ENVIRONMENTAL monitor

SPRING 2020

APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS

OFFSHORE MONITORING

Coral Reef Early Warning System

Central Caribbean Marine Institute

The Shark Lab

California State University

How Lake Erie Buoys Measure It All

Regional Science Consortium

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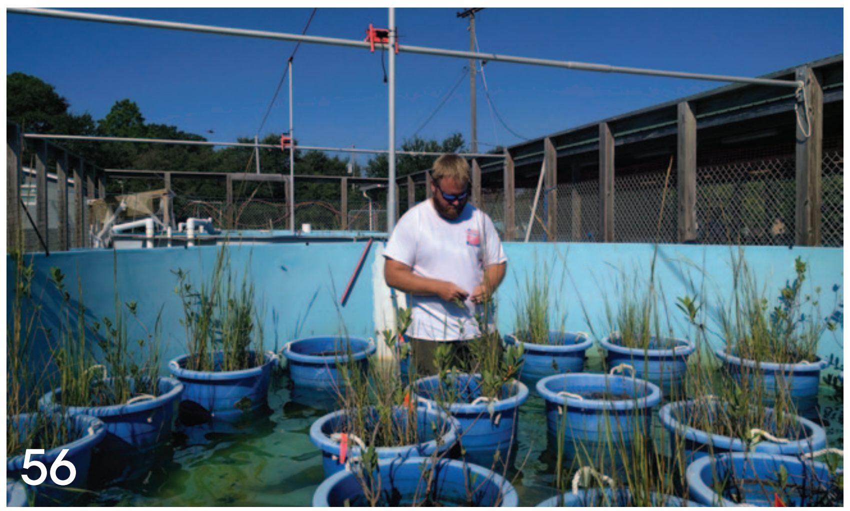
ENVIRONMENTAL PRODUCTS



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ENVIRONMENTAL MONITOR | SPRING 2020

ON THE COVER

The Coral Reef Early Warning Station (CREWS) at Monks Head in Antigua Barbuda, one of five funded under the United States Agency for International Development (USAID) Climate Change Adaptation Program (CCAP) for being implemented by the Caribbean Community Climate Change Centre (CCCCC) in the Eastern and Southern Caribbean.

Photo Credit: CCCCC

WELCOME...

Welcome to the Spring 2020 edition of the Environmental Monitor, a collection of the best of our online news publication. In this issue, we showcase a broad range of offshore monitoring applications.

This edition includes methods and equipment utilized by researchers from various organizations that focus on monitoring offshore environments. You will read about data buoys monitoring water quality in marine protected areas, research along the Californian coast by a shark lab, and how meteotsunamis are more common than once thought. New technology featured in this issue may have applications in the fight against climate-driven impacts on water quality.

Other topics include collaborations with national organizations such as the Great Lakes Observing System and the National Oceanic and Atmospheric Association as well as other programs.

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

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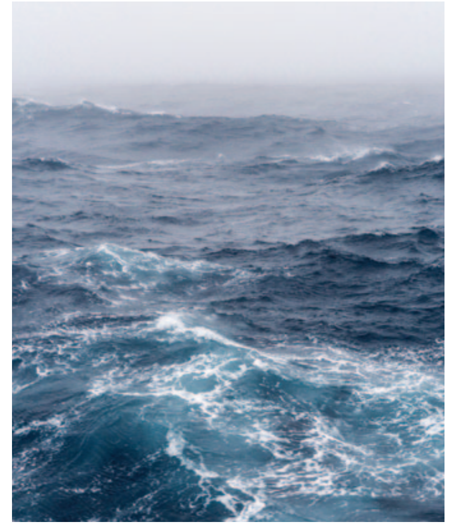


Extreme Wave Heights, Ocean Winds Increasing Globally

Around the world, extreme wave heights and ocean winds are increasing. The greatest increase is happening in the Southern Ocean, according to recent research from the University of Melbourne, as described by Dr. Ian Young. "Our main interest is ocean waves, and we are interested in wind because it generates waves," explains Dr. Young. "Ocean waves are important for the design of coastal and offshore structures, the erosion of beaches and coastal flooding, and the safety of shipping." Waves also have a role in determining how much heat, energy and gas can be trapped in the ocean.

In order to determine how wind speed and wave heights might be changing over time, the team looked at data collected between 1985-2018 by 31 satellites—about 4 billion observations. Then, the team compared those observations to measurements taken by over 80 data buoys deployed around the world. Moving forward and trying to answer these questions, Dr. Young sees the value of a longer-term dataset.

Full story: https://www.fondriest.com/news/extreme-wave-heights-ocean-winds-increasing-globally.htm

Learning With the Student Drifter Program

The mission of the Student Drifter Program, initiated by the National Oceanic and Atmospheric Administration (NOAA) and now administered by the Gulf of Maine Lobster Foundation (GOMLF), is "to establish scientific partnerships between schools around the region and engage students in activities and communication about ocean climate science," NOAA oceanographer James P. Manning. The drifters, typically made with an aluminum (or bamboo) frame and cloth sails, flow primarily underwater with a transmitter above the waterline to send data on its location via satellite every few hours. They stay active with battery power for several months. The students follow the track online using a website where they can see the path of their drifter. As they send data back to students, they can record where the currents carry their instrument.

Depending on what the teams hope to measure, there are different drifters they might deploy. Sharing the data with other scientists helps students understand the value of the long-term fieldwork they are helping conduct.

Full story: https://www.fondriest.com/news/learning-with-the-student-drifter-program.htm

"WireWall" Measuring Flood Risk in Real Time

This past winter, physical oceanographer Jenny Brown and her team at the National Oceanography Centre (NOC), United Kingdom, were trialing a new concept: "WireWall" with colleagues at HR Wallingford. This new system for measuring wave hazard at sea walls allows managers to understand flood risk for existing coastal structures better. "Traditional sensors don't work in spray conditions," explains Dr. Brown. "We've got a lot of oceangoing sensors that measure currents, water depths, all sorts of information, but the second you put them on land and out of solid water, they don't work, often because they're acoustic systems."

Finally, using WireWall, the team can generate a picture of the volume of water overtopping the wall to calibrate overtopping prediction tools to prove the concept. Obviously, such a system needs to be calibrated initially, but Dr. 'Brown's team has confirmed the 'system's performance in a wave flume at HR Wallingford. Next steps for the team? Opening up the system for use by more people and acquiring more data.

Full story: https://www.fondriest.com/news/wirewall-measuring-flood-risk-in-real-time.htm

Photo: (top) Christopher Michel [CC BY 3.0 (https://creativecommons.org/licenses/by/3.0)], (center) James P. Manning, (bottom) National Oceanography Centre

IN THE NEWS

UC Davis Bodega Marine Lab: Performing A Myriad of Environmental Monitoring Programs

A couple of University of California, Davis Bodega Marine Lab programs have been featured in previous Environmental Monitor articles, but there are many more in progress.

Professor John Largier, Coastal and Marine Sciences Institute Associate Director for International Programs, for example, is heavily involved in the oceanographic monitoring project. "Our oceanographic monitoring program incorporates classical water quality monitoring, which is part of the CeNCOOS system. We do this monitoring at the mouth of San Francisco Bay. We monitor water temperature, salinity, dissolved oxygen and pH," Largier says.

Special collaborative sites also do pH and atmospheric CO2. The Seabird stable of equipment is used for this monitoring, as well as Wet Lab, Mini Dot 2 and MarTech. "In Tomales Bay, we also have two buoys doing surface and bottom monitoring. One is located near the mouth of the Bay, and the other one is located near the river inflow. We also do fluorescence monitoring of chlorophyll. In addition, we have sensors at Sacramento Landing, ADCP telemetry buoys, and monthly CTD lines dovetailing with our ocean acidification work," says Largier.

Robotic Fish May Reduce Live Fish Testing Near Hydroelectric Plants

Each year in Germany, as many as 450,000 living fish undergo live animal experiments to test how fish-friendly hydroelectric power plants in the country are. The idea is to discover how readily the fish can move through hydroelectric turbine installations in order to ultimately reduce mortality rates.

Of course, subjecting live fish to a potentially deadly test to save others is a bitter irony. And it's one that a team of scientists from the RETERO research project hopes to eventually mitigate with a robotic fish for testing. Olivier Cleynen and Stefan Hoerner from the University of Magdeburg discuss the complex conditions that set the parameters for the project.

One objective of the RETERO project is to better understand and predict how fish overcome certain conditions when they swim up or down through these installations. The project is scheduled to research and influence the current state-of-the-art of fish passability testing for the next three years, and the team will be updating the public on progress online.

Custom ROV Helps Protect Rockfish in Puget Sound

Washington Department of Fish and Wildlife (WDFW) scientists are using a customized ROV called the Saab Seaeye Falcon on a critical conservation study of threatened and imperiled rockfish. Dr. Dayv Lowry, a Senior Marine Fish Research Scientist, discusses using the ROV to facilitate rockfish conservation and recovery in the Puget Sound.

"With species where mortality is a concern, your goal is to document but not disturb or kill," Dr. Lowry describes. "There are many options for counting fish, such as dragging a net across the bottom or hook and line sampling, for which the mortality rate can be considerable. The typical way to document where fish are, how big they are, and how many there are, is to catch them. Cameras allow us to count and observe fish in their natural habitat, without actually catching, killing, or injuring them."

Next up for the team: continuing to use bottom trawls on deep, muddy habitats, ROVs in deep, rocky habitats, scuba diving in shallow rocky habitats, and combining beach seins, dipped nets, mid-water trawls, and other methods to attempt to discern where these fish are and how many there are.

Photo: Lobsang Wangdu, UC NRS (left), Jana Dünnhaupt / University of Magdeburg (center), Dr. Dayv Lowry, WDFW (right)

Photo: Nichole Barger (left), Mika McKinnon (Right)

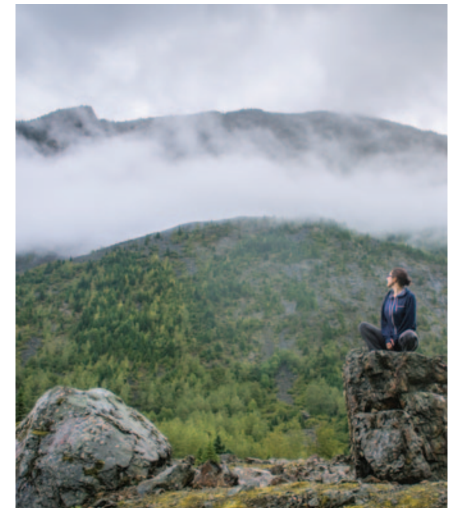
Utah's Canyonlands Research Center

Canyonlands Research Center (CRC) is situated at The Nature Conservancy's Dugout Ranch, over 5,200 private acres of research study area. One of CRC's primary roles is to facilitate research and monitoring work of university and federal researchers. CRC also partners with many organizations to identify the most pressing research needs in this region.

"One of the key types of research done at CRC is drought monitoring," says Nichole Barger, Research Director of CRC and Associate Professor at the University of Colorado at Boulder. Drought is simulated to investigate how it impacts these ecosystems with a particular interest in grassland communities.

In addition to acting as a site for drought research, CRC also functions as a working ranch. There are about 500 cattle in the herd today. CRC has future plans for its working ranch.

While CRC is on private land, it is meant for people to do research. CRC continues to welcome many types of research and researchers into its unique facility.



A Conversation with Mika McKinnon, Freelance Scientist

So much of what many field scientists and engineers do hinges upon their ability to communicate the value of their work. Geophysicist Mika McKinnon details her work as a freelance scientist, and what it's like to do work that touches on science communication in so many areas.

"Thinking about it, my ultimate motivation is I need to feel like my work has made the world a better place," details Ms. McKinnon. "I need to feel like the end result of what I have done has made the world less terrible. And that turned out to be disaster work."

The goal became to better understand how disasters happen, how people interact with them, and how to communicate that information to decision-makers. "A lot of people say things like, 'I don't like math,' or 'I'm not good at science,' or 'I hate school,'" remarks Ms. McKinnon. "Those are popular sentiments, but people enjoy stories. In fact, most of how we learn is through stories. So if you can have plausible, good science in entertainment, not only does it support the story by creating a more plausible worldview that doesn't break our suspension of disbelief, but it also acts as a form of subversive education, where people can learn through the stories they consume."

CREWS:

CORAL REEF EARLY WARNING SYSTEM

For almost a decade, the buoys of the Coral Reef Early Warning System (CREWS) have been situated in the Caribbean Sea, providing the world with weather patterns and data about climate change. In June 2018, a new, state-of-the-art oceanographic buoy was installed by the Central Caribbean Marine Institute (CCMI), which runs the CREWS system. This new addition to the CREWS buoy system offers ocean state and weather data in real-time, all accessible from a computer or smartphone.

WATCHING THE REEF

One of the main goals behind the Coral Reef Early Warning System is keeping coral around the world healthy.

"The purpose of CREWS, which is overseen by the National Oceanic and Atmospheric Administration (NOAA), is to provide a global network of instrument buoys," explains Jon Clamp, CCMI director of operations. "These buoys act in concert with one another and can track and understand global oceanic trends, thereby leading to early warnings of potential destructive trends allowing managers to develop strategies for mitigation of some of these issues."

The buoy contains a weather station, measuring air temperature, wind direction, maximum and minimum wind speed, average wind speed, barometric pressure, relative humidity, rainfall amount, duration, intensity and interval. "It also measures PAR (Photosynthetically Active Radiation) or sunlight, above the water and at up to 1 meter depth," adds Clamp.

Other instruments measure dissolved oxygen, pH, conductivity (salinity) and temperature. This allows the CCMI team to track changes in ocean acidification, a serious threat to corals.
The new CREWS also includes an Acoustic Doppler Current Profiler (ADCP) which quantifies how water moves across the reef system.

"This measures the movement of the ocean water beneath the buoy from zero to 50 feet through 13 different points or about every four feet," states Clamp. "This allows us to look at the complexity of water movement in detail as currents on the surface may not reflect the currents at 50 feet."

A deeper understanding of these currents can help the team to understand how fish and corals interact both inside and outside of marine protected areas.

"Understanding the physical motion of water through the refinement of an ADCP will help build models of localized water movement, to predict the direction and speed of movement of the coral spawn, in turn identifying potential sites for coral recruitment. Identifying these sites can lead to reef managers designating protected areas that may not have been understood prior to this technology," clarifies Clamp. "This can also apply to many other broadcast spawning species. Utilizing water movement as a parameter will improve the understanding and inter-connectivity of many reef species."

BETTER BUOYS

The sophisticated instrumentation package on the new buoy can track rising temperatures linked to coral bleaching and changes in ocean chemistry that affect photosynthesis, acidification and other environmental concerns.

"The new buoy also has a significantly smaller physical footprint, so it is easier to maintain, deploy and retrieve and is, therefore, less demanding on the resources and easier to handle," comments Clamp. "Data is collected and displayed using updated real-time technology via smartphone, which is more responsive and user-friendly. Previously, the data output was unwieldy, and with the new system, we can present data in graphic ways that are easy to understand and therefore relevant to a broader scientific and lay community. Previously this would have been acres of excel spreadsheets. All these elements bring us to the cutting edge of how data and technology are presented and understood, thereby allowing a faster path for environmental resource managers, governmental departments and stakeholders to adapt to the changing needs of our environment."

In fact, thanks to the interlinked cellphone app, a smartphone is really all anyone needs to get conditions and data from the system.

"The smartphone app is available to the general public and is already used by interested stakeholders such as dive shops, sailors and fishermen," confirms Clamp. "The website is available to resource managers, scientists and entities interested in long-term trends and historical records."

Part of the aim of this tech and its implementation is to find innovative ways to restore coral reefs. The team also hopes that they'll someday be using the technology to answer questions they haven't yet conceived.

"The idea is to incubate potential strategies to help coral reefs to develop resilience and to identify coral species that can adjust to the potential environmental changes that we are witnessing now," concludes Clamp. "This equipment can help understand the many different parameters that stress coral species. The data output has led to experimenting with how some corals survive in differing depths, locations and temperature exposure. We are also spearheading projects involving multiple species. Ultimately though, the CREWS allows scientists to ask more in-depth questions due to the refinement of specific data."

CCMI invites readers to watch for new developments on their website: https://reefresearch.org/

All Photos: CCMI

A team member maintains the buoy.

Mobile HAB Lab | Scientists Building Awareness

Photo: Jeanette Schnars, RSC

With multiple reports of animals getting sick and alerts regarding toxic pollution in Lake Erie, one Pennsylvania group has deployed a mobile educational tool to help people understand algal blooms.

"We just launched the HAB Citizen Scientists program this year," explains the Regional Science Consortium (RSC) Executive Director Schnars. "It helps us work with people, especially people who spend time at marinas frequently, that are out there all season long."

The blooms come fast and can disappear just as quickly. Because the water shifts the bacteria around the lake, the RSC relies on observations from visitors to have better information about the conditions creating the blooms, says Schnars. Then, that data gets tested weekly.

"We are also looking at the blue-green algae probes on our near-shore buoy and our Beach Two buoy. So we can get some information from them, but we are actually monitoring toxin concentrations every week as well," said Schnars.

Maintaining that frequency is important. The RSC conducts testing on Thursday, so it's available to visitors recreating in the water over the weekend.

MONITORING FOR MICROCYSTIN

One of the challenges of testing at Presque Isle State Park is its size and popularity. Catering to 4 million visitors annually - more than Yosemite or Yellowstone - the RSC must test sites along almost the entire Lake Erie Shoreline in Pennsylvania.

"When we monitor, we look at the concentration of the cyanotoxin," Schnars says. "We have different thresholds, including a level that is safe for dogs, a human advisory recreational level and a human level where it's no contact."

Schnars said they have exceeded the threshold set for dogs, so advisory signs are often deployed at sampling locations. Part of the purpose of the HAB Lab is to educate people about the particulars of these and other advisory notes, in hopes of increasing scientific literacy.

"What is toxic algae? What are HABs? We received an environmental education grant from the Pennsylvania Department of Environmental Protection to create the Mobile HAB Lab," helping to answer these questions.

First and foremost, the HAB Lab team isn't there to scare anyone. It's an awareness campaign focused on teaching the public about blue-green algae and the conditions that create algal blooms. That could be nutrient runoff dynamics or how blooms move.

But what RSC emphasizes is the need to raise public awareness while not fear-mongering.

"We even experience that with some property managers," comments Schnars. "They did not want to scare tourists or visitors away from popular sites for boating, fishing and swimming. We completely agree. Educational HAB signage uses a popular tagline "If in Doubt, Stay Out". And we continue to educate the public that HABs are produced from a naturally occurring cyanobacteria, however the bloom phenomenon is a product of how humans treat the land and excess nutrient runoff. "

HAB LAB AND WATER QUALITY

Ultimately, the HAB Lab team's goal is to help people see connections between recreation, water quality and health. Despite Lake Erie's role as a primary source of drinking water and recreation, it has historically struggled with heavy metal or PCB contamination. Since algal blooms started creating bigger issues for residents that use Lake Erie, Schnars has strived to teach on the importance of having clean water. One of the results is the training of citizen scientists to report their observational data through the RSC website. "It's actually providing a lot of good additional data for us that we wouldn't have without all those eyes watching what's going on with the water," states Schnars. "They've also been trained, so they can warn others about keeping their dogs out."

If the HAB lab isn't near an already posted sign, the HAB lab might make appearances near citizen scientists' observations.

"Right now a lot of the focus is on Lake Erie because of the intense blooms experienced in the western basin," Schnars said. "A mobile display unit allows us to travel and talk to people recreating in these areas. The mobile HAB Lab also attends seasonal events for pet owners, festivals, and school groups." KL

Canoemobile | A Floating Classroom

Photo: Mary Pat McCarthy, TMACOG

In the summer of 2019, a new way to learn about water recreation and environmental stewardship paddled into Ohio. With the help of the Environmental Protection Agency's (EPA) Urban Waters Program, the Toledo Metropolitan Area Council of Governments (TMACOG) brought the Wilderness Inquiry (WI) Canoemobile "floating classroom" to Toledo for a few days.

Sara Guiher,a Water Quality Planner with TMACOG, said they started designing the program after a representative from the US EPA called in August 2018.TMACOG has a 30-year history of water quality education through the Student Watershed Watch, which provides water quality testing supplies to local classrooms.

"We received funding through the Urban Waters Program to bring programming to the area focused on urban water resources," said Guiher. "The person that we talked to from US EPA suggested Canoemobile, which we had never heard of. As soon as we heard some details, we said, 'how soon can you be here'? Because it just sounded awesome."

The Canoemobile Program brings 24-foot, 10-person Voyageur canoes to various waterways for on-water paddling experiences. Based out of Minneapolis, Minnesota, WI brought seven staff, one serving as captain for each canoe.

With so many first-timers on the water, safety is a priority for the WI team.

"They give a safety talk about water safety ahead of time and fit each person with a life jacket," Guiher said. "Each of the nine passengers in the canoe helps paddle, so they instruct them on how to properly paddle a canoe, how to hold your paddle so you get the least amount of resistance. That way when the passengers get out there, they already have the vocabulary to steer, paddle and stop a boat so that they can listen to their captain and work as a team."

WATER QUALITY COMMUNITY DAYS

The TMACOG and WI community engagement event lasted four days and offered two different types of programming.

"Three of the days were for youth engagement," Guiher details. "We had groups of kids and programming focused for people in underserved communities, both urban and rural, who don't necessarily have regular or easy access to things like paddle sports or canoeing. We reached out to those communities specifically and provided transportation if needed."

The recreation, although valuable in itself, is typically designed to work in tandem with onshore educational events. With the help of 14 community partners, educational activity stations were available for youth attending the event.

"We had a water footprint activity for food you might eat. We did water quality testing. We had an archaeologist talk, and we explored different soil types in different land covers and how that can affect the way that water runs off. There were also tables that featured different animals you might find in or around rivers in the area. So they got a really great educational experience in addition to the paddling experience," said Guiher.

During the four days of programming, 158 people made it out on the water and there were about 300 participants overall. The last day was a Watershed Festival open to all ages.

"I would say at least half of the paddlers had never been on the water at all before," remarks Guiher. "We have some photos of people who were a little hesitant, maybe a little bit nervous at first. But the Canoemobile staff is so great; they really put them at ease." With every first year, there were always potential challenges that were posed. For TMACOG, it was creating enough exposure and community awareness. Because Guiher wanted to boost engagement among young people, that meant reaching out to elementary and high school students.

MORE CHANCES FOR OUTREACH AND IMPACT

The team predicts more success signing kids up for youth days in the future, now that locals know what Canoemobile is.

"That is our shared goal between the Canoemobile, US EPA Urban Waters and Student Watershed Watch programs: connecting people, especially young people, with their urban water resources that they don't have an appreciation for yet. Trying to foster that appreciation and then, hopefully, stewardship."

Although the youth teams don't sample from the canoes, the connection between scientific monitoring, health of the water, and their own recreational adventures is not lost to them.

"We're really glad that we were able to reach so many, especially young people, to be able to help them realize that rivers and water aren't scary as long as you are safe," remarks Guiher. "To see them learn about things on land that impact the water, I think that it just helps to bring together everything that we already do with Student Watershed Watch and our partners."

Guiher and her team think more trips with the Canoemobile program could be beneficial moving forward. Particularly for people who live in urban areas, water in rivers or lakes may look or seem dirty, but still be teeming with healthy aquatic life." KL

OFFSHORE MONITORING

Data Buoy for Open Water Deployments

New for 2020, NexSens Technology has released another data buoy in their growing line of CB-Series platforms. The model CB-1850 is a 1.5m (60") diameter platform intended specifically for coastal and offshore marine deployments.

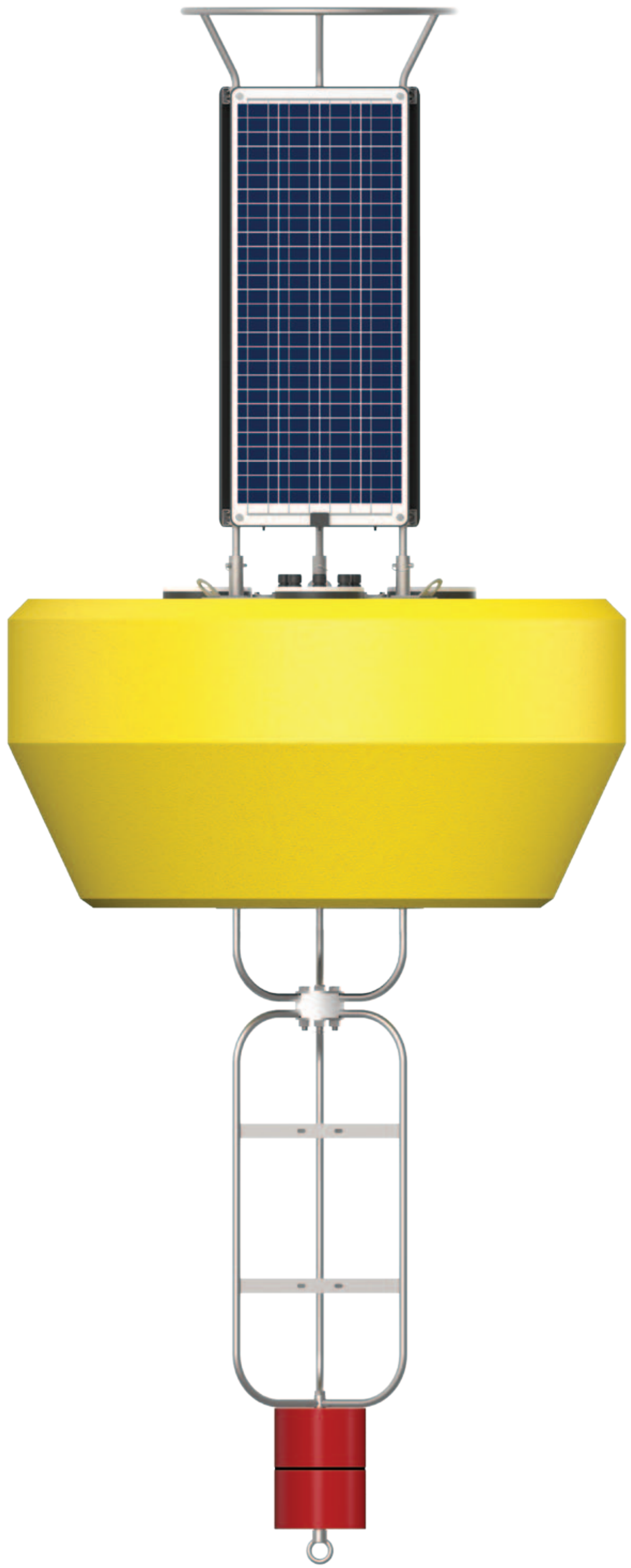
This latest platform maintains the well-regarded features of the CB-Series buoys such as lightweight yet robust construction, multiple instrument deployment holes, sealed center data well, and autonomous solar charging. This allows NexSens data loggers, sensor mounts, and other accessories to maintain cross-compatibility across buoy platforms. Some features new to the CB-1850 platform include optional wet-mateable sensor connectors, user-replaceable solar panels, and reinforced bottom frame.

"We listen closely to the feedback of our customers and try to incorporate these changes into the line," explains Tyler Fondriest, mechanical engineer with NexSens. "We're really excited about these new features and plan to incorporate these changes into the full line of CB-Series data buoys over time."

While customers have the option to integrate their own electronics on any CB-Series data buoy, the CB-1850 data buoy is optimized for use with NexSens X2-CB data loggers. Wireless telemetry options include Wi-Fi, spread spectrum radio, cellular and Iridium satellite. Compatible instruments include wave sensors, met sensors, Doppler current profilers, water quality sondes, and more.

The CB-1850 buoy hull is constructed with a closed-cell, U.S. Coast Guard approved polyethylene foam. A tough polyurea skin covers all exposed foam, and the metal frame is constructed with Type 316 stainless steel to mitigate corrosion in saltwater deployments. Bolt-on sacrificial zinc anodes are also available, and anti-fouling paint can be applied to the submerged components for added protection. A tough polyurea skin covers all exposed foam, and the metal frame is constructed with Type 316 stainless steel to mitigate corrosion in saltwater deployments. Bolt-on sacrificial zinc anodes are also available, and anti-fouling paint can be applied to the submerged components for added protection.

All Photos: NexSens Technology



SOLAR TOWER

High energy solar panels are evenly spaced to collect sunlight from any direction and a top plate is configured for easy connection of sensor masts, beacons and communication antennae.

BUOY HULL

A 1.5m diameter hull provides 1850lbs of net buoyancy and is reinforced with a heavy wall 316 stainless steel frame. Top-to-bottom ports accommodate submersible sensor deployments.

DATA LOGGER

A 10-inch diameter data well houses batteries and provides adequate space for data logging and telemetry equipment.

INSTRUMENT CAGE

A bolt-on instrument cage accommodates the mounting of current meters, water quality sondes, and other sensors. The cage also supports deeper ballast weight and mooring connections.

Eyes Underwater

Poto: Dr. Brian Polagye, Pacific Marine Energy Center

For as long as scientists have been studying the ocean, they have been limited by a lack of power. However, new technologies offer promising ways to harvest energy from waves at sea and put this to work to study the ocean. Brian Polagye, an associate professor of mechanical engineering at the university, has spearheaded research studying how wave energy could power one of their Adaptable Monitoring Packages (AMP).

"Our work in this area has really been ongoing since about 2012," explains Polagye. "We put our first prototype AMP in the water back in 2015. Since then, it's been going through successive evolutions, variations on the package."

The team thinks of AMP, a package of integrated oceanographic sensors, in generations. The first one incorporated cabled sensors. The second, streamlined data transferring. Finally, the third is applying that data in real time.

Polagye directs the Pacific Marine Energy Center (PMEC), among the largest marine energy research centers in the world; a collaboration between the University of Washington, Oregon State University and the University of Alaska, Fairbanks. PMEC is an umbrella organization that unifies marine energy research and development, education and testing going on across the three institutions.

"We've been working on marine energy now for about 10 years. We've learned a lot, but I feel like we've just really scratched the surface of what we can do, both in terms of ocean observation and in terms of using marine energy to power systems," states Polagye.

PRIORITIZING AND PRICING AMP

For many researchers, the cost of simply doing business underwater is among the biggest obstacles. That's beginning to change with systems like AMP. Researchers often use off-the-shelf, consumer grade microcomputers to run them. BeagleBones, Raspberry Pis and Arduinos are all inexpensive options. Blue Robotics has made ROV components available to the masses as well.

Polagye said they deployed their AMP system with the intention of satisfying specific priorities: First, make observations without disturbing marine life, then, make sure all rare events are recorded, finally record those events in the most efficient manner possible.

Prioritization matters because of how quickly data can build up when the equipment is always on. Instead, AMP would only record the rare events that help researchers understand animal behavior, and ignore all the rest. But all that information needs to be operated appropriately, as to avoid biasing the behavior of the animal.

"The AMP is really targeted to do all three of those things in that order of priority," Polagye describes. "To do that, you need to have the hardware to bring all the sensors together, but then you also need the software to blend and use all the data streams in real time, to not bias animal behavior, and to make sure that you're actually capturing rare events."

SENSING THE RIGHT EVENTS

Originally, the team started developing the AMP system specifically to monitor marine renewable energy applications, like tidal turbines. For example, there continue to be concerns over the potential for marine mammals or fish to collide with the blades. Other issues like sea turtles or whales getting entangled in mooring lines were also possible.

"These are low probability events, but if they occur, they can have significant outcomes," explains Polagye. "The AMP system was really designed to try to capture that sort of interaction."

However, the trick with trying to capture these kinds of rare events is that it's almost impossible with just one sensor. But with more sensors means more data—sometimes too much.

"You end up needing to throw sonar, optical cameras and passive acoustics at these sorts of events to actually make sure you capture them and really understand them," remarks Polagye. "The trouble is, when you throw all those sensors at the problem, it's unwieldy to transfer and query the data."

Polagye said his team found if all sensors ran continuously and logged all the data, by years end they would have filled a "metric ton of hard drives."

However, if researchers could increase the number of sensors but train them to only record the significant events, it could solve their space problem.

"A REVOLUTION IN OCEAN SENSING"

The work at the Ocean Observatories Initiative has allowed scientists to deploy higher bandwidth sensors in some of the ocean's deepest places that had previously been unexplored. Polagye believes this may lead to major breakthroughs for marine researchers, but these require cables back to shore.

"There is a real revolution coming in ocean sensing," he remarks. "One of the revolutions that are going on in marine energy right now is this thought that, right now, marine energy generation may be well suited to basically provide power in the oceans in places that we don't have power currently."

From October of 2018 through February of 2019, Polagye's team powered a version of the AMP with a wave converter (a Fred. Olsen Bolt-class Lifesaver) that was being tested off the coast of Hawaii. With the two systems working in tandem, the team was able to make observations as if they were connected to shore via cable, but without that connection.

"We've had something north of 80% uptime on the system since it was deployed," reports Polagye. "It's basically like a small microgrid. The load is our sensor system; the supply is wave energy."

In fact, offshore wave energy presents a host of market opportunities, the grid only being the most obvious. Had Polagye's team tried running their AMP off of batteries, it would have consumed the equivalent of approximately 800 lead-acid car batteries over its deployment.

This highlights the perennial problem faced by anyone trying to get data from the surface to shore. Cables do the job, but when that's not an option, researchers become power starved when they rely on batteries.

"When you're an oceanographer and you're dealing with batteries alone, it's like, 'Okay, how do I get a sensor that has the absolute minimum sensor power draw I need to even get close to the observation I want?'" said Polagye.

Detailed in a report by the US Department of Energy's Water Power Technology Office, wave energy could unlock new and interesting oceanographic applications, from offshore aquaculture to recovery of rare earth elements from seawater yet to be discovered.

Polagye estimates with even a kilowatt of power from wave energy could provide continuous power for autonomous underwater vehicles (AUVs).

A good example for understanding what this could mean is the Malaysian Airlines flight that went down over the Indian Ocean. An 18-month search for the wreckage from man-controlled vessels yielded little results. Had officials air-dropped AUVs and wave recharge stations, it could have dramatically improved the likelihood of finding the plane.

It's not just underwater discovery that could be incorporated, but search and rescue efforts as well. Instead of mobilizing ships after a natural disaster, officials could just use vessels that draw energy from the waves.

Tide Gauge Data Reveal Meteotsunamis

Tide gauge at New London, CT.

Say the word "tsunami" and images of tremendous waves engulfing homes or masses of debris might come to mind. Tsunamis that are triggered by massive landslides and earthquakes are at that scale.

But weather can trigger more localized "meteotsunamis" as well and new research shows just how common these are along the East Coast of the United States. National Oceanic and Atmospheric Administration (NOAA) Physical Oceanographer Gregory Dusek of the National Ocean Service in Silver Spring, Maryland says since a 2013 event they reported on, they've been wondering how often they happen.

"At that point, there really hadn't been any significant work in the US looking at a long data record and trying to determine how often meteotsunamis happen," said Dusek.

As the team that operates the tide gauges, the Tides and Currents office at NOAA is uniquely positioned to know what data is available and how to best use it.

"Initially, I think people generally thought meteotsunamis were quite rare, at least in the US," details Dusek. "There's a lot of work in the Mediterranean, where they are perhaps a little more destructive and meteotsunamis are a little more common, but in the US, I think people thought of these as rare events because the extreme ones don't happen very frequently."

Noting that much of the previous literature focused primarily on which meteorological conditions tend to drive tsunamis, Dusek's team worked to identify those conditions in water level data. The goal was to see if watching meteorological conditions can be a reliably predictive measure of meteotsunamis.

SIMILAR RESULTS, DIFFERENT COASTS

Around the same time Dusek's team was working on this problem, other NOAA and academic colleagues working on the Great Lakes and in the Gulf of Mexico published papers with similar findings.

"We found that instead of watching meteorological data, we should be looking at the water level data for the signal we know to expect," Dusek describes. "Then we can confirm whether the meteorological data supports what we're seeing in the water level data. Approaching it that way makes the process much more efficient, despite high amounts of data."

That was news to Dusek. Until recently, information on the topic had been scant. Before 1996, NOAA tide gauges did not collect six-minute water level data, instead they collected data every hour. Researchers can't resolve a meteotsunami with so little information, however, with 23 years of data, Dusek said they could start doing research.

When the team first developed and tested the algorithm using the 2013 meteotsunami event, they already knew of another event from that year. Surprises came when they discovered even more events.

> I thought wait, is that right? That seemed crazy, you know, that we'd see that many.
>
> **- Gregory Dusek**
> National Oceanic and Atmospheric Administration (NOAA) physical oceanographer

"We knew we had two events that we needed to get right and detect, but when we first ran through the data, we found many events in 2013," remarks Dusek. "I didn't expect to see that many. I can't remember the precise number now but in the teens, I think."

Once the researchers felt comfortable with how the algorithm was working, they applied it to the data from a greater number of years.

"I started seeing 20 to 30 events every year," comments Dusek. "I thought, 'wait, is that right?' That seemed crazy, you know, that we'd see that many. We did extensive validation and sure enough, we're seeing many events, but I think the catch is that the vast majority of them are quite small."

So small in fact that without the data, Dusek doesn't think anyone would know they're happening - a reason why more aren't reported. He estimates most are under a foot or a foot-and-a-half.

After that original study, other papers from the Great Lakes and the Gulf used the same water level data, finding similar results. "So it turns out these things happen frequently in all these places across the US, which confirmed what we were seeing," adds Dr. Dusek.

WARNING OF METEOTSUNAMI HAZARDS

Even with so many smaller events, it's rare to see larger ones that exceed two feet. One could go five years before seeing one if they remained in the same place. Dusek estimates about one larger event occurs each year along the east coast.

"Large ones might not be occurring frequently, but they're occurring frequently enough that we want to make sure we better understand why they're happening and better provide warnings if we need to," he said.

The team's goal became determining exactly which meteorological conditions lead to meteotsunamis.

"We aimed to associate meteotsunamis and whichever their concurrent meteorological conditions might be," details Dusek. "We could then develop a better research strategy for unraveling why specific conditions lead to meteotsunamis more often.

All Photos: NOAA

The better those conditions are understood, the more prepared researchers can be about warning people when they need to be worried or should expect an impact, which is why Dusek's next task is employing their algorithm in real time.

"There's a bit of lag because you have to have enough data before you can establish that you see a wave, so it wouldn't necessarily give you warning before it's arrived on shore," Dusek describes. "It might at least give people some notice away from the initial location though."

For example, in 2013, the meteotsunami arrived in New Jersey first, but then several hours passed before it arrived further south along the coast.

"One possibility is trying to implement our approach in a real-time manner to give people additional information in situations like that," adds Dusek. "That's something the National Weather Service is interested in. The NWS houses the tsunami warning center notification network for seismic tsunamis. In the ocean service here at NOAA, we're exploring whether we can treat these similarly, notifying people right away that there potentially could be a hazard when we detect something somewhere that looks like an event.

The NOAA team will also be exploring the possibility of applying other types of instrumentation such as high-frequency radar to the problem.

"These instruments can also detect meteotsunamis because they're looking at the surface of the ocean. Now that we have this catalog of events, we can better pinpoint how well those systems are picking up the events, and we may also see additional information that could potentially be coupled with the tide gauge data."

Another future point for research that Dusek wants to explore is the connection between tropical storms, nor'easters and meteotsunamis. However, due to the severity of storm surges and large waves, meteotsunamis may not be the biggest priority during those events.

However, an extra meter or so of water atop storm surge can worsen flooding and inundation.

"We discussed modeling some of these specific events to better understand why they are occurring during tropical storms or nor'easters, and whether we can parse out how much they might contribute to inundation," Dusek says. "Is this something we need to be concerned about in some cases with those types of events? That's something else we're looking into with some of our partners."

Right now, the team is prioritizing warning people and a better understanding of whether meteorological conditions are involved.

"Particularly in the summer months, where summer storms and Derechos tend to lead to meteotsunamis, the question is, do these meteorological conditions always lead to meteotsunamis?" Dusek queries. "And what is the threshold, so when the weather service sees these specific conditions, they can be ready." KL

SMARTER, STREAMLINED BUOYS

In the summer of 2018, scientists deployed new buoys in Lake Michigan—smarter, smaller buoys that record and provide data in real time. Ethan Theuerkauf, an Assistant Professor in the Department of Geography, Environment, and Spatial Sciences at Michigan State University, along with LimnoTech project engineer Ed Verhamme detail this development.

SMARTER MONITORING ON LAKE MICHIGAN

Buoys monitoring conditions in the Great Lakes are not a new phenomenon, but Lake Michigan, in particular, was due for some attention at the time of this recent deployment.

"A network of buoys exists in the Great Lakes, but there were only a few in Lake Michigan," comments Theuerkauf. "The few that were in Lake Michigan were far apart, which meant that in some locations, there were no real-time observations. In order to conduct scientific studies of beach erosion along coastal Illinois, we need real-time observations of waves and currents."

The buoys, funded by a grant from the National Oceanic and Atmospheric Administration, awarded to the Illinois Department of Natural Resources, collect data on a variety of parameters. The data is available publicly on the Great Lakes Observing System website.

"These buoys are monitoring wave height, wave period, wave direction, current speed and direction, air and water temperature and wind direction," explains Theuerkauf. "They also have a webcam that shows hourly images of lake conditions."

Ease of deployment was one of the principal reasons for selecting these particular buoys.

"These buoys were chosen because they are smaller, lighter and easier to deploy than the other types of smart buoys deployed on Lake Michigan," remarks Ed Verhamme of LimnoTech. "We've been building and deploying smart buoys on Lake Michigan for ten years, and we're continually evaluating new technology and buoys to make them cheaper and easier to deploy."

The team selected the locations for the buoys carefully, based on holes in existing data due to a lack of in-situ observations along the Northeastern shore of coastal Illinois.

"The Winthrop Harbor buoy was placed right at the Illinois/Wisconsin state line in order to gather observations of potential sediment transport across the state line," states Theuerkauf. "These data are important for developing accurate sediment budgets for southwestern Lake Michigan. The Waukegan Harbor buoy was placed to understand how wave conditions and currents change around that harbor."

The buoys have nearshore placements designed to help study coastal erosion and deeper installations in water depths that range from 50 to 90 feet.

"We wanted to get the buoys as close to shore as safely possible to accurately capture what wave and current conditions are impinging upon the shoreline," details Dr. Theuerkauf. "Waves and currents are altered as they approach the shore from offshore, and we wanted to get in-situ observations of nearshore conditions, which are driving patterns of erosion and accretion."

SMALLER, FASTER, MORE DATA

There is a notable range of features that make these buoys the smartest on the lake.

"These buoys are full of the latest technology, including sensors that use sound waves to measure wind speeds and water currents, ultra-low power motion sensors to measure every wave passing by, high definition webcams about the size of your thumb, the latest cell phone modem technology to transmit buoy and video data, and a matchbox size satellite tracking device," explains Verhamme. "No other buoy on the Great Lakes has this much technology packed into it and can be lifted up by two people."

The buoys that are deployed in the middle of Lake Michigan are 10 feet across, weigh over 2,000 pounds, and require a fully staffed, 225-foot US Coast Guard ship to deploy and retrieve. The design of the new buoys has greatly improved the way that users are able to construct their projects.The Illinois State Geological Survey at the University of Illinois Urbana-Champaign manages the buoys in coordination with LimnoTech.

"These new buoys monitor the same things, but can be deployed by two people and a 23-foot boat in a few hours," states Verhamme. "We're continually pushing the boundary and testing how small we can make each component in the buoy and still collect quality observations. The real cost associated with these buoys will be deploying and retrieving them each season to prevent damage from ice, and the smaller and lighter we can make the buoys, the easier they are to deploy. This, in turn, allows us to deploy more buoys to serve more people across the Great Lakes."

Deploying buoys for the long-term is one of the "big picture" goals for this team, and they take it seriously.

"Considering the full life-cycle cost of acquiring and maintaining environmental monitoring equipment was extremely important to our project team, as we strive to keep these stations operational indefinitely," adds Verhamme. "This meant carefully navigating options related to cost, size, serviceability and reliability."

SMARTER BUOYS, BETTER SCIENCE

Getting lake conditions in real-time has real scientific value for the team, not to mention importance for the public.

"From a scientific perspective, it is important to understand in real-time what conditions are occurring so that we can plan data collection efforts," Theuerkauf describes. "From a public perspective, it is important for boaters, beachgoers, search and rescue personnel, weather forecasters and others to have up-to-date observations of on-water conditions to enjoy the lake safely."

Parsing out which erosion effects are the result of natural forces and which have to do with development is very difficult. The team hopes that these buoys will shed light on this issue.

"This is a major component of my lab group's research," comments Theuerkauf. "We are tackling this issue in a couple of ways. By analyzing past data, such as aerial photographs, we can get a sense of the interplay between natural and anthropogenic forces. We are also gathering erosion and accretion data in response to storms and high water events to isolate the impacts of natural processes versus human impacts."

The buoys have their own specific research questions to help answer, but of course they may prove useful for other kinds of research as well.

"My group is utilizing this data to unravel the processes leading to beach and nearshore geomorphic change," states Theuerkauf. "However, this data could be used for a variety of research studies in such fields as biology, chemistry, physics and ecology." Of course, information from the buoys is also relevant to boaters and other recreational users for safety reasons, as well as commercial fishermen. This is partly why the public has access to the data and visuals, which also helps build support for lake management.

"The primary reason for public access is so that everyone can enjoy the benefits of having real-time wave and current observations in this region that has never had those data before," remarks Theuerkauf. "We've partnered with a non-profit organization, called the Great Lakes Observing System (GLOS), that has expanded public access to buoy data across the Great Lakes. They made it easy for us to add a cell phone modem to our buoys and then use their website and data system to make that data available to everyone."

"One other aspect that guided this project from the beginning was involving the public in as many aspects of the project as possible," adds Verhamme. "While sharing the data with the public didn't meet any specific scientific goals, it allowed us to connect directly to a wider audience for support of the project and will lead to a smarter and better-informed public." KL

All Photos: Ed Verhamme

ONE OF MAINE'S CROWN JEWELS: JORDAN POND

Formed by a glacier, Jordan Pond is among Maine's clearest, most beautiful bodies of water. It's also a critical freshwater resource, and watchful eyes are protecting it.

Dr. Rachel Fowler, Friends of Acadia's aquatic scientist, monitors Jordan Pond. A post-doctoral research scientist at the University of Maine, she is a member of a partnership among the National Park Service, the University of Maine Climate Change Institute and Friends of Acadia that began deploying the Jordan Pond buoy in 2013. Canon provided the initial support for the project.

Friends of Acadia is a nonprofit organization that supports different projects in the park. Bill Gawley and Shannon Wiggin of the Acadia National Park Air and Water Quality Monitoring Program support the project from the National Park Service side of the collaborative. Dr. Jasmine Saros is a professor of aquatic ecology at the University of Maine who studies how lakes respond to environmental change over time. As part of her post-doctoral work, Dr. Fowler works with the Jordan Pond buoy and its data.

"I started working on this project in 2016 while I was a PhD student at the University of Maine," explains Fowler. "My interests lie at the intersection of natural and human systems and how they respond and adapt to environmental change and climate change. I specifically study lake ecology and carbon cycling and how they are affected by climate change. Acadia National Park is the perfect place to work because there is a strong connection of people to the landscape, which includes lots of lakes."

"In this position I help deploy the buoy in the spring, facilitate its data collection throughout the entire ice-free season, work with the team to pack up the buoy in the fall and then I do what I'm working on right now: analyzing the data and trends that we saw over this season," details Fowler. "Also, now that we have seven seasons of data, we're doing some year-to-year comparisons."

"It's a massive data set because we have over 30 parameters that get measured every 15 minutes," remarks Fowler. "We have thousands of sampling events throughout the season, compared to pre-buoy monitoring, when the lake was sampled once a month from May to October. We're talking 16,000 sampling events as opposed to six, so the buoy data really helps us fill in the gaps about what's going on in the lake."

Photo: Matt Fowler

FILLING IN THE GAPS WITH DATA

Among the trends that the team was most interested in monitoring were changing water clarity and dissolved organic matter (DOM) in the water.

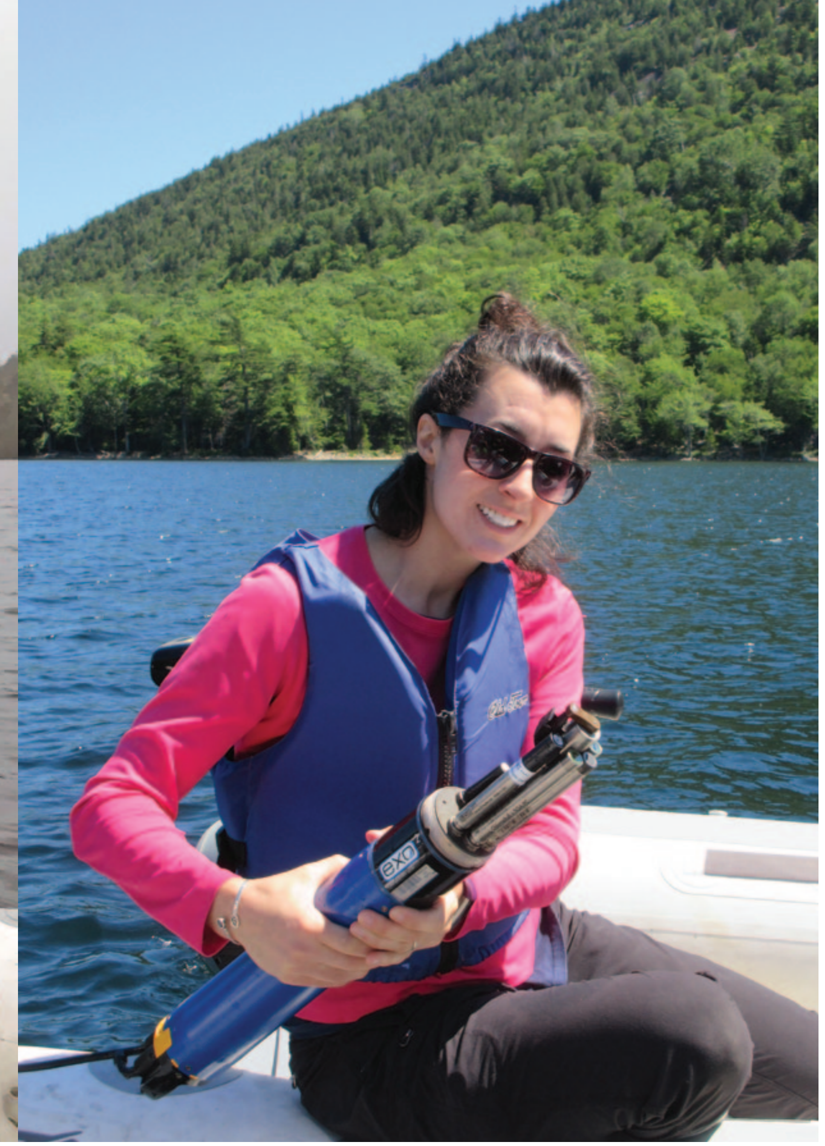
"Since the 1980s, the National Park Service (NPS) staff has been sampling Jordan Pond and other lakes in Acadia National Park monthly during the open water season, monitoring parameters like water clarity and DOM," Fowler describes. "From 1995 to 2010, they found that water clarity was actually declining a bit in the lakes while DOM was going up. When the data revealed that lakes in the park were not quite as clear as they had been in the past, we wanted to know what was going on."

Jordan Pond, a crown jewel of Acadia National Park, is often described as the clearest lake in Maine, so it is a well-suited study site for changes in water clarity and DOM. It's an important tourist draw, and numerous people recreate on the lake. It's also a municipal drinking water source.

"It's not necessarily a bad thing that the water is a little less clear than it used to be, because it may signify a return to pre-acidification conditions, a recovery that happened because of the Clean Air Act Amendments of 1990," states Fowler. "Because of this successful piece of legislation, there's less acidic atmospheric deposition, and that lowers the ionic strength of soils in the watershed. The soil can more readily give up the DOM that it holds, and it gets washed into the lake, making it a little less clear. That's a piece of what we think may be going on."

The team also thinks that trends associated with climate change are influencing Jordan Pond water quality.

"We think that climate is playing a role in what's going on in the lake because, after 2010, that trend in water clarity decline wasn't as well-defined," says Fowler. "In fact, water clarity has been more variable since 2010. We think that's because the lake has recovered from acidification, and the changes that we're seeing now in DOM and water clarity are related to changes in climate, particularly more severe precipitation events."



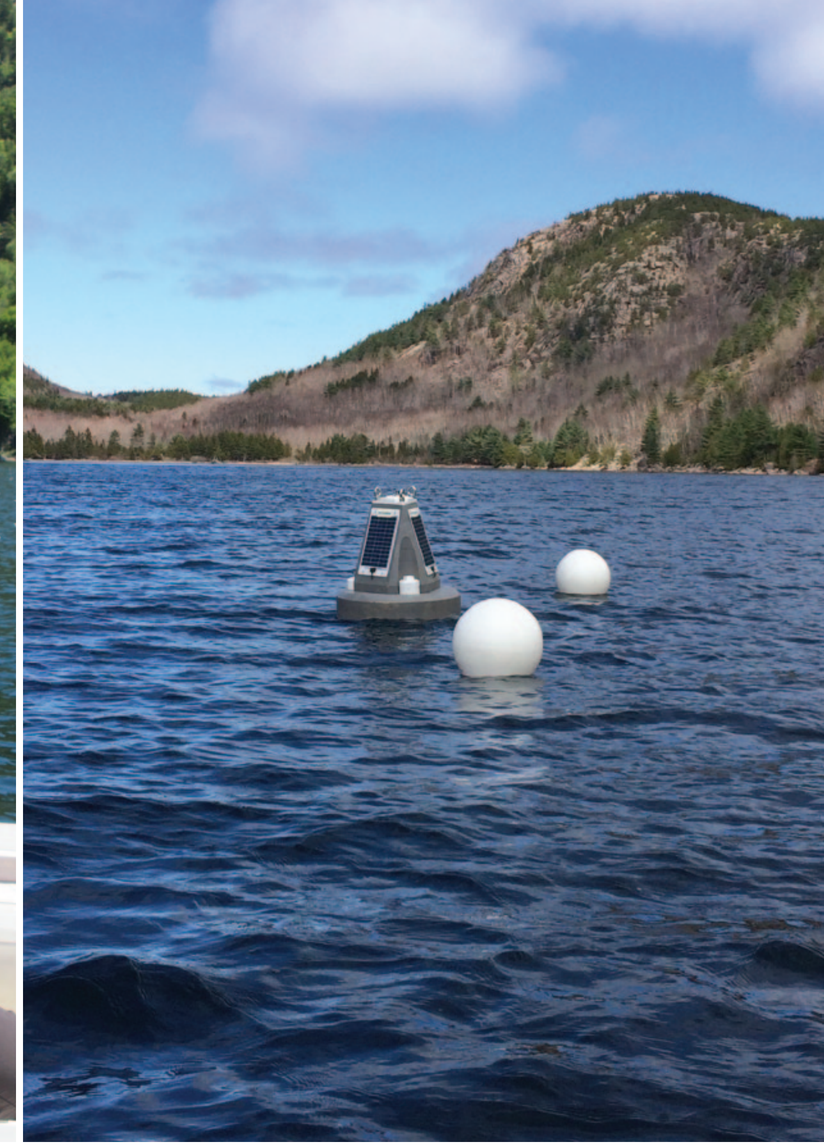


Photo: Rebecca Cole - Will of National Park Service

Photo: Bill Gawley, National Park Service; (left) Nora Theodore (right)

IDENTIFYING NEW TRENDS

The team has the buoy paired with a weather station on the Jordan Pond House, a restaurant located at the southern end of the lake. The weather station tells them about rainfall amounts, air temperature, wind conditions, and related parameters.

"It's really helpful for us to have them working together," comments Fowler. "We can look to episodic events, such as precipitation events, and we can see how those impact parameters like DOM and water clarity in the lake."

The difference in data resolution now that the buoy is in place is striking—and it opens up many new opportunities for the team.

"In previous years, before the buoy, when the National Park Service staff sampled the lake once a month, we might not have had any idea how a big storm could affect water quality in Jordan Pond, and on what timescale. Now, sensors on the buoy are continuously recording water quality data during and after the storm," explains Fowler. "The buoy is helping us to learn more about the effects of precipitation on the lake, which is useful because precipitation events in Maine are getting more severe and they're expected to continue doing so in the future."

It's a complicated research problem to crack because there's really no way to predict exactly how climate change will affect one particular lake system. Although there are trends, each lake is unique.

Fortunately, there is a tremendous amount of local buy-in behind taking action to preserve the resource that Jordan Pond is to the region.

"I wouldn't say people are worried about water quality in Jordan Pond, but we do have many people asking about it, and we are trying our best to do outreach and inform as many people as possible," explains Fowler. "We have an interactive digital display at the Jordan Pond House to explain the purpose of the buoy in the lake and to share water quality findings. Sixty percent of park visitors come to see Jordan Pond and we want to ensure that they keep appreciating its aesthetic beauty."

Of course, the team also watches parameters involved in sustaining Jordan Pond's excellent water quality. This is critical for the local municipalities that use the water for drinking.

"Another great thing about the buoy is that the sampling intervals are so frequent," adds Fowler. "If something unusual were to show up in the data, we could immediately flag it and either go out on the water and take samples, do an experiment or work with park staff to perform some kind of management action. We can respond very quickly now."

In addition to high-resolution monitoring, Jordan Pond is "doubly protected" from threats by point-source pollution—and this is also partly why the changes to the water have, thus far, mostly been benign.

"Its entire watershed is within the Acadia National Park boundary, and it's also a drinking water source, so people can go out and kayak on the lake, but there's no skin contact allowed," remarks Fowler. "It's very well protected, so instead of threats from local pollutants, we are more concerned about bigger picture threats from climate change and atmospheric deposition."

Having just finished their seventh year, the team is excited to get close to a decade worth of high-resolution data they can compare with park data from years past.

"We have just started the long-term comparisons, but we can say that in just the past two years of having the buoy in the water, we've gained new insights," states Fowler. "For example, the temperature profile of the water column and timing of thermal stratification are variable year-to-year. In 2018, thermal stratification happened at the beginning of June and then the thermocline quickly dropped to 10 meters. In 2019, thermal stratification did not occur until mid-June, and then throughout the whole summer, the depth of the thermocline was shallower; about eight meters."

The researchers hope to learn more about these types of changes year-to-year and what that means for the ecology of the lake.

"Importantly for our project, Acadia National Park has a decades-long legacy of water quality monitoring. Previous monitoring consisted of monthly snapshots," remarks Fowler. "Now we have high-resolution data that can enhance these snapshots and fill in all the blanks, and we'd like to continue to expand the project. Jordan Pond is the lowest-nutrient, clearest lake in Acadia National Park, but there are many different types of lakes in the park. We're interested in putting sensor instrumentation in lakes that might not be as clear or low-nutrient as Jordan Pond to get a better idea of how the range of lakes in Acadia National Park might be responding to environmental change."

The team is also exploring ways to monitor what's happening in the park when the lakes are iced over.

"We have data from the buoy in Jordan Pond from May through November, but we don't have a very solid idea about what's going on in the wintertime," Fowler adds. "Last year we put out some exploratory instrumentation in the winter, including temperature and light sensors, and this year we'd like to expand on that. This will give us an idea of what's going on under the ice, and how that might affect water conditions going into the spring season." KL

A HAPPY OYSTER IS A HAPPY TOURIST

A clean environment doesn't just mean improved biodiversity and fresher air. It also means increased real estate demand. That fact was cemented in 2015 after a Florida Realtor's report tied hundreds of millions of property values to the Secchi disk depth of the surrounding water.

The report was explicit about how important the environment was and how it should be treated as such.

"Policymakers and the public would benefit from research into the possible effects of Everglades restoration on water quality in the estuaries of Martin and Lee Counties," concluded the report.

The region's water clarity is defined by a long list of environmental factors, ranging from native oyster populations and seagrass health to the ratio of fresh to saltwater populating the riverways, and weather events that alter local conditions.

When all of these factors sync up, they create what Dr. Michael Parsons of the Vester Field Station calls 'sweet spots.' When they don't sync up, the ecological balance is disrupted and organisms stress. Somewhere along the way, property values also decline.

"We've played a big role in monitoring the ecological conditions so when they (policymakers) are managing water flow, these sweet spots should be targets for when water is released and when water should be held back," said Parsons.

"So we've really helped the process by providing the data looking for these sweet spots," he added.

The Vester Field Station at Florida Gulf Coast University isn't just at the scientific center of this environmental monitoring, but the geographical one as well. Built on Lake Okeechobee, the freshwater basin at the end of these estuary waterways, the field station is constantly measuring the region's water flow and the environmental impacts that stem from it.

Estuaries are dynamic ecological phenomena and the amount of salt and fresh water mixing is always changing. When the dry season peaks, there isn't enough freshwater in the system, which can dehydrate species. When hurricanes barrel into the coast and flood the region, too much freshwater can have a similar, but opposite effect, diluting saltwater and stressing species.

"In both cases, too much hydration, or not enough hydration – it can really throw off your electrolyte balances, your metabolism," Parsons said. "It can be stressful (on the species). Similar things happen with temperatures, heatstroke, hypothermia."

When the balance is thrown off, organisms can't reach their fullest potential, their growth is stymied, and they become more susceptible to predation. Parsons says it can impede an animal's fitness.

For the Vester Field Station, two of the more significant species they monitor for fitness are the oysters and seagrass.

All Photos: James J Greco / FGCU

Both are imperative to the entire foodweb's survival. Oysters filter feed and eat algae, making the water cleaner. They're also an important habitat and food source for other species. Seagrasses provide habitat to a diversity of crabs, fish and other animals. They also reduce flow and stabilize sediment, as well as cause it to settle out of the water column.

"They're definitely connected. They're the canaries in the coal mine, the sentinel organisms," Parsons said. "The general assumption we work with is if they're healthy, everything else is going to be healthy. If they're unhealthy, chances are all other organisms will be stressed."

However, since Hurricane Irma made landfall in September of 2017, oyster populations have taken a hit. Their reefs aren't as widespread as they were 50 years ago. Seagrass mortality has also increased in recent years.

Parsons said researchers overall are seeing "a system in decline." Part of what has contributed to this decline are the extreme seasonal events like hurricanes that have bolstered algae blooms, which can deplete water bodies of much-needed oxygen. Too much or too little salinity also oscillates with these extremes, adding further stressors to the system.

To prepare for these events, the state manages runoff by storing and releasing water into the waterways. Massive infrastructure projects over the last 100 years have helped shape how the Florida populace interacts with the environment.

Where Vester fits into all of this is helping decipher where resources are needed to maintain balance, or find its 'sweet spots.'

"There's a lot of instruments that we can use to measure different parameters in the water – the chemistry of the water if you will," said Parsons.

Researchers at the field station use microscopes for zooplankton and phytoplankton, algae and bacteria – with plans to expand environmental DNA work to get a sense of what exactly is occupying the estuaries.

They collect samples of oyster shells, crabs and fish with lift nets, to better understand how diverse – and healthy – the resident organisms are in the estuary.

They employ mass spectrometers and atomic absorption spectrometers to better understand the chemistry of the waterway.

Researchers even use a pulse amplitude modulation fluorometer (PAM) to measure the photosynthetic rates of seagrass. Parsons said when the instrument sends huge pulses of light to overwhelm that photosynthetic machinery, they can obtain key data on the vegetation.

"By looking at those two differences in fluorescence, the overwhelmed versus what's being utilized, you can calculate the rate of photosynthesis based on the amount of light going in the photosynthetic pathway," he added.

The data collected from the PAM helps researchers understand the fitness of seagrass and how it relates to environmental stressors. Maybe the seagrass is diverting more energy toward making seeds or growing. Maybe it photosynthesizes at different rates during different times.

Perhaps it's photosynthesizing a lot but isn't growing very much because it's unhealthy and needs to repair its root tissues.

While researchers may be experts on these environmental stressors, Florida residents and tourists visiting the state are stakeholders to these issues. As the problems have persisted, their presence in people's lives has increasingly been magnified.

As habitats have diminished, crabs, shrimp and fishes, which are all food that game and commercial fish like to eat, people have watched their seafood product stock decline. Due to severe red tide events, the pinfish, a fish commonly used as bait for fishermen, has also declined.

It's when these events became human problems that politicians and decision-makers began investing more in solutions.

"What it really comes down to is when you have a lot of water coming off the land, we have to prevent flooding and manage the water for people's sake," Parsons said. "(But) we don't always think about the seagrasses and the oysters, so that's where some of the issues come in where we have these environmental impacts because we're not managing necessarily for the estuary health."

And Florida's population isn't getting any smaller. Parsons said almost 1,000 people are moving to the state each week. And a growing population means further pressure on the land and its resources.

"They're moving down here for the beaches, the estuaries, the mangroves, for the fish and birds that are relying on the oysters and the seagrasses. So they realize we have to invest and protect these resources – it does matter now," Parsons said.

"Basically, it comes down to a happy oyster is a happy tourist." JN

THE SHARK LAB

Thirty years ago, white shark sightings near California's beaches almost never happened. For Chris Lowe, who was a graduate student at California State University's Shark Lab at the time, spying a dorsal fin from one of the ocean's top predators was very rare.

Prior to the mid-'90s, an expansive commercial fishing operation and the loss of marine animals decimated white shark populations. If their food wasn't being hunted, sharks were getting caught in gill nets. At that point, they would be killed anyways before getting brought to the market to be sold.

Then in 1994, California residents approved propositions that banned gillnets in state waters and enacted protections for the white shark.

Scientists don't really know how far the population's numbers fell, too. But what scientists and Lowe, who currently runs that same shark lab he was a student of, now know is that juvenile white shark sightings have increased, sighting as many as 12 at a beach at the same time.

"They are coming back. It was a shock because they were in trouble for a while. When we started to look at why that is possible, a lot of things made sense," Lowe said. "These are all juveniles. One of the things we've learned - juvenile white sharks use beach habitats and beach lagoons. They spend more time in these areas."

Whether because the water is warmer or it's shallower or the food is easier to catch, juvenile white sharks use the California coastline to develop and grow. That wasn't something scientists understood years ago.

In fact, scientists still don't know nearly as much as they'd like to know about sharks.

"The challenge has never been public interest. It was always there, but we never had the right technology to answer the best questions posed for 80 years," said Christopher Lowe. "Now, we have those tools, but not the money."

Unless proposals for grant funding meet the criteria of "Do we eat it?" or "Is it endangered?" financial support from state and federal governments are scant.

But white sharks are returning to California. And while their return is praised as a win for the ecosystem and habitat balance, it also means sharks and people are coming into contact with one another. This means the demand for understanding the behavior and physiology of sharks of all breeds has increased in recent years.

SHARK LAB ORIGINS

Most of the Shark Lab's work can be split into two categories - documenting and studying sharks, and developing technology that will aid those studies. That's partly why the lab was started in the first place.

"The Shark Lab was founded in 1966 by Dr. Don Nelson, a renowned shark behavior expert. Our goal has always been to find the best ways to study shark behavior and make it available to the public," said Lowe.

All Photos: California State University Shark Lab

Research that was conducted in its early years was based on developing shark repellents - something the Office of Naval Research was keen on learning more about. But in order to repel sharks, scientists needed to understand the creatures they were repelling.

However, just diving with sharks to observe and study their behavior was too limited, which is how the lab started dipping its toes into the development industry - researching and building tools that could help them with their work.

That meant placing sensors on sharks that could transmit data wirelessly but also withstand the extreme pressures exhibited by the seas and oceans. And of course, all of it had to be waterproof.

"Anything that's easy to do on land, the minute you put it in water it becomes so much harder. Saltwater makes it even worse," Lowe said. "Depending on what it is you're doing, it can be challenging. Animals can make dives down 1,000 meters."

A lot of this technology has roots in the military. It should come as no surprise that sonar and telemetry, two tools often used in science, were first developed by the military. A lot of the technology that Shark Lab engineers tinker and modify is hand-me-down military technology no longer considered classified.

Once in the hands of marine ecologists and engineers, the technology is adapted for biological applications.

"Basically, what we've been doing is taking existing technology and modifying that. The goal is to continue this concept of innovation so we can make giant strides," Lowe said. "What we've learned in the last five years through new tech has exponentially improved upon what we've learned over the last 50 years."

And innovate they did.

Scientists are now using autonomous underwater vehicles and drones to track sharks, people on the beach and how close the two parties are together. There's the inertial measurement unit (IMU) that acts a little like a Fitbit™ but for sharks - tracking its motion, acceleration and calorie burn.

Then there are about 100 acoustic receivers that line the California coastline, constantly listening for any transmitters attached to sharks. When a tagged shark comes within a receiver's range, the receiver logs the time, date and ID number of the transmitter.

These units require a diver go pick up the receivers from the seafloor so it can be downloaded. Now they have buoys with cabled receivers that transmit data in real-time using cell modems, along with relevant environmental data - like temperature and depth.

"We've been doing all of that for a while now," Lowe said. "Thirty years ago, we had to build our own transmitters and put it on the animals to follow where it went. We've also added sensors to the tags that give us more context."

WORK IN THE SHARK LAB

All of this innovation is coming at the right time, too. The Shark Lab tracks all kinds of species, from leopard sharks to horn sharks, blue sharks and even the rare megamouth shark. But the lab also tracks local species that sharks feed on, like stingrays.

And understanding how these species interact with each other, their food webs and the changing environment around them will be key in predicting their behaviors for the future.

"Just knowing where animals are going to be isn't good enough. We need to answer questions on how they make decisions," Lowe said. "to do that, we need environmental data as well."

One application for this data is how sharks might modify their behavior in a changing climate. While some species of white shark can control their body temperatures, they typically prefer cooler waters. As waters continue to warm, Lowe anticipates the distribution of some sharks changing as well.

However, Lowe believes those that will benefit the most from better shark data is the public. But it has to be used appropriately. After the white shark population began to rebound in Australia, there were more reported cases of shark attacks. After the country started tracking shark locations and made that data public to everyone, beachgoers began to use the data like an early warning system, which creates all sorts of problems. Researchers certainly can't tag every shark out there and there were likely times when untagged sharks were close to beaches, but there was no alarm.

That's the completely wrong way to think about sharks.

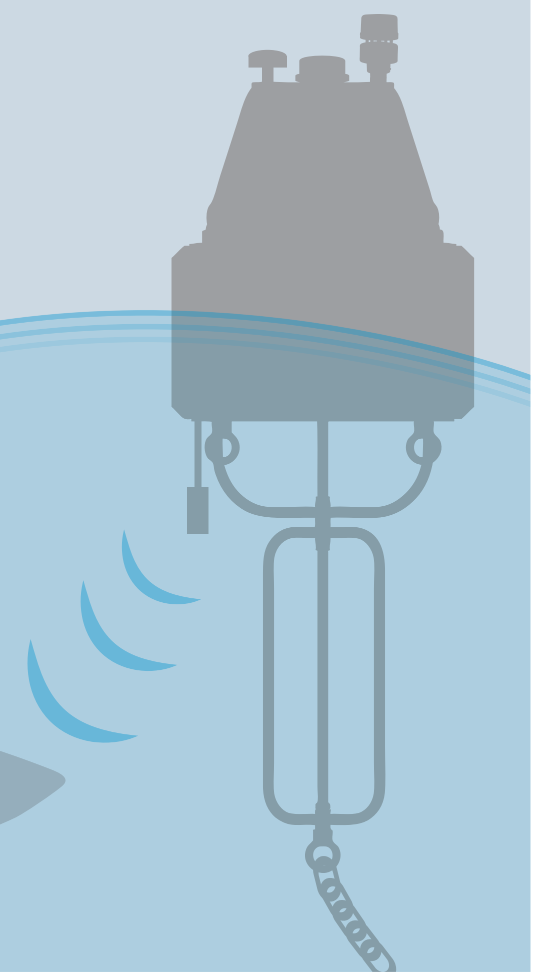
"All of this should be used as an educational tool. We can't tag every shark, but if we tag a decent number and study their behavior, we start to understand their behavioral patterns, which ultimately will help us share the ocean with them."

Prior to the white shark's resurgence, most people didn't realize how much of the oceans they did share with them. It's why so many people feared them. But younger generations are growing up more used to seeing sharks – and less scared of them.

It's a mindset that Lowe wants to capitalize on.

"The time is right to do some of this work because the public sees the sharks through a different lens. Looking through it as they are important to the marine ecosystem, they could be a potential threat - but we don't know enough. So, let's find out." JN

SHARK TRACKING BUOY



The Shark Lab's buoy features an Airmar 200WX-IPX7 weather station that measures wind speed, humidity, temperature, and dew point. The unit is also equipped with a GPS receiver for timing and positioning information, and a three axis accelerometer for measuring pitch and roll of the buoy. Additionally, there is a Vemco VR2C acoustic monitoring receiver that can detect tagged animals within 400 meters of the buoy. An underwater probe for monitoring temperature, salinity, dissolved oxygen, algae, and other water properties is also being incorporated into the design.

Shark Lab engineers have equipped the buoy with three computers, among them 2 Raspberry Pi 4s, and a custom-designed low-power STM32 system monitoring computer. The Raspberry Pis are equipped with add-on circuitry developed at the lab to monitor and process data from virtually any kind of sensor attached to the buoy.

The buoy can communicate with the lab under virtually any conditions because of its versatile radio array. It is equipped with cellular, satellite, HF, and VHF radios for transmitting data, and receiving control messages. The HF and VHF transmitters are extremely versatile because they are implemented as Software Defined Radios (SDR) on the Raspberry Pi computers.

The entire buoy project has been released to the public as open-source. Design details, schematics, source code, and mechanical drawings via GitHub for others to use as a base upon which they can build their own custom solutions.

Graphic: Joshua Pene

Battle of the Trout

How brook trout reclaim native waters

Coloration of the Brook Trout

The North Carolina Wildlife Resources Commission's Inland Fisheries Division has been working to restore brook trout in the state. Coldwater research coordinator Jacob Rash, who works with the brook trout team technicians on this project, provided insight into the work.

"In North Carolina, brook trout are our only native trout species," explains Rash. "With that, come biological and ecological considerations as well as cultural importance. A lot of folks here grew up fishing for brook trout with their relatives, so it's an important species that we work to try to conserve. We've done quite a bit of work to figure out where those brook trout populations are and what they are, in terms of genetics."

The teams capture brook trout using electrofishers and nets, and then measure them and collect samples of their DNA. This process is part of a greater ongoing effort.

"Back in the late-1800s and early-1900s, there was intensive forestry across the landscape," says Rash. "A lot of those methods utilize the streams to transport materials out of the forest. These are pretty intense landscape practices. Folks were realizing even by the early 1900s that they were not seeing all those pretty fish that were once there and intensive stocking took place to try to bring those fish back."

In North Carolina, not only were brook trout themselves stocked back in the waters, but also rainbow trout from the Western US, and brown trout from Europe. Today, brook trout have lost 70 to 85% of their range.

"Folks didn't know this, but those cultured brook trout stocks trace their lineage back to the New England states," details Rash. "Loss of habitat, loss of range, encroachment by brown trout and rainbow trout, and the introduction of genes that were not here traditionally all happened. So, there is influence by those brook trout strains across the landscape."

This has led the researchers to ask several questions as they work to untangle the genetic picture that exists as multiple trout species now co-exist where brook trout once lived alone. For example: Are these the fish that were here? Have they in fact been influenced by stocking throughout history?

"That's why genetic work is so critical," remarks Rash. "It lets us answer that question and helps us figure out which fish we're working with. And that has all sorts of implications, particularly when we're looking to restore brook trout populations."

This matters from a biological standpoint, not just because managers want to preserve this particular trout, but also because keeping them around and healthy is important to efficiently managing the local ecosystem.

"We can now go to donor streams and know, yes, these brook trout are the ones that should be here, and some of those adults may make excellent candidates for us to move to other streams to help establish populations," Rash describes. "That's a lot more effective and efficient than just randomly grabbing populations, because you may not know what they are. We're able to really zero in and make the best decisions possible."

RESTORING NATIVE SPECIES AND WATER QUALITY

Thriving brook trout—the only native trout—in the headwater systems also signals better water quality.

"When brook trout are present and thriving, that means that they've got the habitat suitable to maintain them," states Rash. "If the waters at the top of the watershed are in good enough condition to support brook trout, that is a positive signal for the resources downstream to which these waters flow."

Brook trout are sensitive. If the local aquatic ecosystem is supporting them, it is probably capable of supporting everything else that should be there.

"If you think about a raindrop falling on the top of a mountain, that's going to go downhill," remarks Rash. "If conditions start out well enough to support brook trout up top, chances are that whatever's below them will have conditions that are better than they would be otherwise."

Rash and his team see brook trout populations in North Carolina above 3,000 feet and below that, rainbow and/or brown trout. However, historically it's likely that the brook trout would have been in some of the lower reaches that are currently occupied by rainbow and brown trout alone. These are just a few of the considerations the team weighs as they design a program like this.

"The work that we do is all part of a larger effort," comments Rash. "There are multiple partners involved because we have our focus and other partners do, too. But the issues that impact a species like brook trout don't understand administrative boundaries, so by working with partners, we are all able to work collaboratively to address the larger issues."

For example, Rash's team collaborates with numerous partners such as surrounding states (e.g., South Carolina, Georgia, Tennessee, Virginia), the US Forest Service, the National Park Service, the Eastern Band of Cherokee Indians, Trout Unlimited and the Eastern Brook Trout Joint Venture.

"We all work to share ideas about what we may be doing individually, and pull all of that together to address brook trout conservation as a whole," remarks Rash. "At the end of the day, we're all trying to get to the same goal. I think it takes folks working together, particularly when there are so many aspects to it. It's a challenge, but it's really exciting."

Project goals might include deploying volunteers to collect water samples on an ongoing basis or conducting work to improve habitats.

"Planting riparian vegetation to increase shading, for example," explains Rash. "The larger collaborative approach is focused on improving habitat across the range and improving fish passage so that they can have access to different reaches within the stream."

Local history and culture fuel much of the work and care behind this fish restoration project.

"As the only native trout, for everyone from anglers to biologists like myself, these fish certainly carry a sense of importance that makes them special," adds Rash. "Native fishes should be here. Plus, these Brook Trout are so pretty. If you see one of these, they're one of the more striking fish. When they get those colors that they do, particularly in the fall, it's a special thing. So yes, they do mean a lot to many people." KL

NCWRC Staff Electrofishing during Brook Trout survey.

Photo: J. Rash (left), Thomas Harvey (right)

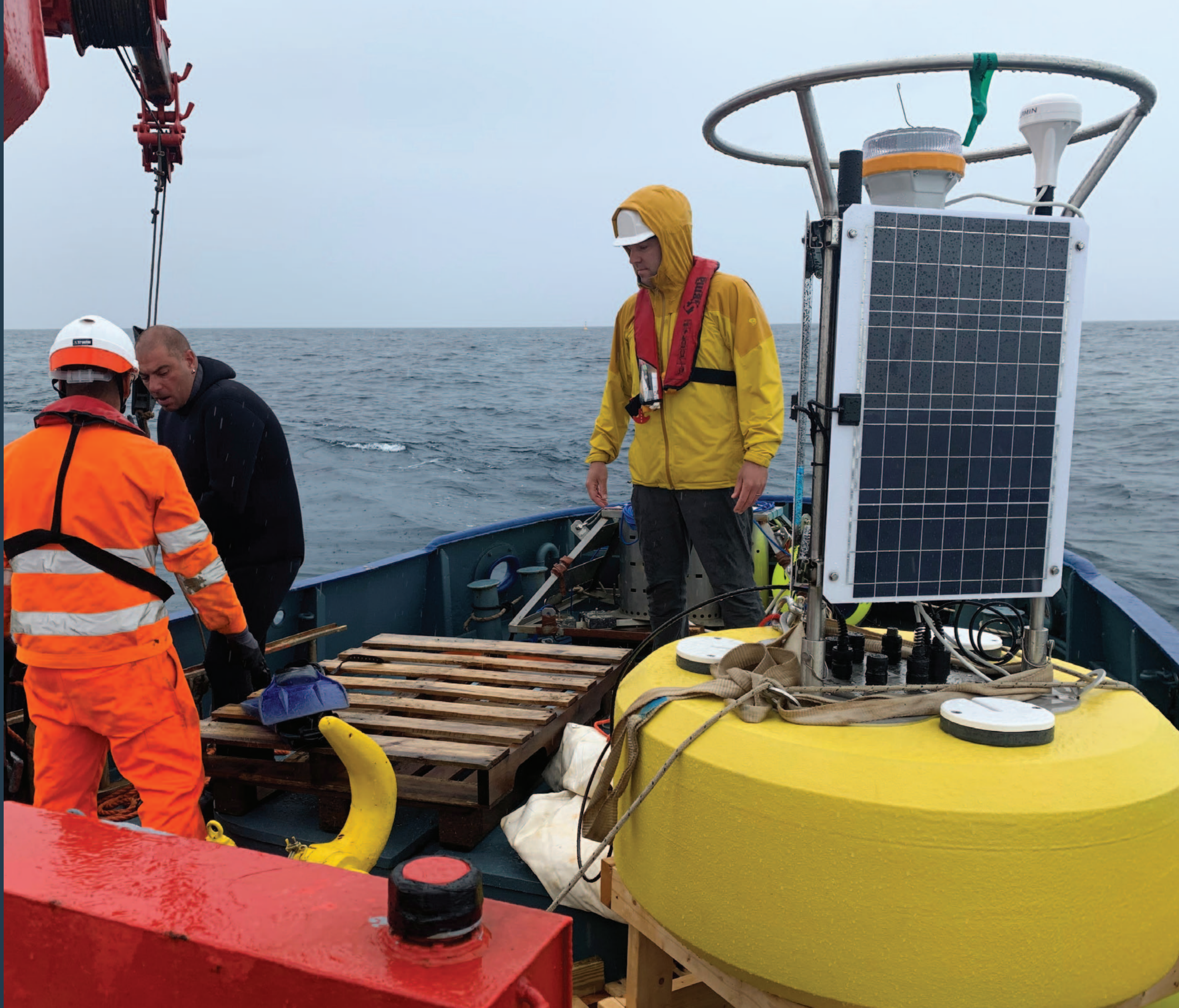
Trans Adriatic Pipeline Construction Monitoring

Pipeline construction began in 2016 to transport natural gas from Greece via Albania and the Adriatic Sea to Italy. The total length of the Trans Adriatic Pipeline when completed will be 546 miles, and the offshore section will be laid at depths reaching up to 2,660 feet.

In fall 2019, Gravity Marine was contracted by RSK to conduct buoy-based monitoring of water quality, currents, and waves on the Adriatic Sea during construction, transmitting data to Italian authorities in real-time. Delivery time was critical for the monitoring aspect of the project, and the system was transmitting data in the Adriatic Sea less than 4 weeks after placing the initial order.

Equipment used for the project includes a NexSens CB-650 data buoy with Iridium satellite telemetry, Nortek AWAC bottom-mount current profiler, and YSI EXO3 water quality sonde with temperature, conductivity, dissolved oxygen, turbidity, chlorophyll, and phycoerythrin sensors. To date, the system has survived two major storms with up to 4-meter waves and continues to provide the project with critical data.

Photo: Shawn Hinz, Gravity Marine



SEASONS CHANGE, BUOY REMAINS

Since the summer of 2018, Wilson Lake in Maine has hosted a data buoy that contains a set of long-term environmental data loggers. The rugged buoy, designed for year-round use, monitors dissolved oxygen and temperature even when it's locked in ice.

University of Maine, Farmington Biology Professor Rachel Hovel discusses the Wilson Lake buoy and her team's work with its data.

"The ability to generate a long-term data set and collect these data over the entire year is really useful, both in the classroom and for asking questions about what's happening in this lake," comments Hovel.

Although the Wilson Lake buoy has been deployed for just over a year, these kinds of deployments have the potential to be very long-standing. Dr. Hovel and the team are working to get everything they can from the station's consistent data collection across seasons and years.

"There's no expiration time on our buoy," remarks Hovel. "We plan to keep it out and maintain it for as long as we can. The only real maintenance that's required is to download the data and replace the membrane on the dissolved oxygen sensors twice a year. Other than that, it's fairly self-sufficient, which is really attractive."

For years, limnologists have been limited to studying lakes during the summer months. However, newer remote sensing technologies and materials are enabling data collection in colder temperatures and under the ice without damage to equipment.

"There are many long-term monitoring buoys deployed worldwide, and many different models and methods for deploying them," details Hovel. "Many buoys are really expensive and highly-parameterized. These are highly valuable, and we get a lot of good information out of them. But we have another model that can be deployed at smaller scales with lower budgets. This helps to fill a science and data gap, in that it can collect data throughout the whole year, and not just during the summer months."

During the spring and fall seasons, lakes experience water column mixing and rapid temperature fluctuations, both of which strongly impact nutrient cycling and biological organisms. The buoy deployed in Wilson Lake actually freezes into the lake ice by design.

> "The ability to generate a long-term data set and collect these data over the entire year is really useful, both in the classroom and for asking questions about what's happening in this lake."
>
> **- Rachel Hovel**
> University of Maine, Farmington biology professor

"Especially as we start to consider more winter ecology questions and the field starts to move more in that direction, I think this is a good potential avenue that's not very burdensome from a resource standpoint," adds Hovel. "A lot of the bigger buoys that some of our colleagues use have to be deployed and taken out using an operation that sometimes involves a crane on a large boat. This buoy is accessible for smaller projects, such as those a lake association would develop, as long as they have enough funding to pay for the sensor. It's relatively inexpensive to set up."

MORE DATA OVER MORE TIME, AND MORE ANSWERS

The Wilson Lake buoy monitors dissolved oxygen and temperature using a series of sensors positioned at approximately two-meter intervals and suspended from the buoy on a line. The line extends to the bottom of the lake, with the sensors recording information at specific points in the water column.

"We are thinking about lake stratification, which happens when the thermal environment in the lake changes, and you start to have a warm layer sitting on top of a colder layer," Hovel describes. "How stratified a lake is and for how long that happens depends on the amount of sunlight, the temperature in any given year, water clarity, and wind dynamics.

In cases of significant stratification, conditions at the bottom may be very different from those at the surface due to this lack of mixing, and surface waters may be too warm for some cold water species.

"There are so many dynamics that stratification can really influence," Hovel says. "For example, long periods of stratification can result in dissolved oxygen depletion at the bottom of lakes and water column mixing can relieve those oxygen limitations by bringing well-oxygenated surface water to the benthic regions. Being able to capture those early spring and late fall periods in particular, when a lot of the larger monitoring buoys are out of the water, is a really important step to answering these questions."

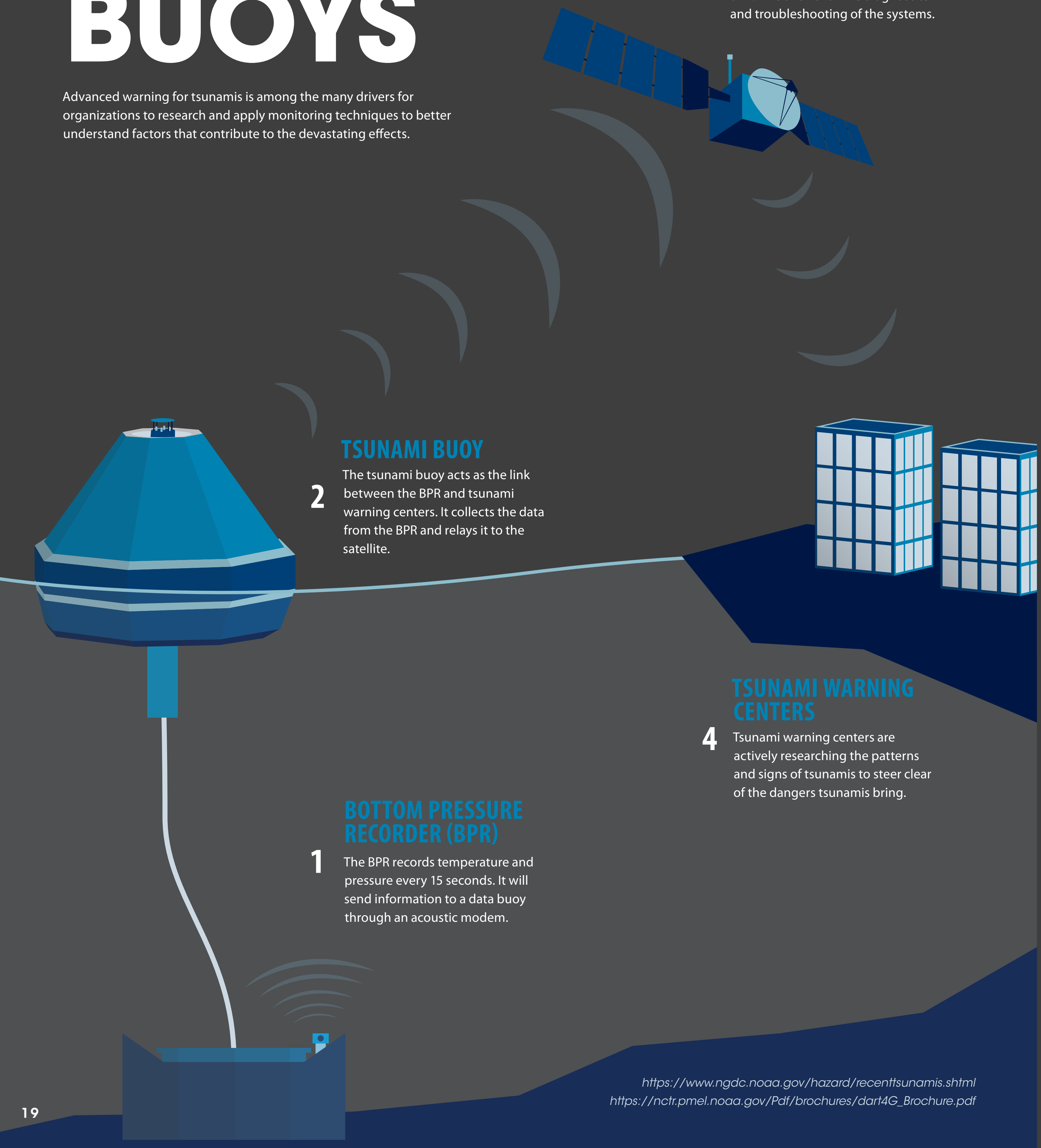
Among the things the team feels sure about: the winter dynamics of the temperate and boreal lakes they are studying are changing notably.

"Winter is warming more rapidly than summer in many places," adds Dr. Hovel. "The sorts of things that we see in ice duration, water temperature, snow cover over ice and what that could mean for under-ice productivity — I think there are just limitless questions that we can ask. And being able to understand what's going on in the winter in these lakes, even a little bit, helps a lot in starting to understand how climate change impacts the lakes that we care about." KL

All Photos: Robert Lively, Friends of Wilson Lake

TSUNAMI BUOYS

Advanced warning for tsunamis is among the many drivers for organizations to research and apply monitoring techniques to better understand factors that contribute to the devastating effects.



3 IRIDIUM SATELLITE

An iridium satellite allows for two-way communication between the tsunami warning centers, and the BPR. This allows for live diagnostics and troubleshooting of the systems.

2 TSUNAMI BUOY

The tsunami buoy acts as the link between the BPR and tsunami warning centers. It collects the data from the BPR and relays it to the satellite.

4 TSUNAMI WARNING CENTERS

Tsunami warning centers are actively researching the patterns and signs of tsunamis to steer clear of the dangers tsunamis bring.

1 BOTTOM PRESSURE RECORDER (BPR)

The BPR records temperature and pressure every 15 seconds. It will send information to a data buoy through an acoustic modem.

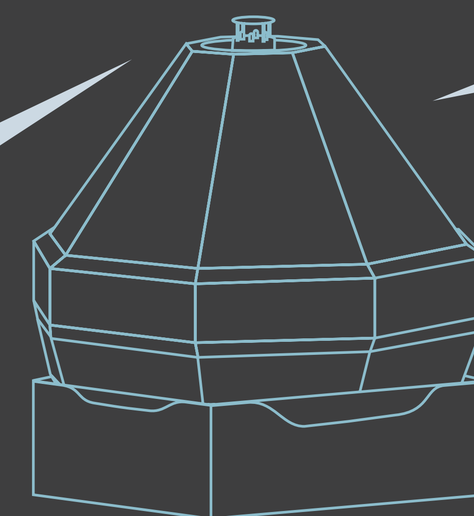
https://www.ngdc.noaa.gov/hazard/recenttsunamis.shtml
https://nctr.pmel.noaa.gov/Pdf/brochures/dart4G_Brochure.pdf

RECENT TSUNAMIS MAXIMUM RUNUP HEIGHTS*

11.00 M	FEBRUARY 6, 2013	SOLOMON ISLANDS
13.60 M	SEPTEMBER 16, 2015	CENTRAL CHILE
22.35 M	SEPTEMBER 29, 2009	SAMOA
29.00 M	FEBRUARY 27, 2010	CHILE
39.26 M	MARCH 11, 2011	JAPAN

*Runup height is the maximum height the wave reaches at the tsunamis max inundation.

DART GENERATION 4



INSTRUMENTS

The buoy is equipped with sensors measuring meterological conditions.

DATA BUOY

Strong, capable buoy able to withstand the harshest environments.

ANCHOR

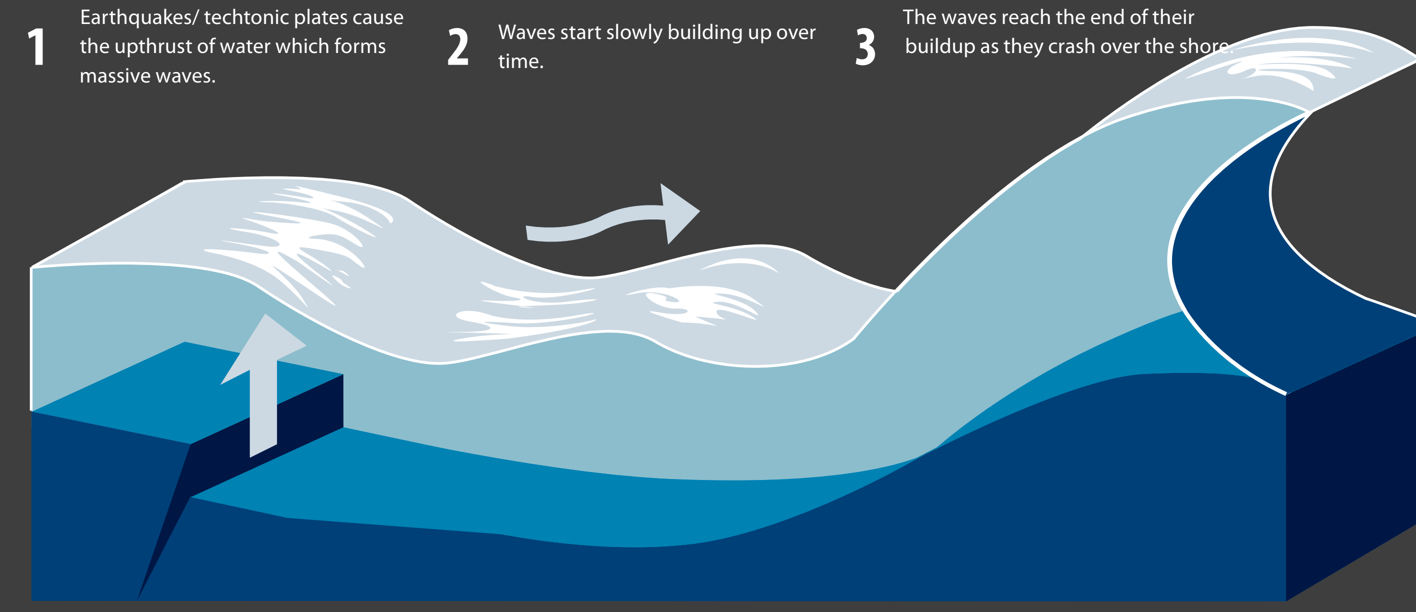
An all-in-one mooring system consists of a cabled anchor that self-deploys when placed in the water.

FORMATION OF A TSUNAMI

1 Earthquakes/ techtonic plates cause the upthrust of water which forms massive waves.

2 Waves start slowly building up over time.

3 The waves reach the end of their buildup as they crash over the shore.



Graphics: Joshua Pene

Photo: Janice Greene

BULL SHOALS
BIOLOGICAL FIELD STATION

Missouri State University's Bull Shoals Field Station, south of Kirbyville, at the Missouri Department of Conservation's (MDC) Drury-Mincy Conservation area, has standard features of the White River Glade Region of the Ozark Mountains, with steep hills, streams, caves, sinks and springs. The five-acre field station site is part of 2,000 acres of restricted-access conservation land.

It has oak-hickory forest and post-oak savanna with bluestem balds (dolomite glades). Its glades, a unique feature, are dominated by grasses and wildflowers, with five endemic species. It has a sinkhole pond marsh with rare manna grass as well as rare and endangered species such as giant cane and running buffalo clover. Wildlife includes deer, wild turkeys, a large variety of migratory birds, and even armadillos. The area also has alligator snapping turtles, the greater roadrunner and many types of lizards and snakes. A federally listed endangered species that lives there is the gray myotis bat.

Janice Greene, director of Bull Shoals Field Station since 2002 and professor of biology at Missouri State, found a rewarding career awaited her at the field station.

"I'm recently retired," Greene says. "I've very much enjoyed my time at Bull Shoals. I've always liked to get outside and explore. I was surprised at the variety of birds here and found them important for getting people interested in our work. Birds can really capture people's attention."

Birds at Bull Shoals are monitored using the Monitoring Avian Productivity and Survivorship (MAPS) protocol from the Bird Population Institute. Multiple monitoring projects at the Bull Shoals Field Station, in addition to tracking feathered friends, include weather, phenology and water quality monitoring. A temperature monitoring buoy project is in the works which will monitor lake temps at multiple levels.

Weather station data has been collected at Bull Shoals since 2002 using a Campbell Scientific weather station tracking 15 variables every 30 minutes. The weather station data is accessible to any researcher.

Soil and fuel moisture in addition to standard measurements such as temperature, wind speed, precipitation and more are tracked.

Phenology data has been taken using a phenocam since 2013.

"The phenocam data is taken in conjunction with the University of New Hampshire National Phenocam website. Pictures are taken every half hour for a six-hour period. We look at green-up and fall color that way. Our phenocam site is focused on a south-facing slope which we can compare to other sites on the National website. It's a long term look at the timing of seasonal changes," says Greene. "That particular south-facing slope was chosen because it represented a 'typical' habitat in our area. It's an open space that also has a forested hillside. The data from the pictures we take goes to the National website. We haven't really processed the data yet, but we plan to soon. We're still in the baseline data gathering phase."

Dissolved oxygen, pH, algal density and turbidity of area waters are measured manually by students and field station staff. The plan is for a buoy to take much of this data automatically.

In addition to these efforts, controlled burns are done by MDC to keep glade areas open, as they have been invaded by cedars. Maintenance through burns has had positive effects, restoring native habitat.

"We are in a unique area, where you see southern, eastern, western and northern habitats crossing. As a result, we get some 'oddball' species that wouldn't typically be expected. We have species endemic to the Ozarks like ringed salamanders, and we also have pygmy rattlesnakes, which are not commonly seen," says Greene. "We've been monitoring birds here for about 10 years, and we get some species now that we didn't use to get, such as the American Redstart. They have extended into our range. Of all the different types of creatures, some birds have an easier time adapting their ranges to changing habitats than some other species. Their ranges may be changing due to climate change, or it could be other factors like local changes in habitats. We haven't been monitoring long enough to see if something is changing or it's just annual variation in distributions."

Birds are netted and banded in the May-to-August timeframe each year.

"Some common summer birds we get here are Kentucky warblers, black and white warblers, indigo buntings and red-eyed vireos," Greene mentions. "There are also some bigger birds here that we see whose breeding range has expanded, like fish crows and black vultures."

There are many factors that affect bird populations in general. These include invasive species such as cats and pesticides like neonicotinoids, which affect insects that many birds eat.

"Habitat loss and change may still be the biggest factor in the population losses in birds we have seen," Greene suggests. "There have been big declines in some species, like the scarlet tanager and cerulean warbler."

Students volunteer to help monitor birds at Bull Shoals. About three to five students participate at one time, for about eight, 6-hour sessions. They help in the MAPS surveys at the end of May up until the beginning of August. Classes come to the field station to document local diversity of reptiles, amphibians, mammals and plants.

Students getting hands-on experience is one of the many aspects of Bull Shoals Field Station that Greene enjoys.

"I came here after completing a doctorate in wildlife and fisheries sciences with research in environmental education," Greene recalls. "I inherited the ornithology course and developed the monitoring program. Previously I had worked in South Texas at a private wildlife foundation. I've always enjoyed getting a class outside. They get a lot out of seeing nature firsthand. People get really engaged by being outside. That being said, technology can draw people outside into nature. Look at the Cornell nest cams, where you can watch raptors feed their young on your computer miles away. Seeing that can create interest by individuals. Getting spotting scopes and binoculars and seeing birds in person can hook people also. Personal experience is even better than seeing wildlife on your computer, but technology can make people want to go outside." LB

AMERICAN SAMOA'S NEW MONITORING SITE

The MAPCO2 buoy depicted in the foreground.

Photo: Nerelle Que, NMS American Samoa

The National Oceanic and Atmospheric Administration (NOAA) and the Pacific Islands Ocean Observing System (PacIOOS) at the University of Hawaii at Mānoa, in collaboration with other partners, recently deployed a new ocean acidification (OA) monitoring site in Fagatele Bay National Marine Sanctuary, American Samoa. Derek Manzello, a coral ecologist with NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) in Florida, is the lead PI of ACCRETE: the Acidification, Climate and Coral Reef Ecosystems Team at AOML.

"ACCRETE encompasses multiple projects that all aim to better understand the response of coral reef ecosystems to climate change and/or ocean acidification," explains Manzello. "We work to provide information to assist coral reef management and restoration, and this includes better understanding threats like OA."

Much of these efforts focus on the in-situ climate change and OA monitoring work that takes place as part of the National Coral Reef Monitoring Program (NCRMP), co-funded by NOAA's Coral Reef Conservation Program (CRCP) and Ocean Acidification Program (OAP).

"NCRMP has a tiered monitoring approach whereby we are taking a lot of measurements across a large spatial area at a low temporal frequency, but are taking many, high-resolution measurements at a high temporal frequency from select key sites," details Manzello. "The NCRMP plan calls for three class III or 'sentinel' OA monitoring sites in the Atlantic and Pacific."

There are two operational sites in the Atlantic in La Parguera, Puerto Rico and Cheeca Rocks in the Florida Keys. Prior to the deployment of the buoy in American Samoa, there was only one sentinel site in the Pacific: in Kaneohe Bay, Oahu, Hawaii.

"I've managed the Cheeca Rocks buoy since 2012, while other partners manage the other buoys," Manzello describes. "I led the installation of the buoy in Samoa because of my experience with the buoy in Florida, but the project will now be led by Chip Young at PacIOOS, which is based out of Hawaii."

The OA monitoring of NCRMP has two paired components: physical monitoring and ecological response monitoring.

"First, there is the physical monitoring of seawater carbonate chemistry, which is in part achieved with the MAPCO2 buoy, that has the goal of determining the magnitude and rate of ocean acidification on US coral reefs," states Manzello. "We have a robust understanding of the rate/magnitude of OA from open ocean time-series data (BATS, HOTS), but the coastal environment and especially coral reefs have seawater carbonate chemistry dynamics that are highly variable both diurnally and seasonally. Thus, we still do not have a solid understanding of the rate and magnitude of OA in nearshore environments like coral reefs."

The team pairs this physical monitoring with ecological response monitoring.

"Monitoring is specifically designed to document the abundances of the important calcifying and bioeroding taxa, as well as their respective rates of calcification and bioerosion. This is done via landscape photomosaic monitoring, census-based calcium carbonate budget monitoring, bioerosion monitoring and calcification monitoring by taking coral cores every five to 10 years and assessing recent rates of coral growth," comments Manzello.

DEPLOYMENT FOR DATA

Fagatele Bay itself is a place more than 160 species of coral call home, as well as dolphins, many species of fish, giant clams and the critically endangered hawksbill sea turtle. The team selected the specific sentinel site for the buoy based on a range of factors.

"First, it's important that there are historical and ongoing long-term monitoring of benthic cover," states Manzello. "It's important to have a baseline by which to gauge future change, as well as to understand how things have changed in the past and responded to other stressors like coral bleaching."

Benthic monitoring has been conducted in Fagatele Bay, part of the National Marine Sanctuary of American Samoa, since the 1970s. This longer-term monitoring highlights a second key consideration Dr. Manzello points out- experts expect the effects of OA to be subtle over time, and manifest as declines in coral reef calcification, with simultaneous increases in coral reef bioerosion and dissolution.

"To be able to document these changes over time, we need to pick sites that have limited impacts from secondary disturbances that might confound the ability to detect an OA signal," remarks Manzello. "For example, you wouldn't want to put an OA monitoring site next to a sewage outfall; that is going to have significant negative impacts on your reef, and you will likely never be able to document an impact from declining oceanic pH. Fagatele Bay has extra protection from other possible stressors and direct human impacts."

Finally, the MAPCO2 buoy itself will require regular sampling, refurbishment, and maintenance—and available local resources to ensure that happens.

"There are several well-equipped partner agencies in American Samoa that made this project possible, including the National Marine Sanctuary, as well as the National Park of American Samoa, the Coral Reef Advisory Group of American Samoa, and the Department of Marine Wildlife and Resources of American Samoa," Manzello says. "After PacIOOS takes over the management of the project, they will continue to work with us here at AOML, as well as NOAA's Pacific Marine Environmental Laboratory in Seattle, and NOAA's CRCP and OAP."

Initial deployment plans for the buoy were delayed two months in 2019 due to a government shutdown and engine trouble with the shipping vessel en route from Honolulu. Due to this, Manzello reports that the deployment was a logistical challenge thanks to

American Samoa, Fagatele Bay National Marine Sanctuary.

suboptimal weather and rough seas. However, with the help of local commercial divers and the efforts of partners Chip Young and PacIOOS, the deployment was successful.

"The Moored Autonomous pCO2 (MAPCO2) system is the gold standard for long-term, accurate, and reliable measurement of seawater CO2 in surface waters," Manzello describes. "This buoy measures carbon dioxide in air and water, temperature, salinity, oxygen, turbidity, pH and air pressure."

Corals in Fagatele Bay

Partners in American Samoa led by National Marine Sanctuaries of American Samoa are also conducting bi-monthly bottle sampling, and the team is using the data from that sampling to calibrate and validate the data from the buoy.

"Also, we are able to measure total alkalinity and dissolved inorganic carbon, two variables that are not measured on the buoy but are part of the carbonate system," adds Manzello.

Meanwhile, these data are reported to the public in real-time. This way, reef managers, scientists, and anyone else can follow CO2 trends and patterns through time, adding their insights.

"The seawater CO2 system of coral reefs can be highly variable from day-to-day and across seasons, so it's necessary to take long-term, high-quality measurements with high accuracy and high precision at a high temporal frequency so that we are able to determine if coral reef environments are experiencing OA at the same rate and magnitude as what has been shown in the open ocean, where there is far less variability," remarks Manzello. "The MAPCO2 buoy takes measurements every three hours and internally calibrates its reading, thus providing accurate data at a sufficient frequency. However, to truly understand the impact of OA on coral reefs, the physical monitoring that is provided by the MAPCO2 and ancillary environmental data must be paired with biological monitoring to understand the impact of changing chemistry on coral reef ecosystems. Otherwise, it's just an expensive chemistry experiment." KL

Photos: Derek Manzello, NOAA (bottom), LCDR Eric Johnson, NOAA Corps., (top)

JEFFERSON PROJECT

Photo: The Jefferson Project

Article first appeared online on November 2, 2018

Reports of harmful algal blooms (HABs) are more common than ever, yet the ultimate mechanisms causing these events are poorly understood. Since 2013, the Jefferson Project began developing technologies designed to achieve a deeper understanding of lakes. In 2018, the project extended a pilot program to Skaneateles Lake in New York.

Leading the charge in that transition at the Jefferson Project is Rick Relyea of Rensselaer Polytechnic Institute (RPI). Growing the project's parameters has always been RPI's intention since they started creating new technology in Lake George in 2013.

"We always planned to expand once we hit a mature stage in the project and bring our technology to other lakes. None of us wanted a one-off proposition on Lake George," explains Relyea. "We intended to use the project as a testing ground, learn about the technology and the lake, and then bring that knowledge to other places where we can be helpful."

Using a partnership between IBM Research, RPI and the FUND for Lake George, the Jefferson Project aims at addressing problems of fresh water shortage.

THE TROUBLE WITH TRACKING HARMFUL ALGAL BLOOMS

Lake George has never had a harmful algal bloom event—but the technology that the team there is developing may offer hope for people working to stop HABs.

"Rapid, real-time monitoring of lake conditions can be very helpful in understanding the underlying mechanisms causing HABs," remarks Relyea. "To understand something that typically unfolds in a matter of days and sometimes disappears in a matter of days isn't an easy thing. It's a really quickly changing lake condition, and we think one of the ways to better understand it is to have rapidly measured conditions of the lake from the temperature and the nutrients, to how the lake is flowing."

There are several challenges for monitoring lakes for HABs, like the length of time it takes to acquire accurate data, usually a process that takes weeks of sampling.

"...when you do that you don't have the ability to look at things that are rapidly changing, because you only have snapshots of data every couple of weeks," said Relyea. "There are a lot of lakes that do have some sensor technologies, but nothing to the level of sophistication that we have on Lake George and have brought to Lake Skaneateles."

The sensor suite on Skaneateles Lake will look a little like what is on Lake George. A pilot project over a four-month period, it'll include some of the same sensors, but not the whole sensor network.

"What we have brought to Skaneateles is a vertical profiler, a weather station on that profiler, and a current profiler built into it," Relyea describes. "Those three things provide three different sets of data on the lake. We have gone beyond what is commercially available to make it a very flexible, integrated system."

The vertical profiler is something the Jefferson Project has built at RPI in collaboration with IBM.

"It's akin to a computer-controlled winch that lowers a group of sensors from the surface of the lake to its bottom, and those sensors measure chlorophyll, blue-green algae, oxygen, pH, temperature, pretty traditional parameters," states Relyea. "It goes up and down the water column, stopping about every half meter and takes readings from top to bottom about every hour, 24/7, to provide the profile of the lake."

The weather station sits atop the vertical profiler to provide information on weather conditions.

Relyea said in order to understand HABS, it's key to understand temperature, wind direction and wind speed. All three influence the severity and proximity of bloom events.

"The world doesn't really understand much more about how the weather conditions play into harmful algal blooms," she said.

The monitoring package is rounded out by an acoustic Doppler current profiler, which uses sound and Doppler technology similar to a police radar gun to determine where and how fast the water and the particles within are flowing.

"Every meter, as you descend into the lake, it can record which way the water is flowing and how fast," remarks Relyea. "We care about that because the direction the water flows is also the direction that nutrients flow, and the direction of moving heat in the lake."

Now, this single, integrated unit has each of these instruments in action as part of one big, floating platform on the water of Skaneateles Lake.

MONITORING SKANEATELES LAKE

When thinking about harmful algal blooms, Florida is probably more likely to come to mind than upstate New York. In fact, Skaneateles Lake has traditionally been a source of drink water for the city of Syracuse.

For this reason, Skaneateles Lake can seem a strange place for these algal events—at least it was in the past.

"Lakes where you expect HABs have some sort of big source of nutrients coming in. These low nutrient lakes, by definition, don't. So no one expected Skaneateles Lake to ever have a harmful algal bloom, and for decades and decades, it didn't," remarks Relyea. "Until September, 2017; they had a big one. The question is: why? And we don't know the answer. No one knows the answer."

Finding the answer is crucial for people in the region, but also for expanding our more general understanding of how HABs develop in freshwater. Unfortunately, it's not an easy answer to tease out.

"These harmful algal blooms in lakes typically happen in the late summer or early fall when you have some source of nutrients coming into the lake, or coming up from the mud in the lake through various processes," Relyea says. "There's also some source of phosphorus and these nutrients are pretty important, but so are unusually hot weather and a series of unusually calm days. Those three things happen a lot where you see a harmful algal bloom, and they seem to have happened in Skaneateles last fall."

Although the bloom appeared during an unusually warm week in September with no wind, the source of the extra nutrients that fueled the bloom remains unknown. Adding further to the mystery of this first HAB was its size.

"It happened for the first time that anyone had ever seen and it happened all over the lake," details Relyea. "When the wind picked up again, it blew all of this algae right near the surface to the north end, which is right where the city of Syracuse draws all of its water. So now you've got undrinkable water in a place where most people would have bet a lot that you'd never see a harmful algal bloom.

But after the bloom event, Relyea's team was asked to start a pilot program on the lake. The plan is to have the platform on-site for about four months, and remove it before the lake gets icy in November or December.

"At that point, we'll have a look at all the data, and we're looking at the data already," adds Relyea. "For example, there was a very localized, small harmful algal bloom about four days after we got on the lake. Nothing like we saw in 2017, but it was still very fortuitous that we got there when we did. We got to collect some data during an event and we're looking at those data right now."

The next challenge the team faces is processing the massive amounts of data they've collected.

"We're talking about thousands of data points per day," emphasizes Relyea. "If they are unfortunate enough to have another localized or large harmful algal bloom, we'll be there to measure those conditions and hopefully have a much better sense of what the early warning signs are if we can identify them."

The grand challenge for the team is where and when the next harmful algal bloom will occur in a particular lake.

"That's really what drives us: to work with all of the folks who have been doing research on Skaneateles Lake for decades before we ever arrived, to partner with them, to put our heads together, and from all the data we have from our sensors and other people's work, identify the best predictors of where and when the next harmful algal bloom will happen," Relyea says. "And that's really a tremendous challenge because that's something that people have not figured out for a couple of decades."

Of course, experts also haven't had the same kind of advanced technologies that Relyea's team is working with. And as the demand for answers grows, their technologies and understanding of how to deploy them will come in handy.

"Although we understand some of the basic things that are associated with this, beyond that, every lake seems different," remarks Relyea. "That's the frustrating part. There has to be some commonality to all of these harmful algal blooms, what drives them and why they're becoming more common. But we don't have a great idea of what that commonality is yet and we're hoping that the technology, which gives us rapid, high-frequency data, will help illuminate some of those answers."

"If this were easy, we would have known the answer years ago," Relyea added. "It is not easy." KL

MEASURING IT ALL AT LAKE ERIE

Since its population bottomed out, the federally-endangered Piping Plover in the Great Lakes has made a comeback for the ages.

A population that once measured approximately 17 pairs and rebounded, hitting 76 pairs in 2017. The same year that count was made, the plovers had also returned to Gull Point, a nesting location that hadn't been used in more than 60 years.

In an effort to understand some of the conditions that have allowed this species to return to its habitat, researchers have directed their attention toward a curious instrument for help.

A buoy that floats off the coast of Presque Isle State Park, near where Gull Point is located.

"Wind speed and direction, as well as wave height, are critical data to anticipate water levels at Gull Point..." said Mary Birdsong, assistant director and lead shorebird monitor at the Erie Bird Observatory. "I count on the RSC weather data because it is far more accurate than any weather app I might have. Wind speed on the mainland is often far less than at Gull Point, and no weather app gives me wave height."

The Nearshore buoy is run by the Regional Science Consortium (RSC). During its operating days, the buoy will collect and send hundreds of data points. It should come as no surprise what kind of data the RSC's Nearshore Buoy collects. But, as in the case with the Great Lakes Piping Plovers, how that data is informing research is where it gets interesting.

Water and air temperatures, turbidity, wave height, wind speed/direction and pH levels all provide audiences the basics conditions of what to expect off the Lake Erie coast in Pennsylvania. But what about understanding regional bird species or the potential toxicity of this summer's Blue-green algae bloom? How about answering why fishermen aren't having as much success when they cast their lures or predicting the precise location where more sand nourishment is needed?

The longer the Near Shore Buoy collects data, the more researchers are finding clever ways to utilize live data compiled from its onboard weather station.

"It's telling all these people different things. The same information that pertains to so many different projects are being used by such a diverse audience," said Jeanette Schnars PhD, the Executive Director of the consortium.

From when the Nearshore Buoy is deployed in the spring to its return journey back on land in the fall, it will collect and transmit information every 20 minutes on around 20 different parameters.

AND IT'S ALL FREE FOR THE PUBLIC TO USE.

"...it offers people information to make informed decisions. Whether to go out on the lake, or not go out on the lake," Schnars added.

While the Near Shore Buoy is one of four owned and maintained by the consortium, it's easily the most versatile - and expensive. Following the $85,000 purchase price the institution shelled out in 2014 to acquire the Nearshore Buoy and its moorings, each winter requires maintenance fees that rise into the tens of thousands.

Despite those costs, data the buoys provide could be considered even more valuable. Just ask the four million visitors that Presque Isle State Park hosts every year - and the agency that runs it.

All Photos: Jeanette Schnars

Due to Presque Isle's popularity, Pennsylvania's Department of Conservation and Natural Resources (DCNR) places special emphasis on beach upkeep and water quality standards. The RSC works with the Erie County Department of Health to monitor water quality for bacterial concentrations (E. coli), which determines swimming advisories at beaches. Since this monitoring process takes nearly 24 hours to obtain results, the RSC also works with the U.S. Geological Survey (USGS) and Mike Rutter, PhD (Penn State Erie) to predict bacterial concentrations at swimming beaches using real-time buoy data.

Like most environmental models, predicting what each day might bring from all the little variances and factors can be challenging, which is why researchers are usually satisfied with a 60% accuracy rate. But the consortium's buoy models hover closer to 80% percent.

The buoy doesn't just aid in day-to-day monitoring. Some data can inform longer-form preparatory decisions, like judging where on the peninsula sand nourishment needs to occur.

"Buoy data collects water data like temperature, but other attachments can also measure water velocity and the direction the water currents are moving," Schnars said. "All this becomes important because over $1 million is spent (annually) on sand nourishment."

Through a grant from the PA Department of Environmental Protection (DEP)-Coastal Zone Management, the RSC collaborates with the USGS to collect data from a remote-controlled data logger and the deployed buoys to model water currents and determine the movement of eroding sand at Presque Isle State Park.

If the day-to-day reports and annual data assessments help boost statewide tourism, then trend data over time helps scientists paint a larger picture of what conditions are determining the output of the lake.

A subject that easily fits this template is harmful algal blooms - one of the better-known cyclical phenomenon that takes place in Lake Erie. Along with the consortium's smaller beach buoy, the

Nearshore buoy uses a Blue-green algae probe. When measuring their concentration in the water, the buoys can quantify the number of Blue-green algae cells present. The RSC is collaborating with the U.S. Geological Survey to create a predictive model using data from the buoy.

"In addition to Blue-green algae cell counts, we can also look at temperature, pH, change in temperature, how quickly it's changing over time. Then we can start putting all that information together and looking backward in time, to understand, 'these are the scenarios when we had high toxin levels or low toxin levels,'" said Schnars.

Harmful algal blooms have been known to contaminate drinking water, deplete oxygen in lakes and even kill pets. Once scientists better understand the conditions put in place when higher or lower concentrations of toxins are released, they can better predict just what kind of algal bloom Lake Erie will experience the following month or year.

The data is posted in real-time on the RSC's website palakeeriebuoy.com, which features each operational buoy, the data collected and a satellite map. Easy enough to comprehend, users now extend to boaters and fishermen preparing trips on Lake Erie. "We use the data from the buoy to plan our sampling trips and to help prepare us for the conditions we will encounter when we leave the dock. Currently, we run a boat angler survey three days a week," Mark Haffley, a biologist out of the Lake Erie Research Unit at the PA Fish and Boat Commission. Haffley added that the commission is even dissecting archived data to bulk up its harvest and catch-per-effort models, as well as better predicting lake conditions from past events.

As the diversity of uses for the data has grown, so has its popularity.

"We have noticed since launching the Near Shore Buoy, people have gotten excited. The website's gotten a lot of hits. This last year, it was off the charts," said Schnars. At its peak, the website was accruing 74,000 views a month, with 14,000 unique viewers returning to the website. And that doesn't include everyone using the smartphone app. Many of those viewers range from members at the U.S. Geological Survey to state-funded agencies, granted funded research projects and prospective boaters and anglers. JN

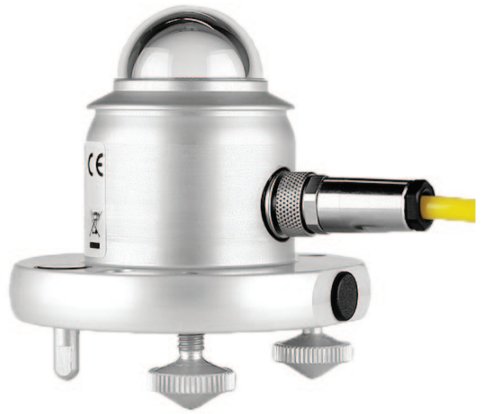
MONITORING GEAR

YSI ProSwap Digital Water Quality Meter

The YSI ProSwap is a versatile water quality meter for single parameter sampling applications (conductivity, pH, DO, turbidity, algae, etc.) with optional integrated GPS and depth sensor.

SonTek SL-Series Side-Looking Doppler Current Meters

The SonTek-SL Series side-looking Doppler current meters are an advanced instrument for water velocity measurement and flow calculations in streams, rivers, and other water bodies.



Kipp & Zonen SMP Series Smart Pyranometers

The SMP series pyranometers are designed for measuring short-wave irradiance on a plane surface, which results from the sum of the direct solar radiation and the diffuse sky radiation incident from the hemisphere above the instrument.

Juniper Mesa 3 Rugged Tablet Computers

The Mesa 3 Rugged Tablet offers powerful new functionality, while retaining impressive features from the popular Mesa 2 Rugged Tablet.

Heron dipper-See H2GO Underwater Drop Camera

The Heron dipper-See H2GO is a self-contained, high-powered, low-cost illuminated underwater inspection camera.

NexSens G2-EXO Water Quality Monitor

The NexSens G2-EXO provides live data access to a YSI EXO multi-parameter sonde. Included solar power pack and integral cellular system provide real-time data and notifications.

Van Essen Diver-Link Cellular Telemetry System

The Diver-Link is a durable and easy to install telemetry unit for AT&T/T-Mobile networks that can be used in a variety of borehole locations such as flush mount and stick-up wells.

Geotech Portable Turbidity Meter

Geotech's Portable Turbidity Meter is designed to withstand the rigor of field analysis with laboratory precision and repeatability.

KEEPING TABS
ON THE TEXAS GULF COAST

From extreme weather such as Hurricane Harvey to spills and other accidents, the Gulf Coast of Texas is no stranger to dangerous situations. This is where the data provided by the Texas Automated Buoy System (TABS) comes into the picture.

Among the nation's most successful and longest-running coastal ocean-observing systems at the state level, the TABS real-time oceanographic buoy system monitors currents, waves, salinity, wind, and other parameters.

"TABS has been running now for 24 years," explains Anthony Knap, director of the geochemical environmental research group at Texas A&M. "I came to Texas A&M six years ago with a background in taking long-term, sustained measurements in the ocean, and being able to show the importance of that sort of effort."

Strategies that scientists employ are shipboard measurements (poking a hole in the ocean by putting a wire down with various bottles on it) and collecting discrete samples at monitoring locations in specific places. These locations, based on physics, biology, or other factors, ensure repeatability at the same spot over time either with ships or other remote tools such as buoys, gliders, etc.

Knap elaborates on the value of monitoring parameters and over time, in the same locations.

"It's a strategy that provides you with temporal changes, an incredibly powerful tool for trying to understand the ocean. There is a massive amount of variability in the ocean due to eddies, which are basically oceanographic storms—just as you have things like hurricanes and lows in the atmosphere or other forms of ocean currents," he said.

Returning to the same spot to monitor over time provides a better sense of how the ocean is changing because it reduces variability and deepens knowledge of ocean mechanics.

"The location of the TABS sites were chosen very carefully, because they represent many of the physical oceanographic parameters that change on the Texas coast due to its bathymetry, the seasonal weather, and other factors," details Knap. "We have eight locations which provide a good representation of what is happening off the Texas coast."

To design the system and select the right sites, team members accounted for the physics of the Texas coast and modeled the problem, identifying the most sensitive locations. The physics of the coastlines largely control problems like storm surge and flooding.

"We put the buoys in the places that are sensitive to the overall circulation of the Texas coast," Knap describes. "The symmetry and the bottom topography will create a storm surge in some places and not others. The main thing is to try to understand differences from place to place and make sure you have a representative model that can help predict change."

WHY MONITORING THE GULF COAST MATTERS

Predictive power is certainly among the reasons to monitor, but there are many others.

"It's important to know what the system is doing at a given time," remarks Knap. "For example, if there's an oil spill or a toxic algae bloom, the characteristics of the location determine the impact on that site and help predict where that event is going to go next."

All Photos: Anthony Knap

In a complex system such as the Gulf of Mexico, additional data from such "moments" allows for increased accuracy in predictions.

"The ocean water is responding to various forces anyway. In cases of contamination, such as an oil spill, it's even more complex," adds Knap. "Unless you have a baseline and a continual measurement at specific points, you're sort of blind."

Fortunately, the Texas General Land Office supports the TABS system and takes its work very seriously.

"The TABS system was developed specifically due to the real chance of an offshore spill contaminating Texas beaches," Knap states. "When you're responding to an oil spill, it's all about which way the current is going and how intense it is. Those factors help you model where the oil is going to go on the beach. You must ensure that you have the best possible prediction so you can deploy assets to control the effect of the spill in the most precise way."

The amount of the existing data GERG has for the existing conditions is fairly unique.

"The Texas coast is probably one of the most oceanographically complete measured systems in the United States," remarks Knap. "We have our buoys, high-frequency radars, gliders and wave-powered surface vehicles that give us information on currents and other water column parameters. I think we pretty much have the Texas coast covered other than the Flower Garden Banks – further offshore."

PHYSICS, CLIMATE CHANGE, AND EXTREME WEATHER

The GERG team is taking a holistic view, particularly with regard to climate variability. Whatever the cause of these changes, the team is committed to preparedness. Along the Texas coast, subsidence due to human activities and global sea level rise together generate more serious problems than they can alone.

"For example, subsidence can cause problems building roads, or affect the groundwater" comments Knap. "Then a global sea level rise of three milliliters per year occurs."

That is very small, but over the course of decades or even hundreds of years, the change is significant—and it is a growing threat that demands both mitigation and prevention.

"The fact is, if you're sitting on the coast, the land is subsiding, and sea level is going up, most of that sea level rise has to do with the ocean getting warmer as it expands," says Knap. "In the ocean, you can also see the effect of heat on the intensity of hurricanes."

Knap recalls the 2005 hurricane season, which was the deadliest and costliest on record. However, ocean dynamics are changing fast.

"When I first got into the climate and hurricane world, everyone cared about the surface temperature of the ocean being 26.5 degrees centigrade; that was more or less considered to be the minimum trigger for tropical cyclones," adds Knap. "What we've learned now is it has even more to do with the thickness and the temperature of the water below that surface of the ocean down to 75 meters or more. This represents a massive amount of energy, not just to start the storm, but to allow it to intensify and stay intensified by preventing it from cooling."

To gather the right data underwater, the team uses automated gliders and other remote vehicles along with its buoy network to examine the thickness of upper ocean water.

"For example, in 2005, during Hurricane Rita, you looked at a map of the upper ocean of the Gulf of Mexico, and everything was red hot: 31 degrees centigrade," continues Knap. "But right underneath, one meter down, the water was very cool. That hurricane could not be sustained - and could not intensify due to the cooler water below which de-intensified the storm."

Clearly, an understanding of the upper limits of heat is important. But before these new measurement technologies, much of this was essentially poorly quantified. With an understanding of some conditions on certain days at set points in time, experts were limited to using climatology data from several decades to predict the future – we have now learned that real-time data is an important addition to historical data.

"The problem is that it's a very active and interactive process, so the upper ocean heat content during one storm may be completely different than the upper ocean heat content during another," states Knap. "Rita decreased in intensity, as many hurricanes tend to de-intensify as they reach the coast, losing some characteristics as they approach landfall. However, recently, Harvey intensified as it approached land; Michael, last year, did the same thing."

PROTECTING OUR COASTLINES

These increasingly intense storms highlight the importance of TABS.

"Think about all of those aspects of what these storms can do, right?" Knap comments. "They're phenomenal, but it's not just the damage to property; it's the overall vulnerability of the population."

By building larger cities on coastlines, we place more people and property in danger.

"We're starting to build megacities in the way of storms," explains Knap. "When Harvey arrived, there hadn't been anything greater than a hurricane category three – making landfall in the US for 12 years. This was the longest drought of major hurricanes since 1860. Until Harvey in 2017, the last landfalling storm of Category 3 or greater was Wilma in 2005. In between that period, coastal development increased, putting more property in harm's way."

There is obviously no way to prevent the storms from coming. But monitoring and understanding ocean dynamics will help us better predict their paths, timing and intensity, helping to save lives and money.

"I think one of the key things for any coastal area is to have decent ocean observations," confirms Knap. "Then, at least you can predict what may happen and make sure people go to higher ground when they can. A lot of people tend to just ride it out—without detailed knowledge of what actually could happen in a specific storm. And this is where I think measurement and modeling is incredibly, incredibly important as it can inform prediction and save lives."

SHACKELTON POINT

Lars Rudstam, Professor of Aquatic Science at Cornell and Director of the Cornell University Biological Field Station at Shackelton Point, says that he has long held an interest in lakes in general, so naturally the Great Lakes, the largest freshwater lake system in the world, have held a fascination for him for many years. He also works on Oneida Lake, the largest lake wholly inside New York. Oneida Lake waters, traveling from the lake to the Oneida River, then to the Oswego River, ultimately flow into Lake Ontario. "In addition to lakes in general and the Great Lakes, I have been especially interested in the impressive data series that has been collected for Oneida Lake," Rudstam notes. "Oneida Lake data is some of the best data that has been collected for understanding species impacts and climate change effects."

The Oneida Lake ecosystem has been the subject of extensive data gathering, some of it going back 60 years. Data has been collected on everything from water quality and nutrients to fish and the birds that eat them. "We are interested in the whole lake," says Rudstam. "We collect data on many aspects."

Lake nutrient samples are collected weekly at Oneida Lake. A Hydrolab Datasonde unit is used to collect temperature, oxygen and pH information. Fluorometers are also used to collect information on algae. For those, German Moldaenke fluoroprobes are used. HOBO temperature loggers are also utilized in the field. The water quality data has been taken for 50 years.

Data on fish have also been taken for 50 years. Data includes fish abundance, diet and growth rates. Parasites on fish are also monitored. "We see parasitic copepods showing up in fish gills," Rudstam mentions. "Invasive species are constantly coming into the system."

Some of the common fish include walleye, yellow perch, smallmouth bass and largemouth bass. "We are also seeing round goby, which eats the eggs of some of the other fish. On the other hand, some of those other fish prey on the goby, and the goby does eat zebra mussels, an invasive species we've had for many years," Rudstam mentions.

A large number of people fish on the public lake, as many of its fish are tasty game fish, such as the walleye. "The current limit is three walleye a day," notes Rudstam. "The walleye population has increased in the past decade. About 50,000 walleye are harvested each year from the lake. We've also been seeing some increase in cormorants, which are fish-eating birds." Sheepshead and carp also live in the lake but are not typically taken as game.

While no plants are specifically being threatened in the Oneida Lake system, European milfoil and starry stonewort, a macroalga, are considered to be invasive and have been affecting the ecosystem.

Photo: Michelle Holeck

Graphic: Joshua Pene

> Oneida Lake data is some of the best data that has been collected for understanding species impacts and climate change effects.
>
> **- Lars Rudstam**
> Professor of Aquatic Science at Cornell and the Director of the Cornell University Biological Field Station

Lake Oneida data shows differences in the Lake over time that indicate climate change. "We have seen an increase in temperature of about two degrees Celsius since the 1970s," Rudstam indicates. "We also have less ice cover duration in the Lake than we used to, about a month less than it used to be."

Oneida Lake's behavior is partly influenced by the fact that it is a shallow lake that doesn't stratify like the deeper lakes in the Great Lakes system. It is only 16 meters deep at most, averaging about only 7 meters deep. "Lake St. Clair is similar; it is shallow also and doesn't stratify," says Rudstam.

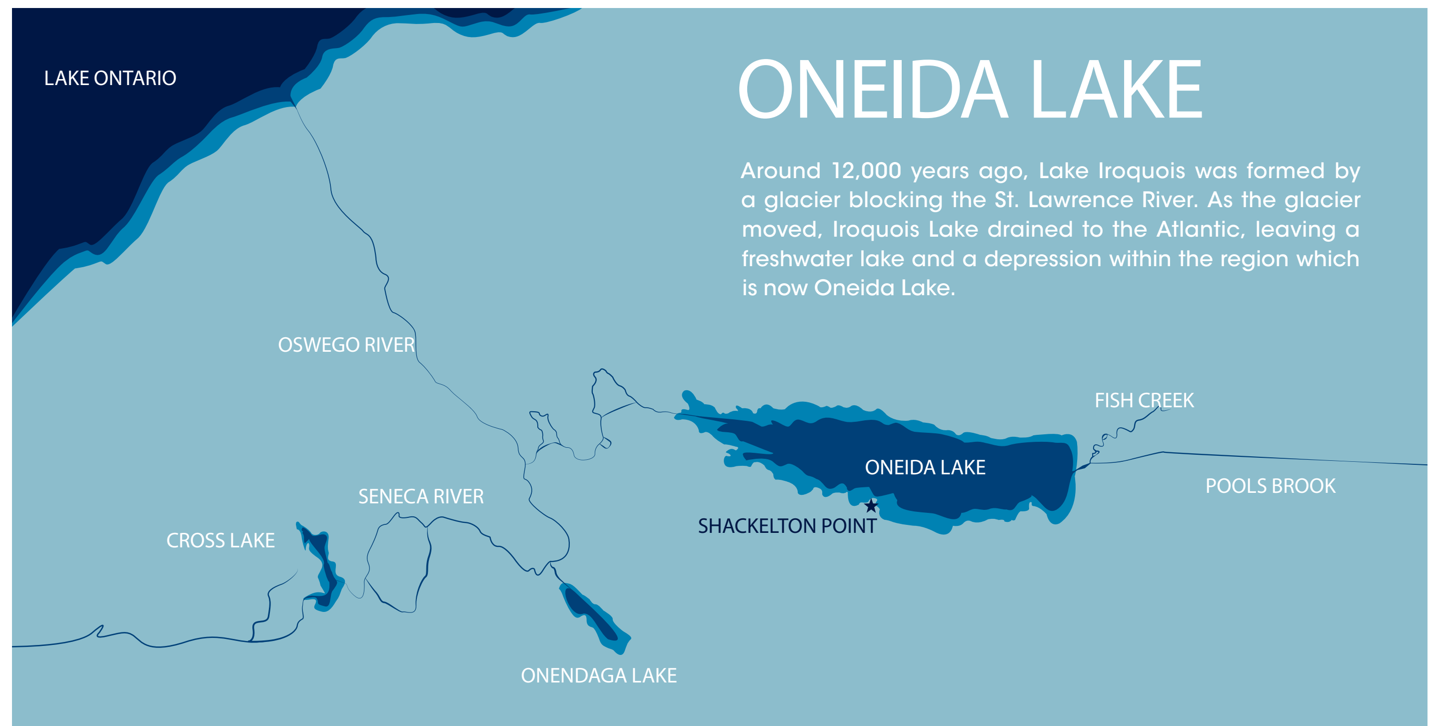
In Lakes Superior, Michigan, Huron, Ontario and Erie, researchers at the Field Station at Shackelton Point have been working with the EPA to monitor zooplankton, chlorophyll and bottom animals such as worms, insects, plants and mussels. Sampling is conducted in April and August, and sometimes at other times of the year as well. The EPA research vessel "The Lake Guardian" is used for these studies. This research is in collaboration with Buffalo State and employs graduate students and several technicians to gather and process data. These data are used to look for trends over time and to create indices for the status of lake ecosystems.

"Blue-green algae is still a problem in the Great Lakes system, as it has been for many years," says Rudstam. "But we have seen some progress with persistent contaminants PCB and DDT. They have been slowly going down. The numbers have definitely become lower since the 1970s."

While he has had a great familiarity with Lake Oneida and the Great Lakes ecosystems over the years, Rudstam has still been surprised by some observations that have been made. "I've been surprised by some effects of zebra mussels, which invaded the lakes many years ago. The mussels have cleared the water, and that has had all sorts of effects for the ecosystem. They are still spreading across North America. In Oneida Lake, they have simply become part of the ecosystem. Instead of trying to eradicate them, I think people have come to realize that we will just have to learn to live with them," he says.

The Oneida Lake data has made it possible to understand many aspects of the lake ecosystem better, and the work on the Great Lakes is used to determine what the future might hold for the largest freshwater system in the world.

"We could not observe the changes we see without environmental monitoring and good data sets," Rudstam emphasizes. "They are critical to our understanding." LB

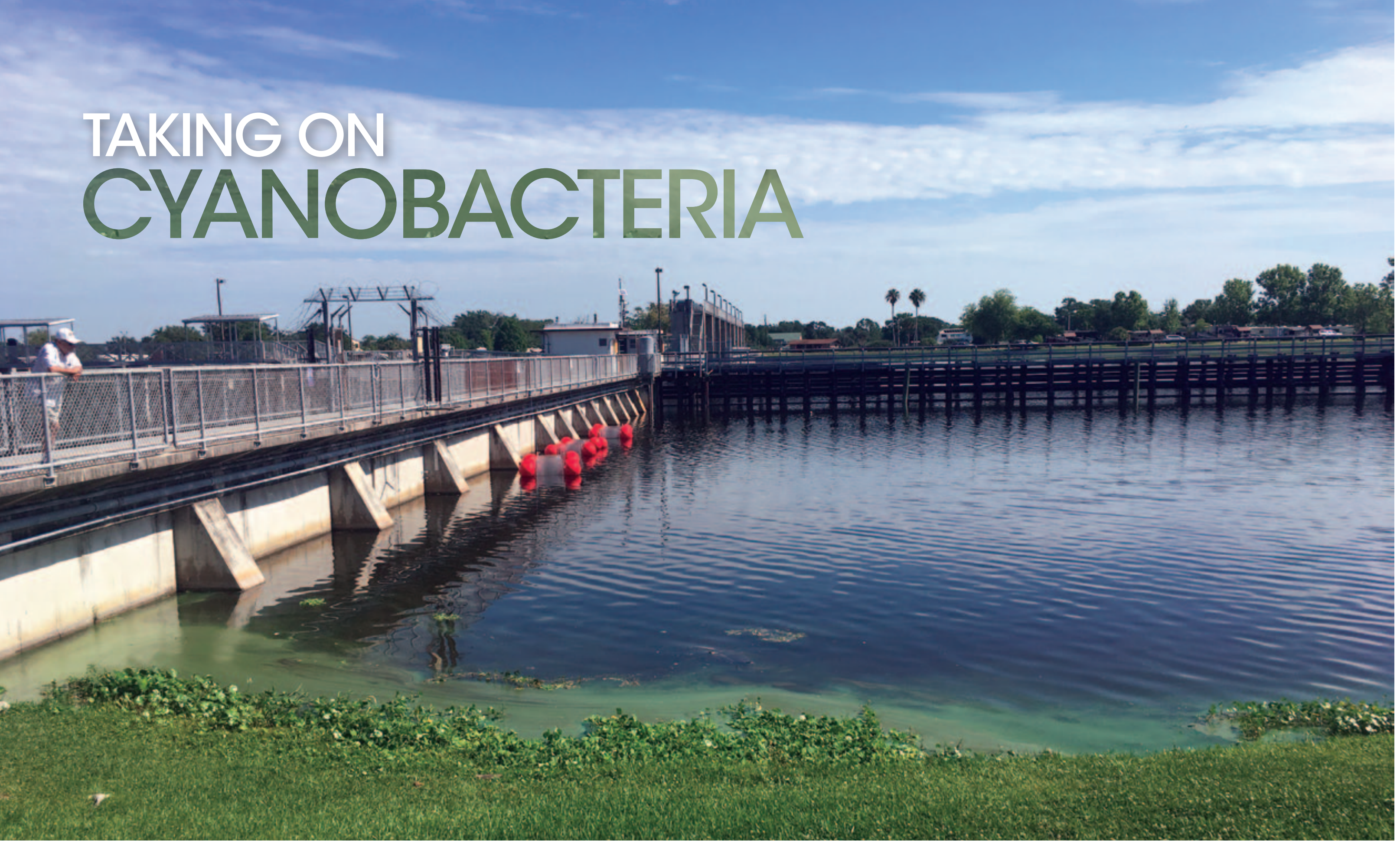


ONEIDA LAKE

Around 12,000 years ago, Lake Iroquois was formed by a glacier blocking the St. Lawrence River. As the glacier moved, Iroquois Lake drained to the Atlantic, leaving a freshwater lake and a depression within the region which is now Oneida Lake.

information from: http://oneidalakeassociation.org/about-oneida-lake.htm

TAKING ON CYANOBACTERIA



As we hear more and more about algal blooms of different kinds across the United States, teams of scientists are working hard to ensure that they don't become our new normal. One project in Florida is taking a multi-disciplinary approach to the problem, including genetic analysis.

The team's work is part of a full-court press in Florida recently, making a serious push to understand what is triggering more frequent blooms.

"This is a very good project," said Dr. Jose Lopez, of Nova Southeastern University. "We're excited about it, and it's a lesson in persistence."

Collaborating with Lopez is Barry Rosen, a USGS scientist who specializes in cyanobacteria. Together, the two have tried just about everything in solving the algal bloom puzzle - a mystery they believe is driven by warming temperatures.

"They simply help things grow, as we know, especially primary producers like cyanobacteria," said Lopez.

What comes to mind for Lopez was a large bloom that evolved off the coast of Florida in 2016. It gained national attention due to its resemblance to guacamole.

"That affected a lot of businesses, if I remember correctly, around the July 4th holiday in 2016," recalls Lopez. "It didn't happen again in 2017, but there were several blooms in 2018. It's a kind of an intermittent thing, and people don't really know what causes these blooms, so that's our main question: can we determine what are the switches that cause cyanobacteria to just burst forth and take over an area of waterway?"

A FOCUS ON THE LAKE OKEECHOBEE WATERSHED

The team is focused on the Lake Okeechobee Watershed for its newest project. Not only due to the watershed's significance as Florida's biggest lake, but also because of its wetland and sugar farm surroundings.

There's also the famed Everglades to the south and the coral reefs to the east, near where the university is located. Despite the freshwater habitats being different from Lopez's traditional research, the same methods for characterizing microbes can be applied.

"We use genetic techniques because we can't culture a majority of bacteria that live in a habitat in any given ecosystem," remarks Dr. Lopez. "About 90 percent cannot be put on a petri dish. So the only way we can really study them and get a handle on what species are there and what they're doing is by reading what genes are there, what their genomes are doing, and what RNA is expressed."

This is the reason for the team's heavy focus on molecular biology and molecular gene sequencing in the project.

"We're going to be looking at meta genomes and meta transcriptomes; these are the unculturable community that's there," Dr. Lopez elaborates. "Most habitats have a community of bacteria. We're looking across the whole consortium of species that might be living in the water, and we hypothesize on pivotal interactions there that may or not be controlling the algae blooms."

Cyanobacteria is the primary species that scientists know of that grows in Lake Okeechobee. The reason is the microcystins that populate in the nearby waterways.

All Photos: Dr. Jose Lopez

Okeechobee, Caloosahatchee River that feeds it, and in nearby waterways is Microcystis.

"Our primary focus has been on two different ideas," remarks Lopez. "One is a synthetic approach, using mesocosms on the Caloosahatchee River."

These are closed systems where the team can safely collect actual river water and add nutrients such as ammonia, phosphorus and nitrates to it in higher doses without environmental impact.

"The idea is to cause an artificial bloom in these mesocosms, which we've already started to do," states Lopez. "We can compare that with what's happening naturally in Lake Okeechobee. We've asked our partners to collect water samples from the lake and other parts of the watershed and we're going to profile the natural communities in those samples."

This takes some of the team out of the lab and into the field. The team conducted their first mesocosm run in May 2019 and the second run in mid-summer, with the idea that they might pick up some new species of cyanobacteria. The third run was scheduled for September after the peak season.

"Maybe there will be a bloom this year, maybe not," comments Lopez. "But we're trying to look at the profiles before, during and after a bloom to see which genes are on and off at each of those periods across this temporal gradient. That might give us some clues as to what's causing these cyanobacteria to bloom."

A layered approach to a complex, interconnected world

This team of collaborators boasts experts specializing in very different areas, which speaks to the complexity of the HAB problem. Any number of factors, such as winds or physical systems, nutrient runoff or temperature, could also be impacting these blooms.

"It is very complex, because first of all, it's a community in water, so you've got hundreds of species there," says Lopez. "We also know that there are nutrients getting into the waterway that have increased these changes in our water. We don't really know which ones might be driving the bloom, so that's why we've isolated a few to start with. We know those are probably being introduced from agriculture."

But there are also numerous human activities in this watershed that are probably having an impact. A rising population around the lake and in Florida means more septic tanks, which means higher nutrient loads. This can make it difficult to target one factor when so many are at play.

"...we're going to be able to tackle just a few of those parameters. We're going to try to do it systematically, and hypothesize about the specific nutrients that we think are in the water, based on the activity," said Lopez.

Perhaps the most interesting reveal from this work, however, will be the deeper profile of these bacterial communities—most of which remain unknown. Just knowing more about these interactions may help crack the HAB problem.

"Using the latest genetic methods and algorithms, I'll think we'll get an idea of how these species interact with each other," Lopez states. "We think that certain heterotrophic bacteria might be affecting the cyanobacteria. These are the consuming bacteria that are also normally there, and they might not necessarily cause any problems. However, I think when the conditions are just right, something triggers the cyanobacteria to start choking, and they begin reproducing uncontrollably."

The toxins in cyanobacteria may not be as bad as the red tide, which causes respiratory ailments—but just having too much overgrowth of the blue-green algae still isn't good.

"It causes anoxia in the water, as they degrade, and overall it's an imbalance in the system," clarifies Lopez. "We're seeing more and more of a tipping point with more frequent blooms, and that's a sign to us that something is not normal. If we can determine what those factors are, we'll work with local managers and agencies which monitor water quality to help improve it."

In fact, looking at genetic factors is a natural water quality study area, and a smart extension of the field, albeit a relatively new one. Still, today's problems demand the application.

"This is happening all over the world, there are blooms in Lake Erie, blooms in China, etc.," comments Dr. Lopez. "People are just not going to jump in the water with a mat of algae on top of it. So it's about time." KL

IN THE GREAT LAKES

RESEARCH FROM AROUND THE BASIN

HURON


Andrea Miehls, USGS. Public domain.

The Great Lakes have had their fair share of issues surrounding clarity, each lake hosting their own set of problems. Recent research by Michigan Technological University, the National Oceanic and Atmospheric Association and the Thunder Bay National Marine Sanctuary sheds light on the recent increase in water clarity in Lake Huron. The new development comes from a recent spike in the exploration of shipwrecks in the lake. Thunder Bay National Marine Sanctuary is home to many shipwrecks that have been the site of various research initiatives lately. Among the wrecks, zebra mussels were found to have covered most of the wreckage sites, where in the past, they were absent. Water clarity has improved over the decades and the focus turned to zebra mussels, who are known to filter contaminants out of water.

"Invasive mussels clear the water and coat the wrecks at Thunder Bay National Marine Sanctuary." Great Lakes Echo, 27 Feb. 2020, http://greatlakesecho.org/2020/02/27/invasive-mussels-clear-the-water-and-coat-the-wrecks-at-thunder-bay-national-marine-sanctuary/

ERIE

Processes, jobs, products and other tasks are becoming "smarter" with the use of devices and machines. The Great Lakes are no exception with the Great Lakes Observing System's new initiative, "Smart Great Lakes." Goals of the pilot project include informing the public on water quality issues before more significant public health events unfold. Many collaborators are involved with GLOS and work together to disseminate water quality data to the public. Another goal includes outfitting all of the Great Lakes with equipment that has proven reliable during times of distress, such as data buoys during the Toledo Water Crisis. Many organizations can benefit from real-time data on water parameters that contribute to water quality issues in areas that supply drinking water to so many. This project hopes to bring together researchers from all over the Great Lakes watershed to work together toward one goal.

For Immediate Release: Great Lakes Observing System Launches the Smart Great Lakes Initiative, 10 Oct 2019. https://www.glos.us/release-great-lakes-observing-system-launches-the-smart-great-lakes-initiative/


Photo Credit: Ed Verhamme, Limno-Tech

SUPERIOR

Over the summer, ecosystem ecologist Amy Marcarelli taught a course for students titled "Lake Superior Exploration," which revealed itself to be quite the journey. This course was designed to educate students about the many facets of the massive freshwater basin that lies so close to their campus. Not only do participants gain experience with field equipment and methods, they learn about ongoing research, culture and stories from different organizations across the basin. Students were able to record and visually observe temperature conditions on the lake in real-time, something that many students have never had the opportunity to experience. Guest scientists and speakers provided a glimpse into the real lives of working scientists. Nearly all of the students in the course have career goals that lie in the aquatic industry, and the experience provided valuable insight on what it takes to make an impact in the Great Lakes region.

Huskies Explore Lake Superior. (2019, September 30). Michigan Tech News. Retrieved from https://www.mtu.edu/news/stories/2019/september/huskies-explore-lake-superior.html


U.S. Fish and Wildlife Service Headquarters / Public domain


New York Power Authority

ONTARIO

Where and how to monitor water quality is always a challenge, particularly in complex aquatic ecosystems. The new REASON Project from a team at Clarkson University is working to demonstrate the utility of using water quality instrumentation in dams on major rivers in the Great Lakes system. Michael Twiss, professor of biology, and his team are taking a new approach at the Moses-Saunders Power Dam across the St. Lawrence River, a main drainage outflow of the Lake Ontario watershed. Dr. Twiss found that much about this section of the river remained unknown, so the team began to conduct fundamental studies of how water changes when it flows out of the lake and downstream. The team's first sensors were installed on the New York side of the power dam in 2014. The project is working to acquire a big picture for policy information so that decisions can be made more effectively locally, and municipalities can use better, scientifically-backed information for planning their own water quality monitoring.

"REASON Project Puts Water Quality Instrumentation in Dams." Environmental Monitor, 22 Jan. 2020, https://www.fondriest.com/news/reason-project-puts-water-quality-instrumentation-in-dams.htm.

MICHIGAN

Sometimes the scientific process makes for a great story, or many, like when discovering the relationship between lake levels and mercury levels in fish. Lake levels in the Great Lakes region rise and fall with some regularity. Peaks happen about every thirteen years. It's a pattern supported by lake level data going back to the 1930s, it's essentially region-wide, and it's determined by what happens over half a continent away. Insight into the changes in mercury levels in fish and loons collected from Wisconsin lakes came into focus when team members noticed a similarity between the changes in water level and the changes in mercury bioaccumulation. "We don't know going forward whether the highs and the lows are going to continue to be more amplified or whether things will level off," Watras said. A few years after worrying inland lakes would disappear, coastal erosion now threatens houses on the Great Lakes that were once considered safe.

Mercury and Lake Levels Rise and Fall Together around Great Lakes. (2020, March 4). Environmental Monitor. Retrieved from https://www.fondriest.com/news/mercury-and-lake-levels-rise-and-fall-together-around-great-lakes.htm


Photo courtesy: Jereme Gaeta

EDUCATION AND RESEARCH AT DAUPHIN ISLAND SEA LAB

Named after French royalty, Dauphin Island sits on the Gulf of Mexico. It is an important stop for many migratory birds traveling from South America as well as many human visitors in search of beach scenery. It is also home to the Dauphin Island Sea Lab (DISL), which serves as the main educational and research center for marine science studies in Alabama. One of DISL's most impressive gems is the Estuarium, a large aquarium where the public can view estuarine organisms native to Alabama, which includes a 12,500 square foot exhibit hall. Aquatic life from the Mobile-Tensaw River Delta, Mobile Bay, the Barrier Islands and the Northern Gulf of Mexico are featured. Outside the aquarium is the Living Marsh Boardwalk, which looks over Mobile Bay.

The Mobile-Tensaw River Delta is Alabama's largest wetland and is home to turtles, gar and American alligators. Mobile Bay has brackish water and is a habitat for blue crabs, stone crabs, horseshoe crabs, oysters, and flounder. Barrier Islands sports hermit crabs, and the Northern Gulf of Mexico supports octopi, lobsters, eels, seahorses, sharks, jellyfish and many others. The Rays of the Bay, an Estuarium exhibit opened in the mid-2000s, features indigenous Northern Gulf of Mexico and Mobile Bay skates and rays, including the Cownose ray and Southern stingray. The newest exhibit is Windows to the Sea, added to the exhibit hall space in 2018.

"Windows to the Sea features a video wall for the public to explore a sargassum community and learn about changes in Earth's history," says Angela Levins, public relations director at Dauphin Island Sea Lab. "Windows to the Sea also provides visitors with educational videos of programs on campus, research happenings on campus and topics of interest in the world of marine science. The exhibit gives the public a view of the sea outside of the four habitat focus areas."

DISL also features a dolphin, manatee and whale stranding research facility, the Marine Mammal Research Center.

"The Alabama Marine Mammal Stranding Network (ALMMSN) uses the center for necropsies and research. There is also the Manatee Sighting Network (MSN) on campus. Both programs are projects of Ruth Carmichael. The Manatee Sighting Network has a great focus in giving us a better understanding of manatee travel. There was a time it was believed that manatees were out of place in Alabama, however, through the manatee sightings we've discovered that manatees migrate to our area in warmer weather and then head back to Florida when the water cools down. MSN has used satellite tagging and citizen visuals," says Levins. "A great paper just came out relating to a portion of this."

Satellite tagging of manatees and public reports of manatee sightings can be found at https://manatee.disl.org.

"Constant water monitoring is a central feature of Dauphin Island research," added Levins.

Dauphin Island monitoring data provides many benefits, including a permanent record of changes in environmental indicators over time, support for research activities through the availability of consistent, high-quality data and potential for the public to track and learn about water quality status. Monitoring information includes user-friendly hydrographic data that is provided via a partnership with many entities, including the Mobile Bay National Estuary Program, Weeks Bay National Estuarine Research Reserve, the Alabama Department of Conservation, State Land Division, Coastal Program, and the Environmental Protection Agency's Gulf of Mexico.

"MyMobileBay.com is a great tool that offers real-time monitoring of our waters at several stations. It's one of several areas of data we monitor," says Levins.

MORE THAN MONITORING MANATEES

Alison Robertson, a senior marine scientist for DISL and assistant professor at the University of South Alabama, has HAB toxins as a primary research focus, looking at fate, transport and biodegradation of benthic HAB toxins as well as toxin effects on marine biota. She uses chemical tracers and signatures (toxins, lipids, proteins, stable isotopes) in bio-indicator species to make ecological risk assessments, as well as model toxin fate and reef food web relationships. She has led HAB toxin outbreak (poisoning) investigations and HAB rapid response efforts, as well as trained many in methods for exposure and toxicological assessment, analytical and bioassay detection of HABs and their toxins. These analyses remain an outreach focus for Robertson and her lab. One of Robertson's big projects is CiguaPIRE.

Seagrass study and habitat restoration are also important topics of interest at DISL with Ken Heck leading the effort. His lab is focused on plant-animal interactions in coastal waters, with an emphasis on seagrass-dominated systems.

Heck has also collaborated with colleagues in efforts to restore northern gulf oyster reefs and seagrass meadows. He has been research director, chief scientist, chair of university programs, associate director of the Alabama Center for Estuarine Studies and director of the Shelby Center for Ecosystem-Based Fisheries Management. He has also collaborated with post-doctoral scholars, technicians and graduate students, as well as mentoring more than 50 undergraduate interns.

Alex Rodriguez, a graduate student working with Heck, won a SeaGrant prize for her work on using drones to monitor sea turtle grazing effects on seagrass. Heck has also been involved in the Deep Horizon oil spill study, which explored the incredible resilience of the Gulf of Mexico ecosystem to the oil spill, and also underscored the need for high-quality baseline environmental monitoring data.

Sean Powers leads fisheries ecology at DISL. Fisheries ecology labs have a variety of projects, such as looking at red snapper on the reef during each season and monitoring growth rates. Red drum is also monitored.

EDUCATION ON THE ISLAND

In addition to monitoring work going on at DISL, there is also a great deal of educational outreach.

At DISL, Remotely Operated Vehicles (ROVs) are part of educational outreach, and a current class of middle, high school and other educators will spend time on DISL's research vessels, see how they operate, talk about research potential, and even build a functioning ROV from circuit board up to get students interested in building, learning, developing skills and exploring the ocean.

"Discovery Hall Programs (DHP) also incorporate lessons on drifters and how they are used in marine science," Levins mentions. "One program that just received funding through the Alabama State Lands Division is a citizen science project. When they are on our R/V Alabama Discovery, volunteers from the community will join us to record details of species encountered during trawling to add to the understanding of Mobile Bay. Tina Miller-Way let me know they just received funding for this project."

Miller-Way, chair of Discovery Hall Programs for Education and Outreach, uses her 20-plus years of experience at DISL to develop the K-12 marine science educational outreach programs. She shares marine science with teachers and students alike and has incorporated data gathering using YSI probes into her educational demonstrations. Her background includes a PhD from Louisiana State University, MS in oceanography from Oregon State University and years of teaching at the University of Mobile and University of South Alabama. She is also education director for Mississippi-Alabama Sea Grant Consortium and serves on the Sea Grant Educators Network Board. LB

All Photos: Dauphin Island Sea Lab

HANDHELDCYANOTOXIN DETECTION

Combating harmful algal blooms (HABs) is no easy task. While conducting tests in a timely fashion is key to mitigating damages, the laboratory equipment needed for those tests can cost a lot.

Qingshan Wei, an assistant professor at North Carolina State University saw that problem, and sought out a solution by developing low-cost sensors, which can monitor the cyanobacteria that generates HABS.

"They have very severe health implications such as brain damage. So far, the standard detection methods still rely on laboratory technology, such as using mass spectrometry to quantify the cyanobacteria," explains Wei.

Those methods are very accurate and sensitive, but it takes both a laboratory setting, qualified personnel and expensive equipment to conduct them.

"We thought, maybe people will appreciate a portable technology that enables onsite detection so they can immediately evaluate that quality of the water in the environment and try to guide their daily activities," Wei describes. "For example, a test to determine whether you can swim or fish. That was our motivation."

The sensors perform well under ideal conditions, but how they perform in the field remains a question Wei's team is looking to answer.

The team also plans to push the technology out to the broader scientific and water management communities to gauge interest.

"That way we can also potentially achieve more collaborations, further improve this technology and perhaps get more funding support to develop new technologies," adds Wei.

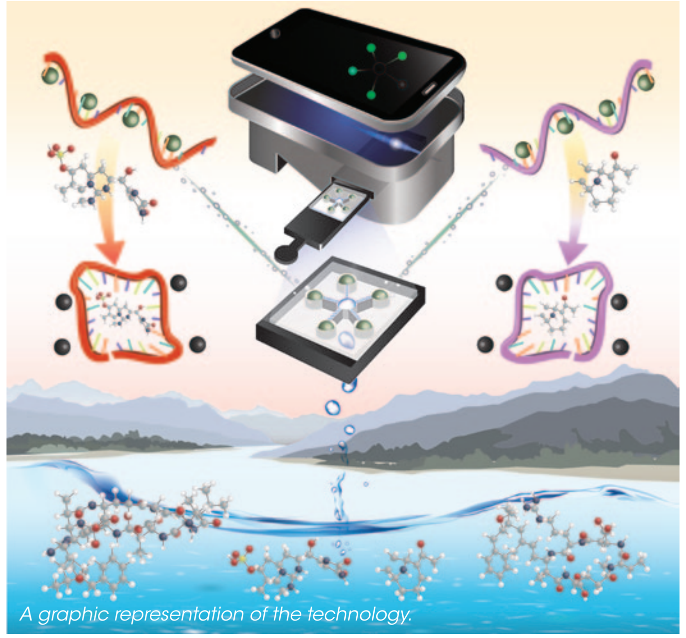
DETECTING CYANOTOXINS WITH A CELL PHONE

As research teams wade into cyanotoxin testing, they have to calibrate the sensors to match guidelines set by the EPA. In Wei's first paper, they recorded a sensitivity level for the sensors that was suitable for recreational water testing.

While the EPA has established regulatory guidelines for two types of cyanotoxins, two others don't have set limits.

"This means the entire field is to try to establish some criteria," states Wei.

However, this isn't the end of the sensitivity issue. Wei said their current sensitivity level meets criteria for environmental water, but not for drinking water.



A graphic representation of the technology.

Photo: Li, Zheng et al, 2019

"WHO's drinking water guidelines are even lower, which means we still have some work to do to further improve the sensitivity for our sensor technology," clarifies Wei. "Eventually, if we can use these portable sensors to quantify the quality of drinking water, I think that that will be even more impactful."

Right now, their sensors are based on an aptamer sequence - single strands of DNA that have been found to bind to particular cyanotoxins. A few are used as binding agents and constructed into fluorescence assay, which allows the team to quantify cyanotoxin concentration.

"We will probably modify it somewhat so we can further improve the detection sensitivity," Wei says. "We can also improve our cell phone reader to make the device more sensitive and detect at even lower concentrations. That will be our immediate next step."

As it stands now, all that's necessary to use the prototype is the custom chip, the reader, and a smartphone. Excluding the phone, it costs $70 in total.

"That's the overall goal to achieve: a single low-cost, portable system that can deliver the quality of measurement you can achieve in a standard laboratory," confirms Wei. "We 3D-print these devices in our own lab. We also created a very simple, disposable microfluidic chip, and eventually, we will be able to load the chemical reagents into the chip."

At that point, the user would add a drop from a water sample and scan with their phone. Eventually, any field scientist user can monitor a lake using the device in a customized way.

Eventually, users would just order the attachment and receive a customized chip, depending on the targeted toxin.

The team also conducted a primitive study on creating a smartphone app, where after an image is captured the cell phone processes and quantifies results immediately. KL

ALGAE-TRACKING SAILBOAT

Scientists from Florida Atlantic University Harbor Branch Oceanographic Institute (HBOI) recently trialed a solar-powered, algae-tracking sailboat developed by Navocean, Inc.

"This boat is so amazing when you see it in action," remarks Jordon Beckler of Florida Atlantic University (FAU), director of HBOI's Geochemistry and Geochemical Sensing Lab..

After being contacted by Navocean and conducting a pilot test in December 2017, the team sent the boat out in December 2018 offshore of Sanibel, Florida, coinciding with the beginning of the Florida Red Tide Bloom (Karenia brevis) that lasted until February 2019.

Beckler is now at the Indian River Lagoon, where severe algal blooms occur. Due to the small size of the algae-tracking sailboat, Beckler believes it could be the "perfect platform" for monitoring these phenomenons.

The boat also offers a mobile monitoring platform for users, requires less technical training or support, more affordable and can be deployed by one person.

Target users include research scientists, water quality monitoring officials, anyone studying Lake Erie algae blooms - anyone interested in real-time data from remote locations.

"We're trying to make this system turnkey so that people can simply send the boat out and keep surveying a series of waypoints for weeks, or even months at a time and get real-time data on chlorophyll, at least from a fluorescent sensor," comments Beckler.

Once calibrated, the boat can be deployed for extended periods of time, partly due to its solar panels. Beckler said they use a sheet of tinted, frosted purple plexiglass material, which makes for a solid fluorescent reference signal when held against a fluorometer.

That single data point from the fluorometer can be used for recalibration or to check if things are still working.

The platform is modular, and can accept any sensor.

"They also have the means to connect sensors that are spitting out serial data or analog data to a little internal data brain so that it could forward the information in real time," he said. "It is already linked up in real time to collect data from a Turner Fluorometer."

"It's detecting when the bloom first emerges, and that is just chlorophyll," remarks Beckler. "You can use a Turner Fluorometer with

Photo: Dr. Jordon Beckler

three or even six channels. In our case, we had three: chlorophyll a, phycocyanin and fDOM."

When the team deployed the boat in Sanibel, they measured chlorophyll a, fDOM, and turbidity.

"The other sensor we used for Lake Okeechobee is a Wetlabs backscatter meter (BB3)," explains Beckler. "We had three channels of RGB backscatter to detect particulate material. Combined with the chlorophyll data, these sensors can potentially be used in tandem for resolving functional groups of phytoplankton, or at least provide clues about which groups may be present."

The team is now preparing to deploy the boat alongside a NASA-funded project called SeaPRISM in Lake Okeechobee. While SeaPRISM measured various angles of reflectance off the lake, Beckler's Navocean vehicle circled the platform and would take backscatter data.

Data could improve algorithms the SeaPRISM uses to deconvolute the backscatter signal acquired by the lake reflectance.

"The easiest things to customize are the channels on a fluorometer," states Beckler. "They aren't the most definitive instruments, meaning there will always be a question of signal interpretation, but they're versatile with lots of sensor options. You can look at hydrocarbons, for instance, so now you can search around for oil slicks."

The team seeks out natural extensions of what these fluorometers can do to find new applications for the boat. They've worked with the Mote Marine Lab in an effort to measure colored-dissolved organic matter (CDOM), as well as red tide. This is done by integrating a Programmable Hyperspectral Seawater Scanner on the sailboat.

"By using a long-pathlength spectrophotometer, spatial measurements of CDOM could be obtained even in the open ocean, yielding data useful for many biogeochemical applications and improving our understanding of light availability, photochemistry and biology, heat transfer, and trace metal availability." KL

Rental Equipment

Rental equipment is available to minimize downtime and cover equipment needs when projects expand.

Arrow Gold GNSS Receiver

The Arrow Gold is the first high-accuracy iOS, Android and Windows Bluetooth GNSS receiver to implement all four global constellations, three frequencies, and satellite-based RTK augmentation.

- Full GNSS: GPS/GLONASS/Galileo/BeiDou/QZSS
- 100% Android, iOS, Windows compatible
- SafeRTK maintains RTK-level accuracy in spotty cellular coverage

SonTek CastAway-CTD

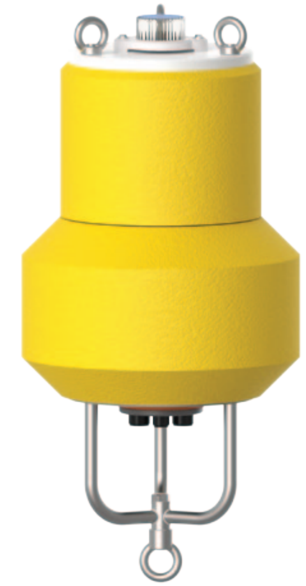
The CastAway-CTD is a lightweight, easy to use instrument designed for quick and accurate conductivity, temperature, and depth profiles.

- Can be used for sensor verification, speed of sound profiles, thermocline profiling, and more
- Sampling rate and sensor response of 5 Hz with 1m per second free fall design
- Designed for CTD profiling down to 100m

EXO2 Water Quality Sonde

The YSI EXO represents the next generation of water quality instruments from YSI. The EXO2 sonde includes six sensor ports and a central anti-fouling wiper option.

- 2 spare ports for adding Total Algae and/or fDOM sensors
- Internal battery pack for unattended logging
- Central wiper prevents fouling and extends deployment



CB-50 Cellular Data Buoy

The CB-50 Data Buoy is designed for quick deployment in emergency response situations including industrial spills and natural disasters.

- Design accommodates X2-SDL data loggers and is compatible with many environmental sensors
- Cellular, Iridium satellite, and radio-to-shore telemetry options available
- Lightweight system can be deployed by a single person

Cyclops-7 Rhodamine Dye Logger

The Cyclops-7 Rhodamine Dye Logger is ideal for time of travel studies, dispersion and mixing studies, circulation, and stormwater retention studies.

- Includes Cyclops-7 rhodamine dye sensor
- Internal battery pack for unattended logging
- Log as fast as 1-minute for up to 28,000 samples

Signature 1000 ADCP

The Signature 1000 ADCP is the optimal tool for turbulence measurements.

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