.

Watchdog groups want to see property owners conduct more frequent tests to hold the energy industry accountable for any potential damage to water quality.

New Mexico's Oil Conservation Division has asserted that no documented proof exists to show groundwater contamination as a byproduct of fracking.

Smart Citizen network provides crowdsourced data worldwide

The world's largest independent environmental sensing network is the Smart Citizen network, according to Fast Company. At the heart of the network is a small kit with a host of environmental sensors.

These include elements for tracking carbon dioxide, nitrogen dioxide, temperature, humidity, light and sound. When assembled, the module sits outside a window or balcony to record local conditions.

Researchers from Barcelona developed the platform and associated website to give people more proactive roles in monitoring atmospheric conditions. Their devices have been deployed by citizen scientists around the world.

USGS study traces carbon fluxes through Colorado and Missouri rivers

A USGS study of two western river basins found that climate and human activity impact carbon movement throughout the basins.

The study examined the Colorado and Missouri Rivers, each of which exhibits a different carbon transport pattern. Carbon levels increase in the Missouri River as it nears its confluence with the Mississippi, while the Colorado showed the opposite effect. Varying precipitation, evaporation and diversion for human usage are responsible for the differences between the systems.

Reservoirs were found to reduce the impact of seasonal precipitation and temperature changes on the carbon flow, as they effectively interrupt the connection between rivers and watersheds.

Citizen monitoring motivates big companies to beef up their emissions tracking

Private citizens who monitor industrial emissions are encouraging companies to get their own high-tech monitoring equipment, according to Bloomberg. Officials at the U.S. EPA say this could lead to more complete and accurate emissions figures.

More on-the-spot data will help companies address unknown emissions violations. More accurate numbers may also help companies tackle emissions problems before they become catastrophic.

Citizen monitoring helped the U.S. EPA discover massive illegal benzene releases by Tonawanda Coke Corp. near Buffalo, N.Y., in a 2013 case resulting in nearly $25 million in fines. Officials with the agency say crowdsourced data may help find other blockbuster violations.

Braving a blizzard to study how air flows around wind turbines

University of Minnesota researchers have harnessed the power of a blizzard to study airflow around large wind turbines, according to a university press release.

The Minnesota researchers braved a blizzard to set up a searchlight next to a 130-meter-tall wind turbine. The searchlight illuminated the snowflakes against the night sky, making it easy to observe and film airflow patterns around the turbine. The video was then digitized and synchronized with data from sensors on the turbine.

The wind energy industry is growing quickly, but interaction between airflows around many large turbines at wind farms leads to an estimated 10-20 percent energy loss. Many wind turbines are greater than 100 meters in height, making field research difficult.

Strange rock suggests substatian water reservoirs deep within the Earth

Deep reservoirs beneath North America may hold as much water as the world's oceans and could be the subterranean source of those seas, according to the Washington Post.

A mysterious ringwoodite crystal, only capable of forming under incredible pressure, provided the first clues to researchers. The stone surfaced in a Brazilian diamond mine, despite being born 325 miles within the Earth's mantle. Scientists found that it was made of 1.5 percent water — soaking wet in terms of mineral composition.

The "transitional zone" in the mantle where ringwoodite originates is likely saturated with water as well. If even 1 percent is made up of water, it would still triple the amount of water stored on the Earth's surface.

Great Lakes green algae protects harmful bacteria

Researchers at the University at Buffalo have found that green algae in the Great Lakes provides protection to bacteria like E. coli and salmonella, according to a release from the university. The algae appears to shield the bacteria from ultraviolet rays that would otherwise kill them off.

Algae blooms can act as barriers, researchers say, between the UV radiation and the bacteria, allowing them to grow mostly uninhibited. This revelation proves that algae are more than just nuisances to beachgoers — they can also harbor dangerous bacteria.

Scientists sampled water from the Niagara River and beaches at Beaver Island State Park to make the discovery. With protection from algae, they say strains of E. coli lived 10 hours longer than without.

Close call on Kīlauea

A lava flow from Kīlauea volcano on the Big Island of Hawaii came awfully close to the U.S. Geological Survey's webcams this spring. Nothing was damaged, but the cameras and other equipment were later moved to higher ground just to be safe. Kīlauea is in the midst of an ongoing eruption that began back on Jan. 3, 1983, making it one of the longest active eruptions on the planet.

Photo: U.S. Geological Survey

Iowa State Stream Monitoring

A series of water quality monitoring courses at Iowa State University is giving students an early taste of the real-world skills they'd use as environmental scientists.

The courses help plug the students into the Ames, Iowa, community while supplying data to Iowater, the state's volunteer monitoring program. It also gives potential scientists hands-on experience in their field very early in their careers.

"Retention of students in the sciences is an issue, and so we wanted environmental science majors to actually be engaged in doing science as early as possible," said William Crumpton, professor of ecology, evolution and organismal biology at Iowa State.

The two courses, which were offered for the first time this academic year, are required for all environmental science majors. The students will collect data using kits supplied by Iowater to look at chlorides, nitrates, phosphates, pH and dissolved oxygen.

The work will give students an opportunity to transition from a student to scientist mentality much earlier than they otherwise would have, said Hannah Julich, the course instructor and a graduate assistant in ecology, evolution and organismal biology. "It helps develop confidence in their ability to collect, handle, analyze and present data," Julich said. "And it gives them actual skills that are used in this kind of monitoring." JG

Silver Springs

A hundred years before Disney World, tourists flocked to Florida to see the crystal-clear water flowing from the Silver Springs, one of the largest artesian spring systems in the world. Thousands of years before that, the springs' supply of freshwater and food supported early indigenous settlements.

Today, the springs and the Silver River that they feed into are suffering from nutrient pollution and reduced flows brought on by Florida's population growth and agricultural production.

Those problems have coated the river's bed with algae and cost the system its place as the highest-volume springs in the world. But the issues have also spurred engagement from students from Vanguard High School in nearby Ocala, where a chemistry class is monitoring the river and gaining experience in environmental science and civic participation.

"Our students are getting way more than they bargained for from a chemistry class these days," said John Hare, who teaches chemistry at Vanguard.

Students participating in the school's International Baccalaureate curriculum visit the Silver River four times a year to draw water samples. They test the samples with a YSI 9500 photometer to measure parameters such as alkalinity, turbidity, pH, chloride, sulfate and nitrate. The students are working with a local advocacy group to build a database of long-term data on the river. JG

Photo: (top) Hannah Julich; (bottom) John Hare

Photo: (top) NOAA; (bottom) W. Cully Hession

DYNAMO in the Classroom

Since the 1980s, scientists have increasingly recognized a globally important tropical weather cycle that originates in the Indian Ocean and has influences on El Niño events, Indian monsoons and pineapple express storms in North America.

And thanks to one teacher's time on a research vessel, this weather cycle is also influencing students in a Los Angeles community college.

Jacquelyn Hams, associate professor of earth sciences at Los Angeles Valley College, spent two months in 2011 aboard the R/V Revelle in the Indian Ocean collecting data on the Madden-Julian Oscillation, a 30- to 90-day cycle that sometimes circles the globe and contributes to global climate and weather patterns.

The campaign gave Hams a pile of scientific data that she brought back to Los Angeles and built into the curriculum for her introductory oceanography courses. Integrating her experiences into classroom lessons has gone a long way toward engaging general education students who might be taking the only science course that they'll ever take.

"When you see your teacher on a ship in the Indian Ocean looking at real radar data — for a general education student, in my opinion, it's a lot better than having a teacher stand up there and show you a PowerPoint or something that may or may not be useful," Hams said. JG

StREAM Lab

When it comes to water quality problems brought on by watershed land-use patterns, Virginia's Stroubles Creek has it all backwards.

The town of Blacksburg and the Virginia Tech campus dominate the creek's upper watershed, bringing on water quality problems associated with urbanization that have landed the creek on the state's list of impaired waters. But downstream of campus, the watershed turns to forest and the stream "fixes itself," according to W. Cully Hession, a professor of biological systems engineering at Virginia Tech.

"In most watersheds you'd think that up in the headwaters you'd have forest, and then down in the middle you might have urban land," Hession said. "So it's kind of flipped over."

Between the city and the forest, the creek flows through a tract of former farm land that the university operates as the Stream Research, Education and Management, or StREAM Lab. The facility supports faculty research and has hosted components of 16 courses. It's also the basis for a National Science Foundation Research Experience for Undergraduates, a program that brings a handful of students to campus each summer to tackle watershed issues from social and physical science perspectives. "For education, it's ridiculously valuable," said Hession, who directs the StREAM Lab.

Monitoring stations installed along the stream provide data that are updated online hourly for use by researchers, educators, and the interested public. JG

TRACKING LEATHERBACKS

Scientists map tracking data from tagged leatherback sea turtles in hopes of cutting down on turtle deaths from commercial fishing

BY DANIEL KELLY

Leatherback turtles don't swim through the water. They fly.

Their bodies have a teardrop shape that lets them shoot through the water at speeds up to 22 miles per hour. Massive pectoral muscles propel them along as their flippers encounter the same forces as airplane wings.

"We actually discuss what they do as flight," said Stephen Morreale, a senior research associate and adjunct associate professor in the Department of Natural Resources at Cornell University. "You can do the same calculations for flying aircraft on their flying wings. Their flippers and body shapes are the same thing. They have attack angles. They have stall speeds."

With such impressive hydrodynamics, the leatherbacks roam all corners of the world's oceans. They were made for long-range movement and have been tracked on journeys from Indonesia all the way to the west coast of the United States, a 12,000-mile trek.

Morreale says all that traveling makes it difficult for fishing operations to avoid the turtles. The mostly commercial ventures use long-line fishing techniques. Lines are often more than 100 kilometers long and lined with meat-baited hooks that snag aquatic life indiscriminately.

Leatherback turtles get entangled in long lines as well as fish. But when an air-breathing turtle gets stuck on a hook, it suffers more because it can't resurface. Frenzied fish along the line pull it down. And the thick bones that make up the turtle's head contribute to one of two outcomes: either the hook goes completely through, which means it can't be removed, or it stabs through the path of least resistance, the eye socket.

Morreale has seen these outcomes firsthand and recently took part in a study that might help minimize them. It combined existing data on leatherback movement throughout the Pacific Ocean, one of the world's largest fisheries, to find areas the turtles are most at risk of being accidentally caught in hopes of helping fishermen avoid them.

"(Tracking leatherbacks) gets complex. You've got to look at it like a movie," said Morreale. "It's not static. These aren't like caribou standing in a field. They're always moving."

So scientists work with the movements, attaching small lanyards behind the creatures' tails that flow in the slipstream. Other tracking structures include harnesses tied around their bodies. Most all include some type of transmitter to share the animal's location.

All of the locational data used for the tracking study were collected through the Argos system of satellites.

Photo: Nathan Robinson

Photo: (left) Samuel Friederichs; (right) Nathan Robinson

Leatherbacks aren't distributed randomly, or even uniformly, said Morreale. That makes it tricky to find areas where they're more likely to be.

"We pinpointed on a Pacific basin-wide scale — which is almost impossible to do — by putting all our data together," Morreale said. "Just to see all the data up on the same screen is pretty phenomenal."

He noted populations of leatherbacks nesting in Costa Rica and Mexico. A foraging area near Monterey Bay, Calif. supports other turtles that come in to feed on its jellyfish. Nesting beaches exist near Papau New Guinea and Indonesia. "We saw animals from both sides of the oceans, and you would think that each side would be of one group or another," said Morreale. But leatherbacks from Central America didn't mix with populations feeding in California.

Feeding areas and nesting beaches are common spots for the turtles, but leatherback locations are also influenced by the time of the year. Morreale says there's a seasonal likelihood for the occurrence of a leatherback turtle. By taking those figures and overlaying them with known industrial fishing zones, researchers came up with fisheries hotspots — places likely to have abundant prey populations that attract both leatherbacks and fishermen.

And then to quantify the risk of a leatherback turtle getting caught, a little math is required. In order to get the long-line probability, the number of hooks deployed annually in the Pacific Ocean is multiplied by the probability of just one leatherback being caught. "Multiply that probability by 760 million hooks and, even if it's miniscule, tell me what you come up with. It's just not even believable," said Morreale.

So what can be done to bring the risk down?

"I've been with the long-line industry a lot and I think everyone would love a gear fix – some magic solution to keep them (leatherbacks) out and exclude them from bycatch," said Morreale.

But there isn't one. Could currently available models say when to close off areas? "That's fine, that's good," said Morreale. "But it's not pinpointed enough." If there's going to be something like that put in place, he says time-area closures, which prohibit fishing in regions during certain periods of likely high leatherback occurrence, are effective and easier to implement.

Morreale says solving a problem like this needs a constantly changing solution. Once leatherbacks are in the ocean, they are always on the move. Fishing boats move from area to area looking for abundant schools. And as many sailors know, the ocean is fickle.

"A good model will react to that. It has to be moving. It has to be multi-dimensional," said Morreale. For example, he says, it would be simple to set up a system that would close areas to fishing if a leatherback turtle were caught nearby. If one is caught, then the likelihood of catching others is higher. "These are the types of things we can aim for."

This comes from someone who has seen leatherback tracking devices go from large obstructions the size of one-liter bottles to mini packages clipped on in less than five minutes. Before telemetry caught up, Morreale says there wasn't a basis to model where the turtles are and where they're going. Now that it has, moving into higher-level, dynamic models may finally allow researchers to answer long-standing questions about leatherback movement and prevent bycatch.

"This is a big problem. We're only at the beginning of it and we only talked about one species of sea turtle here," said Morreale. Six other species are also at risk. DK

A Ruler and a Rain Bucket

BY DANIEL KELLY

The National Weather Service honors 125 years of data collecting at UConn.

As Steve Olsen made his way to the records room in his office building, flicking on a light and keeping track of the concrete floor beneath his feet, he wondered why he was going so far to find a book.

Curiosity, he thought, was the obvious answer. But it was also a matter of tradition: He wanted to know how far back the record reached. When he finally sorted through the pile of dusty boxes, he pulled out what he was looking for.

"The writing was beautiful, almost like a script," said Olsen, manager of the Plant Science Research and Education Facility at the University of Connecticut. "It was amazing how someone had taken the time to write nicely."

As he perused the pages, the very first record was June 1, 1888. A big blizzard, he read, had made its way up the East Coast impacting New York and states nearby. That data marked the first recorded weather measurements at the facility, the start of what is now a record spanning 125 years. For its record-keeping, the National Weather Service has awarded UConn's College of Agriculture and Natural Resources with an Honored Institution Award.

In the late 1800s, the first weather data were collected there using a mercury thermometer and a large can. Observers recorded the metrics each day, marking notes down by hand. Olsen, who began working at UConn in 1988, still collects some measurements that way, though many are recorded by a Campbell Scientific data logger installed in 1992.

At the same time each day, he goes out to a station owned by the National Weather Service that is outfitted with a rain bucket and thermometer and records precipitation and temperature data for the previous 24-hour period. The bucket is about 8 inches in diameter, Olsen says, with a small funnel inside that allows him to measure rain to one-tenth of an inch. He does this by hand.

Photo: (bottom) National Weather Service; (all others) Steve Olsen

Steve Olsen (left) is presented with an Honored Institution Award by William Simpson of the National Weather Service and Gregory Tormey of the UConn Horticultural Society.

When UConn's data-keeping first began, weather data were recorded by hand.

"I like (recording) it manually better for the rainfall - what's in the can is what fell," said Olsen. "There's nothing like going out there with a ruler and looking at it directly."

The automated station is more high-tech, recording data every 15 seconds on precipitation, temperature, wind speed and direction, photosynthetically active radiation and soil moisture.

These two stations are important to the NWS, making up part of its Cooperative Observer Program that has some 12,000 weather stations nationwide. In Connecticut, these number 110. "They're homeowners mostly," said Olsen. "It's good data, but it's splintered."

With a span of 125 years, UConn's data sets help inform future climatic predictions for the region. Olsen says they are also used in-house at the Plant Science Research and Education Facility.

"We do so many different things. I like to say we grow everything but animals," said Olsen. The data are used in research projects and also help with managing the facility's grounds. Sometimes data are shared with graduate students who need them for their studies, or if somebody just wants to know how much rain fell the night before.

"As a farm manager, I'm kind of an unscientific observer, but it's a lot of fun to take these measurements," said Olsen. "It's when we get huge amounts of rain, like 2 inches of rain in one night or 7 inches in two days, that's unbelievable. I think, 'Wow, that was an amazing storm.'" OK

Emergency Response Data Buoy

BY DANIEL KELLY

When natural disasters strike, like mudslides or floods, quick data can be highly valuable both to researchers and those living nearby. Monitoring platforms used at these times are sometimes thrown together at a moment's notice, bringing the quality of data collected into question.

But with NexSens Technology's new CB-50 buoy, first responders have a more reliable option for quickly responding to natural disasters: a multipurpose buoy, capable of supporting environmental sensors, telemetry and data loggers that's deployable from most anywhere.

"While there are other data buoy options on the market, I don't know of any that are as easy to deploy and still offer the range of sensor and telemetry options," said Paul Nieberding, general manager at Fondriest Environmental, the master distributor and integrator for NexSens Technology.

Nieberding says the CB-50 can be deployed from small boats, large vessels or even helicopters, making it the ideal choice for applications where water needs to be monitored at a moment's notice, like industrial spills or natural disasters. And users can configure a CB-50 system to fit their needs.

"The CB-50 is our most affordable buoy platform, and it's the only CB-Series buoy that does not support solar panels," said Nieberding. "The CB-50 is designed to house the SDL500 submersible data logger, which runs on alkaline batteries, includes radio, cellular & satellite telemetry options, and is compatible with most water monitoring sensors currently on the market."

These include turbidity sensors, dissolved oxygen sensors, hydrocarbon sensors, fluorometers, multi-parameter sondes, pressure transducers, depth sonar and more.

For short-term projects, the CB-50 can also be rented as a cost-effective alternative. Renting is a popular choice for customers, especially environmental consultants and government agencies wanting to avoid the capital expenditure, Nieberding says. For those looking to purchase, the CB-50 buoy starts at $1,495 and complete integrated systems are available in the $5,000 range depending on telemetry and sensor configuration.

Still, the biggest advantage of the CB-50 is how easy it is to deploy.

"We've actually shipped systems that were already powered up and collecting and transmitting data in-transit," said Nieberding. "So they could simply be dropped in the water upon arrival." OK

Shrinking Lake Waiau

Hawaii's sacred Lake Waiau — the state's only alpine lake — is shrinking. Scientists are building a record of its changes from old photos.

BY JEFF GILLIES

In late 2013, Hawaii's only alpine lake was on the verge of disappearing. Perched 13,000 feet up the slope of Hawaii's Mauna Kea Volcano, Lake Waiau is normally only around 300 feet wide. This December it had shrunk to around 30 feet across.

The lake is mainly fed by snowfall, and a few big winter storms have since helped it rebound, though not fully, according to Matthew Patrick, a research geologist with the U.S. Geological Survey's Hawaiian Volcano Observatory.

"We're going to be looking at it this summer to see how sustained that rebound really is," Patrick said. "The level tends to drop during the summer months when it's drier, so we'll just have to see if this is a sustained rebound or a transient rebound."

In addition to being environmentally rare — Hawaii's permeable ground makes Waiau one of its few lakes or ponds — the site is particularly sacred to native Hawaiians. As a result, scientists will be tracking the lake through non-invasive methods including satellite imagery and other remote sensing techniques.

For instance, Donna Delparte and her collaborators at the Spatial Data Analysis and Visualization Lab at the University of Hawaii in Hilo created a 3-D model of the lake and surrounding area by stitching together data from several remote methods, including terrestrial LiDAR surveys and a technique method called "structure from motion" that aggregates spatial information from a series of photographs.

"What we wanted to be really conscientious of was that it's a culturally sensitive site, so we didn't want to poke around in the lake," said Delparte, an assistant professor in the Idaho State University Department of Geosciences. "So we wanted to do everything remotely so that nothing was disturbed."

University of Hawaii students Chris Nishioka, Nicholas Turner and Matt Belt processed much of the data for the project, Delparte said.

"A big part of this project was training local students on how to use all this fancy gear and get them the skills so that they were able to use this technology for environmental data collection," Delparte said.

With the data collected through those remote methods, the scientists built a 3-D model that can assess nearly any dated photograph of Lake Waiau and estimate what the water levels were when it was taken. They're hoping that a few generations of tourists will catch wind of the project and supply historical photos, which could help build a record of fluctuating lake levels and precipitation that stretches into the past.

"We're hoping (to go back) over the last 100 years, because it's been a tourist site for a long time," Delparte said. "People have been going up there since the '20s. They go up there and they take a picture."

That kind of information could build a comprehensive chart of what's been happening on the lake and how it might relate to climate change. It's too early to relate recent fluctuations with climate change, Patrick said, but there have been suggestions of warming trends in Hawaii over the past 30 years. Previous studies have shown that the state's alpine areas are particularly sensitive to those trends.

On a shorter time scale, Lake Waiau's recent shrinking does seem to be related to an ongoing drought in Hawaii that began in 2008. A question for future research would be whether this is an unusually severe drought, Patrick said.

In the meantime, anyone with photos of the lake can submit them to askHVO@usgs.gov to help the effort to build a historical context for the lake's decline.

"It's a really special place in many respects, culturally, environmentally and geologically," Patrick said. "And that's why it's really worth taking a close look at recent changes." JG

Photo: Nick Agorastos / State of Hawaii

AFTER THE STORM

Monitoring platforms on Lake Lacawac and other Northeast waterbodies are helping scientists see how lakes respond to extreme weather.

BY DANIEL KELLY

As Cyclone Irene passed over Lake Lacawac in August 2011, the water swirled as the force of wind and rain accelerated normal late-summer mixing by about a month. Other lakes in the storm's path saw similar or greater abrupt mixing, but Lacawac was shielded by its unique geography.

A pristine glacial lake in the Pocono Mountains, "Lacawac was at the small end of the spectrum because it has a small watershed. Its thermal layers were changed by the storm, but it recovered fairly quickly," said Bruce Hargreaves, associate professor of earth and environmental sciences at Lehigh University and manager of a monitoring platform on Lake Lacawac.

Lake Lacawac is part of the Global Lake Ecological Observatory Network and has supported lake instrument research for many years, according to Hargreaves. Through a GLEON collaboration, data collected on Lake Lacawac during Irene were combined with findings from eight other North American lakes in a rare large-scale analysis of high frequency, automated lake data to determine the immediate impacts of an extreme storm.

"No one site can provide data that explain the storm's impact," said Hargreaves.

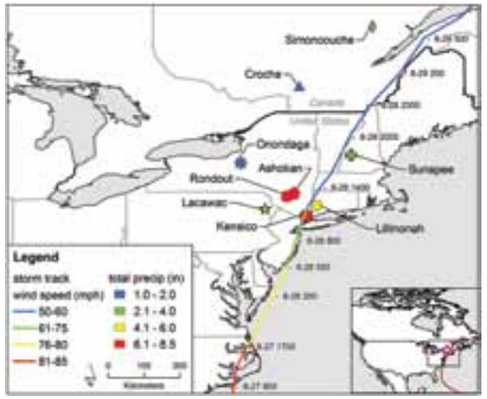
The massive data set in this study shows the role a lake's watershed plays in the impacts it feels. It also shows the importance of lake metabolism, which the scientists estimated by measuring the balance between oxygen production and consumption with automated sensors.

On Lake Lacawac, a raft supports a solar-powered sensor suite, complete with weather station, wind sensor and tipping bucket rain gauge. Radiation sensors track sunlight levels. A thermistor chain tracks water temperatures at different depths. A vented water pressure sensor records variations in the lake's water storage and is used to estimate runoff from the watershed by comparison with measured or calculated rain, stream outflow, and evaporation rates.

Other lakes in the study had similar automated sensors on buoys or rafts. On the seven lakes with oxygen sensors, calculations of lake metabolism showed that the balance between production and consumption had been decoupled by the storm.

This change was explained by the expected influx of organic matter and sediment carried by storm runoff. The influx of organic matter increased the consumption and reduced production. The effect was especially pronounced on Connecticut's Lake Lillinonah, said Jennifer Klug, associate professor of biology at Fairfield University and lead author of the study. She manages a station on Lillinonah with a non-profit group called Friends of the Lake.

Photo: Fondriest Environmental



Cyclone Irene's path over the eastern United States. (Credit: A. Lindsey, K. Weathers' Laboratory, Cary Institute)

"The change in (metabolic) stability in Lillinonah was incredibly dramatic," said Klug. "We saw basically a wall of water come down the river and into the lake."

The researchers learned that the key to understanding how much each lake's thermal structure was disrupted by this storm was watershed size relative to the size and depth of a lake. They coined a new term, the "potential volume replacement" of a lake, to describe just how much of a lake's stored water could be swept away by rain falling into a lake and onto its surrounding watershed.

"Bigger lakes and lakes closer to the storm path had more exposure to wind, and bigger watersheds brought in more runoff, so together these explain the extent of mixing," said Hargreaves. Lake Lacawac is a small lake with a small watershed so mixing impact was reduced.

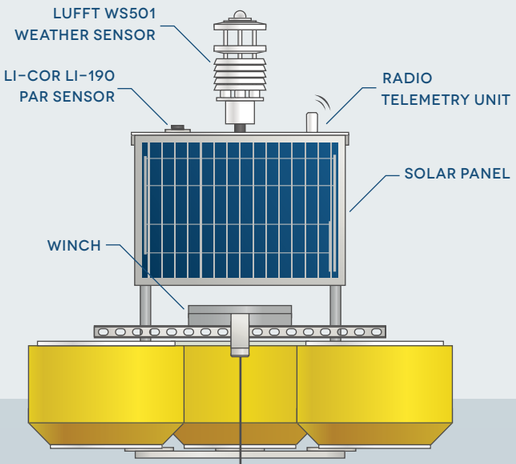
Lake and reservoir managers cannot control the path of a storm, but this study shows that lakes and reservoirs with large ratios of watershed area to lake volume are most at risk for changes to metabolism and thermal mixing from large storms.

Lacawac will continue to benefit from its surrounding landscape when extreme storms hit in the future, and its researchers will be better prepared to monitor their impacts. Hargreaves added a miniDOT oxygen logger to his monitoring platform in June, a gift from Precision Measurement Engineering, Inc.

For the past two years, Lacawac has also been the test site of a new auto-profiling buoy designed by Hargreaves and his colleague Craig Williamson of Miami University to study climate change in lakes. It's managed by Williamson's graduate student Jennifer Brentrup with help from Lesley Knoll, director of science and education for Lacawac Sanctuary.

The sanctuary also received a significant grant from the National Science Foundation for a new science lab that will support ongoing research into advanced instrumentation and climate change. DK

ADDITIONAL WORK ON LAKE LACAWAC

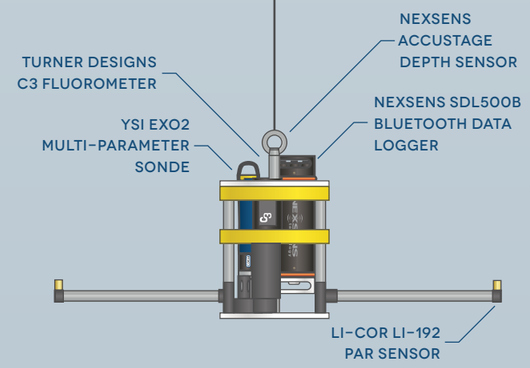


NexSens and Fondriest Environmental worked with Miami University on the design of a new auto-profiling buoy for Lake Lacawac. It's letting researchers study the interaction between the lake and its surroundings by taking measurements on water and atmospheric quality.

The profiler logs weather parameters like temperature, barometric pressure and wind speed, as well as photosynthetically active radiation (PAR). Those data points are recorded by a NexSens 4100-iSIC data logger that sits above water.

On the bottom side, a custom smart winch lowers and raises a submersible data logger and sensor package under the lake's surface to collect information on underwater PAR, wave height, pH, dissolved oxygen and other water quality parameters. The winch communicates with the topside data logger via Bluetooth.

Though still in the testing phase, the profiler is helping Hargreaves and colleague Craig Williamson of Miami University study what impacts climate change is having on lakes. It is managed by Jennifer Brentrup, a graduate student at Miami University, and Lesley Knoll, director of science and education for Lacawac Sanctuary.



DEVILS HOLE DECLINE

A few dozen wild Devils Hole pupfish remain in their tiny desert habitat. A new model will investigate climate change's impact on their mysterious decline.

BY JEFF GILLIES

Devils Hole in Southern Nevada is a groundwater-filled, vansized fracture in the desert bedrock that's surrounded by high fences and motion sensors.

"The sensors are sensitive enough that sometimes chuckwallas kick rocks down and call the police," said Mark Hausner, postdoctoral fellow with the Desert Research Institute.

The security measures are there to protect the only natural population of the endangered Devils Hole pupfish, which fell to record-low numbers in 2013 when counts pegged the population between 35 and 65 fish.

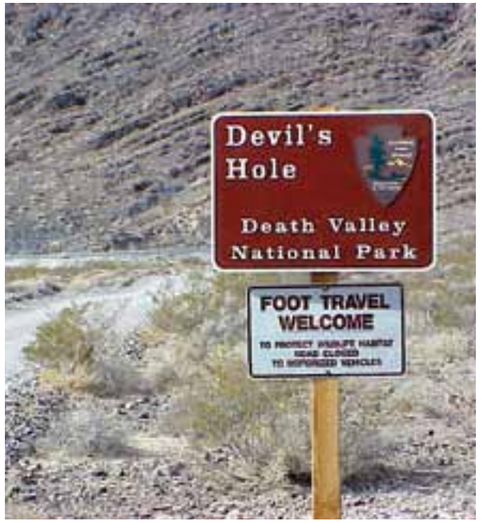
Historically, the population would fluctuate annually from around 400 in the summer to 200 in the winter after a natural die-off. But the species has been in a mysterious decline since the 1990s. Scientists like Hausner are working to test hypothesized influences on the population such as the effects of climate change on water temperatures and the food web.

Devils Hole's surface area is only about about 2 meters by 6 meters, half of which covers a shallow shelf where the pupfish forage and spawn. The other half drops down into a huge underwater cavern with a depth that hasn't yet been determined.

"The divers have gone down to 130 meters, dropped a flashlight and watched it bang around for another 20 meters or so," Hausner said. "But then the angle got too steep for them to see the light."

But the pupfish depend mostly on the shallow shelf, which supports benthic algae growth as well as temperature and dissolved oxygen levels conducive to spawning and juvenile fish development. Though the fish retreat to the pool during the warmest parts of the day, they return to the shelf daily.

To determine the potential influence of climate change on water temperatures, Hausner wrote a model that links variation in water temperatures with local meteorological conditions. He based the model on weather data from a meteorological



The small surface opening of Devils Hole gives way to a cavern that divers still haven't fully explored.

Photos: U.S. Fish and Wildlife Service

Photo: Olin Feuerbacher

station operated by the National Park Service that collects air temperature, relative humidity, solar radiation, and wind speed and direction. Hausner monitored water temperatures in a cross section over the shelf using fiber optic temperature sensors for two days in June 2010.

That was no simple task, as access to Devils Hole, which is within an outpost of Death Valley National Park, is highly restricted by the National Park Service. Equipment must be disinfected before it goes in the water to prevent introducing new species. And researchers who do get access had best not overstay their welcome. As Hausner put it, "Get in, collect your data, get everything out, don't set foot in there again unless you absolutely need to."

Hausner said he saw the inch-long, iridescent blue pupfish swimming over the shelf as he worked, and the fact that those were some of the only members of their species on left on Earth wasn't lost on him.

"It's not something that you forget," Hausner said. "You might see 20, 30 fish during the day when you're working there. Well, that's half the population."

With the model written and calibrated, the work now turns to plugging in projected changes in the region's climate to simulate peak water temperatures. That will give an idea of what will happen to the size of the window of optimal spawning conditions when temperature and food supply is just right.

The results won't just benefit the few dozen pupfish left in Devils Hole, Hausner said. The stress of warming waters brought on by climate change is a threat to fish worldwide. Closer to home, there are three other species of endangered pupfish just in the same complex of desert uplands and springs where Devils Hole lies.

"They're going to be subjected to the same stressors," Hausner said. "Devils Hole is a leader because it's so small and physically limited that it's going to show effects first." JG

MEKONG HOTSPOTS

A USGS study identifies pollution sources in the Mekong River Basin, historically a wellspring of life and trade for Southeast Asia.

BY ALEX CARD

The Mekong River Basin, historically a wellspring of life and trade for Southeast Asia, is wracked by concentrations of contamination that threaten humans and wildlife. A new U.S. Geological Survey study identifies the sources of the pollution, providing the region's governments with information that could lead to restorative action.

Leading the study were members of the USGS, the International Crane Foundation and the University Network for Wetland Research and Training in the Mekong Region. Eight of the network's 18 universities collaborated for the study, and sent teams to explore the Mekong's wetlands over the course of a year.

"It was a really fast turnaround," said Jeb Barzen, director of field ecology at the International Crane Foundation. "We were sampling wetlands on a scale that was unprecedented."

The study looked at pollution hot spots throughout the basin, many of which were located near agricultural operations and seemed to be caused by pesticides and herbicides. Some of the hotspots were found in areas under environmental protection.

"The hotspots are important because they can give you a place to start when looking at how the impact goes up the foodchain," Barzen said. "In Southeast Asia, more than North America, fish are a very important part of the diet… Many of the fish people are consuming are migratory, so effectively they might enlarge the hot spots."

Scott Wilson, a branch chief at the USGS, explained how pollutants consumed at lower levels of the food chain can harm humans.

"Because these things tend to bioaccumulate, they can affect everyone on the food chain — including humans," Wilson said. "They can be passed through breast milk… and have some pretty nasty effects."

Photo: Nguyen Van Hung

Student researchers learn sampling techniques for the study.

Photo: International Crane Foundation

Tran Triet, director of the International Crane Foundation's Southeast Asia program, said that spectrometer analysis of 21 different organic pollutants was performed at labs in the Mekong region. All of the pollutants, including 18 isomers of polychlorinated biphenyls, are restricted under the Stockholm Convention on Persistent Organic Pollutants.

During the yearlong collection process, the teams gathered 530 samples from 450 wetlands. Another year was spent writing the study, and then a third spent navigating the peer review process. These feats, Barzen said, would have been impossible without the cooperation of all the involved entities.

"The USGS couldn't have done it by itself, none of the individual country's governments could have done it by themselves," Barzen said.

About 100 researchers worked on the study. Triet said that the study provided a great opportunity for the region's scientists to learn from USGS researchers in the field.

Barzen suggested that both parties can learn from one another.

"Southeast Asia and the U.S. are not known for great collaboration," Barzen said. "This is an example where Southeast Asia can teach the rest of the world. They can actually demonstrate how cooperation can be done, and just what can be accomplished when you cooperate to that extent."

Providing an example of an obstacle the study was able to overcome, Wilson said, "These wetlands were in parts of the country that were not very accessible — even for the locals within that country."

The study was funded by the Lower Mekong Initiative, a program started by Hillary Clinton.

"As a citizen of a country in the region, I think it's a very good investment from the government of the United States," Triet said. "It's resulted in a very good scientific project."

The next step for the research will involve a more careful examination of the hotspots, but Barzen said countries in the Mekong region need to consider funding new efforts.

"It's important for individual countries to do some more intensive surveys in the hotspot areas," Barzen said. "There's now a capacity to do this research — if there is funding." AC

MEKONG RIVER

The Mekong is the world's 12th-longest river, stretching 4,340 kilometers from China to Vietnam. Its name derives from the Thai and Lao term "Mae Nam Khong," meaning "Khong, the Mother of Water."

The Mekong River and its tributaries are subject to seasonal flow variations, and rapids, waterfalls and other obstacles can make boat passage challenging. However, the Mekong is a vital trade route in the region, as it connects western China to the Southeast Asian countries of Burma, Laos, Thailand, Cambodia and Vietnam.

The Mekong flows to the sea in southwestern Vietnam through a series of distributaries known as the Mekong Delta. The World Wildlife Fund has called the region a "biological treasure trove" for the thousands of new species discovered there, once at a rate of two species per week.

Desert Carbon Sponges

A rare 10-year experiment in an intact arid ecosystem shows deserts will sponge up more and more carbon as atmospheric carbon dioxide levels climb.

BY JEFF GILLIES

Somewhere near the United State's nuclear weapon testing grounds in Nevada, university scientists pumped carbon dioxide-enriched air over cordoned-off plots of desert landscape for 10 years.

The recently published results of that experiment — a rare long-term manipulation of an intact ecosystem — show that arid environments like the Mojave Desert will absorb more and more carbon as atmospheric carbon dioxide concentrations rise over the coming half-century.

The study measured carbon uptake by desert plants and soils in plots exposed to modern carbon dioxide levels and compared the results to similar plots treated with concentrations of the greenhouse gas projected for 2050.

As carbon dioxide concentrations rise from today's level of nearly 400 parts per million to the 550 parts per million expected in 2050, the rate at which desert landscapes sponge up that carbon will also increase, according to R. Dave Evans, a professor of biological sciences and lead author of the study.

"What our study shows is simply after 10 years how much extra carbon accumulates under elevated CO_2," Evans said. "Under a future CO_2 atmosphere, we had significantly more carbon uptake than under ambient conditions."

The experiment took place in the Mojave Desert on the grounds of the Nevada National Security Site, formerly known as the Nevada Proving Grounds and then the Nevada Test Site. The site is 1,300 square miles of desert and mountains operated by the U.S. Department of Energy where nuclear weapons tests in the 1950s produced mushroom clouds that could be seen from Las Vegas.

The site provided protected pristine desert land ideal for the study, but it came with some quirks. That included a high-security environment that required clearance to even carry a camera onsite.

"We had magnificent security, you can put it that way," Evans said. "We didn't worry about anybody bugging our site."

The work occurred within the Nevada Desert Free-Air CO_2 Enrichment Facility, which is directed by Lynn Fenstermaker, Desert Research Institute associate research professor. The principal investigators who established the site and experimental setup are Bob Nowak, professor in the University of Nevada Reno's Department of Natural Resources and Environmental Science, and Stan Smith, professor in the University of Nevada Las Vegas' School of Life Sciences.

"They had the wherewithal almost two decades ago to start to question how these arid ecosystems are going to respond to global change," Evans said. "And one of the biggest factors is elevated carbon dioxide."

The facility launched in 1997 with nine 23-meter-diameter rings that blocked off open-air sections of desert exposed to three different carbon dioxide treatments. Three sites were "fumigated" with ambient levels of 380 parts per million, three more with 550 parts per million and the rest received no fumigation. No one set foot within the rings for 10 years, and researchers relied on a suspended trolley system to make measurements within the plots.

In 2007, the rings were excavated to a depth of 1 meter and meticulously indexed, with each plant's location, species and weight noted. Even the root systems were attributed to individual species. Then the amount of carbon in the plants, roots and soils was calculated.

On average, the organic carbon bound up in the ecosystem under ambient carbon dioxide levels was around 1,030 grams per square meter. Under elevated carbon dioxide, it was an average of around 1,170 grams per square meter.

The results suggest that desert ecosystems' role as sinks for rising atmospheric carbon dioxide concentrations is more significant than previously recognized. And even though forests absorb more carbon, arid landscapes' wide global distribution — they cover 47 percent of the planet's land surface — will bolster their contribution.

This new knowledge comes as a result of a long-term experiment in an intact ecosystem that is rare in any kind of science, Evans said.

"A big experiment like this rarely runs that long just because of the costs involved," he said. "We were very fortunate to have the support of our funders to let it run for a decade and really get some interesting results." JG

(right) Researchers used a trolley system to access the octagonal plots, which cordoned off land on the former Nevada Test Site.

Photos: (inset) National Nuclear Security Administration / Nevada Site Office; (all others) Lynn Fenstermaker

Manipulated Wetlands

Great Salt Lake wetlands are diked and their water levels manipulated to bolster migratory bird habitat. A new study asks what it does to wetland health.

BY JEFF GILLIES

Fieldwork in the wetlands around the Great Salt Lake can be a mixed bag for researchers. On one hand, there's the persistent smell of hydrogen sulfide characteristic of these ecosystems.

"It kinda gets in your pores," said Karin Kettenring, assistant professor of wetland ecology at Utah State University. "After a day of working in the wetlands you go home and wash your hands a few times, you take a shower, and the next morning you sniff your hands and they still smell like rotten eggs."

And that's on top of the "lake stink" that wafts up from the bottom sediments exposed by the Great Salt Lake's fluctuating water levels.

But then there are the millions of waterfowl and shorebirds — species like the American avocet and black-necked stilt — that rely on this oasis in the desert as a critical stopover site in the midst of their North American migratory routes.

"If you're out doing field work in the spring or the fall during the migration periods you'll be surrounded by hundreds of thousands of birds, which is a pretty phenomenal experience," Kettenring said. "They're beautiful birds. They have beautiful calls. They're very elegant."

Many wetlands around the lake are managed to bolster habitat for migratory birds, especially the ducks that draw thousands of hunters to Great Salt Lake marshes each year. These wetlands are impounded and their water levels manipulated, but scientists have no clear picture of how the management practices actually affect wetland health across the lake.

"We know a lot about the discharge of the rivers that go into the Great Salt Lake, and a fair amount about the elevation of the Great Salt Lake, but what's happening in between is generally unknown," said Rebekah Downard, doctoral student in ecology at Utah State University's Department of Watershed Sciences.

All Photos: Rebekah Downard

Downard is leading a study of water levels and other dimensions of wetland health in dozens of sites around the lake. The study seeks to understand how impounded wetlands are managed while developing a better idea of what a healthy wetland looks like amongst the region's arid climate and hypersaline waters.

Water levels in around half of the wetlands surrounding Great Salt Lake are managed to cope with the seasonal loss of source water when the rivers are drawn down for agricultural uses. The managed wetlands are diked and the impoundments flooded when enough water is available before it's diverted for the irrigation season.

"It's the wetland plant growing season too, but a lot of that water is going to agriculture instead," Downard said.

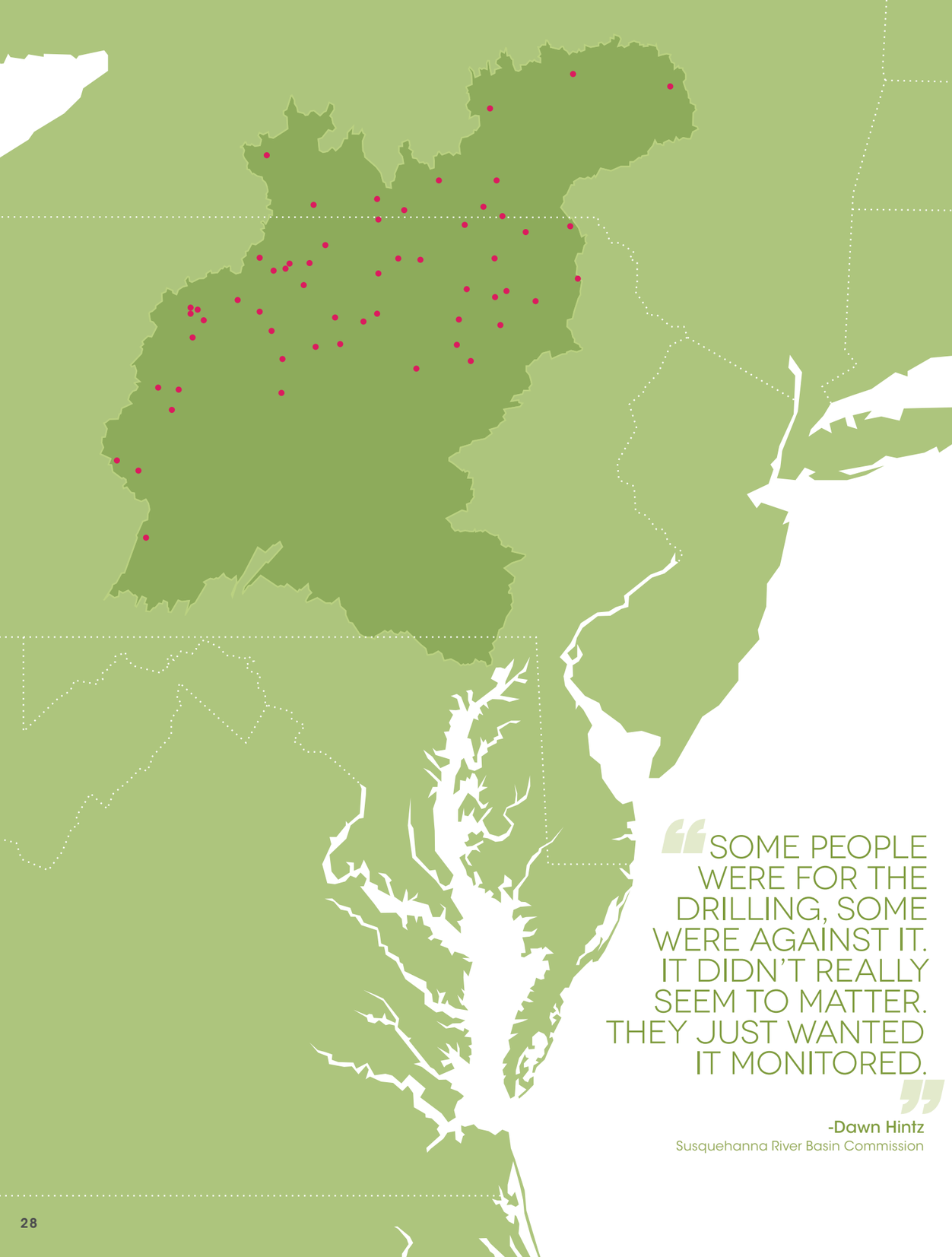
The idea is that these shallow reservoirs will preserve water in the wetlands throughout the growing season while creating habitat for ducks in the private hunting clubs and migratory bird preserves that surround the lake. But the patterns of water level management across the region aren't well known, nor is it clear that storing water in the wetlands is the best plan for the ecosystem's health and function.

To shed some light on both those areas of uncertainty, Downard installed monitoring wells equipped with pressure transducers at 25 impounded and 25 unimpounded wetland sites across the lake. From May to September, the instruments measure water levels every hour down to a meter below the soil and up to 60 centimeters above the surface.

In the meantime, Downard is sampling plant cover, plant species diversity and soil quality across the sites. After a few years, she'll answer questions like how often and deeply impounded wetlands are flooded, how often they go dry, how that affects plant diversity and soil quality, and how that all compares to conditions in the lake's more natural wetlands.

As far as working conditions go, Downard is enthusiastic about her time in the wetlands. The Great Salt Lake's wetlands tend to be less buggy and snake-infested than marshes in other parts of the country, even if they are prone to the occasional bout of lake stink.

"I'm from Utah," she said. "That's what home smells like to me." JG



> "SOME PEOPLE WERE FOR THE DRILLING, SOME WERE AGAINST IT. IT DIDN'T REALLY SEEM TO MATTER. THEY JUST WANTED IT MONITORED."
>
> **-Dawn Hintz**
> Susquehanna River Basin Commission

SUSQUEHANNA STREAM MONITORING

The Susquehanna River Basin Commission's remote water quality monitoring network tracks headwater streams flowing amid Marcellus drilling.

BY JEFF GILLIES

All Photos: Susquehanna River Basin Commission

While hydraulic fracturing for natural gas in the Marcellus Shale in Pennsylvania and southern New York has drummed up controversy, a shared appreciation for clean water quality in the region hasn't been so divisive.

When environmental scientists from the Susquehanna River Basin Commission sought permission from private landowners to install monitoring stations on headwater streams that run through landscapes where drilling has been intense, the response was receptive regardless of their stance on fracking.

"They could be on one side or another," said Dawn Hintz, an environmental scientist with the commission. "Some people were for the drilling, some were against it. It didn't really seem to matter. They just wanted it monitored."

An interstate agency created by a federal compact, the Susquehanna River Basin Commission manages water resources within the watershed, which spans New York, Pennsylvania and Maryland. They're charged with mitigating floods, regulating water withdrawals and protecting fisheries and water quality.

As drilling operations grew in the upper basin throughout the 2000s–along with concerns about potential water quality effects–the commission in 2010 launched a remote water quality monitoring network. The network has grown to 58 stations that continuously monitor temperature, pH, specific conductance, dissolved oxygen and turbidity and broadcast the data online.

The monitoring stations are providing baseline data in small watersheds — some where drilling is intense and others where it hasn't even started, though permits have been issued that suggest operations could be on the way. The stations span public land and private, including some sites where the commission sought permission from landowners and others where landowners sought out the commission.

They targeted streams with watersheds on the order of 30-60 square miles, which is small enough to capture local effects but large enough to carry the depth of water needed to keep instruments submerged. They also sought clean streams without prior degradation, making it easier to pinpoint causes of any new disruptions. Some of the little streams even support drinking water intakes for small municipalities.

"Anything that the public was concerned about, we tried to take into account when we were placing stations," Hintz said. "We obviously cannot have a monitor in every stream, so we were attempting to hit as many as we possibly could that seemed to fit our criteria."

The stations are typically installed in the winter, making for some chilly work days. That was especially the case while putting on one of their New York sites.

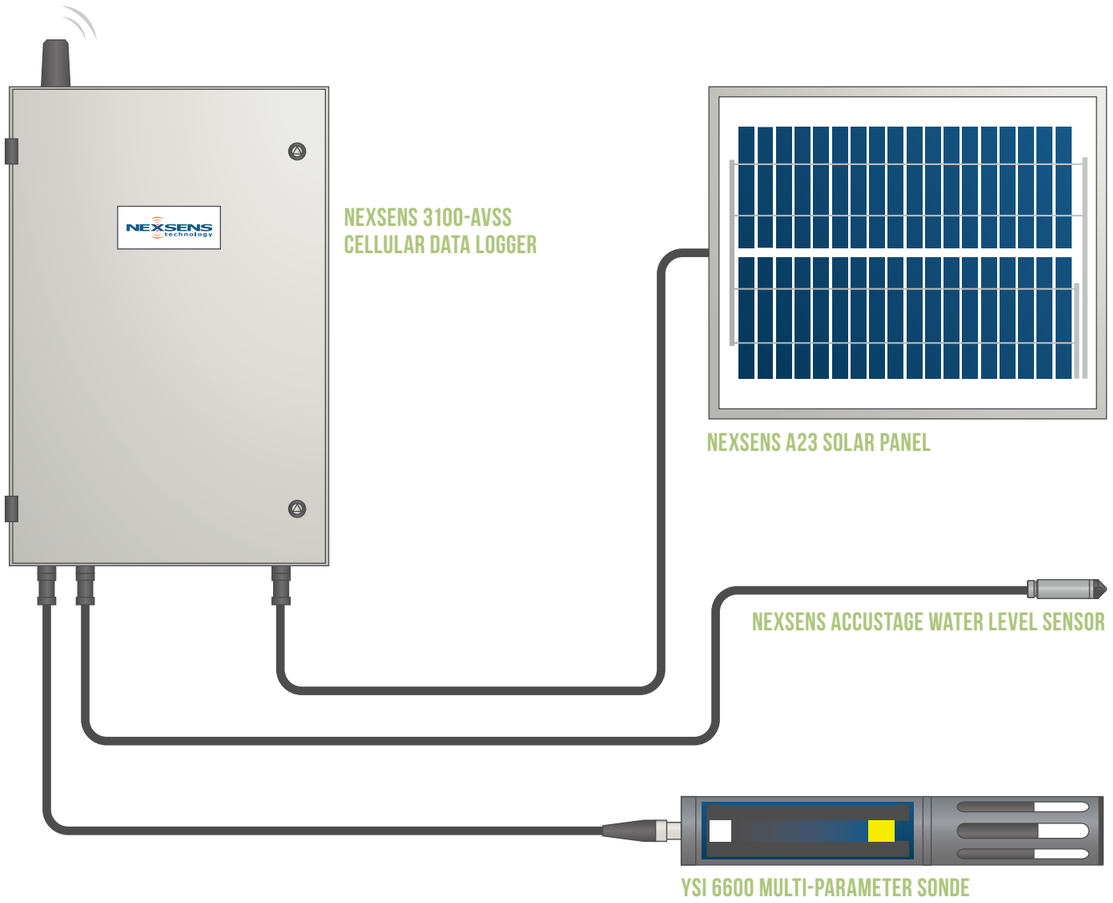
"You could see the ice freezing around us while we're in the stream," Hintz said.

The stations collect measurements every five minutes, a frequency that Hintz said helps make sure the scientists don't miss any events in these small streams, which can flush through quickly. The team receives email alerts when any parameter deviates too far from normal. Hintz said turbidity alerts are common, typically indicating a storm is fueling runoff in watershed. Alerts for pH or specific conductance will sometimes take a team member out to a site to collect samples for more detailed analysis in a lab. It can also indicate that a malfunctioning probe needs to be replaced.

Though they were initially concerned about vandalism to the equipment in some well-traveled areas, Hintz said the only incident so far has been a stolen solar panel. The biggest disruption so far has been Tropical Storm Lee, which in 2011 brought on the highest ever recorded flows in some of their streams and took out whole monitoring stations.

"Not just the in-stream part, but the data logger itself was completely taken down by high flows," Hintz said. "We had a couple months of just trying to clean up, trying to get stations back up and running, equipment fixed, equipment found." JC

TYPICAL SUSQUEHANNA STREAM MONITORING SYSTEM



NEW DATA BUOYS

BY ALEX CARD

The 2014 line of CB-Series data buoys combines traditional NexSens Technology reliability with new innovations designed to handle real-time data collection applications in waters from the Great Lakes to the Arctic.

Each CB-Series buoy comes equipped with at least three solar panels, pass-through holes for water sensor deployment and topside mounts for weather sensors. But the buoys' most exciting enhancement is the addition of a spacious, cross-compatible instrument well that protects delicate electronics.

"The biggest change is we now have a large data well that allows us to integrate batteries, data loggers and other electronics," said Paul Nieberding, Fondriest Environmental general manager. "That gives the customer more freedom to integrate their equipment if desired."

Weighing only 70 pounds, the CB-150 is NexSens' most compact data-collection platform. The buoy fares best in smaller, calmer bodies of water, and during short-term deployments where heavy-duty power supplies are unnecessary. Don't be fooled by the buoy's small profile, however: The CB-150 has proven its versatility through a recent deployment to the frigid waters of the Arctic Ocean.

The CB-450 is the next buoy in the series, granting additional functionality with its larger size. The instrument well offers ample room for a variety of electronic devices. Three pass-through holes make the buoy an excellent platform to deploy most water quality sondes. The size and power output of the CB-450 suit it to operations on inland lakes.

Offering immense power and sensor payload, the CB-950 is ideal for deployment in the Great Lakes, coastal environments and projects requiring power-hungry peripherals. This hefty buoy features durable construction and a large instrument well. Three 30-watt solar panels keep the CB-950 running during long-term projects.

The largest buoy of the series, the CB-1250 boasts the same innovations as the smaller models with the benefits of added internal space, a dual-tier solar array with six 30-watt panels, and buoyancy rated at 1250 pounds.

"The buoys appeal to researchers that need to conduct in-situ measurements on open bodies of water, or regulatory projects during dredge operations where they need to monitor turbidity in real time," Nieberding said.

CB-Series buoys are compatible with many data loggers, but excel with NexSens' own iSIC data logger.

"With a lot of the buoy platforms we integrate the iSIC data logger, along with a wireless telemetry model," Nieberding said. "Options include radio-to-shore, cellular and iridium satellite. That allows customers to not only collect data but transmit it in real time back to their office."

Pricing for the CB-Series starts at $2,995 for the CB-150. Optional features include deep-cycle marine batteries, solar marine lights and sensor mounting hardware. AC

Renderings: Tyler Fondriest, Nate Christopher

WHAT THE LAND WEARS

The nation's premier tool for tracking land cover change gets a five-year update.

BY ALEX CARD

Since its creation in the mid-1990s, the National Land Cover Database has acted as the census of land cover data. Free to use and available online, the newest edition of the database was released in early April 2014, and will continue to help professionals from a wide array of industries monitor land cover changes.

"We are striving to be the land cover census for the nation," said Collin Homer, land characterization program manager for the U.S. Geological Survey. "Just as the population census is about not only the population, but how it's changed, most of our users are interested in monitoring change."

The NLCD is a product born out of necessity, Homer said. In the '90s, less-ubiquitous satellite coverage limited the availability and accessibility of satellite data. The data was under a commercial program and cost several thousand dollars for every image.

The U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration and the USGS spearheaded the effort to create a consistent, affordable national land cover data layer. Their work came to fruition — with the help of several other agencies — in the 2001 NLCD.

"Land cover is the vegetation or material that actually covers the surface of the earth," Homer said. This includes forests, urban coverage, bodies of water, and so on. Homer stressed the difference between land cover and land use: a city park, for instance, would be designated as trees and grass in a land cover layer, rather than urban coverage.

Atmospheric, climate and weather models incorporate land cover data in their forecast maps. Forest and range managers can track changes in topography and canopy cover using land cover data. And up to 60 percent of all analysis under the Clean Water Act is performed with the help of the NLCD. About 30,000 files are downloaded from the NLCD annually, Homer said.

"If you're a user and… the amount and distribution of land cover-age is important, then you need to know where and when it's changing," Homer said.

The current NLCD "epoch" represents a period from 2006 to 2011. The NLCD is updated every five years, and although faster update times are an eventual goal for the database, Homer said a couple obstacles prevent immediate improvement.

"We need a better satellite data stream before we can increase the frequency a whole lot," Homer said.

Cloud coverage also contributes to the current cycle length: "That five-year cycle is in part due to just waiting for enough cloud-free pixels to do our work on." Sometimes, he added, it can take up to three years for a satellite to gather enough suitable data for a particular area.

Although the NLCD is based almost entirely off of Landsat imagery, local aerial photography is used to "train" some satellites and to validate data. More commonplace tools are also employed.

"Sometimes we'll use the same thing that everybody else does: we'll zoom in to Google Earth," Homer said. "Some of the broad scale imagery in Google Earth comes from the same satellite that we use to do our land cover."

Although increased update frequency may be years away, Homer said several upgrades will be made to the NLCD in the near future.

"Because it's so important to be tracking the land cover change nationally, this next epoch, 2016, we will be using the satellite archive to go back in time … to 1985," Homer said. "Users will have a 30-year record of the land cover change." AC

Houston Texas urban expansion in 2001, 2006 and 2011.

Honey Lake, California water level in 2001, 2006 and 2011.

All Graphics: USGS

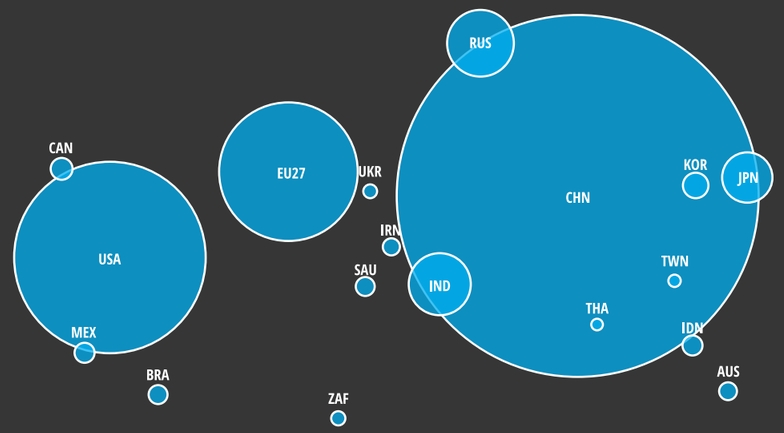
Dahlart, Texas agricultural expansion in 2001, 2006 and 2011.

Payette, Idaho forest loss in 2001, 2006 and 2011.

GLOBAL CO_2 EMISSIONS

Total 2012 CO_2 emissions per country

9860 Mt	CHINA
5190 Mt	UNITED STATES
3740 Mt	EU27
1970 Mt	INDIA
1770 Mt	RUSSIAN FEDERATION
1320 Mt	JAPAN
640 Mt	SOUTH KOREA
560 Mt	CANADA
490 Mt	MEXICO
490 Mt	INDONESIA
460 Mt	SAUDI ARABIA
460 Mt	BRAZIL
430 Mt	AUSTRALIA
410 Mt	IRAN
330 Mt	SOUTH AFRICA
320 Mt	UKRAINE
280 Mt	TAIWAN
260 Mt	THAILAND

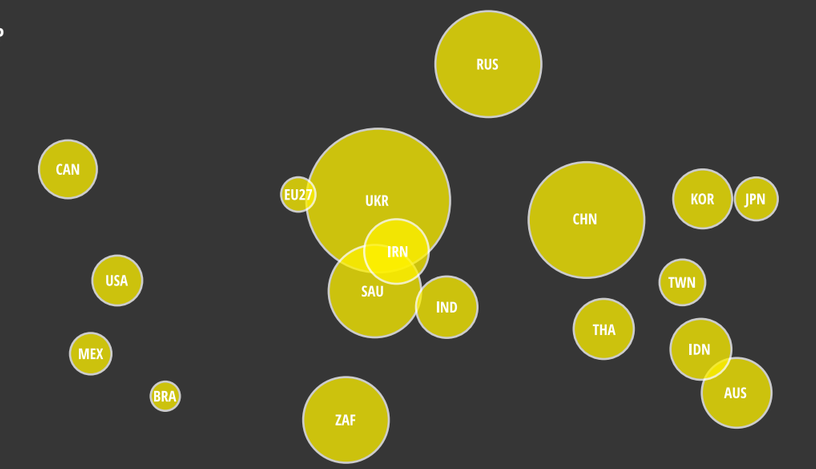


2012 CO_2 emissions per capita

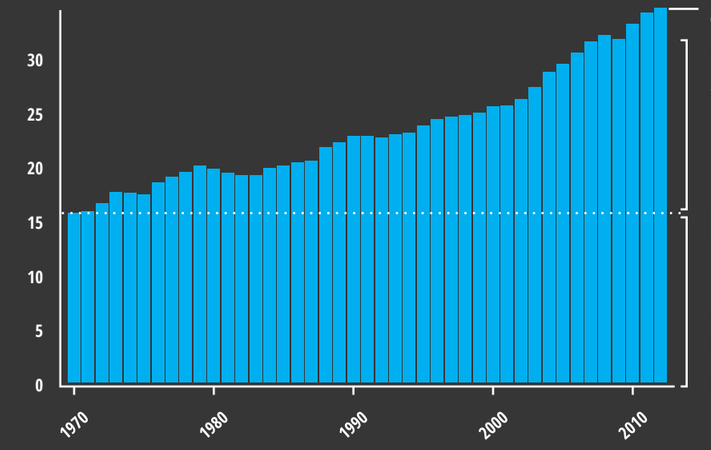
18.8 t	AUSTRALIA
16.4 t	UNITED STATES
16.2 t	SAUDI ARABIA
16.0 t	CANADA
13.0 t	SOUTH KOREA
12.4 t	RUSSIAN FEDERATION
11.8 t	TAIWAN
10.4 t	JAPAN
7.4 t	EU27
7.1 t	CHINA
7.1 t	UKRAINE
6.3 t	SOUTH AFRICA
5.3 t	IRAN
4.0 t	MEXICO
3.9 t	THAILAND
2.3 t	BRAZIL
2.0 t	INDONESIA
1.6 t	INDIA

2012 CO_2 emissions per 1,000 USD of GDP

1107 kg	UKRAINE
891 kg	CHINA
816 kg	RUSSIAN FEDERATION
712 kg	SAUDI ARABIA
659 kg	SOUTH AFRICA
537 kg	AUSTRALIA
497 kg	IRAN
473 kg	INDIA
469 kg	INDONESIA
463 kg	THAILAND
454 kg	SOUTH KOREA
446 kg	CANADA
384 kg	UNITED STATES
352 kg	TAIWAN
331 kg	JAPAN
319 kg	MEXICO
265 kg	EU27
225 kg	BRAZIL



All Graphics: Nate Christopher



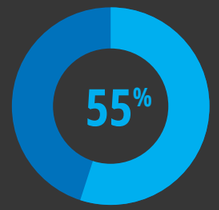
34.5 BILLION TONNES IN 2012

Global CO_2 emissions reached **34.5 BILLION TONNES** in **2012**, more than doubling what they were in **1970** when the **US EPA** was created.

1.1%

2.9%

While totals are still increasing, it is at a much slower rate than in the past. **2012** saw an increase of **1.1%** over **2011**, compared to an average annual increease of **2.9%** since **2000**.



of the total global emissions came from just three regions - **CHINA**, the **UNITED STATES** and the **EUROPEAN UNION**

CHINA
29% share of global emissions

3% INCREASE from **2011**

UNITED STATES
16% share of global emissions

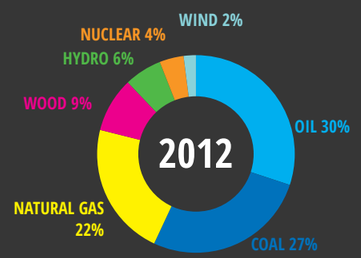
4% DECREASE from **2011**

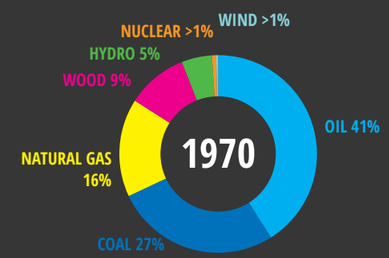
EUROPEAN UNION
11% share of global emissions

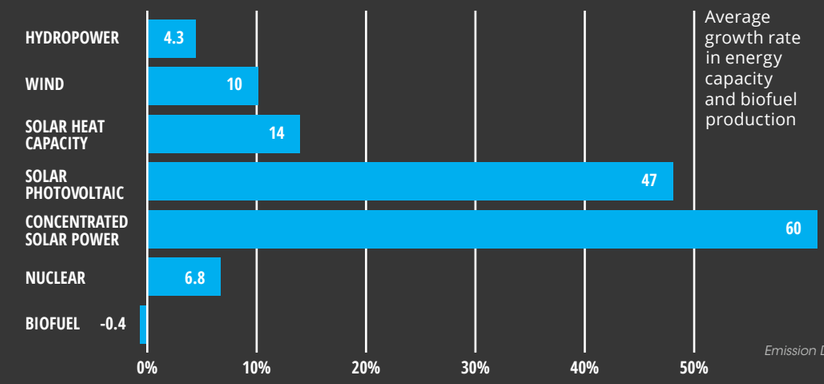
1.6% DECREASE from **2011**

SLOWING DOWN

Annual global CO_2 emissions are still increasing, but at a much slower rate than in the past. A large part of the lower emissions rates are due to an increase in the usage of **RENEWABLE ENERGY**.







RENEWABLE ENERGY

Usage of **RENEWABLE ENERGY** is increasing at a faster rate than other energy sources, although **OIL** and **COAL** remain the top sources of energy production across the globe. As of **2013**, at least **138** countries had renewable energy targets in place.

Information from:
PBL Netherlands Environmental Assessment Agency: Trends in Global CO_2 Emissions - 2013 Report
European Commission's Joint Research Centre: Emission Database for Global Atmospheric Research 32 and 4.2
Ren21: Renewables 2013 Global Status Report
BP Statistical Review of World Energy June 2013

deserted island

On abandoned Kiska Island, archaeologists study human's long-term environmental impacts.

BY DANIEL KELLY

Scientists say the environment of today is built on the actions of those who have already passed. A growing body of knowledge supports this theory and it's held by most as common sense: what we do now affects the environment our descendants will inhabit.

But, scientifically speaking, feeling in your gut that a relationship exists and proving that it actually does are two different things. With more information needed to draw concrete conclusions, researchers look to regions of Earth that have been deserted by humans. Places like Kiska Island, which sits in the Rat Islands of Alaska's Aleutian Archipelago.

The small island was home to a prehistoric population of Aleuts or Unangans, a maritime people who lived there for 6,000 years. This offers researchers a rare opportunity to study the impacts that humans have on regions over time. This summer, scientists will document the last few thousand years of those impacts on Kiska in concert with natural environmental changes that have occurred. The study will bring together a host of disciplines, including biology, geology and anthropology.

"We're constantly trying to understand how our actions impact the environment," said Caroline Funk, research assistant professor of anthropology at the University at Buffalo. "Archaeology is unique in its ability to provide time-stamped cultural and environmental information in addition to human-impact data." She joins co-principal investigators Nicole Misarti, a research assistant professor from the University of Alaska, Fairbanks and Brian Hoffman, associate professor at Hamline University, in overseeing a slew of investigations.

Researchers went in May and June of this year, when it was still cold in the islands. It begins with a flight to Adak, Alaska, the site of an old U.S. military base. From there, they hitch a ride on a research vessel to Kiska. "You go when there will be a boat in the vicinity," said Funk.

A smaller boat shuttles equipment to shore by making short trips. Scientists usually set up camp near a stream and sleep in small individual tents. A large one serves as working and community space.

Researchers live and work in WeatherPort tents while on the Rat Islands.

All Photos: Caroline Funk

An exposed archaeological site on Kiska Island.

Funk has made similar trips in the past and says that complications can come up while living on a remote island. This is especially true given the large rat populations that live on Kiska. They give the archipelago its name.

"One year, they got into our powdered mashed potatoes," said Funk. "Now we have a hammock technique to hang food from the rafters of the WeatherPort (tent)."

Changes in weather conditions can also complicate research.

"We'll work as hard and as long as we can each day, even if it's 40 degrees and raining each day," said Funk. "You don't really want to do that, but the data are so remarkable that it's worth it."

An intertidal survey performed by senior scientist Spencer Wood will record baseline data for the island's food web. Pollen cores, gathered by Nancy Bigelow, a senior scientist from UAF's Alaska Quaternary Center, will show changes to sediments since the last ice age and yield bits of volcanic ash.

"With tephra (volcanic ash) sequences, there's no human impact," said Funk. They provide a good route to understanding changes that have occurred since before humans lived there thousands of years ago. Funk says scientists making this two-month expedition hope to gather enough samples to form a clearer understanding of human and environmental histories for the past millennia.

Archaeological survey and test excavations, led by Funk, Hoffman and senior scientist Debbie Corbett, will also take place across the island to investigate impacts the ancient Aleuts had on the landscape. Funk, who specializes in identifying animal bones, says it's one of the few methods of investigation that will rely on low-tech equipment. "We use our eyes," she said. Other research methods will use mass spectrometers, soil corers and portable X-Ray fluorescence machines.

After all data have been collected, they will be shared with the National Science Foundation, which is providing funding for the project, and made available to researchers via public sources. Funk looks for them to be used by environmental modelers around the world. DK

HIPPO POOLS

BY JEFF GILLIES

Giant hippos that line the banks and swim in the pools of the Mara River in Kenya may be contributing to fish kills downstream of their herds. Scientists who think that could be the case have had a hard time investigating it because the aggressive brutes tend to take exception to humans encroaching on their habitats to sample.

But it appears they may have a solution: Robotic, sensor-toting boats disguised as crocodiles.

"We were joking that it's the first robot that's ever been on the Mara, and someone said it's the first boat that may have been on the Mara," said Paul Scerri, president of the robotics company Platypus, LLC. "You just don't go there."

Platypus is a start-up company spun off from Carnegie Mellon University's Robotics Institute in 2012 that is working to develop small autonomous watercraft for environmental monitoring applications. Researchers from Yale University caught wind of what their boats can do and sought them out for help surveying the Mara River amongst the hippos.

That sounded like fun to Scerri, so he and Chris Tomaszewski, Abhinav Valada and John Scerri, all with Platypus, set out for Kenya in March, where they were hosted by Amanda Subalusky and Chris Dutton of Yale.

The Mara is a fairly small river in the low season, with slow lazy bends that create large pools where as many as 150 hippos congregate. The hypothesis is that, with each animal depositing more than 10 pounds of waste in the river a day, a significant amount of organic matter builds up on the bottom. As it decomposes, microbes consume oxygen and drop the water into hypoxia. When a flood flushes the system, the degraded water moves into fish habitats and chokes aquatic life.

But scientists know little about what's going on in those pools, as each is guarded by dozens of multi-ton hippos, known as one of the most dangerous species in Africa.

To investigate the pools, the Platypus team outfitted one of their boats with a foam crocodile head, an RBR multi-parameter sensor and a Lowrance fish finder to collect sonar data. They'll work with Contour Innovations, a company that will further analyze the sonar data and produce a map of bottom hardness in the pools. The hope is that it will give researchers an idea of whether the pools are lined with soft organic matter or hard rock.

Photo: Paul Scerri

> "IT WAS AN ABSOLUTELY SURREAL EXPERIENCE."
>
> **-Paul Scerri**
> President, Platypus, LLC.

The Platypus crew surveyed bottom hardness, dissolved oxygen and several other parameters in a number of pools before and after storms brought the river up 4 or 5 meters over night.

"It'd go from a very benign, calm place where we we did a lot of testing, to just a raging rapids that was throwing huge trees into rocks," Scerri said. "We didn't even walk down to the edge."

They're still processing the data, but if the before-and-after pictures show that organic matter has been flushed out, it could be evidence that an abundance of oxygen-eating material is suddenly somewhere else in the river.

The Platypus boats are equipped with Android phones with GPS capabilities. In most applications they operate autonomously along preplanned routes, but in this case they stayed under human control in case they needed to navigate away from a defensive hippo.

It was a smart choice, because that's exactly what happened. Scerri said they had already surveyed a few pools and encountered a few curious hippos, but hadn't seen much aggression. But this time, as Scerri's brother John navigated the boat by a pod of bathing hippos, one broke away and gave chase. Suddenly, the normally talkative group was holding its breath.

"It was an absolutely surreal experience," Scerri said. "We're all staring at this hippo chasing the boat."

After a tense few seconds, John piloted the boat to deeper waters where the hippo couldn't move as quickly, and it eventually gave up and turned around.

"It was a 30-second-or-so event," Scerri said. "Felt a lot longer." JG

Hydreon RG-11

Adopting the same sensing technology used in automotive rain sensing windshield wiper controls, the Hydreon RG-11 fits most applications that require a reliable and sensitive optical sensor. As the water hits the surface of the dome, beams of infrared light bounce within the lens to determine the size of the rain drop based on the change caused in the beam intensity. A sophisticated circuitry system and advanced software detect raindrops down to under a half millimeter. The RG-11 is completely sealed off, leaving no room for bugs or debris. Applications include meteorology, rainfall measurements, condensation sensing, irrigation control and wiper control on ships and boats.

Geneq iSXBlue II

The highly versatile, battery-powered iSXBlue II GNSS is the ideal choice for applications in mining, forestry, GIS, agricultural and other industries, as well as in areas where obstructions exist such as dense forests and around buildings. Time is money, and this palm-sized receiver boosts productivity by giving access to both GPS and GLONASS satellites, thus reducing search time.

Real-time horizontal accuracy is obtained at 60 centimeters or better. Fully compatible with mobile operating system devices like iPhone, iPad and iPod, the iSXBlue II works directly within iOS applications such as Esri's Collector App for ArcGIS, ArcGIS for iOS, iCMTGIS and many more.

YSI TruLab

The compact YSI TruLab benchtop meters perform pH and ORP measurements rapidly and reliably. A Continuous Monitoring Control function facilitates the ideal measuring range for pH based on the last calibration, and the instruments' AutoRead function indicates when a stable measurement is reached.

An adjustable timer sends a notification when it is time to perform the next calibration routine to improve measurement accuracy. Data on all models can be exported to a PC via USB. Models 1310 and 1320 also include internal memory and an optional built-in printer to print data directly from the unit.

Hach DR900

Hach's DR900 multi-parameter colorimeter provides easy access to 90 of the most commonly tested water quality parameters. The intuitive user interface and simple keyboard functions allow for quick selection and testing. Up to 500 tests can be stored in the unit's memory for download or transfer via USB port. This meter is also tested to withstand the harshest of environments for greater quality assurance.

FISHSENS SondeCAM

The FISHSENS SondeCAM provides anglers and fishery researchers with a convenient way to view underwater video, identify fish habitat and profile water quality.

The SondeCAM features a built-in precision temperature sensor and optional YSI® pH and dissolved oxygen probe connectivity. Video and data are displayed directly on the Lowrance® HDS 9/12 Touch Fishfinder.

A low-light camera with scratch-resistant lens, durable anodized aluminum body, and cable lengths to 100 meters sets SondeCAM as a first choice for professional fishing and research applications.

Solinst Levelogger App Interface

Monitor water level wirelessly with the Solinst App Levelogger Interface for the Edge, Junior, and LTC Leveloggers. The interface plugs into the top of a direct-read cable, transmits real-time data to an Apple smart device via Bluetooth technology, and enables a direct download of data to transfer by email or to a computer for further analysis.

The Levelogger app runs all major programming functions that would be available on a laptop, but without all of the bulkiness that comes with transporting a mobile computer to the field. A free download of the Levelogger App is available from the Apple App Store.

HOUSEBOATING LAKE POWELL FOR SCIENCE

On Lake Powell, houseboating scientists peer into reservoir's mercury problem.

BY JEFF GILLIES

Lake Powell, the canyon-lined, serpentine reservoir that straddles the Utah-Arizona border, draws millions of visitors every year. Vacationers there often take to houseboats for a mellow week on the water amongst the red sandstone cliffs.

That never appealed much to David Naftz, a U.S. Geological Survey research hydrologist who lived in Utah before taking up a post with the agency's Montana Science Center. But then duty called, in the form of a project to learn more about mercury contamination in the lower half of the 180-mile reservoir.

He and six USGS researchers from across the country — "A lot of the mercury gurus," Naftz said — stayed 12 nights on a 60-foot houseboat on the lake.

"It does sound fun, and it was a fun trip, but there were very long days," Naftz said. Instead of racking up empties or launching day trips into one of the reservoir's 90 side canyons, the scientists were collecting samples and working the mobile laboratory that occupied their vessel's top deck.

"There were a few days of the trip where people were processing samples until two or three in the morning and then getting up at six to start over again," Naftz said.

The trip came about when, after several years of collecting fish with high mercury levels in the southern half of the reservoir, Arizona and Utah issued consumption advisories for that section of the lake in late 2012. That elevated the mercury issue on the radar of the National Park Service, which operates the Glen Canyon National Recreation Area where the lake lies. High-mercury fish included endangered species, the protection of which is a management priority for the park service.

So the USGS crew, along with another researcher from University of Montana, set off in late May this year to get a better handle on the mercury dynamics in the lake. That includes a look at potential sources and the chemical and biological processes driving the mercury contamination. They're also looking at why the issue is much worse in the southern reservoir than in the northern half.

"Why is the mercury problem restricted geographically? That's basically what the project is trying to address," Naftz said.

Their work began on the north end of Lake Powell near where the Colorado River flows into the reservoir. They operated two boats: the "mud boat" gathered samples of the bottom sediments, and another collected water samples and additional data with a YSI EXO2 multi-parameter water quality sonde.

The scientists were also running an instrument that continuously analyzed the air for mercury. That data could give an indication of the effects of nearby mercury sources, including a coal-fired power plant near the Glen Canyon Dam at Lake Powell's southern end.

However, it seems more likely that the difference in mercury levels between the two ends of Lake Powell has more to do with what's going on under the water. The thought is, Naftz said, that particulates cloud the water in the north end of the lake, but the sediment settles out as the water flows south. That clears the water and allows more sunlight to penetrate, fueling phytoplankton growth. Then the plankton die off, which facilitates microbial activity that converts mercury to methylmercury, the toxic form that accumulates in fish tissue.

"It just seems like the conditions for the methylation reaction are perhaps more important than having an actual point source in the watershed," Naftz said.

The researchers were on the water during the spring high-flow season, and Naftz said that the signs of runoff faded and the water cleared as they moved closer to the dam. Now researchers are waiting to see how clearly the contrast shows up in the data.

In the meantime, they're looking forward to a follow-up trip during the low-flow season in August 2015, even if being on the clock means tempering some enthusiasm over a Lake Powell houseboat adventure.

"The houseboat did have a water slide on it, but that was for emergency evacuations only," Naftz said. JG

Photo: David Naftz

SMARTPHONES 4WATER

SmartPhones4Water hopes to fill water management data gaps for developing nations.

BY JEFF GILLIES

In the developing world, where people often turn to low-tech solutions for the challenges of rural life, mobile phones are an outlier. In some low-income countries, cellular networks are more available than electricity or paved roads.

"They've kind of jumped several stages of development to get there," said Jeff Davids, a California-based water resources engineer. "I've seen people plowing a field with oxen, talking on a cell phone."

Davids is the founder of SmartPhones4Water, an initiative he hopes can take advantage of widespread cell phone use in developing countries to address what he sees as something of a paradox in water management in those areas.

Unlike in the United States, where Davids said people tend to think food comes from the store and water from the tap, the connection between water and every little facet of life remains palpable in the rural nations he's visited. Yet the places where that connection is most obvious is also where water resources are often the most poorly managed. Part of that is a lack of data, he said.

When he's hired as an engineer for a project in the U.S., the first thing he does is just start mining data.

"Often times, we complain that there's not enough, but there's still this wonderful treasure trove of at least some information," he said. "We can kind of piece the story together about the hydrology of different watersheds and water quality."

But it's much harder to find that information in developing nations, Davids said. And that can lead to conflicts both within and between nations. For example, it's difficult to develop fair international treaties for sharing water in border-crossing rivers without data on annual flows.

That's where Davids hopes SmartPhones4Water can make a difference. The program is based on server-side software that can generate stream discharge measurements from photos of staff gauges captured and sent from camera- and GPS-enabled phones. Where the staff gauges are installed, empirical relationships between water levels and discharge are developed and loaded onto the server. When a photo comes in, image-processing software reads the measurement on the staff gauge. The GPS tag indicates which site and rating curve the software should use with that level measurement. The server sends a message back to the user with a flow measurement for verification.

MobileTracker calculates discharge from staff gauge photos.

All Photos: SmartPhones4Water

Mobile phones outpace other technology in rural Nepal.

"One of the wonderful things about the technology is it lowers the bar as far as who can collect accurate, verifiable data," Davids said. "Really, anybody can. If you can take a picture of your nephew, then you can take a measurement of the water."

The program is in the very early stages and still faces some questions, which Davids and the SmartPhones4Water team plan to address in pilot projects in the U.S., the Netherlands and Nepal over the next few years. They've already launched a pilot project in Mozambique.

Once the program is up and running, the SmartPhones4Water website will serve as an information hub and help collect smartphone donations to help get the tools into the hands of farmers, students and anyone else interested in doing the monitoring. Eventually, the monitoring work could be a means of employment in regions where people survive on a dollar or two per day, Davids said.

That would be a fine benefit to a program that could also bring flood alerts and water management to the places that need it most.

"There are unbelievable water resources all over the world. We just lack the information that's really necessary to manage it well," Davids said. "It would be like going to the doctor and not having the vital signs." JG

Where the Walleye Roam

Data from acoustic transmitters implanted in Lake Erie walleye will tell biologists where the fish go, when they spawn, and what might trigger their behavior.

BY JEFF GILLIES

Photo: John Beagle / Flickr

The batteries are beginning to fizzle in acoustic transmitters sewn up into 200 Great Lakes walleye, soon closing an early chapter on an unprecedented look into the movements of Lake Huron and Lake Erie's most popular fish.

Those 200 fish were tagged in 2011 in Michigan's Tittabawasee River and Ohio's Maumee River for the first of three walleye telemetry projects funded by the Great Lakes Fishery Commission through the Great Lakes Restoration Initiative. The data will help scientists better understand where the fish spend their time, when they spawn and which environmental factors influence them the most.

"From a purely scientific standpoint, there's a lot of really cool ecological questions that you can answer with these data," said Matt Faust, a fisheries biologist with the Ohio Department of Natural Resources who works on telemetry studies.

There's more than idle scientific curiosity behind the studies. Information about how walleye move around will improve the models that help set commercial quotas and recreational bag limits for one of the most popular catch-and-keep walleye fisheries in the world.

"It's not like bass or muskie where you're out there fishing for a trophy and you catch a big one and let it go," Faust said. "People like to eat 'em. So the more information we have on where they're moving and how that directly applies to setting quotas, the better."

The fish tagged in the Tittabawasee and Maumee rivers in 2011 are part of a study looking at where the fish spend time in lakes Huron and Erie, and whether they move between the two via the Detroit and St. Clair rivers. This year is the last field season — the transmitters have around a four-year battery life, Faust said. The scientists haven't fully analyzed data pulled from hydrophones

Photo: Sean Landsman / GLFC

Telemetry tags are surgically implanted in the abdominal cavity of a walleye.

installed around the study area that record pings from tagged fish, but a preliminary look suggests that a small fraction of the population migrates between the big lakes.

A group of researchers that included Faust tagged another group of walleye collected over reefs out in Lake Erie's western basin where they spawn. It's not clear how much the reef spawners contribute to the overall lake population.

The third and most recently funded study will tag walleye in the Sandusky River to track the movements before and after the city of Fremont, Ohio, removes the failing Ballville Dam. The Sandusky's stock of walleye was once much more productive than it is today, and the dam removal could open access to high-quality spawning habitat upstream.

Faust said the projects have been backed by effective collaborations from a wide variety of partners, from wildlife and natural resource agencies from Ohio, Michigan, New York and Ontario, as well as the U.S. Geological Survey and Carleton University in Ontario.

"Anyone that has a hand in managing the fishes of interest in the Great Lakes is working together to make these projects as successful as they've been," Faust said.

Before coming onboard with the Ohio DNR, Faust worked for the Great Lakes Fishery Commission to develop the Great Lakes Acoustic Telemetry Observation System, whose website serves as an outreach tool and as a data repository for telemetry studies across the lakes.

IN THE GREAT LAKES

RESEARCH FROM AROUND THE BASIN

SUPERIOR

A June 2012 "mega-rain event" that dropped 10 inches of rain on Duluth, Minn., and triggered the worst flooding in the city's history also had a month-long impact on western Lake Superior. A recent study from University of Minnesota Duluth's Large Lakes Observatory shows that the flood plume initially caused phosphorous levels to spike, but colored dissolved organic matter that remained in the surface water for a month likely blocked out enough sunlight to prevent the nutrients from fueling algae blooms.

Elizabeth C. Minor, Brandy Forsman, Stephanie J. Guildford, The effect of a flood pulse on the water column of western Lake Superior, USA, Journal of Great Lakes Research, Volume 40, Issue 2, June 2014, Pages 455-462, http://dx.doi.org/10.1016/j.jglr.2014.03.015.

MICHIGAN

The SeaWiFS satellite-based sensor quantified chlorophyll in the oceans and Great Lakes for 14 years before shutting down in 2010, and a recent study takes a look at what the sensor saw in southern Lake Michigan over the course of its life. That includes a 43 to 51 percent drop in chlorophyll-a concentrations from 1998 to 2010. The decline was especially pronounced over the period of the quagga mussel invasion in the early 2000s. The water closer to shore cleared more quickly than offshore areas.

Foad Yousef, W. Charles Kerfoot, Robert Shuchman, Gary Fahnenstiel, Bio-optical properties and primary production of Lake Michigan: Insights from 13-years of SeaWiFS imagery, Journal of Great Lakes Research, Volume 40, Issue 2, June 2014, Pages 317-324, http://dx.doi.org/10.1016/j.jglr.2014.02.018.

HURON

Little is known about the distribution of lake whitefish in the Great Lakes, and scientists from the University of Guelph in Ontario took to Stokes Bay on Lake Huron's Bruce Peninsula to learn more. Plankton tows in 2011 from mid-spring to early summer turned up densities of larval lake white fish among the highest ever reported in the Great Lakes, with no clear connection between larvae abundance and dimensions of water quality including temperature and dissolved oxygen. The next year, the tows revealed hardly any larval lake whitefish at all — a potential result of an unseasonably warm spring.

Kathleen M. Ryan, Stephen S. Crawford, Distribution and abundance of larval lake whitefish (Coregonus clupeaformis) in Stokes Bay, Lake Huron, Journal of Great Lakes Research, Available online 8 June 2014, http://dx.doi.org/10.1016/j.jglr.2014.05.008.

ONTARIO

Die-offs of water birds caused by type E botulism have become common in the eastern basin of Lake Ontario, and a recent study shows that the lake's islands are not to be overlooked when it comes to documenting the damage. Surveys of six Canadian islands in Lake Ontario produced more than 6,600 dead or dying waterbirds over six years, most of which were likely suffering the effects of the bacterial toxin. The island surveys also identified affected species that don't usually turn up in the common waterbird mortality surveys, which only focus what washes up on mainlands shores.

J. Laird Shutt, David W. Andrews, D.V. Chip Weseloh, David J. Moore, Craig E. Hebert, G. Douglas Campbell, Kim Williams, The importance of island surveys in documenting disease-related mortality and Botulism E in Great Lakes colonial waterbirds, Journal of Great Lakes Research, Volume 40, Issue 1, March 2014, Pages 58-63, http://dx.doi.org/10.1016/j.jglr.2014.01.001.

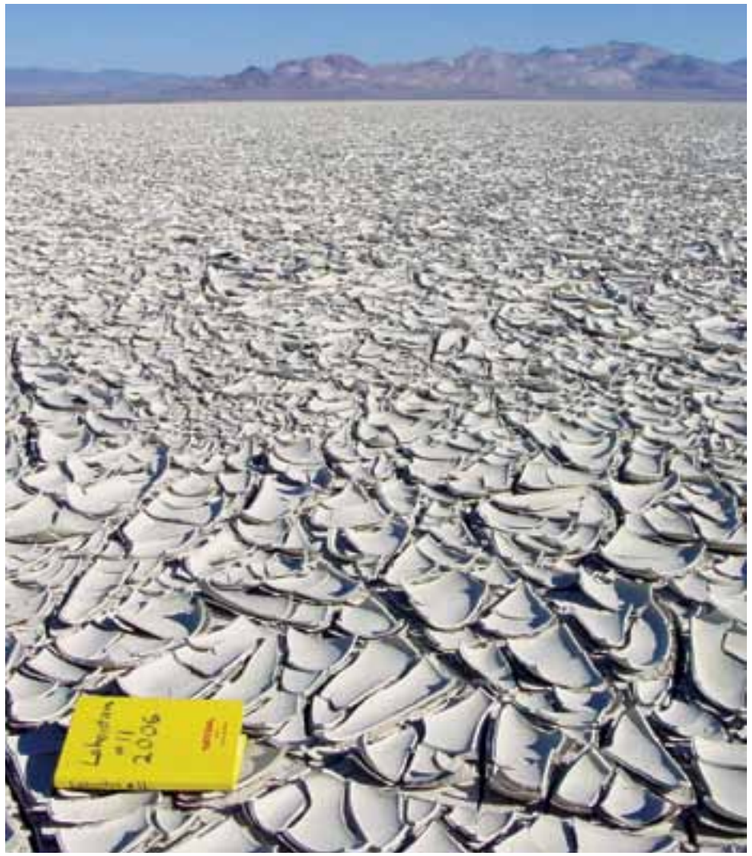
ERIE

Even though total phosphorous loads into Lake Erie have declined since the early 1990s, the lake has become more eutrophic over the same time period. Part of the explanation could be that, while total phosphorous loads have decreased, the loads in some tributaries have increased for chemical forms of the nutrient that are bioavailable and more readily drive algae growth. A recent study from Heidelberg University's, National Center for Water Quality found that dissolved reactive phosphorous exported from the Maumee and Sandusky rivers "increased dramatically" from 1991 to 2012.

D.B. Baker, R. Confesor, D.E. Ewing, L.T. Johnson, J.W. Kramer, B.J. Merryfield, Phosphorus loading to Lake Erie from the Maumee, Sandusky and Cuyahoga rivers: The importance of bioavailability, Journal of Great Lakes Research, Available online 2 June 2014, http://dx.doi.org/10.1016/j.jglr.2014.05.001.

PLAYA LAKES

BY ALEX CARD



Climate scientists are studying the hydrology of quickly vanishing desert lakes to learn more about the hydrologic effects of climate change across the world.

The playa — meaning "beach" in Spanish — is a mineral encrusted landscape found in the arid and semi-arid parts of the world that periodically plays host to shallow lakes. Known also as the salt flat or dry lake, these ephemeral bodies of water are created when rain or snowmelt fills a shallow depression in the playa. The lakes disappear almost as quickly as they form, contributing to the playa's crust of salt and other minerals.

A December 2013 study, conducted by researchers from the Bureau of Land Management and the Desert Research Institute, originally aimed to quantify the effects that Nevada's annual Burning Man festival might have on the Black Rock Playa, while also documenting the characteristics and physical processes of the playa.

According to Kenneth Adams, associate research professor at the Desert Research Institute and co-author of the study, two attributes primarily contribute to the lakes' ability as climate change indicators.

"Because playas lie in the bottoms of closed basins, fluctuations in water level are a direct reflection of the hydrologic balance of these basins," Adams said. "And because playas are commonly found in remote areas with little development in their drainage basins, the hydrology of these systems is relatively 'natural'."

Adams, alongside co-authors Donald W. Sada and Chris Rosamond, monitored size changes in the lake system of the Black Rock Playa with Landsat satellite imagery spanning the last 40 years. This method, however, provided the researchers with no data regarding the volume of the playa. To attain that information, the researchers conducted field studies using a two-receiver GPS, capable of determining location within a centimeter.

Placing a base receiver at a benchmark location and mounting the other receiver to the roof of his truck, Adams drove across the playa and recorded elevation data every two seconds. After conducting the same survey repeatedly over the course of several days, Adams, Sada and Rosamond had enough data to create a topographic model of the playa at a 10-centimeter scale. This model allowed the researchers to develop associations between surface area, volume and depth.

Adams said that although playa lake systems don't necessarily offer unique knowledge about climate change, their role in the larger climate picture is important to understand.

"These lakes are just one other type of geomorphic system that responds to climate change in their own ways and at their own rates," Adams said. "It is important to study a variety of physical and biological systems to gain a more complete understanding of the rates and magnitudes of past climate changes, which may shed light on the effects of future climate changes."

It is the effects of climate change, Adams asserted, and not necessarily the quantifiable change in climatological variables, to which scientists should attribute the greatest importance.

"As a human race, we are conducting a grand experiment, the results of which are still unknown but will probably soon be revealed," Adams said.

Photo: Kenneth Adams

Q&A

Danielle Doremus

On monitoring hypoxia along the Grand Strand

The Grand Strand is a stretch of virtually uninterrupted beach that covers more than 60 miles of the South Carolina coast, including the iconic Myrtle Beach. A hypoxia event in the waters of Long Bay took managers by surprise, but a coalition of scientists have since responded to get to the bottom of the problem. Danielle Doremus, a research specialist with Coastal Carolina University's Environmental Quality Lab, answered a few questions about a three-station water quality and meteorological monitoring network that is helping to uncover the causes and effects of low dissolved oxygen.

Environmental Monitor: What brought about the monitoring network along Long Bay?

Danielle Doremus: The Grand Strand's economy relies predominantly on beach-based tourism, attracting approximately 15 million visitors per year, which substantiates the necessity of monitoring and maintaining the quality of coastal waters. In July 2004, hypoxic conditions (less than 2 mg/L of dissolved oxygen) were discovered in the nearshore waters of Long Bay by faculty and students of Coastal Carolina University. Local fishermen were also reporting flounder jubilees, a phenomenon where various types of bottom-dwelling organisms will leave deeper waters and swarm in large numbers to the surface seeking more oxygenated water. There were also reports of bait fish dying in buckets that were suspended mid water column.

The nearshore waters of Long Bay are also prone to exceedances of water quality standards for fecal indicator bacteria. The sources of the oxygen-demanding substances responsible for sustaining low dissolved oxygen in Long Bay are unknown, illustrating the importance of managing terrestrial flows and the importance of detection and prevention of polluted stormwater runoff and its potential contribution of oxygen demanding materials.

EM: Any clues to what might be causing the low oxygen?

DD: These conditions are thought to arise from a physical constraint on mixing caused by typical weather conditions of the season. Thus resulting in nearshore waters being kept close to the coastline, confining nutrients and organic matter where they stimulate aerobic respiration resulting in oxygen depletion.

EM: What steps have been taken to monitor the coast since hypoxia was discovered?

DD: Several state agencies partnered to establish continuous water quality monitoring platforms at two piers, which were up and running by the summer of 2006. The monitoring stations were equipped with multi-parameter data sondes deployed inside standpipes that were anchored to pilings, just beyond the surf zone.

Due to lack of funding, monitoring ended at one of the piers in 2007. In August 2011, the Long Bay Hypoxia Monitoring Consortium (LBHMC) was established by a resolution of the Coastal Alliance, which is of the mayors from many of the coastal municipalities of the Grand Strand. Efforts of the LBHMC have expanded and further enhanced monitoring at two additional fishing piers.

EM: What's unique about your new deployments?

DD: The two new platforms deploy multi-parameter sondes in the surface and bottom waters from stainless steel zip lines. The zip lines are attached to a robust anchor system built to withstand the high-energy conditions characteristic of the nearshore environment. This novel approach minimizes sampling artifacts associated with standpipes. The surface sondes are mounted to floating sleds that run along the steel cables.

An approximate depth of 1 meter below the surface is maintained by an innovative counterweight system. The sleds are constructed of half-inch copper pipe to help control biofouling. The bottom sondes are stationed approximately 1 meter above the seafloor in water depths ranging from 5 to 7 meters with respect to the tidal cycle.

EM: How is the 2014 season shaping up as of mid-July?

DD: Our hypoxia season hasn't really kicked in yet. It is generally August to September. Oxygen levels have dipped down a little bit, but nothing too noteworthy yet. One of our platforms sustained damage from a recent lightning strike. We're trying to troubleshoot what is damaged and what is not.

Lake Tahoe Clarity

A long-term decline in water clarity on Lake Tahoe has leveled out and stabilized, which is better news than it sounds.

BY DANIEL KELLY

Photo: Scott Kindelberger

Photo: Geoff Schladow

Lake Tahoe is one of the clearest lakes in the United States, helped by the relatively small size of its surrounding watershed and the granitic basin it sits in.

Around 1968, the first year that its clarity was measured by Secchi disk, Tahoe's blue waters were even clearer than they are today. Measurements at that time show an average yearly clarity of more than 100 feet. But such clarity was never reported again as its waters began a decline that lasted well into the 1990s.

At that point, the decline of average annual clarity measurements leveled out and stabilized, which is better news than it sounds. According to measurements taken by scientists at University of California, Davis, the trend of stable clarity for Lake Tahoe is continuing, and they report a 2013 average clarity of 70.1 feet.

"There are very few lakes that have clarity like Lake Tahoe," said Geoff Schladow, director of the Tahoe Environmental Research Center at UC Davis. "The only one that comes to mind is Crater Lake, but that one's in a national park."

Lake Tahoe's surroundings are different, and unlike the untouched clearness of Crater Lake, Tahoe's water is affected by erosion from urban areas. Its surrounding basin is impervious granite, so runoff that is typically absorbed by soil around other lakes makes its way into Lake Tahoe.

But Schladow says the problem of erosion is a bigger concern for clarity than runoff. Airborne inorganic particles like clay and silt, often flung up by cars, make their way in and make the water murkier. Small phytoplankton also contribute to minimized clarity.

The water's cloudiness is measured by Secchi disk, but is also tracked by PAR sensors that measure light attenuation. Schladow and others also measure light's backscatter through Tahoe's wake.

But the No. 1 way to measure clarity is still with a Secchi disk. This is because taking the measurement is simple, and also because clarity measurements with Secchi disks comprise the longest continual measurement that scientists have for Lake Tahoe.

"From 1968 to about 2000, it's a pretty much straight-line decrease. But since 2000, clarity has more or less stabilized around the same levels," said Schladow. "It's neither getting worse or better, but the fact that it's not getting worse is a huge achievement."

Schladow says Secchi disk measurements are taken in two locations that usually yield similar readings. Clarity is a little lower in the summer, but that's expected as there's more dust in the air and more recreation on the water. In the winter months, clarity ticks up.

This same dependency on weather has been shown with ongoing drought conditions in California. Less rain has meant less runoff gets into Lake Tahoe, so clarity for the period has gone up.

But given long-term plans, Schladow says higher water levels expected when drought conditions subside won't automatically mean less clarity for Lake Tahoe.

"Restoration efforts here are targeted at reducing fine particle and nutrient levels, regardless of weather conditions," said Schladow. "In time, we hope we can have a wet year with low impact on water clarity." EM

NEW TECHNOLOGY

Sensorbots

A potentially game-changing invention to monitor the world's oceans got its start in Arizona — a landlocked state with no natural lakes and an ocean hundreds of miles away. Despite the state's coastal deficiencies, researchers at Arizona State University have developed a communications system based on glass spheres called sensorbots that share data with each other through light waves.

Each device stores an entire monitoring network's worth of data. If some go missing, which almost certainly will happen, the knowledge is preserved, said Cody Youngbull, research professor at Arizona State.

"The ocean requires redundancy," he said. "These things could be eaten by giant squid for all we know."

Each sensorbot is a small sphere of clear glass that contains silicon-based photodiodes and receptors. They send out and receive beams of light, and then translate the waves into data sets on their surrounding environments. Each sphere stores a copy of all data individually.

Though sensorbots began as sensing devices themselves, that was scaled back in favor of a port allowing the connection of external sensor packages. With sensorbots, arrays of spheres are needed to cover large areas, but only a few spheres need sensor packages, which can save money. Still, Youngbull says the price of sensing instruments needs to come down in order to meet the needs of networks in the future. DK

Wetland Flow Sensor

Scientists have to monitor engineered wetlands to make sure they're behaving the right way to do the job they were built for, and the way water flows through a wetland is particularly important. Evan Variano, assistant professor of civil and environmental engineering at the university of California Berkeley, has along with his collaborators designed a sensor to monitor those flows like never before.

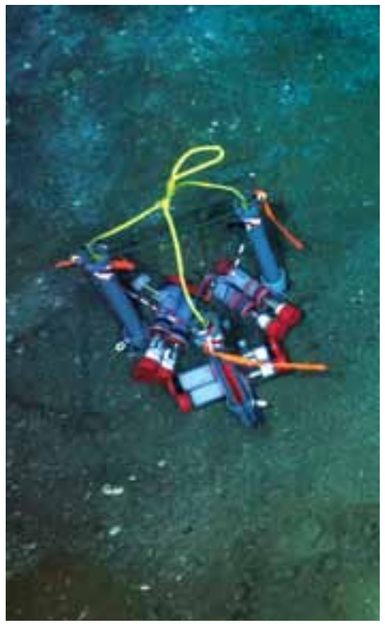
The sensor combines an off-the-shelf camera and borescope with custom optics and code to track the three-dimensional trajectories of natural particles in the water. Those trajectories can give a sense of the magnitude and direction of the average flow at a specific point as well as a sense of the variance.

Variano's tool, which he calls a volumetric particle imager, produces video footage, which operators can review to eliminate non-flow-related motion from skewing the results of the automated data processing. With all the fish and copepods out of the picture, the data processing procedure can calculate the mean flow in and out of the wetland as well as the otherwise imperceptible stirring going on.

"There is a lot of short-term, small-amplitude, high-frequency motion from waves, from thermal convection, from the wake left by fish, from the wind stirring the water surface," Variano said. "All these things are keeping the wetland quite a bit more thoroughly mixed than one would expect." JG

Photo: (top) The Biodesign Institute at Arizona State University; (bottom) Evan Variano

Photo: (top) NSF-OOI/UW/CSSF; (bottom) Ryan Schoeneman



Mosquito Meter

Off the coast of the Pacific Northwest, the Juan de Fuca tectonic plate is sliding under the North American Plate at a rate of about 4 centimeters a year. Except where it isn't. There's a "locked" zone along this fault where the plates are resisting movement, storing up energy that, if released all at once, could produce an earthquake large enough to rattle the coast from Vancouver to Sacramento.

Water flowing up through the ocean sediment carries signatures of the plates' activity, and novel data-collecting instruments are helping marine geologists decipher those signatures with greater clarity.

One of those tools is the mosquito flux meter, named for the proboscis-like needles that extend from its frame down into the sediment. The meter can withstand multi-year deployments on the ocean floor, continuously drawing and storing samples of water that has percolated up from the crust.

Daniel Culling, a staff researcher with the University of Washington's School of Oceanography, works on mosquito meter deployments with Evan Solomon, assistant professor of oceanography at UW. Miriam Kastner, a professor of geology at Scripps Institution of Oceanography, developed an early version of the instrument.

"We've not associated our data with when another earthquake is going to happen," Culling said. "But one step at time. We do have preliminary results that show quite well the abilities of this instrument over any other technique." JG

Cranberry Sensor

A water quality sonde in development at Kent State University is called the Cranberry because it's red and it floats, just like the small and fleshy fruit.

Made with common sensing components, its creators hope it can one day be used in small, inland lakes as part of a one-person deployable buoy package. They are putting their design into blueprints and look to share those with research groups once it has been fleshed out. From there, they'd like to pass the design to members of the Global Lakes Ecological Observatory Network as a standard, inexpensive sensing package that could be deployed on lakes worldwide.

"We're using off-the-shelf sensory probes," said Ryan Schoeneman, a graduate student pursuing a doctorate degree in ecology. He's working alongside Darren Bade, a limnologist at Kent State and the project's principal investigator. "Probes that were never meant to be submerged, we're submerging."

Those are Sensorex and Atlas Scientific probes for dissolved oxygen, conductivity, temperature, oxidation-reduction potential, pH and depth. They're mounted on brass fittings and epoxied inside a red PVC tube and wire into an Arduino microcontroller.

The sonde isn't yet ready for large-scale deployments but can collect data and takes stable measurements. Schoeneman says longer-term testing is needed to make sure the Cranberry will be reliable in the field. DK

TruPulse

LASER RANGEFINDER

With a rugged, waterproof enclosure, the TruPulse 360R rangefinder can measure distances, height and azimuth in harsh conditions.

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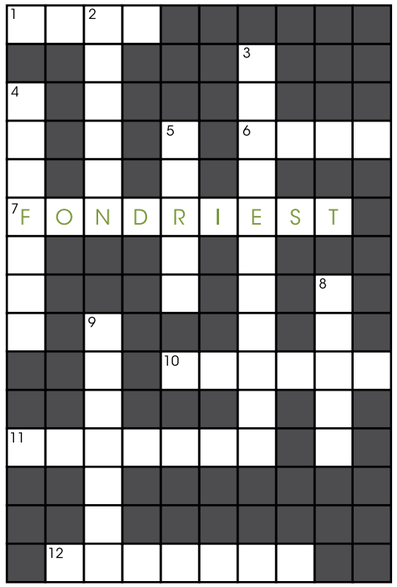
Fish Species

Across

1. Popular varieties of this fish include large-mouth and small-mouth
6. The American _____was once a staple of the United States' fishery industry
7. The trusted name in environmental monitoring and remote sensing gear
10. A favorite bait fish, the tiny _____ is found in streams around the world
11. The _____derives its name from the Canadian French crapet
12. The _____is named for the outward-looking angle of its ocular organs

Down

2. This prized fish comes in varieties such as the Chinook, Chum, Coho and Pink
3. The impressively strong "fish of ten thousand casts"
4. The prominent barbels of this fish resemble the whiskers of a favorite household pet
5. One of the most common fish found in Lake Erie
8. Fly-fishing was originally developed to catch these distinctively-patterned fish
9. Humans have enjoyed the "St. Peter's fish" since Biblical times



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