

ENVIRONMENTAL monitor

SUMMER 2019

APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS

NORTH AMERICAN FIELD STATIONS



Mendocino Coastal Field Station

Giving students hands-on experience in the field

Flathead Lake Bio Station

Investigating climate change on high elevation lakes

Enchanting Eelgrass

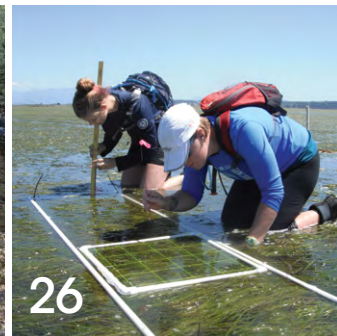
Learning at picturesque Padilla Bay NERR



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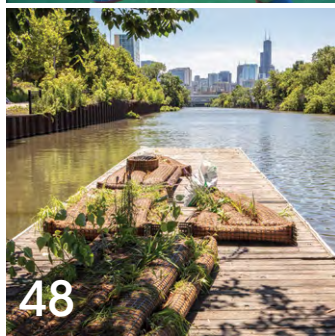
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IN THE NEXT EDITION

The next edition will focus on cameras for environmental research and assessment. Terrestrial, buoy-based and submersible camera applications, products and technologies will be featured.

Cover Photo: Steve Fondriest

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WELCOME...

Welcome to the Summer 2019 edition of the Environmental Monitor, a quarterly collection of the best of our online news publication. In this edition, we showcase North American biological field stations.

This issue includes methods and techniques adopted by field stations. You will see an innovative mesocosm study in the Black Swamp Region of Ohio; the Mendocino College Coastal Field Station, where undergraduate research opportunities are numerous and the New York City Urban field station; whose ability to preserve natural habitats that the community can enjoy is unprecedented. Field stations like Flathead Lake Bio Station have a unique environment where they can conduct research and share findings with other experts in that region.

Lacawac Sanctuary's unique monitoring solutions involve customized monitoring buoys and other innovative solutions. Other topics include field station collaborations with national networks such as GLEON and NOAA as well as other programs.

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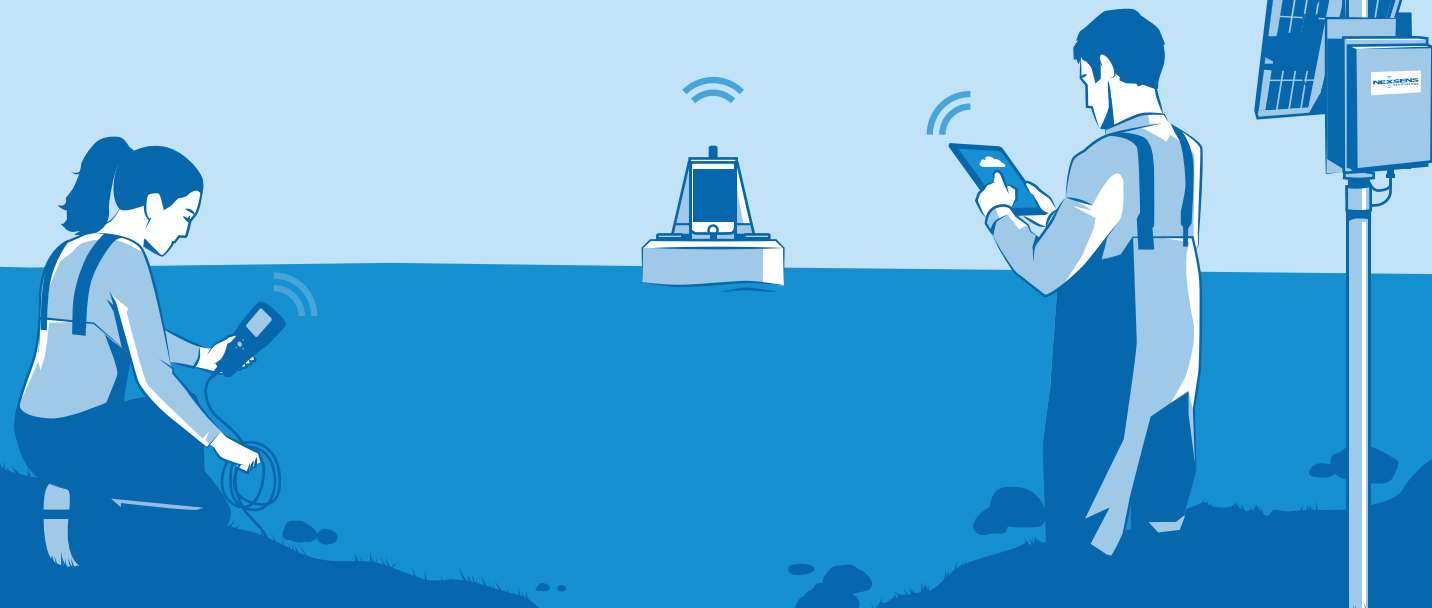
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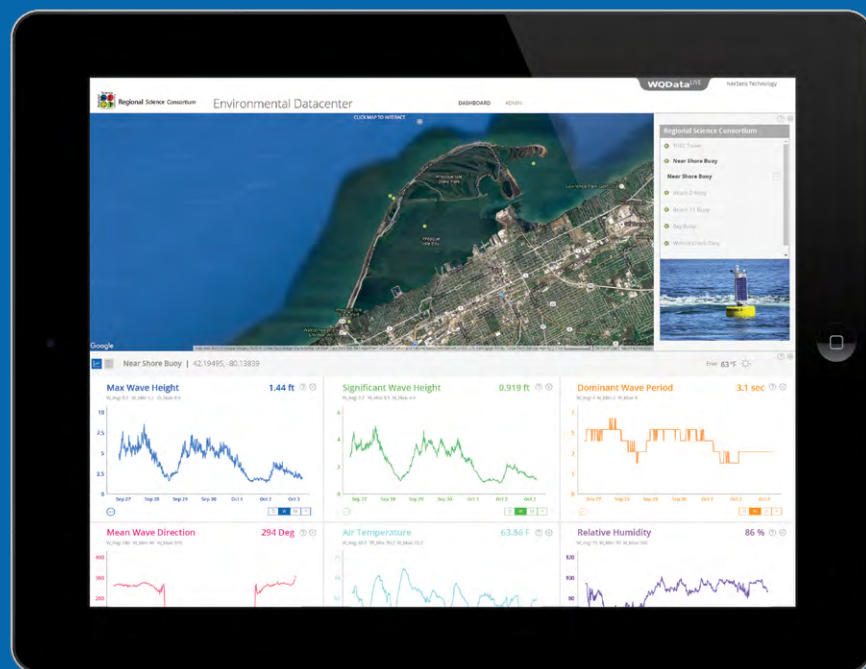
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Building up Oysters: Coastal Conservation & Restoration by Harte Institute

If you want to become acquainted with one of the largest producers of oysters in the Gulf of Mexico, look no farther than the state of Texas, says Jennifer Pollack, Chair of Coastal Conservation and Restoration at Harte Institute for Gulf of Mexico Studies Texas A&M University, Corpus Christi.

"A major focus of ours is restoring reef habitat in the Gulf," Pollack says. "We take hard substrates, like oyster shells, limestone, crushed concrete, or river rock, and put them back in the bay where oyster reefs have been degraded or destroyed."

The Harte Research Institute has been performing oyster reef restoration work since 2009 and Pollack expects to continue monitoring, protecting and restoring oyster populations in the Gulf for many years.

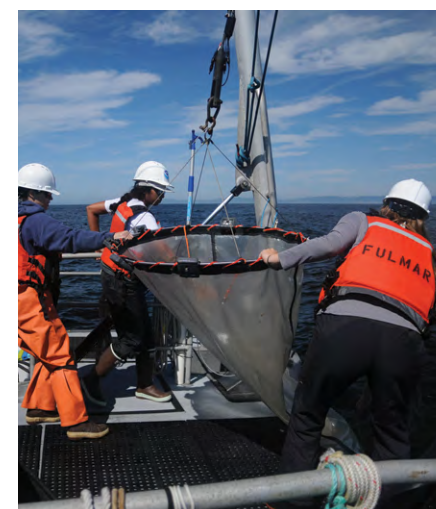
Full story: <https://www.fondriest.com/news/building-up-oysters-coastal-conservation-and-restoration-by-harte-institute-helps-support-whole-shellfish-life-cycle.htm>

Henderson State University's Simonson Biological Field Station

There are several interesting projects going on at Henderson State University's Simonson Biological field station. Dr. Engman discusses the opportunity the college was given back in 2005 to begin work on their field station. The director understands the impact field stations have on students and the communities surrounding them and was especially excited to break ground on this project due to lack of research opportunities existing in the area.

Since opening in 2011, the team has been busy. "We use it as a destination for lots of field courses, like dendrology, entomology, herpetology, ichthyology, general ecology and aquatic ecology. So although those classes meet regularly on campus, we use the station as a field trip destination, and it makes it nice and easy to do some sampling." The field station is even available for public use when the HSU team isn't using it for science.

Full story: <https://www.fondriest.com/news/henderson-state-universitys-simonson-biological-field-station.htm>



Greater Farallones National Marine Sanctuary Helps Protect Marine Mammals

Greater Farallones National Marine Sanctuary, part of the National Ocean Service (NOS) and National Ocean and Atmospheric Administration (NOAA), monitors seabirds and marine mammals, including potentially hazardous interactions between whales and ships along the California coast. Environmental monitoring is done for both long term and short term environmental projects at Greater Farallones. Research coordinator Jan Roletto outlines several projects in the area and instrumentation used to aid in monitoring.

Other monitoring efforts involve the Applied California Current Ecosystem Survey (ACCESS). This monitoring is conducted from a boat three or four times a year and encompasses birds, mammals, shipping traffic and/or the presence of marine debris. The ACCESS project covers the head of Bodega to Half Moon Bay.

Full story: <https://www.fondriest.com/news/greater-farallones-national-marine-sanctuary-timely-monitoring-helps-protect-whales-from-injury-and-death.htm>

Photo: (top) K. Thompson, (center) Henderson State University, (bottom) ACCESS Point Blue/ONMS

IN THE NEWS



Remote Mount Desert Rock Marine Field Station

Owned by the College of the Atlantic, the Mount Desert Rock Marine Field Station, a member of the Organization of Biological Field Stations (OBFS), is a treeless island with a light tower and buildings that were once inhabited by lighthouse keepers and their families in the 19th century. The island is now the home of the Edward McCormick Blair Marine Research Station, and its surrounding waters are home to humpback whales, fin whales, northern right whales, common dolphins and white-sided dolphins. In summer, College of the Atlantic students can spend the summer on the island, with only one boat coming out to the island per week.

"It's physically, mentally and socially challenging to spend extended time on the island," says Dr. Sean Todd, College of the Atlantic's Steve K. Katona Chair in Marine Science and Director of Allied Whale in Bar Harbor, Maine.

No stranger to harsh environments, Todd works in Antarctica as well. Some of his students have also been placed in research positions in Antarctica. Some have prepared for the unrelenting conditions at the world's southernmost continent by doing research at Mount Desert Rock.



The Ozark Research Field Station in Focus

Biological field stations exist all across the country, and now there is a brand new station in the Ozarks. The Missouri University of Science and Technology's Ozark Research Field Station is now open, and director Dr. Robin Verble took the time to speak to EM about the new station.

"We are brand new," states Dr. Verble, who is the founding director of the station. "The University acquired the property officially at the beginning of January 2017."

The Ozark Research Field Station (ORFS) is a nine-acre site nestled inside 300 acres of state-owned land in the Bohigian Conservation area. That 300 acres is surrounded by an additional 6,000 acres of the Mark Twain National Forest.

"It's an old homestead," Dr. Verble describes. "It was originally constructed in 1868. We have a historic log cabin that's been added onto over the years, and it's on the site right now, so there's that interesting historic component. We have a lot of plans for construction of labs, classrooms and other facilities that are all hopefully gearing up this summer."



Microplastic Pollutants in Passaic and Raritan Rivers

A team of researchers from Rutgers University, New Brunswick has found that microplastic particles are polluting the iconic Passaic and Raritan rivers. The recent study reports that the team found more than 300 organic chemical compounds from microplastics in the rivers: 299 compounds in the Passaic, with 255 in the Raritan River and 81 in the Newark and Raritan bays.

The microplastics issue may be far more serious than most people currently perceive it to be, based on these results. Although samples from the Passaic and Raritan rivers had large numbers of compounds in them, there is no reason to assume that the two rivers are unusually full of microplastics. Rather, this appears to be a widespread problem.

The team is now working on describing the various organic compounds associated with the microplastics they've detected. Given that the team—along with other researchers—are finding microplastics so readily, and have evidence that they are moving through food chains, understanding the associated environmental consequences does indeed seem like an important next step.

Photo: (left) S. Todd, (center) Missouri S&T, (right) Dr. Ravit



Shingle Shanty Preserve and Research Station

New York's Shingle Shanty Preserve and Research Station (SSPRS) occupies a unique spot in the middle of the vast six million acres of Adirondack Park. Shingle Shanty is 23 square miles of unmatched biodiversity, with resident animals and plants often living at the edge of their typical distribution ranges. Animals and plants in Shingle Shanty can live in boreal habitat, wetlands, peatlands and/or upland temperate forests.

"Shingle Shanty is a truly unique place," says Steve Langdon, Director of Shingle Shanty. "Many of the species here are living at the edge of their environmental tolerances. There are intersections of environments you just don't typically see elsewhere, and as a result, there are intersections of animal and plant communities that are exceptional."

"Being able to monitor environmental variables like temperature at a scale that informs the management of peatland ecosystems in the Adirondacks is really important. Our goal is to develop a baseline to understand where these systems are before they change."

Photo: (left) Mike Lynch Photography, (Right) Government of the Northwest Territories

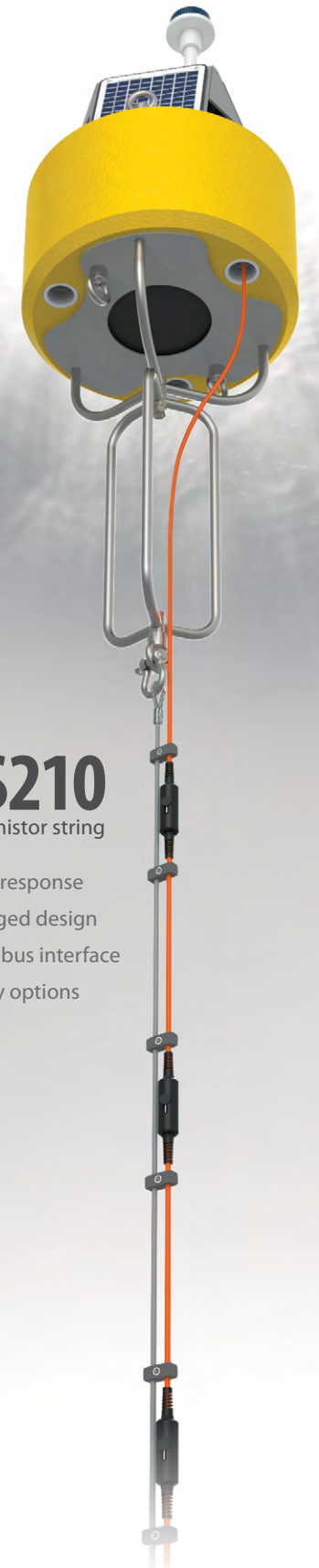


Science in the Sub-Arctic: the Tundra Ecosystem Research Station

As scientists from around the world work to advance global understanding of polar ecosystems, biological field stations in arctic and sub-arctic regions offer a unique opportunity for investigators. The Tundra Ecosystem Research Station (TERS), a multi-purpose biological field station established in 1994, plays a key role in long-term monitoring of and research into the tundra ecosystem.

Robin Staples is the TERS contact on behalf of the Government of the Northwest Territories (GNWT) for water quality monitoring that takes place in the Coppermine and Lockhart Basins, river watersheds which are among the Canadian Central Arctic region's most important river systems.

"Recent status and trend reporting from regional and local monitoring programs has shown that mining and exploration has influenced water quality in these basins," states Staples. "Observed changes are currently limited to local water bodies near the various developments. The overall hydrology and water chemistry of the basins has not been altered in a significant way."



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BIOLOGICAL FIELD STATIONS ACROSS AMERICA

BY KARLA LANT

Biological field stations (BFS) are invaluable tools for researchers and the general public—and when people learn about science and nature at biological field stations, everyone benefits. EM spoke to Colorado State University (CSU) assistant professor Jill Zarestky about her recent research on the ways learning happens at BFS across the US.

For Dr. Zarestky, the work began with questions she and her colleagues couldn't answer. They wanted to know how field stations were approaching outreach. They didn't know, and there was no literature on the subject.

"A lot of this stemmed from questions that Rhonda [Struminger of Texas A&M] had about what they were doing at their research station in Mexico that people in the bio-science disciplines couldn't answer," explains Dr. Zarestky. "[Collaborator] Michelle Lawing is a bio-scientist and she calls herself a field station groupie. I'm in education, and I had a lot of questions, myself. We came together with the social science, the natural science, and the practical experience to address these questions from a place of needing practical answers."

EDUCATIONAL OUTREACH AT BIOLOGICAL FIELD STATIONS

At the beginning of their research, the team saw educational outreach happening at various BFS, sometimes based on staff interest, other times stemming from funding requirements. The researchers hoped to modify the language we use to describe biological field station missions so that their educational components could be part of the "baked-in" design instead of "tacked on" extraneously.

"If people could see how educational outreach for the general public connects to the mission of the field station rather than a fun sideline or something you have to do for funding, it could become a benefit to the field station as a whole in fulfilling its research mission and connecting the field station to its local community and other stakeholders," states Dr. Zarestky. "We can think about our experiences at field stations as opportunities for the general public to learn science by connecting to



The Schoodic Institute, Acadia National Park.



The 2018 OBFS conference site in Maine.

nature. Those are big, worthwhile things that deserve some real attention."

The outstanding question became: how?

"A lot of our work at this point, including the conceptual framework, has been helping people think through their educational outreach with a baseline of intentionality," remarks Dr. Zarestky. "You can do whatever you want to do, but first figure out what it is that you want to do, and then design to achieve that purpose."

This begs the question: what are BFS across the country doing now? Is it consistent from place to place? Should it be?

"One of the things that's particularly interesting about field stations is that they cover the entire spectrum of possibility," comments Dr. Zarestky. "There are field stations who employ teams of professional educators who do excellent work; they're knocking it out of the park. And then there's the one-person-shows where somebody is trying to do everything at a field station all by themselves. That spectrum of possibility and expertise and resources I think connects to the spectrum of who's winging it and who's got it figured out."

Zarestky and the research team assert that it is key for researchers to connect with each other so that people working in BFS are aware of resources that are available to them.

"For example, you want to do a program for third graders on water quality. Perhaps someone at another station already has one of those. Ideally, you could talk to them and support each other," adds Dr. Zarestky. "There's a lot of really excellent stuff happening, and some people in the BFS community don't know where to turn for support or help. If some of this work can create those resources then everybody benefits."

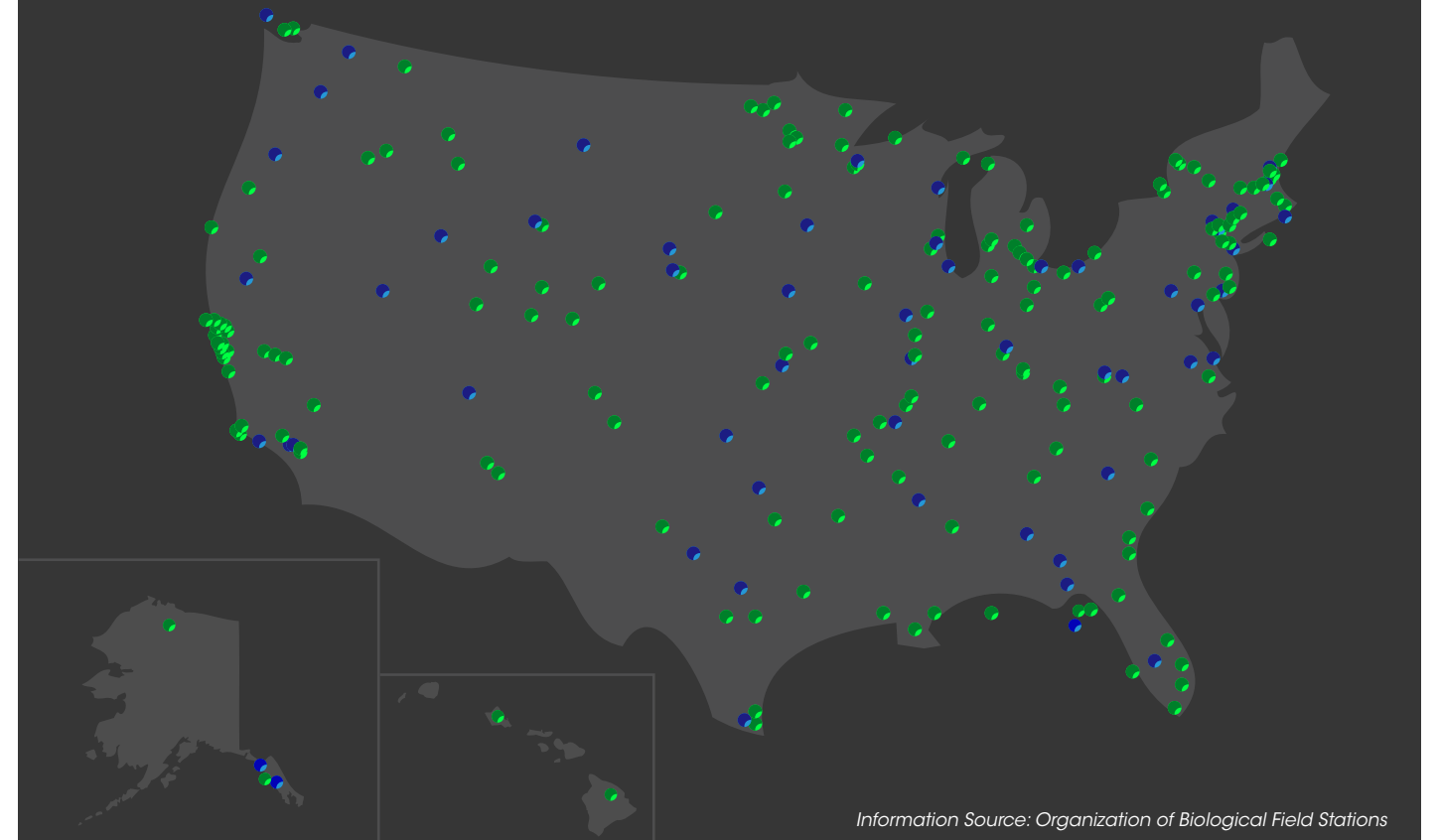
MOVING AHEAD TO MEET THE CHALLENGE

The team's pilot study results are published in a recent paper.

"The data in the published paper was from 20-some stations, and our current, ongoing study is over 160 stations with over 350 educational programs across the country," explains Dr. Zarestky. "We learned from that pilot study that the issues were

FIELD STATIONS NEAR YOU!

Station Member of OBFS
Non-Member of OBFS



Information Source: Organization of Biological Field Stations

just so much more complex than we were able to capture in that smaller sample. We really needed to figure out a way to capture some of that complexity."

The ongoing challenge right now is how to process the diverse data.

"We've got data on field station descriptive characteristics, funding, distribution of resources, number of personnel hired, number of programs run, training, all the different design elements of a program," details Dr. Zarestky. "It's so complicated that it's a little bit slow for us to see patterns emerging. I think the biggest surprise is how much diversity there is in these programs. To accurately process the data in a way that we can make sense of things that matter to the people who represent all of this diversity, has been really a learning experience for the research team."

Ideally, the team sees their work helping to usher in a new, two-pronged approach to field stations as both scientific infrastructure and human resources investments which will demand skill building and mentoring.

"We really need a body of professional development resources," remarks Dr. Zarestky. "From the data we're analyzing now we're getting some big picture ideas of how complicated it is. The next step will be figuring out how to turn that into resources field station personnel can use to do a better job with their

educational outreach based on whatever a better job means for them in their field station."

The team already knows there is a need for their research.

"That's part of why the project is so well-received by the Field Station community," states Dr. Zarestky. "To have an almost 50 percent response rate on a survey that can take about 2 hours—people don't do that unless they see the value of it. I think there's a real need for this in the community and that community is becoming acutely aware of it."

The larger public also has a lot to gain from well-equipped biological field stations staffed with people trained to educate.

"One of my favorite findings was that approximately 78 percent of the U.S. population lives within 60 miles of a biological field station, and 98 percent lives within 120 miles," emphasizes Dr. Zarestky. "Most field stations want people to come visit. They want to show off their science. Field stations exist in these sites because they are unique or important in some way, and that's worth knowing about. This is a tremendous opportunity and I think we have a lot more bandwidth to increase."

"I'm hoping that some of the value of this work is going to be helping scientists think a little bit more about how they can leverage their research and their space to connect with people," adds Dr. Zarestky. ^{KL}

Photos: Rachel A. Short

Graphics: Joshua Pene / Fondriest Environmental

Underwater ROV Program Inspiring Youth



This summer, the Shedd Aquarium team began to reach out to local communities in a new way. They ran excursions on Lake Michigan and the Chicago River using ROVs equipped with underwater cameras to introduce land-dwellers to what's underwater.

Shedd Aquarium Learning Programs Manager Sadie Norwick and Communications and Public Relations Coordinator Kayley Ciocci spoke to EM about Shedd's innovative ROV public programming.

INSPIRING CONSERVATION WITH TECHNOLOGY

The pilot programs using the ROVs began in 2018, but the Shedd team has been using ROVs to educate the public for about 10 years.

"Our longest-running program is our Shedd Underwater Robotics Club Program," explains Norwick. "We work with local schools to connect teachers and students to engineer, build, and design their own robots. We fill the program every year and have a waiting list."

The program allows students and teachers to work with underwater robots—not for one day, but all year long.

"We give teachers all the curricula, supplies, and support they need to build the robots," details Norwick. "Then they return to school and start their own in-class or afterschool clubs. Towards the end of the school year, all the clubs from the entire area, across all grades, get together to showcase their robots, get them in water, and connect with scientists and others that use underwater robots in their work."

Underwater robotics allows students to envision themselves in a wide range of possible future careers while learning about science, technology, engineering, and math.

"The need to waterproof the robots is an additional challenge," Norwick describes. "These students are incredible, and it's not only the engineering and science process. We also see teamwork, communication, and leadership—those skills that students are going to need to be successful in life emerge through programming like this."

SPARKING COMPASSION AND CURIOSITY

The Shedd team uses a relatively simple ROV, the VideoRay Scout, to "hook" new learners of all ages.

"It's a professional grade ROV that's very easy to use, and is an easy way to connect our learners to the underwater world," details Norwick. "It allows teens in our High School Marine Biology Program, for example, to really be immersed in being a field scientist for a week. They learn many different scientific techniques, including using an ROV for research."

The unique challenges the team faces in the Great Lakes region enrich Shedd's outreach work—and meeting those challenges prompted the team to use ROVs in programming.

"One challenge we face is awareness, getting our community connected to our waterways," details Norwick. "We did the urban programs this summer to get more people to see what's under the waves. We were intentional about using ROVs. You don't have to dive in or have SCUBA or even snorkel skills; you can just connect right away and see fish and plants. Creating that little spark of compassion and curiosity helps lead to conservation."

This broad approach pays off for the Shedd, sometimes in unexpected ways. For example, the team now uses custom ROVs that can't be found anywhere else—thanks to their programs.

"In addition to the VideoRay, we have various student- and teacher-made ROVs that have been built here throughout the years," Norwick mentions. "Those are some of my favorites because they're the most creative. An ROV can be simple, just some motors, or you can add lights and cameras. They can be designed and engineered to perform whatever task you want them to. The innovation created by students is very impressive."

The Shedd team hopes that more people—whether they're scientists or not—will use ROVs to explore the world beneath the water.

"Technologies like this can go places that people can't, and connect us in really unique ways to a whole new world underwater," remarks Norwick. "There are so many opportunities, for exploration, for fun, for careers. It's a really exciting technology to explore and to have, and they can come check it out here at the Shedd." ^{KL}



Photos: Shedd Aquarium

Diversity Dominates on the Coast

Mendocino College Coastal Field Station; Ukiah, CA

Mendocino College is a 2-yr college in the California Community College system with great dedication to encouraging its students to pursue science and fieldwork. The area has many diverse and beautiful habitats, including intertidal zones and coastal prairies.

"We take pride in our ability to get our students out in the field for hands-on experiential learning activities at our Coastal Field Station," says Dr. Steve Cardimona, Professor of Earth Science at Mendocino College and Chair of Mendocino College's Coastal Field Station Committee. "As we are a Hispanic Serving Institution with a population that is a larger percentage female, many of our students are under-represented in the sciences."

Biology instructor Dr. Brianna Zuber gets her classes out to perform ongoing monitoring of the health (diversity) of the local intertidal zones. Zuber has also recently begun some studies of the California Coastal Prairie.

"We try to give our students hands on experience like they might get if they were in the field as citizen scientists, except the experience is part of their classes," explains Cardimona.

Different species are monitored in the very different habitats of intertidal zones and coastal prairies. "Sea stars are one of the major species we monitor. We are looking for species diversity health as well as looking for signs of sea star wasting disease in the intertidal areas," says Cardimona.

One of the California Coastal Prairie species being carefully monitored is the non-native, invasive ice plant. "The ice plant was introduced for erosion control, but it turns out it has the opposite for the coastal bluffs," says Cardimona.

External groups have utilized the College Coastal Field Station site for specific environmental monitoring, such as UC Davis for sea-surface current monitoring and GPS instrumentation as a part of the broader Plate Boundary Observatory administered by UNAVCO, and complementary diver groups from UC Santa Cruz and Reef Check California.

"In the future, we plan on continuing to gather monitoring data and build our databases, in part by installing a similar weather station at our coastal field station," says Cardimona.

Another, larger goal of the Mendocino College Coastal Field Station is the continuing support of the Math, Engineering, Science and Achievement (MESA) program at Mendocino College. MESA seeks to provide encouragement and help for students interested in pursuing a four-year degree in math, science or engineering.

In his 17 years at Mendocino College, there have been some unique happenings during the course of doing fieldwork. "About a year ago, my biology colleague Brianna Zuber was on a bluff with our marine biology class, observing harbor seals, and incredibly, they saw the birth of a harbor seal pup," he recalls fondly.

Cardimona looks forward to many more years of introducing Mendocino College students to field work at their Coastal Field Station and supporting many more budding scientists, especially those from underrepresented groups. "I also hope to connect the world with small colleges and field stations," he says. ^{LB}



Photo: Dr. Brianna Zuber, Spring 2018

CB-50 DATA BUOY

NexSens Technology's Latest Water Quality Buoy



The NexSens CB-50 Data Buoy is designed for quick and easy deployment as well as retrieval in lakes, rivers, estuaries, and coastal waters. The buoy is in use worldwide for limnology studies, source water protection, compliance monitoring and emergency response. The buoy can be deployed from small boats, large vessels or even helicopters, making it the ideal choice for applications where water needs to be monitored at a moment's notice or in situations where larger platforms will not work.

When fitted with the NexSens X2-SDL Data Logger, the CB-50 is compatible with a variety of instruments including turbidity sensors, dissolved oxygen sensors, temperature strings, hydrocarbon sensors, fluorimeters, multi-parameter sondes, and more. The X2-SDL supports (16) D-size alkaline batteries, and in many situations, provides adequate power for an entire project or season without the need for battery replacement. No solar panels are needed, which further support the compact size and low profile.

The buoy is often deployed with 3/8 chain and a 50 - 70 lb anchor from an integral bottom eye as a single point mooring. Built from the same materials as the larger CB-series buoys including a 316 stainless steel frame, closed cell polyethylene foam and an abrasion resistant polymer coating, the CB-50 will endure the roughest of seas.



All Photos: NexSens Technology

NAVIGATION LIGHT

The optional solar marine light has a one to three nautical mile range and securely mounts to the buoy's top plate for maximum visibility.

BUOY HULL

Constructed of cross-linked, closed-cell polyethylene foam with a heavy polymer skin, the buoy is abrasion resistant and designed to last for years.

DATA LOGGER

The CB-50 accommodates the NexSens X2-SDL submersible data logging system, which includes an integrated power supply and optional wireless telemetry.

BUOY FRAME

An indestructible, heavy-wall 316 stainless steel frame provides support for the foam hull. The frame can be fitted with sacrificial zinc anodes.



RESTORATION, TESTING, RESEARCH AND EDUCATION

BY KATELYN KUBASKY

Fondriest Center for Environmental Studies; Beavercreek, Ohio

A few years after Ohio became a state in 1803, George Harner arrived in Greene County with a land deed signed by then-President Thomas Jefferson and Secretary of State James Madison. The homestead was largely old forest and wetlands and also included a fen-fed stream—the Beaver Creek.

As was the case with much of the Ohio Territory, the forests eventually gave way to land clearing and grain farming. Harner's descendants, including his son John and John's wife, Sarah Koogler, continued to work the rich soil for many years to follow.

Much of the original property and surrounding land has fallen prey to urban sprawl. However, several protected areas remain today, including the Beaver Creek Wetlands, Koogler Wetland/Prairie Reserve, Beaver Creek Wildlife Area, Siebenthaler Fen, Fairborn Marsh, and the newly-established Fondriest Center for Environmental Studies.

Fondriest Environmental, a leading supplier of monitoring products, purchased a 72-acre tract in 2014 which serves as the site for the field station. The Fondriest team then initiated a large restoration, including invasive species removal, sustainable agriculture practices, and erosion control measures.

The team also added a stocked lake with native shoreline plantings, and preserved a mid-19th-century timber-framed barn onsite. The facility and conference center supports a wide range of uses.

This new biological field station initiative is consistent with the company's vision and values and has become an essential part of the business strategy. The technology deployed at the station showcases some of what is possible in the field.

A real-time network of monitoring sensors collects, records, and transmits environmental parameters from specific areas of concern to the cloud. Data is presented on flat-screen displays in a conference center and is available to researchers, visitors, and the public. Water level, water quality, stream flow, and weather conditions are continuously recorded. Several environmental webcams capture video and still images for continuous visual record and can be accessed remotely.

PRODUCT AND SYSTEM TESTING

The Fondriest field station represents more than an ethics of sustainable environmental practices. It is also an expression of our company commitment to reliable products that have been tested and optimized in the field to meet actual conditions.

Fondriest engineers and scientists use the facilities and property to test new and existing products and technologies in real-world deployments. This field testing helps certify product performance and sensor accuracy for both company products and the many brands the company supplies. This hands-on work exposes the R/D staff to many of the uncertainties and obstacles associated with field deployments and ultimately leads to more reliable and easier-to-use products and systems.

SET UP AND TRAINING

One of the greatest uncertainties for field scientists and other professionals deploying equipment is how it will work in action. Industry professionals regularly visit the Station for training with Fondriest application engineers.



The Fondriest Center for Environmental Studies is home to many forms of wildlife such as chipmunks, deer and Monarch butterflies.

Calibration, systems integration and deployment training sessions are available for technicians before equipment is shipped to the project site. With this approach, personnel can be fully prepared and knowledgeable before a project begins.

EDUCATIONAL OUTREACH

Station staff work with K-12 programs to support experiential learning through sampling and monitoring. Staff scientists guide students in activities like the deployment of a data buoy that records water quality data and using water quality meters. Real-time data collected at the station is available to students and teachers on mobile devices and computers, allowing for field data review and analysis in the classroom. Programs like these provide excellent opportunities for students to foster an interest in the environment and grow into passionate scientists as well as the environmental stewards of tomorrow.

UNIVERSITY RESEARCH

Fondriest scientists and engineers support local universities to prepare science students for professional careers. They attain

Application scientists install sensors at the station.



All Photos: Fondriest Environmental

valuable skills by learning the techniques and methods for sampling and environmental monitoring that many organizations perform regularly. Graduate and undergraduate students can perform studies from start to finish by developing a plan, carrying out the research and presenting data and results.

NATURALISTS

Whitetail deer, coyote, waterfowl, raptors, and other wildlife make their home near the field station and in the surrounding areas. Habitat restoration efforts include the installation of bluebird and duck boxes, the maintenance of native wildflower meadows, the construction of a fish structure, invasive plant removal, and boundary planting of native grasses. A honey bee apiary located on the property encourages pollinators and, in turn, helps to maintain a balanced ecosystem.

A lake provides habitat for native fish, frogs, snakes, and turtles, and is monitored in real-time with a NexSens CB series buoy for water quality and weather conditions. The water level is continually recorded at the outfall along with rainfall and other weather parameters. The data are available 24/7 at the datacenter.

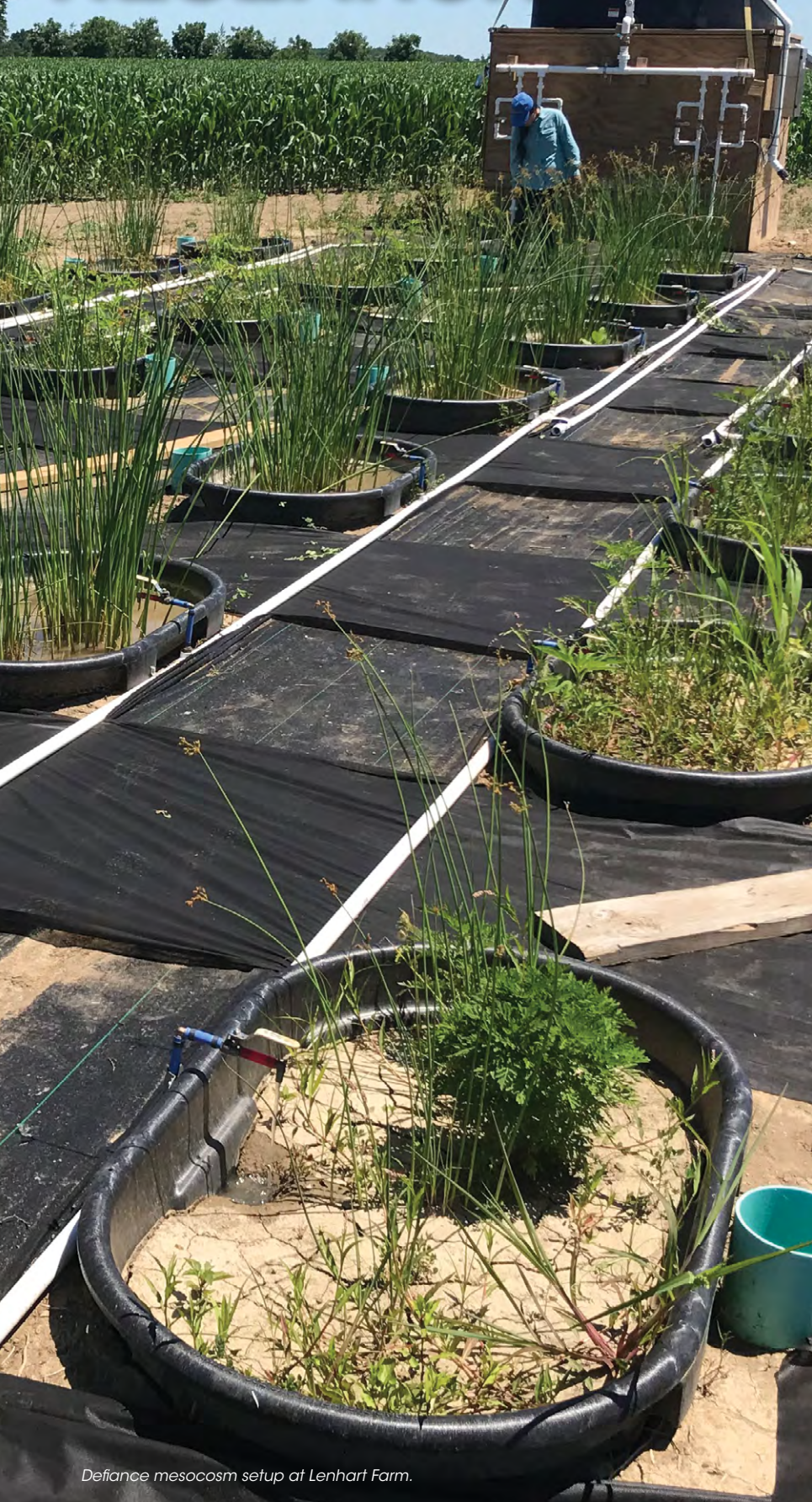
Members of the Fondriest staff as well as local citizens serve at the station as naturalists. The group documents intriguing flora and fauna, which are uploaded and presented on WQData LIVE web datacenter. The data center is accessible on any platform with internet and gives the flexibility of mobility and data upload in the field.

CONFERENCE CENTER

With ample meeting space, a full kitchen, restrooms, sleeping quarters, and a large study/workspace with great views of the natural areas surrounding the site, visiting scientists and special interest groups find the center accommodating and inviting. Extensive care and thought went into the restoration, from the hand-built fixtures to the handsome timber wood that was preserved from the original structure.

The staff works with local organizations and special interest groups that are dedicated to conservation and restoration of the natural areas surrounding the property. The conference center is a great space for groups like these to meet and discuss future plans. Learn more at fondriest.com.

BLACK SWAMP RESEARCH



Defiance mesocosm setup at Lenhart Farm.

How Bringing Back Conquered Wetlands Could Help Solve Harmful Algal Blooms.

BY LORI BALSTER

Once submerging about 1,500 square miles of northwest Ohio, the Black Swamp was viewed as an enormous nuisance that made settling the region difficult for hundreds of new arrivals seeking new lands to build homes and raise families. After about 40 years of extremely hard labor and a few key technological advancements such as drainage tiles, the Black Swamp was emptied and its wetlands destroyed. Underneath the swamp waters lay some of the most nutrient-rich and productive farmland in the world. The families, who now had plenty of room to raise houses, fence off pastures and grow crops became fruitful and multiplied, establishing the Lake Erie region as an agricultural powerhouse for almost the next two hundred years.

All the farming success, however, had a cost. Fertilizer components such as nitrogen and phosphorus, while making high-quality, productive soil even more productive, also ran off into surrounding waterways. Nutrient levels became too high in the waters, causing Harmful Algal Blooms (HAB) that depleted oxygen and contaminated drinking water, killing fish and rendering water undrinkable for surrounding farms and towns. As climate change increases average water temperatures around the globe, HABs are becoming more frequent and more intense in Lake Erie, especially since 2011, as elevated temperatures only encourage algal growth. The Lake Erie HAB of 2014 rendered Toledo residents' water undrinkable for days. While HABs wax and wane with the seasons, the overall trend each year is in the direction of worse HAB effects. A simple solution, however, seems elusive: on the one hand, farmers use nitrogen and phosphorus-laden additives to boost farm productivity. On the other hand, nitrogen and phosphorus are also the reason behind HABs, which can poison the water supply. Farmers depend on the productivity of their land to produce the crops thousands of people rely on. However, these are some of the same forces that cause HAB and contaminate the waters. Any solution must maintain farm productivity, while also preventing—or mitigating—HABs. But does such a solution exist?

World-renowned wetland ecologist Bill Mitsch, Eminent Scholar and Director of Everglades Wetland Research Park, College of Art & Sciences, and Sproul Chair for Southwest Florida Habitat Restoration at Florida Gulf Coast University, believes there is. And he believes the revived Black Swamp, a source of so many obstacles for the region's original settlers, may show the way towards maintaining farm productivity and tackling HAB.

"Basically, you have to use the land itself as the solution. Nothing else is really effective or practical," says Mitsch. "Wetlands are fantastic at removing excess nutrients and contaminants from waterways. If the Black Swamp area wetlands were partly restored, we would go a long way towards correcting the HAB problems we are seeing more and more of today. But we need wetlands that are compatible with still maintaining productivity of the Lake Erie area's farms."

The Lake Erie region isn't the only region that could benefit from the approach of resurrecting wetlands long supplanted by agriculture and development. "There are parallels in Lake Taihu in China, in the Florida Everglades, in Toronto and other places all over the globe. My colleagues and I have set up mesocosms in several geographical locations to prove that this idea could work and that we could scale it up to solve real HAB problems that the Lake Erie region and other areas are confronting right now, and will continue to confront in the future," Mitsch explains.

At each site, there are 28, plastic, 100-gallon, Rubbermaid™, tubs each of which represents a physical model of a wetland. There are four conditions, with seven replicates for each condition. Seven replicates are high water (standing water above the soil) with high flow rate, and seven are high water with low flow rate, seven are low water (moist soil but no standing water) with high flow rate and seven are low water with low flow rate. Water is fed, by gravity, into and drained out of, the mesocosms every

Bill Mitsch's PhD student BingBing Jiang taking water quality samples at Defiance Ohio wetland culture experiment, May 2018.



All Photos: Bill Mitsch

week. Each mesocosm is one square meter in size, thus making calculations easy. The Defiance site is unique, however, in that it has an in-flow control system that allows Mitsch, his students and staff to control water flow remotely. The in-flow control system was designed by Fondriest Environmental. The system can be controlled via laptop or phone.

"Having our remote system in Defiance has been tremendously helpful," says Mitsch. "The site is far away from many of our other activities, so not having to make the three-hour drive from Columbus required to reach the site is a huge time saver."

The Defiance tubs have been equipped with devices that allow data to be uploaded and valves to be controlled remotely. Water is fed into the tubs from a 1,500-gallon tank via gravity. The input of water into the mesocosm and output of water are both measured. "We can put in a designated amount of water per week," says Mitsch.

Although the Defiance site water flow is controlled remotely, water quality sampling is still performed manually. Mitsch's water quality samples are then sent to his lab in Naples, Florida. Water quality samples are taken every other week.

Nutrients measurements include total nitrogen and phosphorus. Both total and reactive phosphorus are measured as well as total nitrogen and nitrate. "These are potentially tied to the HAB," says Mitsch.

The nutrient samples are packed in ice and are sent express mail to the Mitsch's south Florida lab in Naples, where they are analyzed by a British-made SmartCam autoanalyzer system. All of Mitsch's sites use the same lab.

"Interestingly, we have found that the low water versions of the mesocosms are taking up more phosphorus than the deep water ones, at least at Buckeye Lake," Mitsch adds.

Two loading rigs are used for mesocosm system water flow. The low flow version is 10 cm per week, and the high flow rate is 30 cm per week. For comparison, precipitation (rain and snow) contribute an average of about 2 cm per week at the Ohio sites and slightly more in Florida.

The two water depths are independent, and they are determined by the height of the outflow standpipes next to the tubs, with the longer pipes (20 inches) giving their mesocosms standing water, and the shorter pipes (16 inches) giving their mesocosms no standing water, just moist soil. PVC elbows are under the tubs, and the pipes are attached to the elbows. Larger diameter pipes surround white standpipes, protecting them and allowing easy removal of the standpipes to change the water levels if needed.

The two conditions of either standing water or no standing water lead to distinct differences in the mesocosms. "The standing water ones lead to aerobic conditions, the ones without standing water are mostly anaerobic," Mitsch explains. "Also, the standing water ones will choke out non-wetland plant species, while favoring wetland vegetation. Soft-stem bulrushes thrive in standing water conditions, but most other plants don't. If you look at the tubs with no standing water and just moist soil, you can readily see more grass species and other plants growing in there."

Soft-stem bulrush was planted in October 2017 in mesocosms in the Defiance site and continues to dominate in the deep-water mesocosms. The mesocosms with moist soil now have many other varieties of plants surviving, some not wetland plants, which is clear even with a cursory visual inspection.

The water Mitsch uses in his mesocosm setups is from nearby ditches or rivers discharge areas that normally receive nutrient-laden runoff. Every week, water is added to the system by pumps and then to the mesocosms by gravity.

"Starting around February and through May or June, the ditches are filled with water," says Mitsch. "They're full of phosphorus and algae flowing to the Maumee River and on to Lake Erie! It's the same algae and nutrients that are trashing Lake Erie."

But Mitsch may change all that if his mesocosms are scaled up in the future and put to work in the former Black Swamp region.

"Early results from our mesocosms in Defiance have been shown to remove 80 percent of the total phosphorus in the water, which is pretty impressive," Mitsch points out. "The phosphorus is absorbed by both wetland plants and the soil. It is an ecosystem effect, not simply due to the plants or soil by themselves."

Even so, taking productive land out of commission to reintroduce wetlands that produce no commercial crops has been a tough sell for area farmers. While they want to address the HAB problem, they don't want to produce less food and make less profit.

Pipe draining farmland in former Black Swamp region into a drainage ditch, mid-June 2018.



If the Black Swamp area wetlands were partly restored, we would go a long way towards correcting the HAB problems we are seeing more and more of today. But we need wetlands that are compatible with still maintaining productivity of the Lake Erie area's farms.



- Bill Mitsch
Scholar and Director of Everglades Wetland Research Park

"What we want people to realize is, we're not suggesting that land be permanently taken out of commission to make wetlands. For our mesocosms, if you take the standpipe out, the mesocosm will go back to being dry farmland again. We're advocating flipping the land. Have a wetland area, then after three years flip it back to dry land. Farmers will also save money since they won't need to fertilize their fields in that case, since the wetlands have already pulled up all the phosphorus out of the ditches and other runoff water. That phosphorus is then available to crops after the land has been dried out and put back to use as farmland," Mitsch explains.

"We may need 100,000 acres," says Mitsch. "But it would all go in and out of rotation as farmland. In its wetland phase, the tile system can be corked up to create wetlands, and the cork pulled out if you want farmland instead."

Mitsch suggests farmers could get paid for conservation easements if they create wetlands. There could also be water quality trading or nitrogen trading credits. Also, farmers could get financial credit for taking phosphorus out of the environment.

"Wetlands are also the best ecosystem for removing CO2 from the environment," says Mitsch. "Farmers could get carbon credit for removing carbon from the atmosphere as well. They could buy or sell carbon credits. So farmers could get credit for saving fertilizer, get conservation credits, water quality credits and carbon credits."

"I've been intrigued about 'fixing the planet' since the very first Earth Day in 1970," Mitsch reflects. "I had an engineering degree, but I knew nothing about the environment. I decided I was going to learn about it. I've been learning ever since." ^{LB}

Photo: Bill Mitsch

THE RIVER STATION

BY LORI BALSTER



Thomas More Biology Field Station; California, KY

In 2017, Thomas More Biology Field Station, a member of the Organization of Biological Field Stations (OBFS), celebrated 50 years of river research. Christopher Lorentz, Professor of Biological Sciences at Thomas More University and Director of the Thomas More Biology Field Station, has a milestone of his own to celebrate. "As of 2018, I've been involved with the Field Station for 25 years," says Lorentz. "In the time I've been here, we have seen a positive shift in many areas. We've seen measurable improvement in the water quality here, increased interest in the river and a greater acknowledgment from the public about the importance of the Ohio River."

The Thomas More Biology Field Station is located on the shore of the Ohio River, one of the first U.S. commerce routes. "We cooperate with greater Cincinnati and northern Kentucky waterworks. We are upstream of Cincinnati and Kentucky, so we act as an early warning system for the drinking water aspects of the river," Lorentz explains.

"Biomonitoring and assessing the river is a major research focus for us," Lorentz says. "Monitoring for blue-green algae and Harmful Algal Blooms (HAB) is also one of our most important goals. The last major research focus is conservation of aquatic organisms, a big one for us being freshwater mussels."

Eastern hellbenders, the largest salamander in the eastern U.S., are a protected species that the BFS raises to ultimately increase their numbers in the wild.

Photo: Bruce Crippen

"We have a 24/7 flow of river water into our labs," says Lorentz. "The river water also brings in plankton for analysis and we also have data sondes that give us water chemistry information for constant monitoring. Fondriest provided us with an applet which allows our website to provide real-time monitoring data." Monitoring equipment used at the Thomas More BFS includes a YSI EcoSens 9500 photometer in the lab; two data sondes, YSI 6920 and YSI 6600, in the two constant flow river tanks and several YSI Pro Plus field units. From May to October, a wireless camera system mounted on the side of the river takes river pictures every 30 minutes. Lorentz credits Mike Waters of Northern Kentucky University for development of the camera system. The frequent pictures help to monitor for formation of HAB.

Lorentz also participates in the Ohio River Basin Alliance and also is active in ORSANCO.

Thomas More BFS has also worked to do its part to raise awareness of the public to the importance of clean water and river health. Recently the University has invested in the Field Station with a new STEM Outreach Center. "Alongside our research, we do a substantial amount K-12 outreach to local schools and we work with local watershed groups, like those for Licking and Banklick Rivers," Lorentz says.

Having provided high-quality river research to the region for over 50 years, coupled with STEM outreach to the public, Thomas More BFS researchers seem poised to tackle the next 50. ^{LB}

RESEARCH AND EDUCATION AT MAGPIE RANCH



BY LORI BALSTER

Bob and Mary Neher Montana Research Station; Drummond, MT

Pablo Weaver, Assistant Professor of Biology at the University of La Verne in California and Director of the Bob and Mary Neher Montana Research Station, could win a prize. "If they gave out a prize for farthest driving distance from your university office to your biological field station, I'd definitely have that one clinched," says Weaver, laughing. From La Verne to the field station is a 16-hour drive, about 1,100 miles. "People ask why we have an interest in a field station that's so far away from our university base. The answer is really pretty simple: it's a world away from our university, with its own unique environment and culture. It allows our students to experience something completely different from our southern California college campus. They really get out in the wild and immerse themselves in the science."

Students have always been integral to the field station. "In fact, Bob Neher built the field station with the help of university students," says Weaver. The 187-acre field station was created 25 years ago by Bob Neher to provide research opportunities for students. This summer there will be 16 undergraduate students at the field station: 3 chemistry majors and 13 biology majors.

"The chemistry and biology students have different research objectives," says Weaver. "While the chemistry students will be

looking into heavy metal contamination, the biology students will focus on evaluating stream health and looking at wildlife, such as cavity nesting birds at Clark Fork River."

Heavy metal contamination is of special interest because the field station is located near the former copper mining towns of Butte and Anaconda. Area headwaters start in Butte and Anaconda then go to the Clark Fork River, which has several Superfund sites. "Silver Bow Creek and Warm Springs were historically heavily polluted due to the copper mine," Weaver adds.

Anaconda also has other claims to fame. It has a manmade structure that is a big point of interest. Or rather, the tallest. "We have a historical smokestack here that is the tallest masonry structure in the world," says Weaver. "At 585 feet, it's taller than the Washington monument. Also, the movie 'A River Runs Through It' was filmed in the area and talks about the town of Anaconda and the politics of the time."

This summer, the undergraduate chemistry students will be looking at copper, cadmium, zinc and lead levels in the soil around the old mining operations for their summer work. The chemistry group has been looking at potential heavy metal contamination in surface soils and in bird feces. The bird feces will give a sense of any metals making their way up the food web.

The undergraduate biology students, on the other hand, will be using kick nets, Surber samplers, and scrub brushes to evaluate the health of benthic systems in the area. They will be using the Hilsenhoff Biotic Tolerance Index to identify samples with a high

Photo: Pablo Weaver



La Verne students sampling benthic insects at Carpio Creek, Montana.



Magpie Ranch, part of the Bob and Mary Neher Montana Research Station along the Clark Fork River, Granite County, Montana.

degree of pollution-tolerant organisms and thus higher levels of mining contaminants.

Weaver and the biology students will also be looking at the EPT Richness Index of field station waters, which can be expressed as the percentage of the sensitive orders (Ephemeroptera, Plecoptera and Trichoptera) to the number of chironomid taxa found. "The mayflies, stoneflies and caddisflies are not very tolerant of pollution, but the true flies, in particular, the Chironomidae, are much more tolerant," Weaver explains. "The more diversity we see, the better."

The Superfund sites on Clark Fork River have already undergone significant restoration. Wetlands were reintroduced in the early 2000s. Creek meandering was reintroduced, and Milltown reservoir was taken out. The dam was also removed.

"Samples are collected from the headwaters down to Missoula, which is about 250 kilometers," Weaver mentions. Samples will be compared to those obtained at the reference site, which is at Rock Creek. "The waters of Rock Creek are pristine," explains Weaver. "That's the site where they filmed the fly fishing scenes from 'A River Runs Through It.'"

While the students are not yet gathering pH, water temperature and other types of water chemistry data, there are plans to incorporate such data in the future. YSI multiprobe instruments are being used for gathering field data for teaching demonstration purposes and will soon be incorporated into student

La Verne biology students collecting benthic insect samples in the Clark Fork River, Montana.



Photos: (left) Monica Rios, (right) Bob Neher, (bottom) Pablo Weaver

research. The field station is currently collecting weather data using an AcuRite 01036M model weather station.

"In terms of the insect diversity, it is interesting to note that the diversity has been good since we started collecting data in 2010, much different from the 1990s soon after smelting operations ceased," Weaver observes. "We've been seeing good diversity in mayflies, and that's been true for the stoneflies and caddisflies also."

While there were still plenty of fish kills in the Clark Fork River in the 1990s, by the 2000s the fish populations were making a comeback. "Today, we have healthy rainbow trout and brown trout populations, and fly fishermen come here on guided fish tours," says Weaver. "Rock Creek has been designated as a Blue Ribbon fishery." The Blue Ribbon designation is given by the U.S. government. It is only given to recreational fisheries of exceptionally high quality.

In addition to improvements in the fish populations due to restoration work, wetlands have returned to field station areas as well. Wetland birds such as kingfishers, flycatchers, red-winged and yellow-headed blackbirds are now commonplace, as well as birds of prey that hunt fish, such as ospreys and bald eagles.

Restoration work has resulted in the return of native willows, cottonwoods and aspens. Elk, white-tailed deer and beavers have since returned to the site. "We also have river otters, coyotes, black bears and yellow-bellied marmots," Weaver adds. Moose and bighorn sheep can also be found at Rock Creek.

In the future, Weaver and the other researchers would like to have programs at the field station year round.

While Weaver enjoys many things about the Bob and Mary Neher Field Station, one of his favorites is the wildlife. "Montana has great mammal life. Our field station is also just four hours from Glacier and Yellowstone."

Currently, Weaver is in the early stages of working on a bluebird paper. "I'm also looking for collaborations with more researchers and students. I'd like to get more students, teachers and researchers up here at our field station," he emphasizes. "I encourage anyone interested in doing research to come and pay us a visit." LB

FROM ACID RAIN TO CYANOBACTERIA



BY LORI BALSTER

The Cary Institute of Ecosystem Studies; Millbrook, NY

Steve Hamilton is a freshwater ecologist at Cary Institute and professor at Kellogg Biological Station, a member of the Organization of Biological Field Stations (OBFS), at Michigan State University. Hamilton explains, "Environmental monitoring is how ecologists keep a finger on the planet's rapidly-shifting pulse. By tracking ecological indicators over long timescales, we can identify patterns and better understand how ecosystems are changing. This understanding will guide us as we work to adapt to and mitigate environmental degradation."

The discovery of acid rain in North America by Cary Institute founder Gene Likens is a case in point.

"In the 1980s, the pH of precipitation (rain and snow) in the eastern United States was surprisingly acidic – a pH of around 4.3," says Hamilton. "By monitoring precipitation chemistry in the White Mountains of New Hampshire, and then in Ithaca, NY, Likens was able to link increasing air pollution from sources such

as vehicles and power plants with rising precipitation acidity. This finding, a product of environmental monitoring, helped underpin the formation of the Clean Air Act."

Since the passage of the Clean Air Act, precipitation has become far less acidic and is now closer to pH 5. For reference, water with a pH of 4.3 has five times the acidity of water at pH 5.

Today, Cary's freshwater monitoring program spans local to international scales – starting with a stream that runs through the Institute's property, Wappinger Creek, which has been monitored since the 1980s.

Victoria Kelly is the Environmental Monitoring Program Manager at Cary Institute. Kelly says, "A concerning trend that has emerged from the Wappinger Creek dataset is increasing salinity – the result of salt treatments applied to icy winter roads. Salt accumulates in the soil and groundwater and can take decades to flush out. Salt pollution threatens drinking water and ecosystem health."

To continuously measure salinity in Wappinger Creek, researchers use a conductance probe because the electrical conductivity of water is dominated by road salt. Campbell Scientific

sensors are used to continuously measure water level, water temperature and specific conductance for the Wappinger Creek monitoring. By documenting the fluctuating salt concentrations and identifying their ecological effects, Cary scientists help build the case for smart road salt application among regional municipalities.

Kelly explains, "Without long-term monitoring of salinity in Wappinger Creek, it would be difficult to connect road salt contamination with other ecological effects. These data show us that salt concentrations are increasing in the environment. This raises a red flag. Without better management, the trend will intensify, putting streams and aquatic life at greater risk. We share this information with managers and recommend best-practice strategies to help achieve safe winter roads as well as healthy streams."

Cary research follows Wappinger Creek from Millbrook into the Hudson River – a continuous monitoring effort that now exceeds 30 years.

Hamilton is a collaborator on the Hudson River program. He says, "Cary scientists help maintain a network of automated sensors on the Hudson in partnership with the Hudson River Environmental Conditions Observing System (HRECOS). These long-term datasets illuminate overarching trends across the Hudson ecosystem; water quality and invasive species are two top areas of monitoring."

During the ice-free season over the past 30 years, Cary researchers have sampled the river to measure a range of water quality indicators including nitrogen and phosphorus levels, algal biomass, sediments, conductivity, and populations of phytoplankton and zooplankton. Sondes are used to measure pH, conductance, dissolved oxygen and chlorophyll at various depths. YSI EXO sondes, as well as a YSI ProODO meter, are used for the Hudson River work. A YSI EC300 field meter is also used to measure conductivity.

Cary aquatic ecologist Stuart Findlay leads a network of citizen scientists who monitor submerged aquatic vegetation throughout the freshwater portion of the Hudson River.

Findlay explains, "Native water celery beds are especially important as they provide essential habitat for fish and other aquatic organisms. However, invasive species such as water chestnut



Left: Dr. Stuart Findlay and David Fischer collecting a sample of microzooplankton with a plankton net for the NSF-funded Long-term Research in Environmental Biology project. Right: Dr. Kathleen Weathers of Cary Institute with a sediment core retrieved from beneath an ice-covered lake.

are robbing water celery and other native plants of resources, making it difficult for them to survive. By maintaining long-term records of aquatic vegetation – including the location and condition of native beds – we can help managers better conserve native plants and target invasive species management efforts."

From local stream monitoring to sampling the entire length of the Hudson River, Cary freshwater research extends into international waters with programs like the Global Lakes Ecological Network (GLEON). Co-founded by Cary ecosystem ecologist Kathleen Weathers, GLEON is a grassroots network of lake researchers, managers, and citizen scientists studying lakes around the world. Monitoring buoys on these lakes collect information on water quality, weather, and gas exchange between lakes and the atmosphere.

Harmful algal blooms—often composed of cyanobacteria—in lakes are a key research focus. Lakes are turning green as excess nutrients from industrial and agricultural pollution flow into water bodies and fuel cyanobacteria growth. These blooms can become toxic – rendering freshwater undrinkable and unfit for recreation. Early warning of an impending bloom can help managers alert lake users to prevent human contact with toxic water.

Weathers says, "We are developing methods to forecast cyanobacterial outbreaks using satellite imagery and drones, paired with long-term on-the-ground data collected in lakes throughout the northeast. The efficacy of these systems relies on long-term environmental monitoring, which makes it possible to identify patterns and determine conditions indicative of an impending bloom." ¹⁵



Photo: Holly Ewing, Lake Sunapee, NH

Photos: (Left) Heather Malcom, mid-Hudson River; (Right) Midge Eliassen, Lake Sunapee, NH



ROCKY MOUNTAIN RESEARCH

Rocky Mountain Biological Laboratory; Crested Butte, CO

The Rocky Mountain Biological Laboratory (RMBL) has been a hotspot for a broad range of environmental variability. Perched near Gothic, Colorado, an old mining town, RMBL, affectionately known as “Rumble,” exposes scientists and students to mountain ecosystems at only 1160 meters’ elevation on the bottom of the Black Canyon, all the way to the top of Uncompahgre Peak, at 4360 meters.

Sitting pretty atop this natural theater for biodiversity is Executive Director and biologist Ian Billick. Dr. Billick spoke to EM about RMBL, some of their research projects, and what the biological field station is offering to the region and the scientific community.

THE FIELD STATION EMERGES

Dr. Billick sees the emergence of the field station as part of the development of modern science.

“In the 1800s, a lot of what we would consider pure biology was taxonomy; think of the British navy or Charles Darwin collecting organisms and documenting diversity,” explains Dr. Billick. “Ecology, the study of how organisms interact with their environment, emerged in the 1910s, as people began to want to study organisms in their natural context, not just collect them and take them back to Kew Gardens or for the British Museum. Field stations really started to emerge in the western US in the 1910s and 1920s, and RMBL was founded in 1928, on the tail end of this emergence of ecology.”

“In the late 1920s, Gothic offered one place where you could teach a mammology or botany course, and you could travel up and down this elevational gradient and show students so many different things,” states Dr. Billick. “Because it was an old abandoned mining town they didn’t have to spend a lot of money on buildings and laboratory space, they just moved into those old buildings. That’s how RMBL got started, and it began as a non-profit, so it’s always been run and operated by scientists.”

As science evolved in the 1950s and 1960s, a professional scientific class appeared—around the world, and at RMBL as well.

“In the 1950s, a cadre of hardcore *Drosophila* geneticists emerged,” details Dr. Billick. “Theodosius Dobzhansky, one of the founders of neo-Darwinian thought, spent time at RMBL. Many others did too through the late 1950s and early 1960s.”

After the Soviet Union sent Sputnik into space, the federal government pushed more money into sciences in the 1960s, and a large cohort of scientists started their professional careers in the early 1970s.

“We saw a lot of scientists start research programs, and these were kind of experimental programs often combined with long term monitoring,” says Dr. Billick. “For example, David Inouye started monitoring plant flowering times here in the early 1970s. Because it’s a beautiful location to which scientists are anxious to return to, we ended up becoming one of the centers for one of the largest collections of long term studies. What we see now is many scientists that come, often applying new techniques,

whether it’s genomics or protein work, and embedding them within the context of these long term datasets.”

LIFE AT RMBL

Like other large, active field stations, hundreds of researchers might be present at RMBL at any one time.

“We have about 250 scientists and students come through in a typical summer,” describes Dr. Billick. “Most of the biological systems are fully active in summer, and that’s when we get a lot of the students. So it’s sort of a combination of the academic schedule when the students are available and when the biological systems are active, that lead to that kind of intensive use in summer.”

This pace isn’t about to let up; the RMBL team won money to build new research laboratory space just over five years ago because of the interest in integrating long-term data with emerging laboratory techniques.

Undergraduates work at RMBL in several different ways.

“We have an undergraduate research program with 40 to 45 students, typically,” comments Dr. Billick. “They design a research project to do with a scientific mentor for approximately 10 weeks. They collect the data, and then they write it up. Scientists will also hire their research teams, so there will typically be another 40 to 60 undergraduate research assistants that help scientists collect data.”

In addition to their own pursuits, researchers and students at RMBL engage in community outreach.

“We have a visitor center that we run from early June into mid-September,” remarks Dr. Billick. “We do twice daily free tours, and we have about 15,000 people that will go through the visitor’s center each season. We had a day last summer when about 500 people went through in one day. We also have a number of programs that we do for our donors, paid tours in addition to the free tours, and students that write articles for the local newspaper.”

INNOVATIVE TECHNIQUES, NEW DISCOVERIES

One of the greatest strengths a field station like RMBL offers the community is the dynamic combination of long-term data and new technologies and ideas.

“With emerging technologies, genomics, and remote sensing, scientists from a lot of different disciplines can now ask questions out in the field that they couldn’t ask before,” explains Dr. Billick. “It’s opening up the kind of scientists that work at the Field Station. It’s going beyond just ecology and evolutionary biology to include medically-oriented scientists. Other researchers can take advantage of remote sensing. I think we’re kind of going through a change in field science.”

Dr. Billick should know. He came to RMBL as a student in 1988 and has observed major changes in the field since that time, such as the plummeting cost of genomic sequencing.

“We have one project where they are using natural variation in hundreds of thousands of plants to construct the genomes,” details Dr. Billick. “They break the chromosomes up into 50

BY KARLA LANT

Photo: RMBL



The Gothic, CO townsite in autumn.

different sections, and they put the plants out and measure everything about their phenotypes. The mechanics of constructing genomes from near-inbred lines, growing those in the greenhouse, putting them out in the field, being able to link phenotypic traits, and looking at genotype by environment interactions, these are techniques that people weren't even thinking of ten years ago."

Snow science and more advanced hydrology studies are finding their way to RMBL, including a NASA study.

"NASA has been developing radar-based approaches to measuring snowpack," states Dr. Billick. "Historically, snowpack is measured at SNOTEL sites, where they measure the weight of the snow. To know how much water is in the snowpack, typically you weigh it, but running scales all winter long up in the high country is not a simple thing. There's only a handful of places where they measure snowpack, but with climate change, snow accumulates in different ways at different times. NASA's been doing flights in April and using radar to estimate the water content and snowpack. We've had scientists that come out and dig snow pits simultaneous with the NASA overflights so that they can validate the radar measurements that they're getting and ideally use that to improve the forecast for water runoff and water availability on the Colorado River."

Isotope research is also starting to take off, and it's bringing RMBL with it.

"We've got one project where they're using isotopic signatures to look at the life cycle of a snowflake," Dr. Billick describes. "You can determine how long it takes to go from being a snowflake to showing up in a river. Across the board, there are all of these crazy new techniques that can be applied in the field, so there are a lot of scientific disciplines that would benefit from asking questions and running experiments or collecting data in a natural environmental context. They just haven't had the power to observe those processes before."

This process creates what Dr. Billick calls a "virtuous cycle."

"The more information people collect, the more of a foundation there is for people to take advantage of," he adds. "And so the

more data that you collect, the more scientists you attract, the more scientists you attract, the more data they collect, and then that just attracts more scientists."

New techniques for analyzing complex datasets are also game changers for field scientists.

"Last year we saw two or three different projects talking about machine learning; I'd never seen a field scientist talking about applying machine learning techniques," comments Dr. Billick. "I think we're developing techniques that allow synthesis and integration of data, coming to us from other disciplines, just like the genomics are developed in different contexts that have applications in field science. We're seeing the same thing on the informatics side. I think it's a convergence of these different things that's allowing field science to blossom."

Of course, although specific discoveries might be surprising to Dr. Billick, the idea that field stations foster innovation certainly isn't.

"Field stations are often a location for innovation on sensing techniques," Dr. Billick remarks. "Scientists are often pushing the envelope. Many science advances are based upon developing new ways to see and measure things. From the monitoring side, often the equipment or techniques that people are employing were originally developed within a field station context." KL



Scientists coring on Gothic waters.

Photo: RMBL

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ENCHANTING EELGRASS

BY LORI BALSTER

Each of the 29 National Estuarine Research Reserves (NERR) in the U.S. has at least one feature that sets it apart. For Padilla Bay NERR, located in the town of Bayview Washington, in the heart of the Salish Sea, a feature that sets it apart can be summed up in one word: eelgrass.



Nicole Burnett and Christa Kohnert sampling eelgrass in Padilla Bay as part of long-term biomonitoring.

Dr. Jude Apple, Research Coordinator at Padilla Bay NERR, explains that the importance of the eelgrass to marine life, as well as its contribution to the Padilla Bay area, cannot be over-estimated. "We have one of the largest contiguous eelgrass meadows in North America. It is the largest contiguous eelgrass meadow in the lower 48 states. Only Alaska has a larger contiguous one. Ours is about 9,000 acres. It's hard to explain how beautiful it is, and how critical it is to wildlife here. It's a fantastic nursery for so many species, including salmon, crabs and herring. It's also habitat for marine birds like the great blue heron and black brant. It's also an important hunting ground for raptors such as bald eagles, which are abundant here"

Apple became Padilla Bay's Research Coordinator three years ago. Previously, he held a faculty position at Western Washington University, but even then, was collaborating with researchers at Padilla Bay NERR. Apple also has been running workshops for teachers through support he receives from NOAA's Environmental Literacy Grants program. The workshops feature environmental topics such as climate change and utilize real-time data gathered through NERR's System Wide Monitoring Program (SWMP). While there are many environmental topics of research in the Padilla Bay area, such as planktonic community health and sea star health, the big interest for Padilla Bay is monitoring the vibrancy of the eelgrass meadow. "We're the only Reserve that has its Sentinel Site and Surface Elevation Tables (SETs) established exclusively in eelgrass meadows. Most of the other NERRS have their SETs in salt marshes," says Apple.

While the 9,000-acre eelgrass meadow is unique to Padilla Bay NERR, there are other features of the NERR program there which are shared with the other 28 NERRS all over the country. "We do the same System Wide Monitoring Program (SWMP) data gathering protocols as the other NERRS," Apple mentions. "That includes monitoring weather using a designated weather

station, and monitoring water at various locations in the Reserve, gathering data such as water depth, temperature, salinity, dissolved oxygen, turbidity and pH." Two types of data sondes are currently being used to gather this data: YSI 6600 and YSI EXO-2 sondes. "We have 12 sondes in circulation, and we're going to buy a couple more. We've almost, but not quite, replaced all our YSI 6600 sondes with EXO-2 sondes. We've found the EXO-2 sondes to be a big improvement over the older 6600 ones. The EXO-2 ones have wipers to reduce biofouling and we've found they last longer in the field," adds Apple. Some of the data sondes at Padilla Bay NERR are located at four core environmental monitoring stations, with two sondes in rotation per station. Two years ago, an additional station was added. This station was special, as it added a deep incoming ocean water habitat to the monitoring mix. "The Padilla Bay dive team deploys our sonde for that station," says Apple. "That location is 75 feet deep at high tide and 60-65 feet deep at low tide. A pretty big flux."

In addition to the beautiful, otherworldly eelgrass meadows, a research focus at Padilla Bay that other NERRS do not typically have is the purple sea star, including a pointed interest in sea star wasting disease. In 2014, Padilla Bay researcher Heath Bohlmann started seeing high numbers of diseased sea stars. "By 2015, we were starting to see a definite increase in sea star wasting disease deaths. We started monitoring the sea stars in Padilla Bay in 2009, so we had the data showing clear declines. It ended up that we lost almost 90 percent of our purple sea star population. It was an absolutely devastating outbreak across the entire Salish Sea. A viral pathogen is suspected to be associated with the deaths," Apple explains. "We are still trying to understand why the outbreak was so bad. Sea star wasting disease has been around for years, but for some reason it became catastrophic." Recovery of the purple sea star is still occurring.

Photos: (top) Jude Apple, (bottom) H. Bohlmann

Padilla Bay's sea star monitoring does not occur in isolation. The NERR is part of the multi-agency rocky intertidal network (MARiNe), a West Coast network monitoring the rocky intertidal community. In addition, it has partnerships with NOAA, UC Berkeley and other organizations. Padilla Bay NERR is also part of the Washington State Department of Ecology. "We work hard here at Padilla Bay," says Apple. "My colleagues here are great."

While researchers, students and other visitors can observe Padilla Bay's eelgrass meadows directly, other habitats at Padilla Bay can be explored at the Breazeale Interpretive Center. There are free classes on plants and animals in the Padilla Bay Area.

For researchers such as Apple, however, the 9,000-acre eelgrass meadows will always provide the biggest, most unique environmental monitoring draw. "The eelgrass meadows are special to me," says Apple. "They can take on an unearthly beauty. I remember being out here in the dark at about 3 AM on the water, out gathering data in the eelgrass, and there was a wave of bioluminescence around the boat. It was like a scene out of Avatar. There were planktonic polychaetes, hundreds of them, surrounding the boat and making the water glow in the dark. There's just nothing else like it. You never forget seeing something like that."

Padilla Bay NERR continues to offer unique experiences for researchers, students and other visitors to enjoy. The beautiful, biologically critical and seemingly vast eelgrass meadows are no small part of what makes Padilla Bay special.

"Our eelgrass is like the rainforest of the intertidal environment," Apple reflects. "It's that important, and that precious of a habitat."

NEW YORK CITY NATURE



New York Urban Field Station; New York City, NY

BY LORI BALSTER

While some people might conjure up images of towering skyscrapers or dazzling Broadway shows when they think of New York City, the city is actually about 40 percent green space, with over 11 percent of that being natural areas. The City of New York Parks & Recreation (NYC Parks) manages about 10,000 acres of these natural areas, which is about half the size of Manhattan (other major natural area managers in New York City include the National Park Service as well as other City and State agencies).

As Erika Svendsen, a Research Scientist with the USDA Forest Service expresses it, "Although our acreage does not compare to the national forests and grasslands, we have unique natural areas that are critical habitats for people, plants and wildlife." Svendsen works at the NYC Urban Field Station whose stated mission is "to improve quality of life in urban areas by conducting and supporting research about social-ecological systems and natural resource management." It began as a partnership between the USDA Forest Service, NYC Parks and the non-profit, the Natural Areas Conservancy.

There are several researchers at the station working on issues ranging from environmental stewardship to urban forest health. Svendsen's specific focus is on understanding the social benefits of these natural areas and how the public interacts with, as she expresses it, "everyday urban nature." As Svendsen says, "These areas have social, biological and cultural significance. People use them for bird watching, hiking, jogging, contemplation and

to reduce stress. They are a very special part of the New York City experience."

A major objective of the New York City Urban Field Station work is to conserve natural areas, which it does in partnership with the Natural Areas Conservancy. The Natural Areas Conservancy seeks to protect New York City's 20,000 acres of forests and wetlands so that everyone can enjoy them. Their team of scientists and experts promote nature in all five boroughs, working in coordination with the NYC Parks. The Conservancy's goals are to 1) protect 7,300 acres of urban forest while also providing high-quality recreation for New York City, 2) improve coast resilience through salt marsh restoration, in partnership with NYC Parks,

Clara Holmes uses an RTK GPS for shoreline monitoring to get accurate geolocations of the wrack line on the beach after storms.



Photos: (top) Chris Haight, NYC Parks; (bottom) Jessica Murray, NYC Parks

3) conduct groundbreaking research, and 4) get New Yorkers outside. The emphasis is on the health and maintenance of the park spaces, achieving clean air and clean water, as well as keeping the social benefits of the park spaces intact.

People use the New York City natural areas as places to relax, explore and have fun. But these natural areas also can inspire people to become more engaged in the care and stewardship of the land.

"People can be catalysts for positive change," Svendsen explains. "Over the years, we have documented the work of hundreds of community groups that have worked to improve the quality of NYC's urban nature. We have documented these groups in our Stewardship Mapping and Assessment Project, or STEW-MAP Project, which details the dedicated work of community groups throughout the city. In NYC, ecological restoration and protection can be a challenge with so many people who want to access these special places. New York City natural areas must be accessible to the public, but they are also a resource that must be protected. As the STEW-MAP data shows, there are hundreds of dedicated groups working on behalf of their local environment."

One of the many ways New York City communities get involved in stewardship is through citizen science projects involving environmental monitoring. Environmental monitoring is at the heart of assessing, maintaining and restoring natural areas. One such environmental monitoring project in the New York City area is the Billion Oyster project, a citizen science project coordinated by the New York Harbor School with the goal of restoring one billion live oysters to New York Harbor by 2035. The project ultimately hopes to involve hundreds of thousands of school children in the monitoring and restoration of NY oyster beds.

New York City citizen scientists, as well as research professionals, do many other kinds of environmental monitoring in NYC natural areas. Other monitoring includes various shorebird and wading bird species such as piping plovers, the six local species of herons, black skimmers, and common and least terns; reptilian life such as diamondback terrapins; amphibian life such as red back salamanders; and horseshoe crab monitoring.

Georgina Cullman, Ecologist at NYC Parks, mentioned a few more monitoring projects underway. NYC Parks often uses environmental monitoring as part of ecological restoration efforts; both in preparation and to monitor their effectiveness.

One such exciting restoration project was the installation of a "fish ladder" (fishway) over the 182nd Street Dam on the Bronx River to allow anadromous river herring to go upstream to spawn. As the first dams on the Bronx River were constructed in the 1600s, river herring migration to freshwater in the Bronx River had been blocked until 2015. NYC Parks, with our partners—particularly the Bronx River Alliance, a local non-profit focused on education and restoration surrounding the river, monitor the fishway during the river herring migration season with an underwater camera, Ocean Drop underwater video camera by EZ spyCam, and Salmonsoft software to document the return of river herring to the Bronx River via the fishway.

Habitat monitoring is performed as well. "We use RTK GPS (Real-time kinematic Global Positioning System). This gives us very precise elevations as well as locations, which we use for




Emily Stephan, NYC Parks, and Alexandra Cook, SUNY ESF use RTK GPS for our salt marsh restoration project.

bio-benchmarking so we can use this to design our salt marsh restoration. With this information, we can determine the best placement for *Spartina alterniflora* versus *Spartina patens* in our restorations. We have also used it to document salt marsh sparrow nest elevations in Idlewild Park, Queens. Idlewild Park is right next to JFK airport," Cullman mentions. "Another use of the RTK GPS is shoreline monitoring. We can use this technology to get accurate geolocations of the wrack line on the beach after storms and to document how beach profiles change over time." This monitoring is important to track erosion, important for ecological and risk assessment.

NYC Parks also undertakes water and soil testing. Hach DR300 pocket colorimeters are used for measuring phosphates and nitrates. YSI Professional Plus Multiparameter, YSI 63, and YSI 556/559 handhelds are used to measure pH, conductivity, salinity and temperature. Water turbidity is measured using a Secchi disk. For soil monitoring, a Kelway soil tester is used to monitor pH and moisture content. In addition to direct measurements of water metrics, benthic invertebrates are sampled as indicators for stream health.

New York City natural areas today are more heavily used than ever, meaning the objectives of environmental monitoring and restoration are as important as they ever were, if not more important. However, the citizens of New York City continue to pull together to make that happen.

"We have really active and engaged communities in NYC that care about urban nature and beyond," Svendsen emphasizes. "It is exciting to work in this field as there is always something new to learn about the unique benefits that urban nature provides to us all." 

Photos: (Right) Chris Haight, NYC Parks

NEWBORN LAKES CLIMATE RESEARCH

Flathead Lake Bio Station; Polson, MT

University of Montana professor Morton Elrod founded the FLBS back when the lake was challenging to access. “We like to call it the oldest year-round freshwater field station in North America, we’ve been around since 1899,” remarks Dr. Elser. “We have about 25 to 30 full-time, year-round employees. We have four tenure-track faculty members of the University of Montana who are housed here year round, many other research faculty, staff scientists, administrators, and educators.”

“It’s not just any lake; it’s the largest freshwater lake in the western United States,” comments Dr. Elser. “Flathead Lake is bigger than Lake Tahoe. It’s a big economic driver for western Montana.”

“We work on what I call the newborn lakes,” explains Dr. Elser. “These are the lakes that are appearing as the glaciers retreat. In the last 50 or 60 years, a number of lakes have appeared in Glacier National Park where the glaciers used to be. So we’ve been sampling those, and it’s quite a spectacular undertaking, and also a heck of a lot of work to get up there to some of those basins because they’re not served by trails or anything.”

Thus far, the team is just trying to characterize these nameless lakes—but even that wouldn’t be possible without the biological field station.

“People wonder, what the heck is a field station?” remarks Dr. Elser. “People think about it as a tent in the woods with a microscope in it or something; we just don’t have the sense that field stations are a real gradient. I’ve been in field stations that are like that. And then there are other ones that are really well developed, and this is one of those.”

The Flathead Lake Bio Station is, truly, a hub of scientific inquiry in the region—one that experts rely on.


“I always think, what is a field station about?” queries Dr. Elser. “I think of it as a piece of scientific infrastructure. Astronomers have big fancy telescopes and physicists have particle colliders. I think ecologists and environmental scientists have field stations. It’s sort of an investment in scientific infrastructure. There are things that just could not be studied or be discovered or be learned about without having this kind of facility available. It’s like a particle collider but for ecologists.” 

Photo: Dr. Jim Elser



GLACIAL LAKE RESEARCH

BY LORI BALSTER

Lacawac Sanctuary; Lake Ariel, PA

Lacawac Sanctuary's claim to fame is that it possesses the southernmost unpolluted glacial lake in the U.S. Pristine lakes are rare today, and Lake Lacawac is an invaluable resource for conservationists and research scientists. Lacawac Sanctuary was also named a National Natural Landmark in 1968. The name of Lake Lacawac, interestingly, comes from the Lenape Indian term for fork. Consisting of 510 acres, the Sanctuary includes mature second-growth forests, two ponds, several wetlands and a mile of Lake Wallenpaupack shoreline. There is also a suite of buildings that date back to the turn of the 20th century. Some of the buildings, such as the Ice House, the Lodge and the Carriage House are on the National Register of Historic Places.

Lake Lacawac is so untouched and so precious, only researchers are allowed to use watercraft on the lake. Swimming and fishing are also not allowed. "Not only do we need to restrict the lake to researchers, if they want to use their own watercraft they need to wash it with a four percent bleach solution before they can go out on the lake," says Beth Norman, Director of Science and Research at Lacawac Sanctuary. "Otherwise, the risk of contamination with invasive species is just too high."

Norman is a relatively new addition to Lacawac Sanctuary, arriving in February 2018. Her doctorate was completed at Virginia Tech in the area of Biological Sciences, specifically Aquatic Ecology. She did postdoctoral work at Trent University in Ontario and Michigan State University.

"Lacawac Sanctuary wanted someone with the right research background for this position, and I wanted to work at a place where I could not only do my own research but also interact with researchers all over the world. I also like that we're not just a field station here, but also an education center. The Director position here turned out to be a great fit for me," says Norman.

All kinds of students visit Lake Lacawac, from preschool age to high school to undergraduates. Undergraduate and doctoral students, usually about 5-7 students, work there in the summer on about 15 projects. Lacawac Sanctuary educational facilities are designed to bring research science and scientific methodology out into the open, so students can see how the research process actually works. "People like to see scientists doing actual science," Norman explains. "That's one of the great things we offer here."

Norman's current research involves taking a look at nitrogen cycling at lakes in the region, and how nutrients move through the ecosystem.

"I would say our big focus here is limnology," says Norman. "We have the southernmost unpolluted glacial lake in the U.S. because, in the early 1900s, this area was purchased by a family for their second home. As a result, the entire watershed here was not developed." This created a boon for researchers. "We can study the ecological area here that has been untouched by people. It's a rare find. We can, therefore, isolate the effects of climate change, look at native, pristine plankton populations and gather remote sensing data with buoys," Norman adds.

Lake Lacawac has two main research buoys: the RAFT and the ARTHUR. The RAFT has been on the lake since 1992, and it's on the lake year round. During the winter, it is docked on the lake, but still gathering data. It takes data every 15 minutes, year round. There is also a weather station on a platform on top of the RAFT, which transmits information about lake weather. Lehigh University's Bruce Hargreaves did much of the pivotal work outfitting the RAFT.

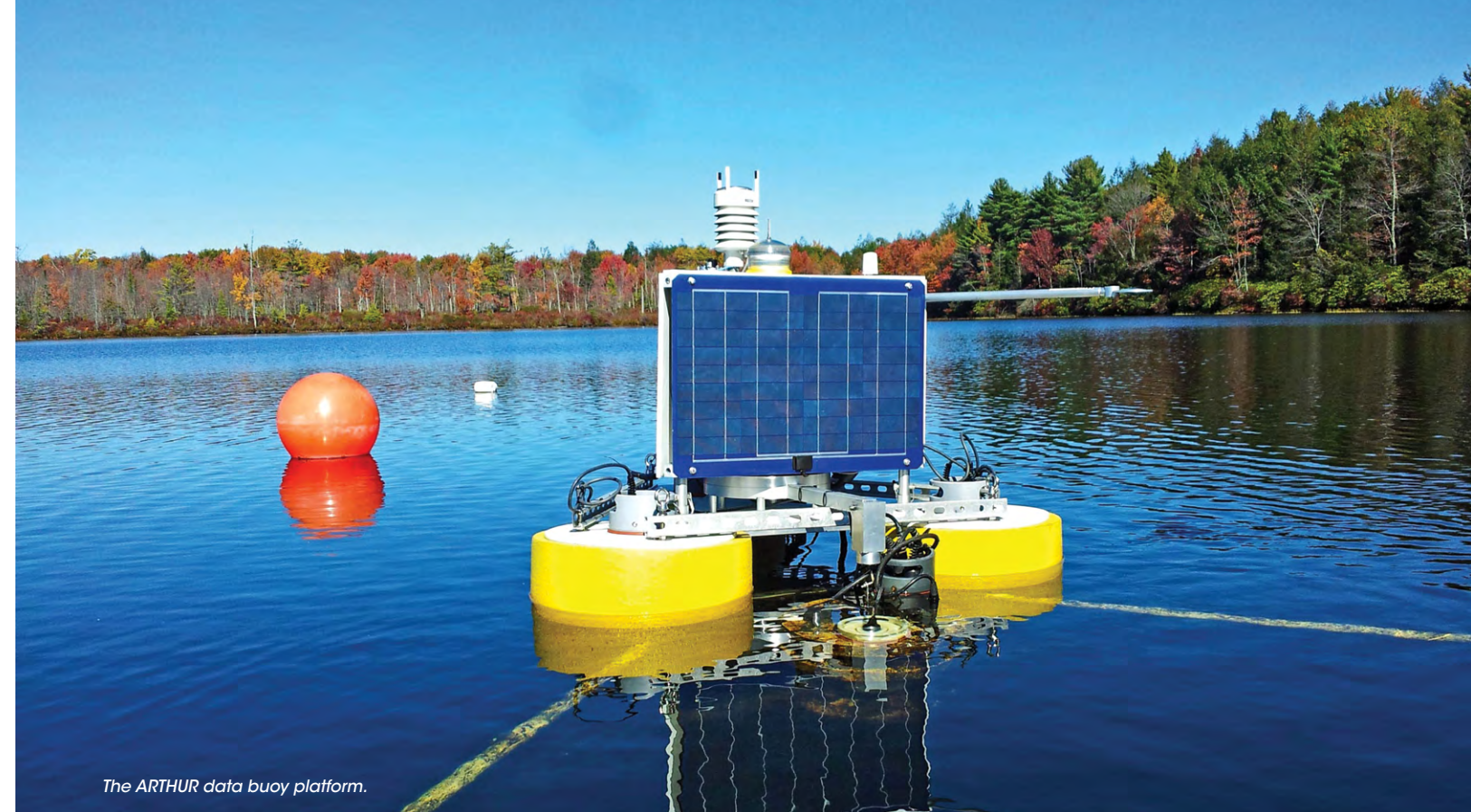
The ARTHUR buoy, named for Arthur Watres (founder of the Lacawac Sanctuary), also sports a meaningful acronym. ARTHUR is also: Aquatic Resource for High Frequency Underwater Resource. It was launched on the lake in 2011. The ARTHUR goes in and out of the lake each summer. It has recently had additional sensors added. What makes the ARTHUR unique is that it has a winch with a buoy platform that can go up and down the entire water column. Every six hours it does a complete profile from top to bottom to top again. The ARTHUR is run by Miami University in Oxford, with Craig Williamson acting as the POC for the effort.

Data gathered by the buoys include temperature, dissolved oxygen, pH, conductivity and chlorophyll-a. The lake also has dissolved oxygen sensors every meter.

A weather station is also located on land, and it gives terrestrial wind speed. YSI handheld meters, Pro Plus units, are used for work on Lake Lacawac and on other area water bodies. These are used to measure pH, conductivity and temperature. "The



Sitting on Lake Lacawac year-round is the research platform, RAFT.



The ARTHUR data buoy platform.

information we gather is disseminated widely, as we are also a member of the Global Lakes Ecological Observatory Network (GLEON)," says Norman. "The data are used in many ways, including helping area leaders make management decisions."

"Something we keep an eye on in the lake is algal concentrations," Norman mentions. "We don't currently see HAB like many other bodies of water have in this area since this lake is pristine and people aren't using it for transport. Even so, we are always concerned about the possibility of invasive species." Each pond, for example, has unique equipment to prevent contamination.

"The pristine lake conditions make it possible for us to separate local vs. global drivers in changes we see," Norman explains. "It's important to keep it pristine, or we won't be able to make those very important distinctions in our research."

In addition to the extensive Lake Lacawac studies, there is also a deer browsing study that has been ongoing for 20 years. "There are two permanent study areas, one with deer and one without for comparison. We are looking at the impact of deer browsing on forest regeneration," Norman mentions. "Deer are native to this area, but they were almost completely wiped out by the early 1900s. Later, deer were imported to this area for hunting. Deer you see here today are likely descendants of those imported deer."

Some invasive species Norman and others keep watch for include milfoil plants, tough macrophytes that can be rehydrated after drying up; Asian clams; and zebra mussels.

Some native fish species in Lake Lacawac are perch, sunfish, smallmouth bass and pumpkinseed. Red-spotted salamanders can be found in the area, as well as bald eagles (though the bald eagles aren't nesting).

"We've lost the American chestnuts we used to have in the 1900s," says Norman. "It's actually easier for us to protect the lake than the forest."


The lake is a seepage lake. One side is sandy, and the other side is a bog. "We're trying to restore habitat for the Golden-winged Warbler," adds Norman. "They like scrub habitat, so we are selectively logging the canopy to try to help them."

Some of the 20th-century buildings on the property are also a focus for preservation. "They are some of the first examples of the Adirondack style of architecture in the Pocono region," Norman indicates.

In terms of future plans, Norman says Lacawac Sanctuary plans on doing a better job curating the data they already have. "We would like to get it better organized and archived," she says.

In addition to all the other special things about Lake Lacawac, Norman mentions it's also a really good place to deploy prototypes. "There are so few people here, and the only ones who are here on the lake are researchers. That means if you launch a prototype here, no one will mess with it," Norman says.

Lacawac Sanctuary is involved in long term biological research funded by the NSF. They have collaborations with Miami University in Oxford and RPI in New York. "We're all committed to long term data collection," Norman says.

Working at Lacawac Sanctuary has been rewarding for Norman. "It's really gratifying to see students invested in their own research and in making Lacawac Sanctuary work. It's a communal research effort," she enthuses. "I also love living on site. Where else can I wake up and see a black bear pressing its nose on my window?" 

Photos: courtesy of Lacawac Sanctuary

MARINE SCIENCE ALONG THE OREGON COAST

BY KARLA LANT



Oregon Institute of Marine Biology; Charleston, OR

For almost a century, researchers and students from the University of Oregon (UO) have been doing marine science along Southern Oregon's coast. The Oregon Institute of Marine Biology (OIMB) has provided unique opportunities in its permanent location for nearly as long. OIMB Education Coordinator Dr. Maya Watts spoke with EM about the lab and the educational and research activities housed there.

LIFE AND LEARNING AT OIMB

UO's people began to research and teach near Sunset Bay in 1924, with tents for laboratories. By 1929, the university had a permanent site chosen for the lab, and in 1931, when the land was deeded to the school, former Army Corps of Engineers buildings in the area became the first lasting OIMB structures.

Today, both year-round research and educational programs are carried out at the facility.

"We're the University of Oregon's marine lab," explains Dr. Watts. "We have seven resident faculty that teach and conduct research at OIMB. Another is based on main campus in Eugene but has a lab here."

The OIMB's unique location helps foster a real sense of community and camaraderie.

"We're two-and-a-half hours from the main campus, which means that our graduate students and faculty live here

year-round," details Dr. Watts. "The really nice thing about that is that it becomes this tight-knit community in which everybody knows everybody well. Plus there's an open-door policy where students can just walk in and talk to professors anytime."

Classes take place at OIMB in the spring, summer, and fall terms, and 20 to 70 students study at the field station during a typical semester. Life at OIMB offers an intensive experience for marine biology majors.

"Summer is our busiest term, with spring and fall terms having slightly fewer students," comments Dr. Watts. "Marine biology majors make up the bulk of the students as they are required to be at the marine lab for one full academic year, three terms, but we get many students from other majors and visiting students from other institutions."

The marine science full-day class schedule allows students to physically go out to observe low tide first thing in the morning, and then return to the lab for a lecture, for example.

"It makes it much more of an immersion experience because they're spending all day with their professor, their TA, and their peers," states Dr. Watts. "They live in the dorms, and they're usually on a meal plan, so they're kind of living and breathing marine biology while they're here. Most of our students came to the UO for the marine biology program. They are excited about coming to OIMB and don't want to leave after they've been here. They're used to having that small class, hands-on, field-based experience."

OIMB offers a variety of courses, ranging from biological oceanography, embryology and larval ecology, to invertebrate zoology, biology of fishes, and marine birds and mammals and

many others. In addition to formal education, the University of Oregon's aquarium and museum, the Charleston Marine Life Center, is just across the street from OIMB.

RESEARCH AT OIMB

Although education and teaching are a high priority at OIMB, the professors at the station are also full-time researchers.

"Our professors love the marine lab, because classes are small, with 10 or 15 students, 20 if the class is full," Dr. Watts says. "There are many marine habitats nearby that are relatively pristine—tidepools, mudflats, salt marshes, sand dunes, and beaches. We have research vessels and a small ROV, so we can check out the sub-tidal population, too."

Biological oceanographer Dr. Alan Shanks is researching Dungeness crabs.

"Dr. Shanks does oceanography related to early life history stages, larval and young stages, including how they travel, and what happens when they settle," explains Dr. Watts. "One of his major projects is working on the Dungeness crab, our local crab fishery species. He and his team have collected baby crabs in light traps for over a decade to help predict future crab fishery catches from the number of babies caught in the light trap."

This research may also help scientists and policymakers better plan for a future of food-scarcity, in which aquaculture is likely to play an increasingly important role.

"People in Dr. Shanks's lab have also been developing fishery techniques for gooseneck barnacles, a real delicacy in many places," states Dr. Watts. "They're researching how to grow them via aquaculture since they're mostly found intertidally, and they'd be easy to over-harvest. They've explored how to grow them in the lab, and how much food and water flow they need to remain viable."

A student diving, holding a sea snail.



All Photos: OIMB



OIMB researchers on an outing.

OIMB's Director, Dr. Craig Young, focuses on reproduction in the deep sea. This means that he conducts research in various ocean basins studying a range of habitats—and so do OIMB students.

"He works on chemosynthetic communities that exist at hydrothermal vents and methane seeps, that live off sulfur or methane bubbling up from the ocean floor," comments Dr. Watts. "He's studied how larvae develop; whether they travel long distances to surface waters to feed, or whether they remain at the bottom; and how far they can move between patchy habitats in the deep sea."

Dr. Svetlana Maslakova, another OIMB faculty member, works on nemertean (ribbon worms), unsegmented worms.

"They're a phylum in their own right and some of them have a distinctive, interesting larval stage, and a catastrophic metamorphosis during which the developing juvenile eats the larval body from within," remarks Dr. Watts. "Dr. Maslakova studies larval development in these worms and the genetics behind that development using cool tools, such as confocal microscopy to visualize their development. She is a systematist and the world expert on nemertean, traveling to distant places to study the biodiversity of the phylum."

While extensive educational and research opportunities exist at OIMB, Dr. Watts sees even more inherent value in the facility and the community that has developed there and at other marine labs.

"Really important discoveries come from marine labs. Many of the particulars on how fertilization works (from sea urchin eggs) and how electrical excitability and nerve action potential works (using giant axons in squid) were discoveries made by scientists working at marine labs," comments Dr. Watts. "New techniques for visualizing are now available because of marine lab research. There's a lot of value, not only in the research itself but also in teaching the next generation of scientists in small field-based courses how to formulate their own questions. The contribution of marine labs such as OIMB to our future is substantial." KL

SCIENCE ON THE ANIMAS RIVER

BY KARLA LANT



Hermosa Creek, Colorado.

The Mountain Studies Institute; Silverton, CO

For around four years, aquatic ecologist Scott Roberts has been at the Mountain Studies Institute (MSI) in Colorado, most recently serving as Water Programs Director. Mr. Roberts recently took the time to speak to EM about the MSI and its programs, starting with community and educational outreach.

"We're a not-for-profit, environmental education and research center based in the San Juan Mountains," explains Mr. Roberts. "We do on the ground environmental research, mine hydrology, water quality monitoring, and forest health monitoring, and try to distill and distribute that information to address specific concerns that arise in the community. One thing that differs, I think, in our research program is largely driven by concerns in the community, rather than our own kind of academic pursuits. It's usually shaped by efforts to try to address questions that come about in the community."

Adding to MSI's mission of outreach into the overall community is the team's goal of following through. "When we do have an education mission, we try to bring results from our monitoring, news of the case studies, to help teachers in our local schools incorporate that into their curriculum," comments Mr. Roberts. Educational outreach works in two ways at MSI: outreach that is directly aimed at the public, and outreach to schools in particular.

"We try not to do research or science in a vacuum; we want to share with the community and we do that in a number of ways, including through public presentations," details Mr. Roberts. "We have public meetings where we give a presentation of information but also an opportunity for people to ask questions. Knowing that not everyone can come to a public meeting, we try to put a lot of information online, and it's in formats that are easily digestible by community members. For example, we have a picture book style document on our website that walks people through interpreting water quality monitoring results for the Animas River here."

The MSI team also conducts outreach in schools, appearing in classrooms with guest lessons or taking kids from local schools to the forest or the Animas River for hands-on lessons in aquatic insects, water quality, or how to measure forest health to give young people an opportunity to engage in science. This tactic allows researchers to include educational components in even their regular research—a smart way of doing more with existing work.

ENVIRONMENTAL SCIENCE SHAPED BY GEOGRAPHY AND COMMUNITY

There are many facets to environmental science issues in the San Juan Mountains in Southwest Colorado where MSI is situated. The region spans forest, water, and climate category issues, but within them, there is a great deal of diversity, much of it driven by local geography.

"I'm a geographer, by training, so I like it when people ask those kinds of questions," remarks Mr. Roberts. "A lot of our questions arise in the community specifically because of geography. For

example, the San Juan Mountains are a highly mineralized area. We had mining here and we're still dealing with the impacts from legacy mining on water quality. The types of forests that we have influence beetle outbreaks and forest fires, some of which are naturally occurring on this landscape. Of course, there are questions in the community and concerns about how these issues affect them, downstream, or their forests."

Any member of the community can get involved with MSI programs based on these kinds of concerns—or simply because they're interested.

"We have citizen science programs trying to get people to go out and about hiking, making observations of species of concern and bringing that information back to a larger database to help track organisms," Mr. Roberts describes. "Not just young people, we do try to engage adults in our classroom curriculum as well."

MONITORING THE ANIMAS RIVER

The MSI team has been engaged in water quality monitoring throughout its history, but water quality has been a bigger community concern since a 2015 release of mine water into the Animas River. The release, which made the international news with its bright orange water, was called the Gold King Mine release.

"Of course that captured international attention and raised a lot of concern in our community about water quality and the health of aquatic life," comments Mr. Roberts. "In response to that community concern, we certainly expanded our water quality monitoring both spatially and temporally to try to address some of those questions."

Then in 2018, the 416-fire burned a substantial portion of a major tributary to the Animas River.

"Having already established this water quality monitoring program, we were really poised to be able to conclusively assess the impacts from that fire, because we had this before data set," remarks Mr. Roberts. "We knew what the condition of the river was before the fire, so now we track the impacts after the fire, and we could more conclusively say what the impacts were and also attribute those impacts directly to the fire. If we didn't have that kind of before data, we wouldn't be able to do that." These kinds of results highlight the value of long-term



Benthic sampling in Hermosa Creek, Colorado.

monitoring—by both experts and laypeople—and the careful collection of data from an established field station.


"We've seen large amounts of sediment and black ash and organic material moving downstream," Mr. Roberts describes. "We've seen high levels of nitrogen and phosphorous, really high levels of metal like aluminum, iron, and even mercury. We had a fish kill in July, after the fire as some of the first monsoon rains fell on the burn scar and carried water and sediment down into the Animas River. You didn't have to be a biologist to observe it, just regular community members walking along the river could, unfortunately, see dead fish and fish gasping for their lives."

The team is now working to investigate further, to determine what the water quality was like during the fire event, which caused the fish mortality, and how aquatic insect populations changed after the fire. Water quality remains a serious concern for the MSI team based on levels of metals, in particular.

"Because we had this longer-term data set on the Animas, over the past twenty years or so, we detected levels of aluminum, iron, mercury, manganese that were higher than any other time that we'd recorded in the past twenty years," Mr. Roberts points out. "And that includes even when the river turned bright orange in the Gold King Mine release. That was a little unexpected, how high the levels of aluminum, iron, mercury, and manganese were."

The team looks at water quality in two contexts: comparing historical observations deciphering the meaning of the metrics for aquatic life. In this case, after the 416-fire, levels of aluminum, iron, and mercury were high enough to suggest there could be a concern to aquatic life in the Animas River.

"There's not really the same kind of water quality criteria for physical damage that can be done to fish from sediment and ash and organic material moving downstream, but there certainly is an impact," Mr. Roberts states. "In fact, that may be most responsible for the fish kill, sediment clogging fish and insect gills, organic material damaging gills as the river gets choked with it."

The presence of heavy metals could also be a component of local water quality problems. Finding out is what the team hopes to tease out now and in subsequent years of data collection, the longer term impacts on aquatic life. 

All Photos: Scott Roberts, Mountain Studies Institute



Scott Roberts, Aquatic Ecologist and Water Programs Director, Mountain Studies Institute.



NOAA CHESAPEAKE BAY INTERPRETIVE BUOY SYSTEM

BY KARLA LANT

For the past two years, the NOAA Chesapeake Bay Office has been partnering with Fondriest Environmental to phase out their legacy data buoy systems and replace with NexSens CB-1250 data buoy systems. Several members of the Fondriest team recently participated in a buoy deployment on the Chesapeake Bay, and Byron F. Kilbourne PhD, an oceanographer at the NOAA Chesapeake Bay Office, spoke to EM about the office, their team, and the change.

"The NOAA Chesapeake Bay Office was initially formed as a NOAA liaison to the Chesapeake Bay Program, which is a federal partnership with the states for the management of the Chesapeake Bay led by the Environmental Protection Agency (EPA)," explains Dr. Kilbourne. "Every other federal environmental program or office has a liaison to the Chesapeake Bay program. The USGS, EPA, Department of the Interior, US Fish and Wildlife, and NOAA all have program offices."

LIGHTER BUOYS, BETTER DATA

In the past, the NOAA Chesapeake Bay team used the AXYS WatchKeeper buoy.

"They're fine for some environments, or for programs that have their own vessel operations capabilities," Dr. Kilbourne describes. "We have a zodiac-type open boat and another boat that's a little bit bigger, but neither is up to the task of deploying the AXYS buoy, so we have to contract all that out."

According to Dr. Kilbourne, the AXYS buoys weigh in at around 4,500 pounds each including the anchor.

"You don't have to lift all that at once, but the amounts that you do have to lift are heavy enough that most of the ships that can do that with no problem have a pretty deep draft," remarks Dr. Kilbourne. "Most of the areas that we're working in are pretty

shallow out of the way. The program budget for those kind of vessel operations is pretty low, so the bigger boats that can handle that equipment with no problem would chew up our annual vessel contract budget in one trip."

It has been a challenge for the team to find vessels that can handle the AXYS buoys over the years within budget, and this has led them to struggle to respond to various problems in a timely way.

"The NexSens buoy brings us the flexibility to bring our vessel operations in-house, or even if we're still using contractors, it really broadens the spectrum of vessels that are appropriate for the job," adds Dr. Kilbourne.

The biggest difference in the two buoys for the NOAA team during the deployment process is weight, not total size.

"The NexSens CB-1250 buoy is lighter, although the way we've customized it from top to bottom it's actually a little bit bigger in total length," states Dr. Kilbourne. "However, we're able to totally instrument the buoy, and have it completely plugged in and sampling, as if it was in the water, on-deck. This way we can pick it up from the side, and drop the whole buoy in, tested, working and ready to go and be done with it. The whole deployment, from the time we get on-station to the time we're driving away, is less than an hour."

Although the team cannot pick up the NexSens buoy in the same way, retrieving it is still a simpler process due to its lighter weight.

"We can pull the superstructure off in one lift, and then we can pull the buoy up in one lift, and it's greatly simplified our operations here," remarks Dr. Kilbourne.

Simplicity hasn't been the only benefit to making this change, however. Easier deployment and retrieval also means better, more reliable data and improved performance.

"What the smaller buoys have brought us in terms of reliability is pretty huge, because we can service them with the vessel we already have," Dr. Kilbourne says. "A day or so after we got the Jamestown buoy in the water, somehow it got pulled up into the shallow mud that was in the riverbank there, and we had to go and pull it back off. We did that with our own vessel and not with a contractor, so that was a huge help with our operations. Because of the buoy, we were able to respond in a timely way. That's a huge help to our maintenance effort."

MORE MONITORING POWER, BETTER USE OF DATA

Now the team will be phasing in customizations such as SeaView Systems SVS-603 Wave Sensors over the next few years. Even with more monitoring power, the team will be working to put the data to use more effectively to offset the bottom line to operating a program like this—a cost that has very little to do with buoys and much more to do with the people who work with them.

"We have to have a facility to operate from, we have to have vessels, we have to have trucks to pull those vessels, we have to have lifting equipment, forklifts," details Dr. Kilbourne. "Whether we have one buoy or whether we have 50 buoys running in some geological area that you can service from at least one field facility, the baseline cost of about \$850,000 a year remains. Even with only one buoy, you'd need one technician, one oceanographer or other scientists, and one person to do all the software on the back end."

For the NOAA team, one of the questions is how to get more value out of the data and the program—and how to do more with the data.

One of the buoys deployed in the Chesapeake Bay.



All Photos: Fondriest Environmental



The 81-foot University of Maryland Rachel Carson research vessel on its way to deploy a buoy.

"The data supports a lot of recreational and small scale commercial use," Dr. Kilbourne describes. "It also supports commerce in that there are marinas and other businesses driven by recreational use. It is incorporated into the weather service for their marine forecast for the Chesapeake. But it's not in NOAA's system that helps direct commercial and other ships into port, and it's not in current use by either the Maryland or Virginia Pilots' Associations to guide ships into port. To the best of my knowledge, it's not published anywhere in the academic journal record. And it's not used to do ecological forecasting, such as trying to predict harmful algal blooms."

Part of what Dr. Kilbourne has been working on is making those connections and improving the quality of the data record so that potential users feel it can be trusted.

"It's a 10- or 11-year record that we have at this point, and I have done all the archival quality control, if you go to the National Center for Environmental Information there's a download," remarks Dr. Kilbourne. "It's all in NetCDF format so anyone can download the data, and it's flagged according to good, bad, suspect, or not-examined, for quality control. I think they can be relied upon. And it's also totally documented, so if anyone ever disagrees with my assessment they can look at the method and they can make their own call."

"The other way to get more value out of it, in my opinion, is to add more stations," adds Dr. Kilbourne. "Adding more stations doesn't cost a lot more. A lot of the cost of the program is fixed, so the upfront cost of funding the equipment out to 15 buoys from 10 doesn't cost a lot more operationally."

Finally, Dr. Kilbourne has been trying to make the case that the NOAA team should conduct research in the Chesapeake when they have downtime and are not busy maintaining the buoys.

"When I was a graduate student and a postdoc, I found that when it comes to models, datasets that are created in support of some idea that is investigated separately are often very useful," states Dr. Kilbourne. "For example, I wrote a paper about a storm that I experienced in the Southern Ocean when I was a graduate student and the impact of that storm on some observations that we were making around that time. I was able to say, 'This is the two week period that I was there, and these are the measurements that we made during that time. We don't have any other data, but we have this long record of simulated winds for the whole earth. And if we look at this two weeks and that two weeks, we can make some assumptions about the broader scale.'" KL



ADVENTURES ON APPLIEDORE

OVER 50 YEARS OF UNDERGRADUATE RESEARCH EXCELLENCE

BY LORI BALSTER

Located on Maine's Appledore Island, the largest of a nine-island archipelago six miles off the coast of New Hampshire and Maine, Shoals Marine Laboratory has been providing undergraduates from the University of New Hampshire, Cornell University and colleges throughout the US with unique coastal research experiences for over 50 years. Shoals Marine Laboratory was the first undergraduate-focused marine research institution and is still the largest in the nation.

"We offer roughly 15-20 collegiate-level courses each summer," says Gregg Moore, Associate Research Professor and Academic

Coordinator for Shoals Marine Laboratory, University of New Hampshire Department of Biological Sciences and Jackson Estuarine Laboratory. "We offer as many as four courses at any one time on the island, with each intensive course lasting two weeks." Moore is heavily involved with teaching undergraduates and conducts a variety of research projects. "I've got vegetation and coastal salt pond/rare species monitoring studies on Appledore as well as larger projects spanning salt marshes and dunes and other coastal habitats of MA and NH. Most recently, I'm collaborating with partners in the British Virgin Islands to study mangroves following the devastating hurricanes Irma and Maria," he notes.

The Shoals Marine Laboratory offers programs from May to August. There can be as many as 100 students on the island, and for the two weeks they are doing coursework and related research, they live on the island full time.

Moore mentioned some of the major long-term monitoring projects going on at Shoals. "We have an intertidal communities

monitoring program that has been gathering data for over 50 years," he says. "To complement the long-term intertidal study, we recently established a terrestrial monitoring array consisting of permanent, one square meter vegetation plots across the island. We use drones to map the island plant communities and will seek to use this data to track vegetation changes over time. Using the drones has really been a huge improvement in gathering data. It's very rough, thorny terrain in many parts of the island, and I've even had to clear paths with a machete just to get to different areas and do mapping. The drones, on the other hand, fly above all of that. It's much easier for them to get information." They have several drones, such as the 3DR Solo and DJI Phantom, and others that are more expensive. "We can carry up to five cameras on some of them, which is a pretty good payload," Moore adds.

In the vegetation mapping, an Unmanned Aerial Vehicle (UAV) was employed to create a high resolution, georeferenced photomosaic of Appledore Island. The photomosaic was created to establish a fine-scale quantitative baseline for spatial analysis

of vegetation community distribution. Visible light (RGB true color) and NDVI (normalized difference vegetation index) geotagged imagery of the island was acquired at an altitude of 60m at an effective 1.67cm ground resolution using a MAPIR Survey3 camera mounted on a 3DR Solo UAV platform. Flight planning and control for UAV flights completed for this survey used 3DR Tower software. Programmed survey flight lines insured 80% overlap with neighboring images to increase resolution and facilitate subsequent photomosaic production using Pix4DMapper software.

"Once the imagery was mosaicked for RGB, we began a supervised classification to identify and quantify major vegetation zones and/or discrete plant communities using ArcGIS software interactive classification methods. This classification uses 60 georeferenced waypoints noting existing vegetation to the species level within the site's photomosaic image to capture unique signatures (i.e., vegetation, bare ground, etc.). Additional refinements to the classification are being completed with ARIS Grid & Raster Editor, a third-party extension for ArcGIS, ArcMap software," Moore explains. He credits The Nature Conservancy with giving him some good advice on mapping and collaborators at UNH's Geospatial Science Center (GSSC).

There are some rare plants on Appledore that are monitored with special interest. These include Dwarf spikegrass (*Eleocharis parvula*) and Red goosefoot (*Chenopodium rubra*). "We have about 300 vascular plant species here, and relatively few invasives – which we monitor closely," Moore notes.

Another significant study effort at Shoals Marine Laboratory is soil salinity mapping. "We gather soil pore water data to make salinity contour maps, which help us determine which salinity certain species prefer. The mapping can help us identify pockets of hidden salinity in the coastal salt pond habitat or even among tiny pockets of vegetation trapped in the rocky, granite shore," says Moore. "We have a unique and rare environment here at Appledore. Our coastal salt pond habitat can undergo fluid changes in salinity. It can go from freshwater all the way to polyhaline, which means there are some unique species that manage to survive and thrive here where many other species cannot," Moore explains. "The environment maintains a seed bank, and at the right conditions, the seeds will germinate. You find there are species of vegetation, some waiting for a long time until suddenly the right conditions to emerge are there, and then you see them. They were there all along."

One of the ways soil salinity is studied on Appledore is through electromagnetic induction (EMI). Pore water—water trapped in soil—is analyzed for conductivity and a specially developed algorithm is used to reliably convert the EMI values to salinity. Pore water apparent conductivity (ECa) was measured using electromagnetic induction (EMI) techniques with a Geonics model EM38 paired with a Trimble Nomad handheld data collector with a Garmin R1 wireless differential antenna. ECa measurements integrate conductivity values over the effective penetration range of the instrument, which in this case is approximately 0.5–0.7 m. Geo-referenced ECa data is collected continuously while walking meandering transects through coastal wetland habitats. Resulting conductivity data (mS/s) were converted to salinity (ppt) using an algorithm derived from prior work along New Hampshire's seacoast (Moore et al. 2011). A salinity contour map was then generated in ArcGIS 10.2 using the inverse distance weighted raster interpolation function in

Photo: G. E. Moore



Moore launching a vegetation mapping UAV (3DR Solo) outfitted with a pair of MAPIR Survey3 high-resolution cameras to capture RGB (visible light) and NDVI imagery.

ArcToolbox to illustrate soil pore water data obtained using EMI. When plotted, ECa measurements are particularly valuable for visualizing detailed salinity patterns on a landscape scale. The EM38 unit was calibrated on-site each day. In addition, direct measures of pore water salinity were conducted by means of the sipper technique (Portnoy and Valiela 1997) at 12 locations in coastal salt pond, using a hand-held refractometer as quality control for comparison to EM38 results. Subsurface pore water was sampled at two depths (10 cm and 40 cm). Direct salinity measurements, as well as those calculated from ECa, are reported as means \pm 1 standard error.

Salt becomes trapped in the island sediment. The rare species that thrive there respond to the amount of salt in the environment, and they need to be close to the ocean. "They need the salt spray and the storm overwash, or in some cases, penetration of the sea through the porous rocky beach and into coastal pond depressions," says Moore.

"The halophytes here are especially notable," he says. "Little salt marshes are created via fissures in rock and what is interesting about those is, they have the same diversity as a large marsh you might see on the mainland. All your favorite salt marsh plants are there, but it's all in a small area, some as small as a few square meters in size."

Interestingly, some species that are common invasive species in many environments find the habitat on Appledore to be too harsh. "We don't have a problem with the Common reed (*Phragmites australis*), which many nature reserves struggle with. In fact, we haven't found any on the island - yet," Moore adds. "We also don't have much purple loosestrife or honeysuckle, but when we see these we actively remove them by hand pulling and bagging."

In terms of water quality monitoring in the island's only permanent freshwater pond (Crystal Lake), SML's David Buck leads summer research interns using a YSI 566 multi-probe is used to gather the standard suite of characteristics, including dissolved oxygen, pH, conductivity and temperature. Dave's team also employs fluorometers that measure chlorophyll A and phycocyanins as part of an ongoing monitoring program for harmful algal blooms and uses an enzyme-linked immunosorbent assay

(ELISA) to quantify concentrations of microcystins in the water (toxins produced by cyanobacteria).

As for Appledore fauna, there is a rookery of Greater black-backed gulls and Herring gulls, as well as muskrats and four species of snakes. Visitors to the island might encounter minke whales and harbor seals on the sail over, while larger cetaceans are just offshore. The Shoals also boasts a relatively large colony of common terns as well as endangered roseate and Arctic terns on White and Seavey Islands where SML's staff scientist Liz Craig manages an active tern monitoring program overseen by SML Director Jennifer Seavey in collaboration with New Hampshire Fish and Game.

While Moore's research on Appledore is critical, he has another central purpose: to facilitate undergraduate opportunities for University of New Hampshire students. Most have declared majors, often in Biology, Zoology, and Marine Estuarine, and Freshwater Biology (MEFB), but students can come from any background as long as they have an interest in marine biology. "I introduce them to opportunities on the Island," says Moore. "The students who have completed our courses on the island tell me it changes their lives. There is absolutely unbelievable student enthusiasm. It's the equivalent of a full semester of work squeezed into two weeks. It's a ton of work. But the students are up for it, and I love watching them rise to the challenge." **LB**

Students recording precision elevations of intertidal habitat zones using RTK-GPS.



Photos: (Left) M. Routhier 2018, (Right) G. E. Moore



SHARK AND RAY DECLINE

BY KARLA LANT

FinPrint, the largest survey of reef sharks and rays in the world, completed the field work stage in 2018. This international effort used Baited Remote Underwater Video Station (BRUVS) surveys for monitoring shark and ray populations. EM spoke with Michelle Heupel, a marine ecologist and a fellow at both the Australian Institute of Marine Science (AIMS) and James Cook University (JCU), who serves the FinPrint project as Pacific Ocean Lead Scientist, and Conrad Speed, a quantitative marine ecologist and post-doctoral scientist from the Australian Institute of Marine Science, works as a post-doctoral scientist on the FinPrint project.

"We're conducting BRUVS surveys to determine the relative abundance of shark and ray species on coral reefs around the world," explains Dr. Heupel. "We hope to see where reef sharks are still doing well, and where management or conservation intervention is needed to help maintain or recover populations."

The project itself is centered upon the alarming fact that at least one quarter of all shark and ray species are endangered; the remaining species are nearing threatened status.

"Many shark populations around the world are in decline, largely due to targeted fishing and bycatch," Dr. Speed states. "The project aims to determine what the main drivers of shark and ray abundance and diversity are, as well as identify what actions can be taken to reduce or minimize impacts on this group of animals."

BRUV SURVEYS AT WORK

BRUVS are a non-intrusive tool for observing underwater life.

"The BRUVS used in this project are lightweight designs that can be hand-lowered and lifted into reef habitats," Dr. Heupel describes. "The unit consists of a lightweight frame that includes a small, inexpensive video camera in an underwater housing and a bait arm that holds a mesh bag of minced fish in the field of view. Each unit is equipped with floating rope and a buoy for recovery of the unit."

"Deployments are between 60 and 90 minutes and are spaced far enough apart so that the bait plume from each unit does not influence each other," adds Dr. Speed.

Once the field campaigns are finished, team members review the video footage to identify species and record their abundance.

"We use the maximum number of a particular species seen in the field of view at any one time as an estimate of relative abundance," Dr. Speed explains. "We can then compare that with other BRUVS from different reefs to get an idea of how abundance and diversity of one reef compares to another."

"Although BRUVS have historically used bait to attract predator species, we often see individuals and species not attracted to the bait in the background of footage, such as manta rays, and some groups are now baiting BRUVS with algae to try to measure herbivorous fish abundance," states Dr. Heupel.

ANSWERING QUESTIONS ABOUT POPULATIONS IN DECLINE

One of the goals of FinPrint is to detail which reef features are most important to retaining sharks and rays in abundance—at both local and global scales.

"When we analyze the data from the videos we will look to see if there are relationships between shark occurrence or abundance and reef features," details Dr. Heupel. "For example: are sharks more likely to be present in areas of high coral cover? Relationship of shark abundance to prey abundance is one of the questions we'll be exploring with prey density used as a factor in the analysis to see if it helps explain the patterns of shark abundance we see in the data." **KL**

To read the full article: <https://www.fondriest.com/news/finprint-determining-relative-abundance-sharks-rays-using-bruvs-surveys.htm>

MONITORING THE HEALTH OF ALASKA'S MARINE LIFE

BY LORI BALSTER

Sitka Sound Science Center, Sitka, AK

The Sitka Sound Science Center is located on the former site of the Sheldon Jackson College campus, once a Presbyterian Missionary School for Alaskan Natives in the 1880s. Over time, the school changed hands and is currently owned by several non-profits. Originally a place where boys could learn boat-building, shoe repair and printing, and girls could learn housekeeping and cooking, by the 1970s students were arriving to learn aquaculture and fish sciences. They also built the first salmon hatchery in Alaska with a state-issued permit. The College closed its doors in 2007 and reopened in 2010 as the Sitka Sound Science Center. The enthusiasm for research continued, and the Center took over the College's hatchery.

Sitka Sound Science Center now functions as a biological field station and is a member of the Organization of Biological Field Stations (OBFS). "As a field station, we have two main objectives: 1) to be a center for education and educational outreach, and 2) to perform marine research," says Heintz. Research at Sitka Sound is done in coordination with various other research entities, including the U. of California at Santa Cruz. "One of the big interests we share with Santa Cruz is monitoring the effects of ocean acidification on nearshore species. One of the ways we can help protect nearshore species from acidification is by maintaining healthy kelp beds. Vulnerable marine creatures,

such as herring embryos, may be protected by kelp. This is an active line of research being conducted in Sitka. Along with the U. of California at Irvine, we help to monitor marine biodiversity," Heintz mentions.

There is also an interest in landslide research. "There was a big landslide a couple years ago where people were killed. We have been partnering with the Rand Corporation to develop an early warning system," he adds.

Sitka Sound Science Center has also been working with NOAA and the Alaska Fishery Science Center on indices of ecosystem conditions for juvenile fish, especially on monitoring their nutritional condition. Calorimetry is used to monitor juvenile fish. Surveys conducted by NOAA, in the Bering Sea and the Gulf of Alaska, occur in alternating years. Surveys last 6 weeks and sample a gridwork of 130 stations located 30 nautical miles apart. These surveys are part of NOAA's ecosystem monitoring. Heintz says, "We get a profile of the water column by collecting water samples at various depths." Chlorophyll content is determined by fluorometric means, and a SeaBird CTD is used to get water temperature, conductivity and water depth data. "This data is very precise, good enough for oceanographers to use," says Heintz.

They also collect zooplankton data. "We have two sets of nets called bongos, one set of two nets has a small mesh size and captures small zooplankton, and the other set has a larger mesh size and captures larger, faster swimming zooplankton. By having these mesh sizes and netting systems, we will be able

to collect microplankton all the way up to krill," says Heintz. Zooplankton are preserved for later analysis. One of the nets is quantitative, the other can be used for specific sampling requests. Copepods are sorted to the species level, frozen, and brought back to the lab where a spectrofluorometric method is used to measure their lipid content. In this way, the amount of fat/energy available to the fish that eat the copepods can be measured. "The more fat the better," mentions Heintz.

After the zooplankton is caught, trawl nets are put out to sample fish. The trawler catches fish as far down as 30 meters deep (the top 30 meters of the water column) and the net is 180 meters wide...a huge net. "There are big wings that go out the sides, making for an enormous catch capacity," Heintz says. The net begins with a one-foot mesh and goes all the way down to a quarter inch mesh.

After the trawl is finished, the catch is sorted by species. Samples are retained for lab analysis. Stomach contents of fish are removed and analyzed for prey. Data on the fish diets, weights and lengths are taken. Calorimetry is also used to measure the calories/energy content of the fish per unit body weight. "The energy content shows us how likely the fish as a group will be able to survive," Heintz explains.

NOAA has gathered 16-17 years' worth of data on the aquatic species of the Bering Sea. "We've learned that if there are cool conditions and a late ice retreat in May, some fish species have good fat stores and survive well. On the other hand, if the conditions are warmer and there is an early ice retreat, those same species have less body fat and don't survive as well," Heintz explains. "So it is very concerning that the Bering Sea has had no ice at all for the past few years. It's rapidly warming. That's bad news for the fishermen." The ice helps protect species from storms off the northwest coast of Alaska, north of the Bering Strait. No ice means they are considerably more vulnerable to storms in addition to prey changes and other negative effects due to warming. Sitka Sound is now cooperating with NOAA to help in the analysis of the samples and understand how changing conditions affect other species in the Bering Sea and the Gulf of Alaska.

Heintz recalls a terrible warming event that happened in January 2014 in the Gulf of Alaska: the arrival of The Blob. "It was a huge mass of super warm water that extended north and west from the California coast up to the Aleutian Islands. It was as much as two standard deviations warmer than normal," he remembers. "It caused the high mortality of whales and collapse of the area cod fishery. It also caused a massive seabird die-off by 2015 due to the numbers of cod, herring and other fish dwindling. The event ended in 2016, but by then it had changed the whole ecosystem. By 2017, 80 percent of the adult cod were gone." NOAA also declared an Unusual Mortality Event (UME) for area whales in 2016. The whale deaths were a consequence of zooplankton and fish deaths due to The Blob. "A UME is declared based on standard surveys of whales. It was clear that the relative whale abundance had changed since 2005," says Heintz. Impacts were felt by humpback, fin, minke and gray whale populations. These populations will need to be monitored for years to come as the climate changes and warming occurs.

In addition to all the biological data, weather data is also collected by Sitka's weather stations. Data collected includes wind speed, wind direction, temperature and precipitation. The



Sitka Sound Science Center's Courtney Weiss estimating of the energy content of fish through a calorimeter.

weather station in Juneau also gathers air pressure data. "All the airports here have meteorological stations," Heintz notes.

Along with weather data from the weather stations, there are National Data Buoy Center NOAA weather buoys off the coast gathering sea level height, air pressure, air temperature, conductivity, wave height and water temperature data.

Sitka also does monitoring for the National Park Services at Sitka National Historical Park (Totem Park). "We collect temperature, dissolved oxygen and pH using YSI equipment," says Heintz.

Even though his position is still quite new, Heintz has already formed a positive view of Sitka Sound Science Center. "There are great people here, and I am excited by the new challenges and the possibilities," he says. "As we develop the research program, I would especially like to emphasize herring, as we have the only operating herring fishery in Alaska here." **LB**

Callie Simmons of the Sitka Sound Science Center stands next to gear used to monitor conditions in the Sitka National Historic Park.



Photo: Chantal Cough-Schulze

Photo: (Bottom) Tandi Stephens, (top) Tayler Jarvis



Heron dipper-See EXAMINER Inspection Camera

The dipper-See EXAMINER vertical downhole inspection camera is a cost-effective way to perform well inspections, maintenance, and installation quickly and accurately.



SeaView Systems SVS-603 Wave Sensor

The SVS-603 Wave Sensor is a highly accurate MEMS-based sensor that reports heading, wave height, wave period and wave direction via RS-232 or logs to its on-board data logger.

Airmar 150WXRS Ultrasonic WeatherStation Instrument

Airmar's WeatherStation 150WXRS provides real-time information on rain intensity, accumulated rainfall and event duration.



PME miniPAR Logger

The miniPAR logger is a portable, submersible instrument for measuring diffused sunlight through water, or PAR (Photosynthetically Active Radiation).



Hach DR300 Pocket Colorimeters

The DR300 maintains the pocket colorimeter legacy of reliability while providing state-of-the-art data transfer capability and connection to Claros.



Sequoia LISST-ABS Acoustic Sediment Sensor

The LISST-ABS from Sequoia Scientific is a low-cost sensor designed specifically for measuring suspended sediment concentration at a single point.



YSI ProSolo Water Quality Meter

The YSI ProSolo features expanded measurement capabilities with ODO/T and ODO/CT probe options and is ideal for a variety of applications including aquaculture, coastal, estuary, and wetland sampling.

NexSens CB-950 Data Buoy

The NexSens CB-950 Data Buoy is designed for deployment in lakes, rivers, coastal waters, harbors, estuaries and other freshwater or marine environments.



CHICAGO'S WILD ISLAND

BY KARLA LANT

The Chicago River is in many ways a quintessential urban American waterway. In parts of the city, it materializes between slabs of concrete and asphalt. It doesn't wind its way between banks as a natural river might; the Chicago River takes the course given to it by humans, splitting streets and bridges. A feat of engineering; the river once flowed into Lake Michigan, until humans decided to reverse that course and force the river to empty into the Mississippi River Basin.

However, this level of interference has taken its toll on the Chicago River. The South Fork of the river's main branch was once a sewer for the meatpacking industry of the Union Stockyards. Those days it was called "Bubbly Creek" thanks to gases from decomposing entrails and blood infiltrating the water and bubbling to the surface. The State of Illinois issued "do not eat" advisories for the river's fish due to contamination by mercury and PCB.

"It is no secret that, historically speaking, the Chicago River is not a good place to be a fish," remarks Dr. Andy Casper, the Director of Freshwater Research in the Haerther Center at the Shedd Aquarium in Chicago. "Water quality issues, especially industrial and combined sewer overflows, along with a lack of suitable aquatic habitats combined to form a real problem. However, since the Clean Water Act helped reduce industrial pollution and the City of Chicago and Metropolitan Water Reclamation District (MWRD) have made progress on combined sewer overflows, habitat becomes the limiting step."

Thanks to the persistence and planning of many in the region, however, the Chicago River is enjoying a chance to make a comeback. Dr. Casper explains that Urban Rivers, a local non-profit, generated the floating habitat idea. The island would be made up of

many individual modules, and the Urban Rivers team believed that inspiring local people from the neighborhood to come down to the water would lead to the cleanup of plastics in the river.

Their next step was to raise money, find partners, and engage local people in building and monitoring the module habitat. The murky waters are now home to a river "island," an artificial floating eco-garden designed to improve the water quality naturally, and engage locals in preserving the river. The island and its planned companions will make up a "wild mile" in the Chicago River, an urban oasis for Chicagoans to enjoy.

THE "WILD MILE"

The wild mile North Channel site in the Chicago River is located adjacent to Goose Island and the Whole Foods store on Kingsbury. The spot was chosen by the Urban Rivers team based on their pilot work which indicates that the shallow water, low boat traffic, low river flow, ease of access by kayak, and ease of viewing from the cement riverfront walkway make it the optimal location.

"The location of our install was chosen largely because it's the most convenient spot," explains Phil Nicodemus, who serves as both the director of research for Urban Rivers, as well as the Nature Outpost Stewardship Coordinator for the Shedd Aquarium. "We already had worked at this spot, so there's a research foundation there, and it was easy to establish relationships with the businesses on the river there. There's no commercial traffic allowed, it doesn't seem to ever freeze over in the winter, and it's a relatively calm area of the river, all of which make it easier to study which of our plants are best suited for



Each species of plant was carefully chosen for the island.

these wetlands, and which species will need more protection if we're going to keep up the diversity."

As of July 2018, Urban Rivers and Shedd Aquarium had teamed up to place a new 260-square-foot floating garden of native plants in addition to the existing 1,500-square-foot island. This new river island will be home to species such as Dudley's rush, marsh marigold, queen-of-the-prairie, and swamp rose mallow. These plants are in turn drawing more insects and other animals back to the river.

The floating island modules are constructed of coconut coir, an inert growing medium made of coconut husks. Tubes of rolled coconut coir are lashed together on a stainless steel frame and connected to wooden pallets that are stuffed with leaves and submerged. This element of the island draws invertebrates, minnows, and tadpoles to the wild mile.

"We choose the plants under the guidance of our botanist, Peter Nagle, who works at the botanic garden managing many of the same species we're using," details Nicodemus. "Since this is such a novel growing platform, a lot of what we're doing right now is just trial and error. For instance, in our first install we tried out a forb called 'rattlesnake master' which should be able to handle a reasonable amount of moisture from terrestrial experience, but it didn't survive past the first year. We want to maximize the diversity of species, but in the long run we're going to want to select for the species that give us the most ecological bang for our buck, and pick plants that are going to be able to thrive long-term—meaning 20+ years—on the islands, while still keeping diversity high."

RESTORING THE RIVER

To round out the modules, the teams add waterfowl boxes and turtle logs, and the entire setup is monitored by an underwater camera on a live feed. The islands are already attracting monarch butterflies and black-crowned night herons. Common carp—an invasive yet very hardy species—are using the water underneath and around the islands as a mating ground.

"In very healthy, high-quality ecosystems the invasive Common carp can certainly be a big problem, especially uprooting aquatic vegetation and stirring up mud from the bottom while they are pursuing their invertebrate foods," remarks Dr. Casper. "However, the Chicago River ecosystem is not high-quality yet. It is highly modified with concrete lining the shore, loose muddy

bottoms, and a real lack of naturally varying river flows. Water quality is way better than it used to be, but big storms can still really muddy the waters too."


Adult Common carp are very tough fish, and they generally tolerate all of the problems the Chicago River presents well—that, Dr. Casper points out, is why they are such a successful invader. However, their young are still just as vulnerable as native fish.

"The fact that we have been seeing them spawning in and around the habitat modules in the spring is a sign that the tolerant fish can make it," adds Dr. Casper. "That is welcome news that leads us to think that if we install more high-quality habitat, like the Shedd's River Island, that we might actually be able to have more Bass, Bluegill, and the minnows and chubs they feed on, too."

Next, the Shedd and Urban Rivers teams will be adding humans back into the mix in the form of kayaking citizen scientists. Of course, researchers from both teams will monitor how the islands are doing, and analyze how they are impacting water quality. Eventually, so will citizen scientists participating in the Kayak for Conservation program. Volunteers will kayak around the islands, observe, and tally the number and variety of species, both animal and plant, that are on and near the modules.

"We're tapping into a lot of citizen science networks so that we can compare our islands to terrestrial settings," states Nicodemus. "For instance, we will be using the National Phenology Network's system to compare our plants in terms of seasonal stages to the rest of the country, to make sure our plants have the right timing and we aren't missing out on some key seasonal shifts that might harm their appeal to birds or pollinators. We will also have volunteers count pollinators and length of time they visit the islands."

This will complement Nicodemus's ongoing research, as well as the fish surveys and macroinvertebrate sampling being conducted by the MWRD.

"I will be using periphyton sampling plates to measure changes in chlorophyll a and algal diversity, as well as using 96 well ecoplates to measure microbial functional diversity," adds Nicodemus. "Combined, these projects should give us a good idea of what these indicators were like before we installed any islands, and after we installed our first 1,500 square feet of islands, and will capture how much more we are changing the ecological situation in the canal as we expand out, with the ultimate goal of being able to precisely define the benefits of these native planted floating wetlands to the local wildlife." 

The team prepares to put the island to work in the river.



All Photos: © Shedd Aquarium/Brenna Hernandez



Archbold Biological Station; Venus, FL

The oil industry is sometimes viewed as an enemy of conservation. But it was the oil industry that enabled the founding of Archbold Biological Station, one of the members of the Organization of Biological Field Stations (OBFS). Descended from John Dustin Archbold, President of Standard Oil of New Jersey, Richard Archbold used his private wealth to further the cause of field research and education. He became an explorer, aviator and perhaps most importantly, a research associate with the American Museum of Natural History. He established Archbold Biological Station in 1941 after the father of his friend, Donald Roebing (from a famous family himself), donated 1,058 acres of pristine land in the heart of Florida to further Archbold's research dreams.

Hilary Swain, Executive Director of Archbold Biological Station, explains some of the valuable fruits of Richard Archbold's legacy: research and monitoring records that go back far enough to offer a long view of the changes in the land and wildlife. "We have weather data that goes back more than 75 years. We have long-term data sets for other types of data, too, such as hydrology, atmospheric, landscape and biological records. Our research data have been very important for many groups," says Swain, who has been Executive Director for 20 years at Archbold.

Stored samples are diverse. They include everything from blood samples from Florida scrub jays, the only species endemic to Florida, to large museum-type specimen collections.

Since 1941, Archbold has been collecting environmental monitoring data under the broad categories of climate, hydrology, atmospheric, species and landscape. Archbold's long-term goal is to make the most of its extensive environmental monitoring data and associated metadata available publicly.

According to Swain, there are two overarching goals for scientific work at Archbold. The first is the conservation of biodiversity; the second is the maintenance of natural cycles.

The first major category of work at Archbold, the conservation of biodiversity, has a focus on long-term tracking of rare and threatened species. This involves conservation and population biology. Blood samples with DNA data are collected in the field. Traditional field techniques like using binoculars and field notebooks to track individual's movements and other population changes are also used. Bushnell Trophy Trail camera arrays are used to track animal movements and help with creating population estimates. "Our researchers use trail cameras to tell us what animals are out there and where they are moving. These animals can range from gopher tortoises to Florida panthers. Some larger species, such as black bears, have been tracked using Lotek radio and satellite collars. Larger birds such as Crested Caracara have been tracked using VHF radio tags," says Swain.

The second major category of environmental research at Archbold, maintenance of natural cycles, has a focus on cycles of

Four scrub-jay chicks in researcher's hat.



Photo: (bottom) Dustin Angell, (top) Archbold Field Station

All Photos: Dustin Angell



(Left to right) Steffan Pierre, Water Conservation on Ranchlands; John Fitzpatrick (Florida Scrub-Jay Researcher & Director of Cornell Lab Ornithology); Hilary Swain, Executive Director of Archbold Biological Station; Angela Tringali (Florida Scrub-Jay Researcher); Samantha Apgar (Florida Scrub-Jay Research Intern).

carbon, water, nutrients and fire. Climate data, flooding and drought data, and controlled burn data are all included in this category. Archbold has controlled burn records that date back 50 years and fire mapping at Archbold dates back to the 1980s. Most fires are about 50 to 200 acres in size, and currently, a DJI Phantom 4 Pro drone is used to track fires. "From drone imagery, we develop fire intensity maps where each cell is 5 x 5 meters. The Archbold 'grid' is made up of about two million of these cells," says Swain. Archbold land management data is maintained in MS SQL databases. "While the actual data are very important, management of these data is vital," adds Swain.

It is because of intensive data management that Archbold can keep track of its multiple hydrology data streams, which come from its 20,000 acres of land, part of headwaters of the Everglades. There are at least 20 water projects currently going on at Archbold. "We have data from Lake Annie, which we've been collecting since the 1930s," Swain says. Lake Annie is a special pristine 90-acre sinkhole lake, whose sediment cores show a record of area vegetation for the past 40,000 years. Many types of instrumentation are used at Archbold, including LI-COR equipment for measuring light and photosynthesis. LI-COR sensors have been used since 1983. A sonde is used to collect temperature, pH and oxygen data on a 15-minute basis. Temperature data are taken down the full lake profile which is 67 feet deep. "At first our lake data were collected manually, then with data loggers," says Swain. By 2008, fully automated lake data were being collected, including weather data, pH, conductivity, temperature, air and light. Archbold contributes lake data to the Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI) a major hydrological database, supported by NSF. "We are now anticipating adding an EXO-2 sonde with additional sensors to deploy on a planned Fly Dog OSCAR profiling buoy. Much of the data and deployment technology on the new buoy will be from Estonia," Swain mentions.

As well as all the data gathered at Archbold's Station property, more typical of a nature reserve, a large proportion of the water and other types of data are collected at Archbold's full-scale cattle ranch, also on its property, with 3,000 head of cattle. One

of the cattle studies, for example, is used to evaluate long term sustainability of American agriculture.

"The ranch, which is managed for research and education, is part of the Long-Term Agroecosystem research network (LTAR)," Swain explains. "It's one of the 18 research sites networked by the USDA for long-term research. We collect controlled fire data on the open grasslands, as well as carbon cycling data and hydrological data to represent a typical cattle ranch. Reconyx trail cameras are used to track animal movements on ranch land. We have eddy flux towers which track CO2 and methane fluxes, in a collaboration with the University of Illinois study since 2012." The cattle ranch has seen its share of pioneering work. "We were one of the first installations where methane sensors were deployed," Swain says with pride. The results from these data are available to policymakers and to the general public or are in the process of being made public. "Archbold's goal has always been to get data such as those collected by LTAR into public hands and agency hands," Swain emphasizes. Archbold protects 20 threatened and endangered species living on its large property, including the Florida scrub jay and 15 listed plants. Archbold's Florida scrub, an ancient sandy ecosystem with oak and other acid-loving plants and grasses, is ideal habitat for many of these rare flora and fauna.

Archbold has a staff of about 50 people, with about 20-30 graduate students and interns.

Archbold's research efforts enjoy support from the NSF and collaborations with other universities such as the University of Florida. Archbold is also a member of the Global Lake Ecological Observatory Network (GLEON) and contributes to global lake ecology data.

Swain has enjoyed her 20 years at Archbold Biological Station. "Science, conservation and education make up the tapestry of my everyday life," Swain says. "I am lucky to be here." ^{LB}

ENVIRONMENTAL MONITORING BUOYS

NexSens CB-Series Data Buoys are designed for deployment in lakes, rivers, coastal waters, harbors, estuaries and other freshwater or marine environments. The floating platform supports both topside and subsurface environmental monitoring sensors including weather stations, wave sensors, thermistor strings, multi-parameter sondes, Doppler current profilers and other monitoring instruments.

The ideal coastal water monitoring buoy station remains light enough to deploy readily but is larger, heavier, and more stable than its inland cousins so it can withstand high winds and storms.

Buoys and instruments deployed with them are flexible, allowing for upgrades and changes to buoy systems over time as water quality monitoring and research priorities fluctuate and regulations change.

NexSens CB-650, NexSens CB-950, and NexSens CB-1250 data buoys are specifically designed for water monitoring systems deployed in offshore environments. Relative to other large ocean-going platforms, the CB-series buoys are sized specifically for large lakes and coastal waters, so a large ship or vessel is not required for deployment or retrieval.

NexSens buoys are constructed with an inner core of cross-linked polyethylene foam with a tough polymer skin. There are several wireless options for getting your data back to shore, including cellular, Iridium satellite data transmission, spread spectrum radio, and WiFi. Analog and digital communication options include RS-232, SDI-12, RS-485, mA, VDC, and pulse count.

Each model guards subsurface instruments—and allows them to be quickly deployed—as they pass through three sensor holes with female NPT threads. A bottom mounted instrument cage provides a deep mooring for instruments and provides ballast weight for improved stability.

Three integrated solar panels are evenly spaced around the buoy to capture sunlight from any direction and provide adequate battery charging. The solar tower can be quickly detached and installed either before or after deployment. Optional battery banks offer 12VDC at 28, 56 or 84 A-Hr for power demanding applications such as onboard video cameras, fast sampling wave sensors, Doppler current meters, and frequent data transmissions.

Each buoy hull has a central data well that accommodates data loggers, batteries, sensors, and other tools, and increase in holding capacity as the models go up. The standard data well lid provides pass-through connections for sensors, power, venting, and more. These fittings can be backfilled with epoxy or sealant to ensure waterproof ports. A data well plate can be supplied with user-defined connectors or as a NexSens data logger, the X2-CB. A connectorized lid provides a plug-and-play solution for industry standard sensors.

The CB-450 and CB-150 buoys are small and lightweight enough to deploy from small boats yet built with the same materials and technologies used in large coastal buoys, thus providing a floating platform for years of service even in extreme environments. Outfitted with topside lifting eyes and bottomside mooring eyes, rigging is quick and easy. Structural strength is achieved with a through-hull stainless steel frame and bottom cage structure, which can also accommodate multiple sensors, just like the coastal models.

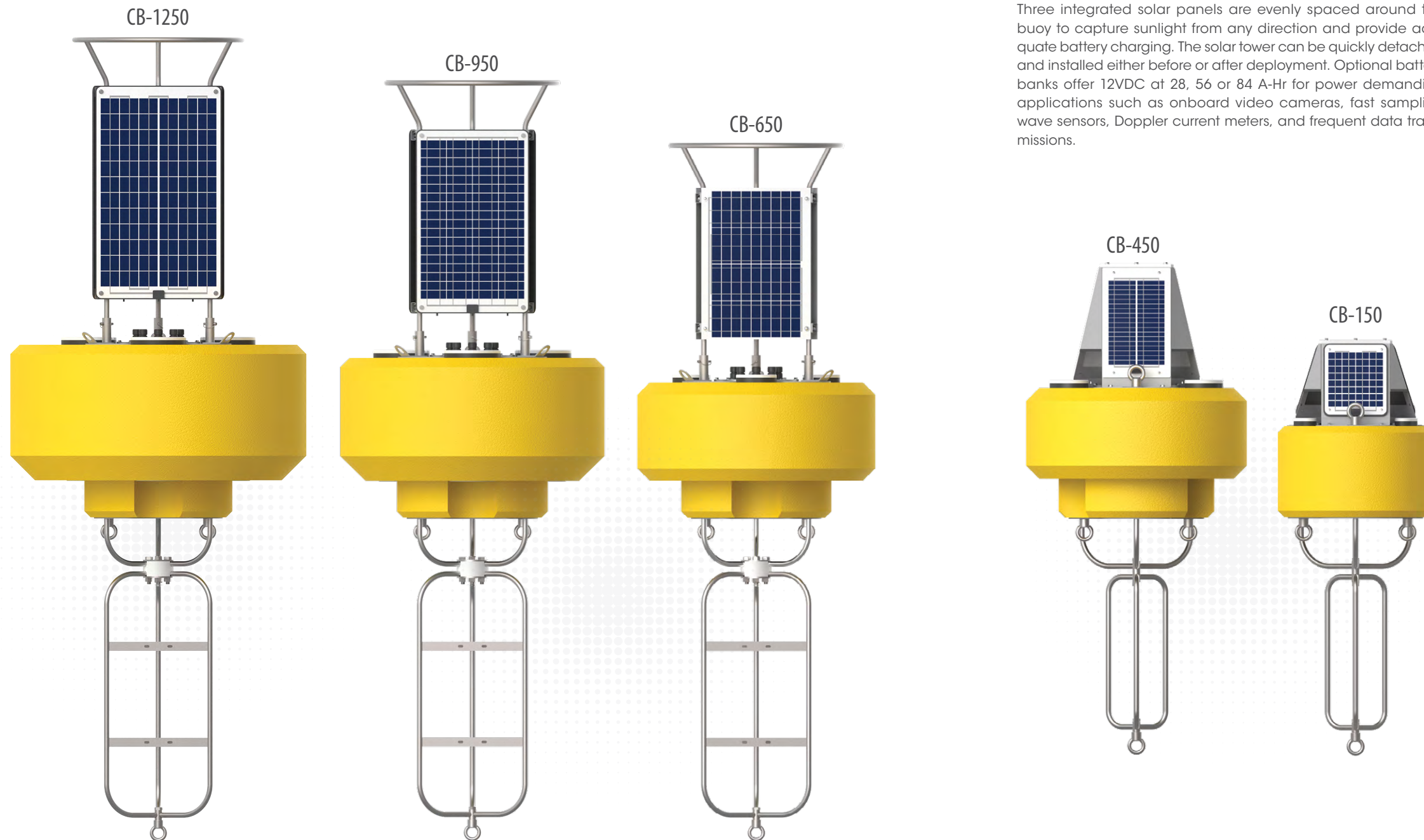
Data buoys offer streaming data in real-time with sampling frequency as often as every minute, 24 hours a day, 7 days a week, 365 days a year. This allows for a comprehensive understanding of how water quality is changing, and adjust accordingly.

Data buoys allow independence from a power source and can deploy anywhere, as needed. Battery and solar power options as well as a range of telemetry choices mean remote sensor control and data access, even along a remote shore. Buoy platforms can also stay connected to online systems and servers, communicating data and conducting routine maintenance with minimal interruption.

Finally, thanks to data management software tools, organizing and interpreting data as soon as you get it is feasible. Use the WQData web datacenter, a secure option for users to store, present, and create graphs of the data. This program ensures that the software alerts the right manager should water quality parameters exceed set limits, eliminating the need for continuous data monitoring.

NexSens coastal and marine buoy monitoring systems use instrumentation that is designed to meet the demands placed on them during longer-term deployments, despite the harshest of conditions and the most stringent requirements for data. We work with customers to customize buoy monitoring systems, allowing them to do more year after year, as modular platforms with many sensor options.

For more information on NexSens data buoy platforms, email customer-care@fondriest.com or call 937-426-2151 to speak with an applications engineer.



IN THE GREAT LAKES

RESEARCH FROM AROUND THE BASIN



Lindsay Ensing [CC BY-SA 2.0]

HURON

Huron Pines, an organization out of Northern Michigan, is committed to a holistic approach for solving issues within the Great Lakes Basin. The group heads the Lake Huron Forever Project; a partnership including six regional teams working toward developing action plans and executing them, with help from local communities. The Lake Huron Team consists of both American and Canadian organizations such as Lake Huron community foundations: Bay City, Grey Bruce, and Northeast Michigan; Grey Bruce Sustainability Network; Grey Sauble Conservation Authority; Michigan Department of Natural Resources; Saginaw Basin Land Conservancy and the Conservation Fund-Saginaw Bay Watershed initiative network. The Lake Huron initiative focuses on ensuring the long-term health of the Great Lakes. Starting with an Action Agenda, the plan is approved by both the community and the committee before submission for grants. The group hopes to provide communities with access to clean and safe water by implementing stormwater management solutions. With continued support from neighboring districts and the collaborative efforts of all organizations involved, the Lake Huron Forever Project advances.

Huron Pines (2019) *Committing to a Healthy Lake Huron Forever. (Program Description)* Retrieved from <https://huronpines.org/glow/>

ERIE

David Boughton of the Penn State Sea Grant College program and Janyl Jumadinova from Allegheny College's computer science department team up to build research robots that can record water quality data at various depths for extended periods. This technology would allow researchers to achieve a better profile of selected lake parameters, given the range of the platform. From experience with the students, Boughton was able to come up with the idea of adding sensors to the robots. For this branch of the project, the team is joined by student Elisa Wright, who majors in Environmental studies and computer science. Wright can encompass all of her passions into this one project; she writes the programs that help gather environmental data. Through this collaboration, the team hopes to develop the robot into a submersible device capable of gathering and transmitting data to help students better understand water quality measurements.

Allegheny College (2019) *Allegheny Faculty-Student Team Helps Develop Underwater Robots to Perform Lake Research*, by Richard Stanley (News Article) Retrieved from <https://sites.allegheny.edu/news/2019/02/19/allegheny-faculty-student-team-helps-develop-underwater-robots-to-perform-lake-research/>



Nicholas A. Tonelli [CC BY 2.0]

SUPERIOR

Invasive organisms are becoming a more regularly discussed topic as their prevalence becomes unmistakable. As oceans and lakes warm, the non-native species are welcomed into a previously non-habitable area; where they can and will choke out native organisms. Northland College researcher Toben Lafrancois looks into their presence around the Apostle Islands of Lake Superior. While Superior is less known for the invasive mussels due to lower temperatures and nutrient levels, there have been sightings throughout. Superior has lower densities than other Great Lakes, and scientists believe that mitigation efforts will be more successful than in systems with a higher abundance. A Great Lakes survey, including the area of the Apostle Islands, aims to determine the species' origin waters. Conducted by Mike McCartney of the University of Minnesota, the survey uses DNA sequencing to reach the goals of the study and hopes to limit the range of the species.

Wisconsin Public Radio (2018) *Researchers: Invasive Mussels Not Widespread In Apostle Islands Of Lake Superior (News Article)* Retrieved from <https://www.wpr.org/researchers-invasive-mussels-not-widespread-apostle-islands-lake-superior>



Giorgio Galeotti [CC BY 4.0]



Serena Livingston, [CC BY-SA 2.0]

ONTARIO

Since the 1970s, when NOAA was in its early operation, an attempt to protect and restore areas that require preservation and protection has been underway. There are currently 13 national marine sanctuaries and two national marine monuments operated by NOAA's Office of National Marine Sanctuaries. The process for inclusion/exclusion from this designation is long and sometimes ineffective, as the site must hold both "historical" and "cultural" significance to the nation for consideration. Recently, Lake Ontario has been in the running as a designation, now moving into the public approval portion of the process. Members of the community can attend scheduled meetings and engage in discussions that could help the 1,700 square-mile area gain protection. The area considered for preservation holds around 20 known historical shipwrecks, one military aircraft and one of the oldest confirmed shipwrecks, The HMS Ontario; making it a unique area that deserves the designation of a protected marine sanctuary.

NOAA (2019) *NOAA seeks public comment on proposed Lake Ontario National Marine Sanctuary. (News Release)* Retrieved from <https://www.noaa.gov/media-release/noaa-seeks-public-comment-on-proposed-lake-ontario-national-marine-sanctuary>

MICHIGAN

In the 1990s, water levels of Lake Michigan rose significantly and researchers lacked technology to evaluate and track bluff failures. As water levels are again rising, specialists are equipped to investigate the preliminary signs of bluff failure. The Wisconsin Geological & Natural History Survey and UW-Madison can gain a better understanding of why areas around the lake are experiencing bluff failures more readily than others. The team installed groundwater wells to help understand and monitor groundwater properties that contribute to landslides. Drones are used to map the area and track change. Another unique aspect of this study is the method used for monitoring bluff movement; a wire stretched from bluff-to-land that registers any movement. The goal is to create mathematical models that integrate the methods of the study to provide a sort-of "early-warning" for the community on potential bluff failures. Scientists believe that even as water levels recede, impacts on bluff structures will continue.

University of Wisconsin-Madison (2019) *As Lake Michigan rises, bluffs collapse and geologists explore (News Article)* Retrieved from www.news.wisc.edu/as-lake-michigan-rises-bluffs-collapse-and-geologists-explore/



Shawn Harrison, Public domain

Rookery Bay

SPECIAL PLACE FOR RESEARCHERS BY LORI BALSTER

“Mangroves have a special 3D structure that makes them unique,” says Dr. Brita Jessen, Research Coordinator for Rookery Bay National Estuarine Research Reserve (NERR) near Naples, FL. “The structure helps trap sediment and it also creates structure for fish, crabs and other species, especially the ones that are young and vulnerable.”

Some notable species that make their homes in Rookery Bay mangrove forests are red drum, snappers, stone crabs and blue crabs. There are also designated mangrove forest areas for the small-toothed sawfish.

“Mangrove forests are highly productive,” Jessen adds. “They take up carbon from the air and convert it to biomass, so they are good for carbon storage, too.”

The mangrove forests of Rookery Bay Reserve are conserved in perpetuity, an enormous value to the growing community for recreation, water quality and protection. Covering a 110,000-acre area to the north of the Ten Thousand Islands area, Rookery Bay was designated a Sanctuary in 1978 following the determined efforts of the Collier County Conservancy to purchase and preserve Rookery Bay and the surrounding land.

In addition to the mangrove habitat, Rookery Bay also has beach habitat that supports many notable species, including loggerhead turtles, green turtles, Wilson’s Plover, Least Terns and Black Skimmers.

As part of the Florida Department of Environmental Protection and in coordination with the National Oceanographic and Atmospheric Administration, Rookery Bay NERR works with partners such as the U.S. Geological Survey, the Fish and Wildlife Service, several local universities, and non-profits such as the Conservancy of Southwest Florida and the Coastal Resources Group. Like the other NERRS, Rookery Bay utilizes the System Wide Monitoring Program (SWMP) for monitoring purposes. Water quality parameters that are measured continuously include temperature, pH, dissolved oxygen, turbidity and salinity; nutrients and chlorophyll are measured monthly and weather data; air temperature, wind speed, rainfall, photosynthetic active radiation, or PAR is monitored continuously. There is also a robust vegetation and benthic habitat map of the area that is currently being updated. All of these data are provided through the Centralized Data Management Office (CDMO) for research, education and management on its website, www.nerrsdata.org. The

Rookery Bay station has a telemetry unit that transmits data to the CDMO.

“We have five data sondes to gather water quality data. At four stations we deploy YSI EXO-2 sondes, with one station using the older YSI 6600 sonde,” says Jessen. “We actually have about a dozen active Xylem/YSI sondes, because we are constantly swapping them for maintenance. We also use a Teledyne ISCO autosampler for diel samples, and we have a Campbell weather station.”

A “Sentinel Site” program is currently in development. Through this program, Rookery will monitor changes in coastal vegetation in relationship to elevation, sea level, and groundwater level and salinity. Surface Elevation Tables (SETs) are monitored throughout the Reserve.

Rookery Bay NERR currently has a special wind sensor made to withstand hurricanes. “Unfortunately, though, our cable was not, and it broke loose during 140 mph hurricane winds,” Jessen recalls.

Jessen found the arrival of Hurricane Irma to be an exciting time at Rookery Bay. “We decided to leave in three of our five continuous monitoring stations (whew, thank goodness they all stayed in place!). These stations gave us great information about the immediate changes during and following the storm. We recorded the tidal recession and storm surge, the salinity change from precipitation, and (at two stations) a prolonged drop in dissolved oxygen following the storm. For about a month following the storm, our resident fish populations were very low, but the population size appeared to recover about one month out. We are still looking into the data for any species-specific effects,” she says.

Rookery Bay also plans to use Motus, a Canadian/US sensor network of monitoring stations that utilizes automated radio telemetry to gather data on the movements of small creatures. In the future, Rookery Bay plans to use nano-tracking with sensors small enough to be affixed to birds, bats or even insects.

There is also site-specific monitoring which mainly focuses on resident or migratory wildlife in the Reserve: shorebirds, wading birds, demersal fish, juvenile sharks, nesting sea turtles, crocodiles, gopher tortoises. The avian program uses Compudata Systems and SensorGnome to power Rookery’s Motus receiver.

Invasive flora and fauna are monitored, as well as recovery after prescribed burns, which Rookery Bay NERR does during the January – March timeframe. “We recently bought a drone to look at the fire season landscape,” says Jessen.

Wildlife studies mentioned above are special for Rookery, but the NERR often works with partners to standardize methods and share data. For instance, the sea turtle monitoring program identifies nests (Rookery cages those for protection from predators), “false crawls” where nesting was not successful, and hatchling success. An additional study looks at nest and sand temperatures along an elevation gradient, which is also being replicated by two sister NERRs in Florida. The sea turtle monitoring program uses Onset Hobo temperature loggers.

A fish trawl program has been running for nearly two decades in the Ten Thousand Islands area. Each month a trawl is conducted in three bays receiving different levels of freshwater input. This study has been recently enhanced by an acoustic monitoring program in partnership with NOAA, where Rookery Bay researchers tagged resident fish and juvenile sharks and deployed an array of acoustic receivers within two bays. The fish monitoring program uses Vemco acoustic tags and receivers. They hope to learn more about how different seasonal salinity regimes factor into habitat use by the fish populations.

The shorebird and wading bird monitoring programs focus on critical habitat areas throughout the Reserve as we monitor populations of resident or migratory birds, nesting attempts and successful breeding.

Many people come together to make Rookery NERR research successful. The Rookery research team has five members. They work closely with resource management, which has an additional five researchers. Since Rookery work is science-based management, there is often collaboration across departments for combined resource monitoring and stewardship.

In addition, interns help during the busy nesting seasons.

Undergraduate or recent graduate internships on specific projects (recent examples are a GIS project and a carbon flux study in mangroves) are also supported.

One keystone of the Reserve is to serve as a research platform for visiting scientists and their students. Sometimes professors bring a field class to stay in the Rookery dormitory and conduct work. There have been several visiting graduate student researchers, either supported on external grants or through the NERRS system. Recent graduate student research includes: a Florida Gulf Coast University student studying the effects of hurricane Irma impact on wading bird habitat use, a Florida International University student studying estuarine trophic links of shark populations, a Florida Gulf Coast University student examining habitat use by invasive pythons, an Ohio State University student examining

food web relationships of invertebrates along tidal channels and a Florida State University student studying effects of human interactions on dolphin populations

Currently, there is no official citizen science program at Rookery, but there is an amazing group of dedicated volunteers: boat captains, birding experts, and strong-muscled men and women who help haul in and count the fish trawls. Rookery also works with a group called Team Ocean who helps with stewardship and communication for the Critical Wildlife Areas and seasonal closures within the Reserve.

In addition to all the monitoring work and research, Rookery Bay is a steward of the 110,000 acres through restoration and active management. One past undertaking was the removal of invasive Australian pine next to the reserve. “The pine trees allow erosion to happen that you don’t see with the mangrove forests,” says Jessen. “The pine trees don’t have the special root structure the mangroves have that trap sediment and hold the coastline together.”

Another major restoration project is the future restoration of the Fruit Farm Creek area. The construction of Highway 92 in the area impeded natural tidal flow and caused water to stay in the area longer than normal, gradually resulting in acres of mangrove forest die off. In the “die-off” site, the canopy has been lost and there are scant, stunted mangroves growing. “But what I’ve found fascinating is that it’s still habitat for some very resilient species of algae, invertebrates and wading birds who stop by in the early morning before the heat comes in. Even in extreme conditions, nature finds a way to persevere,” says Jessen.

Jessen has been Research Coordinator at Rookery Bay NERR for two years. Before Rookery Bay, Jessen was a doctoral student at the University of Rhode Island’s Graduate School of Oceanography. She also previously worked for another NERR, running a nutrient enrichment program at Jobos Bay NERR in Puerto Rico, the subject of a previous article in *Environmental Monitor*.

Jessen has enjoyed her work at Rookery Bay NERR thus far.

“We have a team of extremely dedicated staff. I’m always learning from them. I am very proud that we take a thoughtful approach between consistent monitoring, but with improvements as technology or new information becomes available. It’s important to maintain standard protocols but also allow for change when it makes the most sense,” she says.

In summary, Jessen returns to the statement that the Reserve is a platform for research: “If any *Environmental Monitor* readers would like to reach out to us to explore new approaches to monitoring, we would be happy to support that. We have a long list of additional monitoring needs to enhance our knowledge of change in our region, and partnerships are the best way we can achieve it,” she says.

Photo: A black skimmer (DEP/Rookery Bay Research Reserve).



THE AGUADRONE

BY LORI BALSTER

"I came up with the idea about five years ago," says Dan Marion, Founder and CEO of AguaDrone, based in Vero Beach Florida. "I do a lot of fishing, and I came up with the idea of a waterproof drone that could help with my fishing, and could help others fish, too. I came up with the idea of interchangeable pods for different functions I wanted, so it wouldn't be hard to switch functions to suit what I needed while out there trying to catch fish."

Since then, Marion has been contacted by Shark Tank, Make Me A Millionaire Inventor and Discovery Daily Planet in Canada. "Everyone's been calling me!" Marion laughs. Not only people who fish, but also researchers, including marine biologists and others who spend their lives delving into the inner workings of fish and other aquatic life. Harbor Branch in Florida, a biological field station that was the subject of a previous Environmental Monitor article, is just one of the research facilities that has been in touch with Marion. "My idea for their facility is to use our waterproof drone system to look at red tides and other Harmful Algal Bloom (HAB) aspects," Marion says. "Their problem was that they wanted to gather samples near the shore, but using their current methods, they couldn't get samples beyond a certain distance. Our drone system allows them to do that safely and efficiently."

The AguaDrone system uses two eight-ounce sampling bottles attached to the drone. "You can send the drone out with bottles attached to the bottom, lower it in the body of water you want to sample, and the drone will pick up the samples and bring them back to you without spilling them," says Marion.

The AguaDrone can use several pod attachments for various purposes. There's a pod for gathering water samples, a pod that acts as a wireless fish finder and a pod that helps someone fishing to cast with more precision, to name a few. "Our pods are unique and we have patents and patents pending for them. Also for the bottle harness," Marion adds. The drone weighs about 4 pounds, 1 pound of which is the pod or sample bottles when filled with water.



This prototype was used to verify lifting capacity of filled containers.



The fish finder pod is shown here in action.

One of the pods has probes to measure typical water parameters of interest such as dissolved oxygen, salinity, pH and dissolved solids. "That pod unit was made in house, including the probes," says Marion.

AguaDrone has the first and only system with a wireless sonar pod that sends a wireless signal to a smartphone or tablet, turning the AguaDrone into a fish finder. "It's a patented system which gives water temperature, depth, underwater structure information and fish marking," Marion explains.

The AguaDrone also has a waterproof gimbal pod for watching and recording live fish underwater from the surface. "We can attach an action camera in the Gimbal pod such as a GoPro then the gimbal pod is attached to the bottom of the drone using 11 connector rings on the pod connecting to 11 spring connectors on the bottom of the drone," mentions Marion.

The AguaDrone can also be used to drop bait with more precision, raising chances of a good target strike, but the drone itself is not used directly for fishing.

While AguaDrone has many possibilities, there are a few restrictions on the technology. "You have to keep the drone in your line of sight and follow rules set by the FAA," says Marion.

In the future, AguaDrone plans to continue focusing on marine research. "We want to be part of the solution for collecting data on HAB," says Marion. "There are all sorts of other interesting applications we have been involved in as well. For example, there is a project where our drone is used to identify jellyfish clogging up the turbines of power plants. They clog up water intakes for generators and the generators overheat. Who would have thought? I honestly am hearing of new ways people might use AguaDrone all the time."

The AguaDrone company has six principal members who are specialists in electrical engineering. Some were formerly employed by 3D Robotics, one is a helicopter pilot, and most are members of the U.S. Army. Marion's son acts as the COO. **LB**

Photos: Dan Marion

Photo: Stevens Institute of Technology

AI-POWERED ROBOTS

BY KARLA LANT

Researchers from Stevens Institute of Technology are training robots to adapt to unpredictable oceanic conditions using machine learning. Robots that can inspect underwater infrastructure autonomously could reduce risk to human divers and provide improved security. However, additional possibilities for deploying AI-powered robots underwater are numerous.

A MORE ACCESSIBLE PLATFORM

Some of America's most critical infrastructure is hidden underwater. Inspecting and protecting it can be a challenge because human divers who do it must all be trained divers, engineers, and safety experts.

Smart underwater robots might be able to remove humans from the equation. Brendan Englot, Professor of Mechanical Engineering at Stevens, spoke with EM about several projects developing algorithms for the low-cost, open-source mini ROV platform: blue ROV.

"We're interested in accurate, autonomous inspection of subsea structures, spanning many different types of infrastructure," details Dr. Englot. "The interest is increasing automation in subsea oil and gas operations so that divers and operators face less risk."

TRAINING ROBOTS TO EXPLORE THE OCEAN'S DEPTHS

Developing applications that would enable persistent surveillance and inspection of the health and integrity of piers, bridges, ship hulls, and other underwater infrastructure, the team has focused on two basic research questions.

"One is how you explore an unknown environment," Dr. Englot describes. "Imagine you have to inspect a damaged pier. You know its geographical boundaries, but you don't have a good prior model of it from before the damage, and you don't know where all the structures are located, or where any obstacles are. The robot has to be able to dive down within the designated boundaries you gave it, explore on its own, avoid collisions, and come back with a complete 3D map of the structures contained in that area."

The team is developing algorithms that will help a robot explore an unknown environment more efficiently, and make decisions about how to map and how to use its sensor data to decide where to drive next as this evolving map is coming together. The other basic research question the team is pondering is how the robots can tackle underwater uncertainties such as currents without a perfect model describing how everything behaves.

"Winds, waves, and other kinds of disturbances in the water, and the properties of the robot's sensors also will vary depending on the conditions of the environment," remarks Dr. Englot. "Turbidity



Dr. Englot and an ROV.

may reduce visibility, and your Acoustic Positioning System might not work well if the water is very shallow or if there are many submerged structures surrounding the robot."

The team is building a machine learning framework the robot can use to learn to maneuver in an environment with an imperfect model—or no model—and monitor the water parameters around it to learn.

"Our robot is equipped mostly with perceptual sensors, so it's able to measure its own motion relative to structures, or its motion relative to the surrounding water," clarifies Dr. Englot. "It needs to know how fast it's going, but this also has the potential to incorporate environmental measurements, we've thought about that. We haven't performed research to date where we're collecting measurements from the water itself, but many of the techniques that we're using to do inspections and build maps of underwater structures could also probably be applied to mapping water characteristics in the desired region."

THE UNDERWATER ROV OF THE FUTURE?

One promising application for this kind of AI-powered underwater vehicle is more persistent monitoring of underwater infrastructure.

"They're easily deployed," states Dr. Englot. "Unlike a diver who might only be able to dive periodically, robots could be tasked with inspecting and mapping on demand. Robots patrolling for environmental monitoring might also be able to help handle oil spills and other emergencies."

Of course, challenges such as underwater wireless communication remain.

"There would have to be some way that the robots could upload their data remotely," adds Dr. Englot. "That continues to be one of the biggest challenges when you have a multi-robot framework or an untethered framework: getting the data to the people who need it." **KL**

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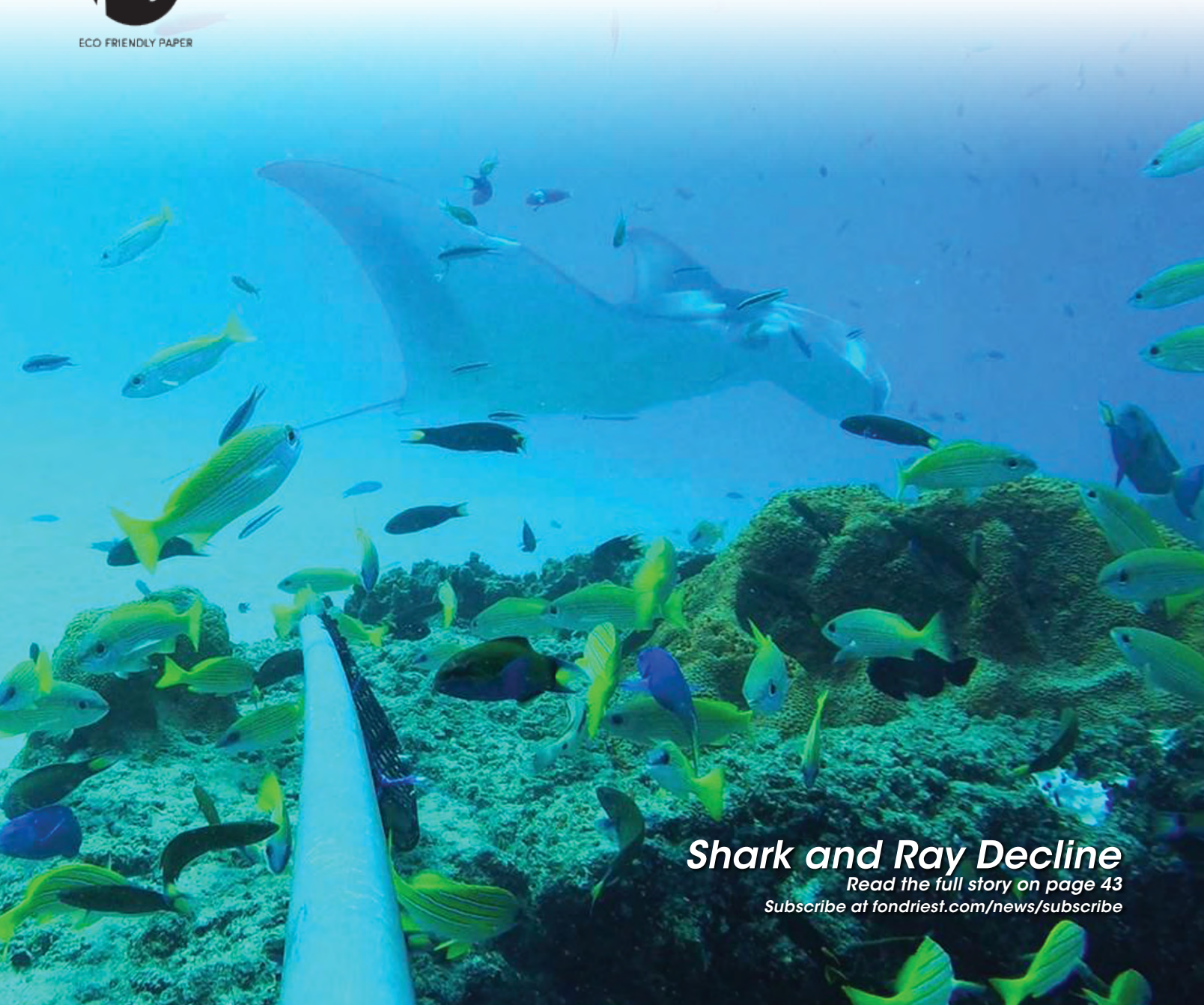
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