ENVIRONMENTAL
monitor
SPRING 2021
APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS

MONITORING WATER QUALITY

Chloride Contamination:
A threat to thousands of Northeast and Midwest lakes

Everglades Restoration:
A story of wetlands and water

Appalachian Streams:
Slow recovery from mining's lingering effects

Welcome...

Welcome to the Spring 2021 edition of the Environmental Monitor, a collection of the best of our online news publication. In this issue, we showcase a broad range of water quality monitoring applications.

Going from coast to coast, this latest edition covers nutrient loading impacts in San Francisco Bay, as well as restoration efforts in the Florida Everglades. Closer to the Midwest, we look at surface mining impacts on Appalachian streams, plastics in the Great Lakes, and wildlife returning to Michigan's Rouge River.

Our writers also look at threats to coral reefs from sewage, as well as elevated chloride levels in lakes resulting from increased farming and development. Other topics include research at the CSULB Shark Lab, Duke University's mooring WIzARD, and finding new value for Gar across the scientific and fishing communities.

Located in Fairborn, Ohio, Fondriest Environmental is the trusted partner you can turn to for help with environmental monitoring projects. We assist in everything from planning and monitoring to systems integration, equipment calibration and training. Our specialists have years of experience integrating and deploying remote systems and working with leading suppliers such as YSI, Hach, Thermo Scientific, Solinst, NexSens and many more.

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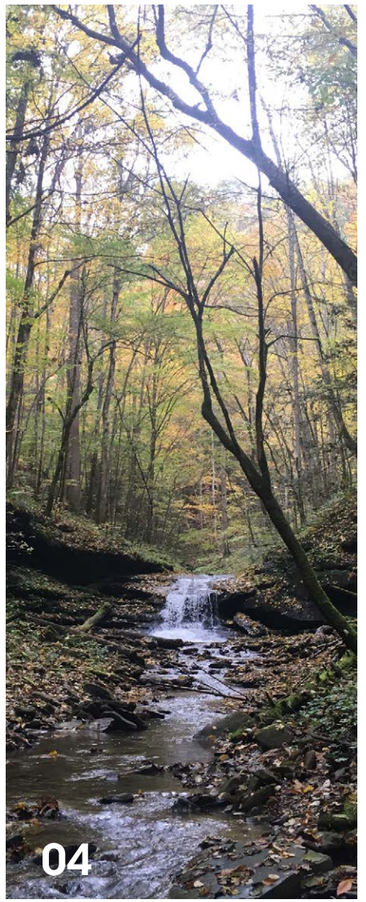
ON THE COVER

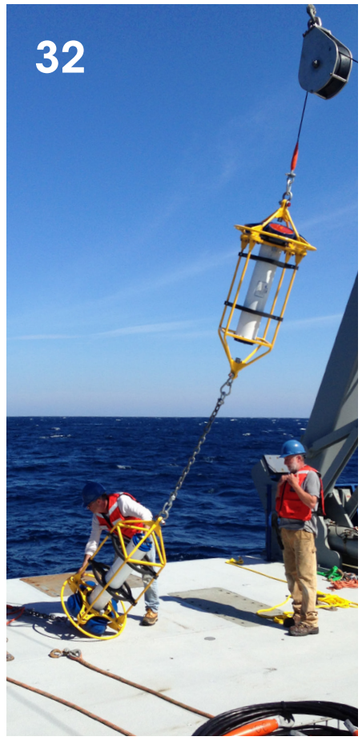
Emily Holliday uses a YSI ProDSS multi-parameter water quality meter at the Fondriest Center for Environmental Studies, in Beavercreek Ohio. The ProDSS measures dissolved oxygen, pH, turbidity, conductivity and more.

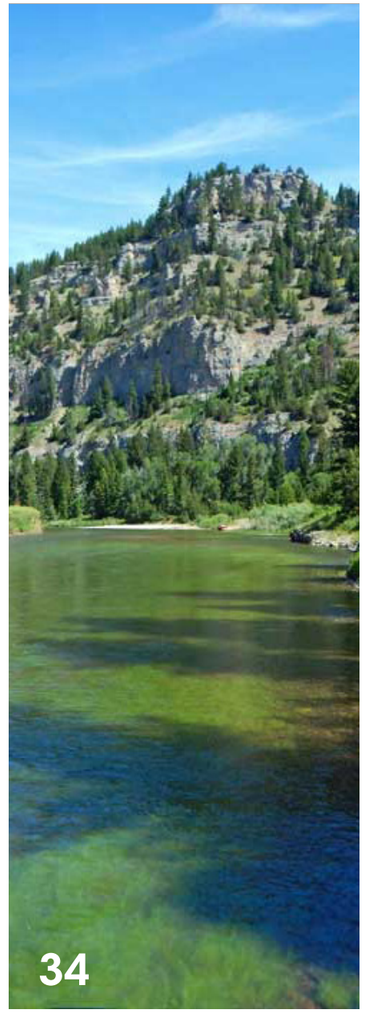
Emily Holliday is an Applications Scientist at Fondriest Environmental. She is involved with building and integrating remote monitoring systems, calibrating and testing water quality sondes, and working with customers on the startup and deployment of new monitoring systems. She has an AS and AAS degree from Sinclair Community College, and a BS and MS degree in Earth and Environmental Science from Wright State University.

Contents

03. On the Web
04. Appalachian Streams
06. Trout Lake Station
08. Product Innovation
10. The Shark Lab
14. Measuring it all at Lake Erie
16. Everglades Restoration
18. Unseen Sewage Threat
22. Featured Photo: Estero Bay
24. Nutrient Phenomena
28. Citizen Science
30. Water Quality Concerns
32. Duke's WIzARD
34. Montana's "Unique Gem"
36. Chloride Contamination
38. Aquaculture Innovation
40. Gar-Bage Fish No More
42. Plenty of Plastic
44. Special Offers







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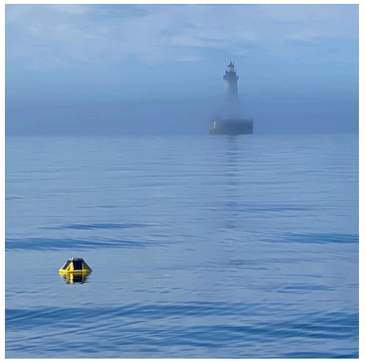


Buoys in the time of Covid: Delays to important information

In early 2020, Michigan found itself facing one of the worst outbreaks of Covid-19 in the country. Universities and research institutions had to pause some scientific research, while some ongoing initiatives slowed to a crawl. This year, as the buoys were ready to be deployed, new safety restrictions were put in place that made the collaborative effort difficult to achieve. Seeing a need for more data to keep fishers, boaters and recreationists safe, researchers deployed "spotter buoys" to collect wave data as well as other physical characteristics on the lake.

Snowmelt, Stormwater and Contamination in Saskatoon

In Saskatoon, potentially harmful elements in runoff can exceed the guidelines for runoff set by the Canadian government. Codling and a team of researchers from University of Saskatchewan, published research this March in Environmental Science and Pollution Research into the levels of certain metals and PFAS during major runoff events: spring snowmelt and runoff from summer storms.

Lessons Learned from 35 Years of AOC Restoration

The Great Lakes region is a center for manufacturing and trade and has been for a long time. As a result, certain places around the Great Lakes have been dump or release points for industrial pollution, sometimes for decades or centuries. The community partnerships and restoration efforts that turned a dump in one corner of Muskegon Lake in west Michigan into a haven for plants, wildlife and recreational fishers ran parallel to other efforts around the lakeshore and the Great Lakes since 1985.

APPALACHIA'S LONG RECOVERY

Appalachia may be as closely associated with mining as it is to anything else. That close relationship will leave its mark on the area's streams long after the last mine closes.

A nine-year study recently published in Science of the Total Environment shows that long after mining activity stops and the land is left to heal, streams and stream life are slow to recover.

"We could be really fine point and say that some of them seem to be recovering very, very slowly," said Carl Zipper, professor emeritus of environmental science at Virginia Tech University. Most of the streams studied didn't show signs of recovery.

Zipper is part of a team of researchers who have studied a group of 18 mining-influenced streams since 2011, watching how levels of contamination and insect populations respond to the closure of nearby surface mines.

Only five of the eighteen streams they monitored showed signs of recovery. That the number was so low was a surprise, Zipper said. Even for the streams that showed signs of recovery, the recovery was very slow.

These schedules could be highly variable. Streams might take much longer to heal.

Mining-impacted streams in Appalachia

There could be hundreds, if not thousands, of Appalachian streams contaminated by runoff from coal mines, Zipper said. And surface mines are particularly adept at contaminating mountain streams.

In surface mining, miners dig an open pit or remove stone from a mountain to access the valuable substance below. Mountain top removal is likely the most widely known type of this mining. When the mine is closed, the unused rock that was dug out is used to refill the mine and the landscape is left to heal. Where before, rainwater would run off the mountain into a stream, it now filters through the newly porous mountainside before washing into the stream. This disturbed landscape exposes the water to much more of the mountain than before. Any harmful substances previously locked away in the rock are now exposed and likely to wash into streams.

In laboratory experiments, water running over rocks like these did eventually wash away the harmful elements and reach healthy levels, Zipper said. Following the recovery rate found in lab experiments, the mine-affected streams in Appalachia would recover in 40 years. The real world doesn't act like a laboratory though, and the streams could take much longer.

"Our knowledge of basic geochemistry tells us they must be recovering," he said, "but with some, the recovery was not detectable."

Monitoring mines' effects on streams

The researchers tracked levels of various salts in the streams—their salinity—by measuring specific conductance. The salts in question aren't table salt, but salts more commonly associated with coal mines: those made of sulfate, bicarbonate, magnesium or calcium. Mines around the world increase salinization in streams to similar effect, though the salts in question could be different, Zipper said.

Sensors monitoring conductance were placed in the streams and a measure was recorded every 15 or 30 minutes over the course of the eight years.

Photos: Thomas Cianciolo

That long, thorough record of salinization revealed in some streams that slow crawl toward health could take decades. Because Appalachian streams have very low natural levels of salinization, the return of sensitive aquatic insects and other indicators of stream health could be slow to return.

The importance of macroinvertebrates

Though macroinvertebrates are small and easy to miss, they play a large role in their ecosystem.

"They're indicators. They're the base of the food chain," Zipper said. Any decline in their population could have ripple effects downstream and up the food chain.

Zipper noted their role in feeding larger species and in breaking down organic material.

These insects need to pass water through their external membranes to keep their bodies functioning. Saltier water makes that process more difficult and can throw their internal chemistry out of whack. They can't survive without the historically clean Appalachian waters.

"The natural waters of the Appalachians are very dilute," Zipper said. "They evolved to exist in very dilute waters."

The team collected aquatic insects several times a year to track their recovery. Unsurprisingly, macroinvertebrates were slow to return to streams that had not become significantly less salty.

Beyond ecosystem health, there are legal considerations too. The Clean Water Act protects aquatic macroinvertebrates, and the streams aren't currently at the benchmarks set.

Monitoring provides important insight

The surprisingly slow recovery of these streams points to the importance of long term monitoring. Though eight years is a significant chunk of time, currently unanswerable questions, like how long it will actually take for a stream to recover, could be answered if the monitoring extended for years into the future.

Researchers monitoring the effects of mining on Appalachian streams.

"We have literally no idea how long it's going to take," Zipper said. The estimates put forward in the study are based on laboratory experiments that don't necessarily correlate to real-world conditions. And, each mine and each stream are different, making it even harder to apply lab results.

Extended monitoring will lend greater insight into a varying, widespread and surprisingly long-lasting environmental disruption.

"These surface mines are pretty significant landscape disturbances and they have significant environmental effects," Zipper said. He said there is "no doubt" the team hopes to continue the monitoring project for as long as possible. There are still a lot of questions to be answered about this very, very slow recovery. AB

THE SCIENCE NEVER STOPS AT TROUT LAKE STATION

Summer's effects on the ecology and hydrology within Wisconsin's inland lakes are well studied. Data collection is easier and many field-deployed sensors and equipment can withstand the conditions of a Midwestern heat in July.

But what about changes in the winter? The historic assumption is that not a lot happens. Frozen conditions on the lake's surface render the normally shifting environment underneath quiet and undisturbed. However, researchers at the University of Wisconsin Madison Center for Limnology are discovering that's not exactly true.

"It's often difficult to sample, especially during bookends when ice is just freezing or when ice is thawing in the spring. It's just not safe to get out there," said Noah Lottig. "So we've been working to develop platforms that can be deployed easily underneath the ice."

In mid-to-late November, the underwater platforms that have sensors attached to them are deployed in one of several lakes monitored by Lottig and his research team at the North Temperate Lakes Long Term Ecological Research network. The sensors sit in the water until early May.

Data from the fieldwork measuring heat exchange and oxygen abundance will inform questions regarding lake stratification, long term changes to water temperatures and the role weather has in influencing the physical dynamics of lakes.

Lottig hopes the data collected will also inform management decisions and guide modeling efforts to better understand biology in the ecosystem – like thermal habitat loss for the walleye species, which is an important game species in Wisconsin.

To understand why recruitment for the organism is declining and the role climate change plays in that trend, scientists will need data that until recently was not feasible to collect. The necessary sensor technology was too expensive or wasn't accessible. And without data from previous decades, it's not easy to contextualize change over time.

However, researchers at the Trout Lake Station, which operates under the University of Wisconsin's Center for Limnology, have benefited from the institution operating as a source of long-term research and data collection that few other places have had the luxury of working with.

Utilized by academics from around the world, the Trout Lake Station functions as a temporary home for anyone interested in studying the area. "We have more than 30 different organizations coming through for long or short durations to collect data. Each summer, we have 9-10 core projects that have students working and living on-site," said Gretchen Gerrish, Trout Lake Station director. "We accept visitors from all over, as long as it's research based."

Photos: Bethany Prochnow

Originally founded in northern Wisconsin in 1925 and surrounded by lakes, Trout Lake Station got its start as a Long Term Research Ecological Research site in 1981 after funding was approved by the National Science Foundation. Catalyzed by a need for more robust research that tracks environmental changes over time, the station plays host to several research projects year-round.

One researcher from the University of Wisconsin Eau Claire is studying the species richness and distribution patterns of mosses in different water habitats. Another researcher from UW Madison wants to better understand the relationship between yellow perch and rainbow smelt fish populations.

Over the 2020 winter, two researchers periodically plowed the snow that blanketed the ice covering one of the many bogs in the region. They wanted to understand how sunlight affects the water chemistry and biological processes of organisms under the ice.

Then there's the Global Lake Ecological Observatory Network (GLEON), which interprets and disseminates high-resolution sensor data to help understand the response of lakes around the world. That could be modeling the metabolism across lake gradients, mapping climate change's effects on spring-winter runoff and lake productivity or assessing mussel and zooplankton's importance.

"Trout Lake Station has a long history and has been instrumental in developing approaches for deploying high-frequency sensors on lakes for monitoring a variety of water quality parameters," Lottig said. "Two of the founding members (of GLEON) were researchers that did that kind of work at the Trout Lake Station."

Since the early `80s, those scientists have deployed different versions of high-frequency sensing platforms on the lakes. Where earlier sensors were only built to measure dissolved oxygen and water temperature, newer ones can quantify a multitude of different chemical and physical dynamics of lakes, including carbon dioxide and methane, two primary contributors to the world's warming climate.

In a current study, when looking at how levels of gas released into the atmosphere from lakes when ice cover melts, teams have deployed sensing platforms with eddy flux towers attached to them that monitor the output. While the high cost of that specific technology has made it inaccessible to most research centers, Lottig says sensor equipment has evolved a lot over the years and become more affordable.

"One of the things we see is as that as the cost of sensors decline, we're adding new sensors to the platforms," he said, adding that more scientists will be able to incorporate them "once the cost becomes reasonable."

The Trout Lake Station has capitalized on the opportunity by running workshops to make sensing data more available in more lakes. In one example, teams are educating groups on how to build temperature strings on their own. Where commercial forms of the equipment cost upwards of $15,000 apiece, their slightly-less accurate versions cost only $700.

"It's bringing the community together to develop a knowledge base across agencies, academics and lake associations in a variety of different types of groups," Lottig said.

Without the democratization of new and advanced equipment, research in understudied areas will continue to stymie efforts for scientists to understand their environment and managers to employ best practices in those regions.

Remembering the dearth of understanding of what happens in lakes when winter comes, a research team compiled much of the readily available research on what happens underneath ice in lakes around the world. They found studies completed at the UW Center for Limnology accounted for nearly half of all data globally.

"It has a big influence on the field and the ability of folks to ask and answer really interesting questions," said Lottig. JN

(Right) The crew from the Trout Lake Station's 2019 year sitting on a dock extending into one of the many inland lakes under the center's research.

Wave Buoy

The CB-25-SVS Wave Buoy by NexSens Technology offers the latest in real-time wave observations in a compact, affordable, and easy to deploy platform. At 18" hull diameter and less than 30 lb. (13.6kg) weight, it can be used for drifting, tethering or mooring applications. The buoy accurately measures wave height, period, direction, and more using SeaView Systems' industry-leading SVS-603 sensor, relied upon in buoy networks by NOAA and many others throughout the world. External sensor ports with wet-mate connectors support GPS, meteorological, and water quality sensors for maximum flexibility.

The buoy is constructed of an inner core of cross-linked polyethylene foam with a tough polyurea skin. A rechargeable battery with integrated solar panels power the wave buoy continuously, and all electronics are housed in a quick-removable waterproof package with wet-mate connectors. Three 1.5" pass-through holes facilitate cable routing of underwater sensors.

Available with integrated 4G cellular or Iridium satellite communications, the CB-25-SVS Wave Buoy sends data in real-time to the cloud-based WQData LIVE datacenter. In a basic configuration, this free service allows users to securely access and analyze data, as well as share data through an API or auto-report. Subscription-based tiers of WQData LIVE are also available for advanced reporting, alarming, and data management.

Wave Buoy Features

- Integrated accelerometer-based wave sensor
- 4G cellular or Iridium satellite telemetry
- Supports a variety of environmental sensors
- Autonomous battery & solar power
- Rugged polymer-coated foam hull

(Left) Located in the center of the Wave Buoy hull is a NexSens X2-SVS wave data logger with integral battery, sensor connections and cellular or Iridium modem.

*For more information, visit **NexSens.com***

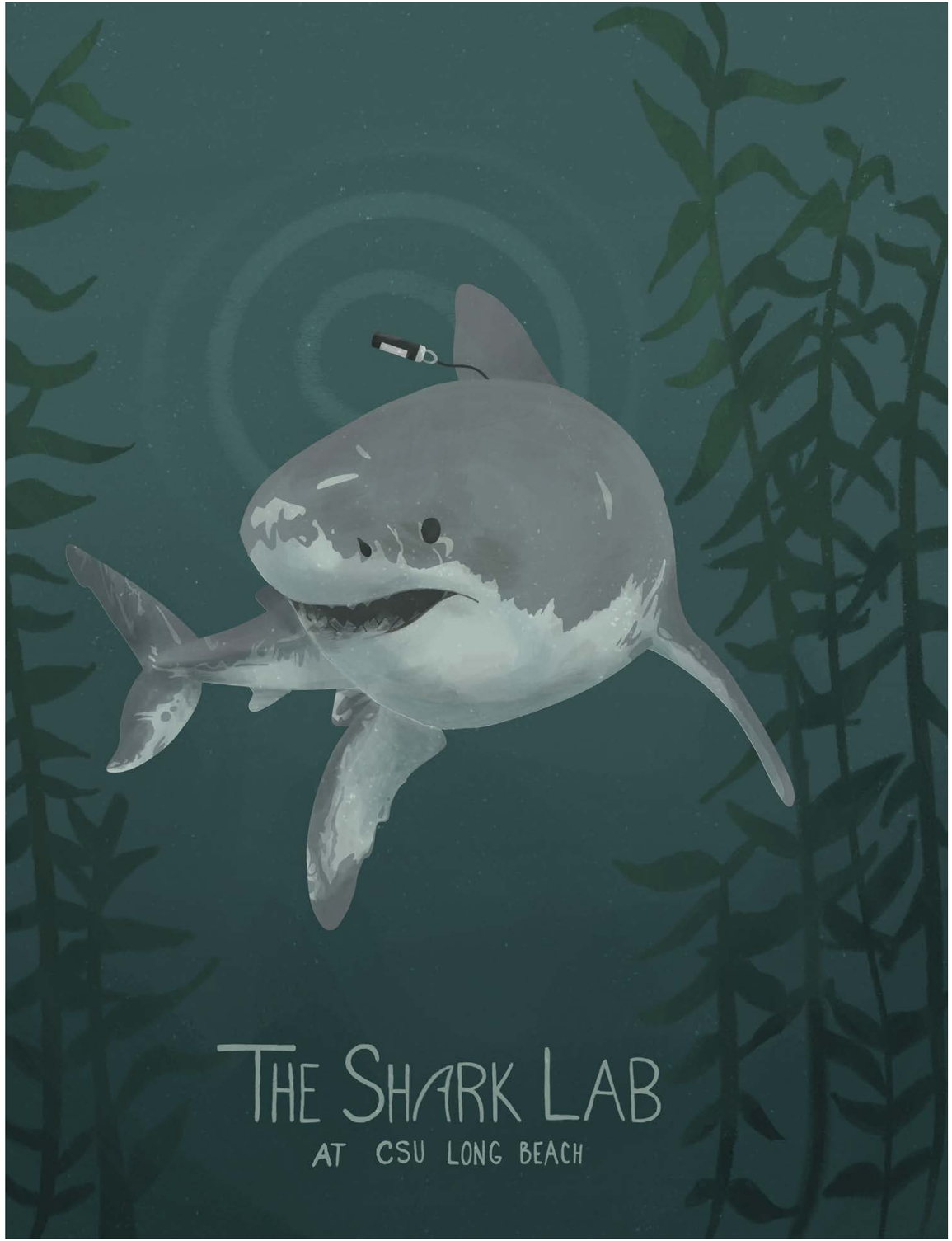


Illustration: Emma Jones/ Fondriest Environmental

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

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

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

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

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

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

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

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

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

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

Shark Lab Origins

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

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

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

However, just diving with sharks to observe and study their behavior was too limited. Which is how the lab started dipping its toes into the development industry – researching and building tools that could help them with their work That meant placing sensors on sharks that could transmit data wirelessly but also withstand the extreme pressures exhibited by the seas and oceans. And of course, all of it had to be waterproof.

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

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

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

"Basically, what we've been doing is taking existing technology and modifying that. The goal is to continue this concept of innovation so we can make giant strides," Lowe said.

"What we've learned in the last five years through new tech has exponentially improved upon what we've learned over the last 50 years."

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

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

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

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

Work in the shark lab

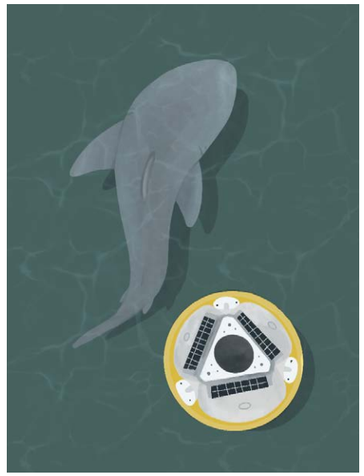
All of this innovation is coming at the right time, too. The Shark Lab tracks all kinds of species, from leopard sharks to horn sharks, blue sharks and even the rare megamouth shark. But the lab also tracks local species that sharks feed on, like stingrays.

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

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

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

However, Lowe believes those that will benefit the most from better shark data is the public. But it has to be used appropriately. After the white shark population began to rebound in Australia, there were more reported cases of shark attacks.



NexSens CB-150 Data Buoy outfitted with an acoustic receiver tracks tagged sharks

After the country started tracking shark locations and made that data public to everyone, beachgoers began to use the data like an early warning system, which creates all sorts of problems.

Researchers certainly can't tag every shark out there and there were likely times when untagged sharks were close to beaches, but there was no alarm.

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

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

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

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

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

Dr. Chris Lowe releasing a tagged juvenile white shark (below)

Photo: CSULB, Illustration: Emma Jones/ Fondriest Environmental

Birds, Fish and Shifting Sediment

MEASURING IT ALL AT LAKE ERIE

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

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

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

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

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

The Nearshore buoy is run by the Regional Science Consortium (RSC). During its operating days, the buoy will collect and send hundreds of data points. It should come as no surprise what kind of data the RSC's Nearshore Buoy collects.

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

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

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

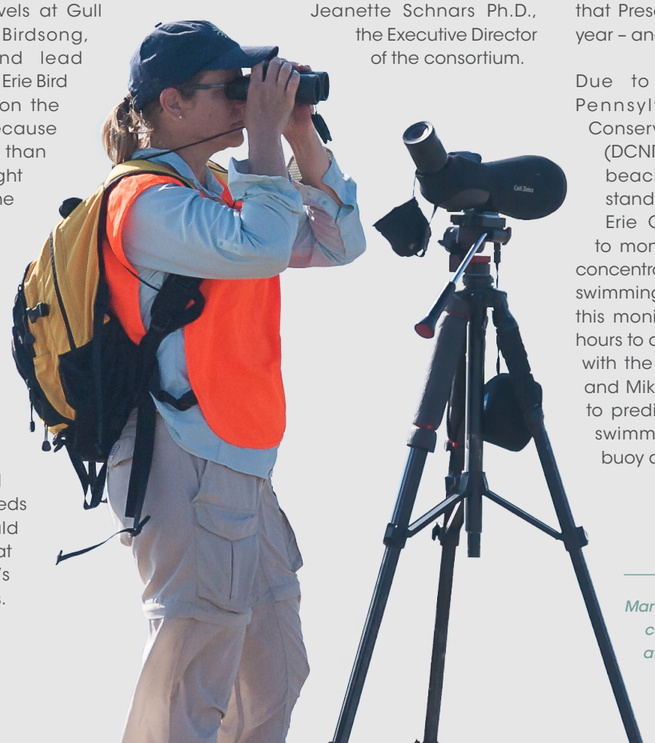
From when the Nearshore Buoy is deployed in the spring to its return journey back on land in the fall, it will collect and transmit information every 20 minutes on around 20 different parameters.

And it's all free for the public to use.
"…it offers people information to make informed decisions. Whether to go out on the lake, or not go out on the lake," Schnars added.

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

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

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



Mary Birdsong, from Erie Bird Observatory, conducts routine shorebird monitoring at Gull Point on Presque Isle State Park.

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

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

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

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

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

A subject that easily fits this template is harmful algal blooms – one of the better-known cyclical phenomenon that takes place in Lake Erie.

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

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

Jeanette Schnars, executive director of the Regional Science Consortium, collects water quality data near one of the center's buoys that help track temperature, pH and turbidity.

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

The data is posted in real-time on the RSC's website palakeeriebuoy.com, which features each operational buoy, the data collected and a satellite map. Easy enough to comprehend, users now extend to boaters and fishermen preparing trips on Lake Erie.

"We use the data from the buoy to plan our sampling trips and to help prepare us for the conditions we will encounter when we leave the dock. Currently, we run a boat angler survey three days a week," Mark Haffley, a biologist out of the Lake Erie Research Unit at the PA Fish and Boat Commission. Haffley added that the commission is even dissecting archived data to bulk up its harvest and catch-per-effort models, as well as better predicting lake conditions from past events.

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

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

Photos: Jeanette Schnars

EVERGLADES RESTORATION: A STORY OF WETLANDS AND WATER

The Everglades, Florida USA

The Everglades are famous as a popular tourist destination. In 2019, over one million people visited the famous national park that makes up their southern portion. They are also famous, though probably less so, for ongoing, large-scale restoration efforts aiming to restore some of the hydrology that earned the system the nickname the River of Grass.

Restoring the River of Grass to something closer to its former state will provide timely relief for vital wetlands that support wildlife, industry and the 8 million people that utilize the Everglades for the fresh water they provide.

Restoring a vital ecosystem

Water flowing through the Everglades gets held up by wetlands and recharges the Biscayne Aquifer, which supplies some of Florida's most populous places with drinking water. Over 5 million people draw drinking water solely from the Biscayne Aquifer.

Water from the Everglades system also supports huge agricultural enterprises, especially in sugar cane production. In 2019, Florida produced more than 17 million tons of sugar cane. That production is concentrated south of Lake Okeechobee, one of the largest freshwater lakes in the United States.

Starting in the first half of the 20th century, major flood control initiatives redirected water east and west, rather than allowing it to flow south through the Everglades. For the same reason, rivers were channelized and cut off from their flood plains. The flood control strategy worked but had unintended consequences. Wetlands in the Everglades store a huge amount of water, but changes to the area's hydrology have diminished their capacity, Paul Julian, technical lead for Everglades restoration in the Florida Department of Environmental Protection told Environmental Monitor.

This occurred through a process called subsidence, the result of compacting wetland soil. Less storage capacity is a threat to drinking water supplies as well as wildlife habitat.

Photo: Paul Julian

While Everglades restoration "won't turn back the clock" on subsidence that has already occurred, Julian said, it will keep the process from starting elsewhere or continuing where it has already begun.

When a wetland dries out

Subsidence occurs when peatland dries out. Peatlands, a type of wetland, are landscapes that are flooded most of the year. Under water, dead plant matter decays slowly. Over years, this slow decomposition creates absorbent, black soil rich in organic material. This peat soil absorbs and holds up water, filters it and allows it to recharge aquifers. It also stores a lot of carbon. "If you alter the hydrology, you have the potential to dry out wetland systems," Julian said. "When you dry out a peatland system, you have what's called subsidence."

When long submerged peat soil is exposed to air, it begins to oxidize and break down more quickly. As it breaks down, it compresses and shrinks.

In some areas where measures exist, peatlands have subsided significant amounts, releasing stored carbon into the atmosphere. At the University of Florida's Everglades Research and Education Center, past researchers sunk a cement pole through the peat soil and into the bedrock. In 1924, the top of the pole was even with the ground. Today, more than six feet of the pole has been exposed. Subsidence and dry peatlands mean the soil is more susceptible to erosion from both wind and water, too, Julian said.

Halting subsidence requires a restoration of the area's historical hydrology. A huge effort, guided by the Comprehensive Everglades Restoration Plan, aims to mimic closer-to-natural hydrology by managing the quality, quantity, timing and distribution of water in the area. Getting those four factors right is so central to restoration efforts that one partner organization involved in the project, the National Park System, says, "If we get the water right by restoring [quality, quantity, timing and distribution], the ecosystem will respond positively."

Julian thinks the restoration effort is vital to the Everglades long term health. "If we don't restore the everglades, we have this potential to—I know this isn't a technical term, but—screw things up," he said.

Major restoration efforts underway

Julian splits his time between working with scientists researching the best ways to restore the Everglades and permitting projects that will carry out that plan. The permitted projects of the Army Corps of Engineers and the South Florida Water Management usually "build [water control] features or destroy features" depending on how they impact water movement and flood control, Julian said.

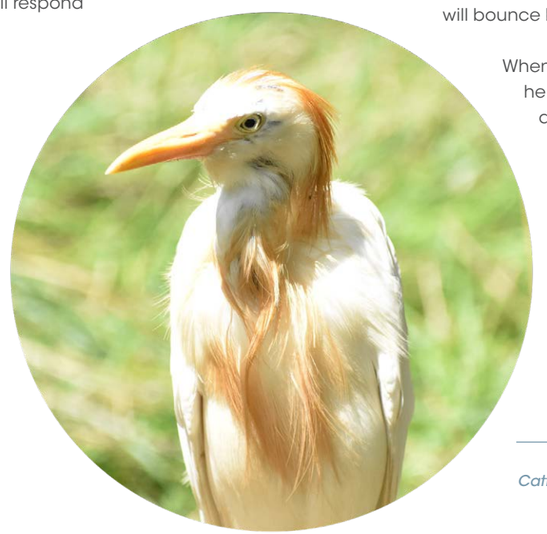
The soon-to-be-completed Kissimmee River restoration is one key example of this process and the quality, quantity, timing and distribution philosophy.

In response to severe flooding, miles of the meandering Kissimmee River were turned into a canal, beginning in the 1960s. While this protected communities within its floodplain, it disrupted the natural cycle of floods and eliminated acres of wetlands. Now, 40 miles of the river's meanders are being restored. Miles of floodplain will also be restored, marking a return of quality habitat and historical floodplain hydrology.In the Everglades themselves, signs of restoration are apparent, too.

"THE ECOSYSTEM MEMORY IS IMPRINTED ON THAT SOIL"

- PAUL JULIAN

In 2018, a supercolony of nesting wading birds—storks, ibises, egrets and more—occurred in the Everglades. Some birds nested in their largest numbers since the 1940s. Such events suggest that the restoration projects are having an impact. "We think maybe that doesn't happen without these projects," Julian said. It seems to suggest that the Everglades will bounce back given a chance.



When Julian is hiking in the Everglades, he says his attention is often directed down, toward the soil. The history of a place is recorded in its soil, he says. Floods, erosion and the slow process of decomposition in a peatland can all be seen in the right soil. "The ecosystem memory is imprinted on that soil," he said. Soon, the soil may be laying down memories of the Everglades restoration.

Photo: Emma Jones/ Fondriest Environmental

Cattle Egrets are one of the many species of birds commonly found in the Everglades National Park.

Illustrations: Emma Jones/ Fondriest Environmental

SEWAGE

An Unseen and Ignored Threat to Coral Reefs and Human Health

It's an open, dirty secret that the ocean is used as the ultimate sewage solution.

Each year trillions of gallons of untreated waste are sent to the ocean due to a widespread lack of sanitation technology or infrastructure that needs updating as cities and populations grow. As the impact of untreated sewage on the ocean becomes clearer, attention to the problem and strategies for dealing with it have not kept up.

"This is a massive problem and it's been largely ignored," said Stephanie Wear, senior scientist and strategy advisor for The Nature Conservancy. Wear has turned her attention to raising the alarm about the effects of sewage on coral reefs, which often loses airtime to other pressing issues like climate change and overfishing.

The impact of sewage on coral reefs is widespread and will require some major infrastructure projects, new technologies and broad changes in how we approach sanitation issues. But it is also a solvable problem, Wear said. Some first steps are raising awareness, increasing monitoring and, in some cases, applying simple infrastructure fixes. Cleaning up the sewage seeping or running into coastal waters will benefit not just reefs, but also the people who are too often made sick by the water they rely on for food and livelihood.

"An invisible problem"

Wear has had firsthand experience with the problem she's now tackling. Years ago, while conducting coral reef conservation on St. Croix in the Caribbean Sea, her drive to work took her across a small, foul-smelling rivulet that crossed a street.

The stream was raw sewage, escaping from a pipe somewhere uphill and crossing the street on its way to the ocean. It was a small—just enough to hear as you drove over it—picture of the problem facing coastal waters and coral reefs around the world.

"Sewage pollution is extraordinarily prevalent," Wear said. "That isn't fully appreciated because it is an invisible problem for the most part."

Sewage enters oceans in all sorts of ways. In the United States, it's often due to combined sewer overflows. In many cities around the country, sewage and stormwater run in the same pipes to the same wastewater treatment facility. During rains, sometimes even light ones, the increase in stormwater can overwhelm the system. One common solution is to allow the excess sewage, stormwater and other wastewater to flow directly into a body of water.

In large cities, that can add up to a lot of untreated sewage in nearby waterways.

Each year New York City releases 27 billion gallons of untreated sewage and stormwater into the environment. Nationwide that number is 1.2 trillion gallons, Wear said. Combined sewer overflows around the country lead to beach closures and the contamination of shellfish beds. Many cities are working to separate sewage and stormwater lines, eliminating combined sewer overflows.

Sewage can also seep into coastal waters through the groundwater. A recent Supreme Court case dealt with such an issue in Hawaii, where the Maui County wastewater treatment facility was the source of wastewater that was reaching the ocean and sickening a reef.

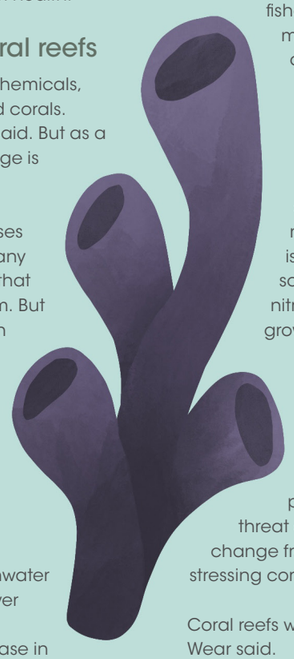
The state of Hawaii has 88,000 cesspools, underground sewage storage pits that can leach waste into groundwater. Hawaii set a 2050 deadline to replace every cesspool.

In certain places in the developing world, the problem of sewage in the oceans is more visible. "There are a lot of places where the ocean is the toilet," Wear said. Instead of places of leisure and relaxation, certain beaches are places of business—well, doing one's business—and the outgoing tide acts as a beach-wide toilet flush.

Regardless of how direct or obvious its source, sewage is making its way to coastal waters. There, it does damage to coral reefs, jeopardizing human and ecosystem health.

The problem of sewage and coral reefs

Sewage is a harmful cocktail of nutrients and chemicals, many of which are known to harm humans and corals. "Public health is the number one thing," Wear said. But as a coral conservationist, it's clear to her that sewage is bad news for corals as well.



It is difficult to prove that specific sewage releases have harmful effects on coral. There are too many variables out in the ocean to definitively prove that a specific event is connected to a specific harm. But many of the components of sewage have been shown to be harmful to coral in laboratory experiments. By breaking sewage into its individual parts, it's possible to sketch out the effects of sewage on coral in the ocean. That's what Wear did in a 2015 article, which reviewed research into sewage's component parts and showed that it can have broad, deleterious effects on coral.

Components that harm corals range from freshwater to pathogens to heavy metals. Lower salinity over a period of 24 hours is tied to increased coral mortality. Pathogens that cause white pox disease in corals come from sewage. Heavy metals are tied to coral bleaching and coral mortality. Sewage is also full of nutrients, like phosphorus and nitrogen that give coral competitors an unfair advantage.

"In coral reefs, nutrient poor water is a good thing," Wear said. With a flood of nutrients like nitrogen and phosphorus, algae and seaweed growth can choke out corals, cutting them off from the sun and killing them. An algal reef doesn't harbor the diversity of life that a coral reef does or as effectively buffer coastal communities from storms, Wear said.

Sewage and wastewater also include sources of endocrine disruptors, like pharmaceuticals and plastics, which can slow growth and reproduction rates in corals.

Antibiotics show up in sewage and have the potential to disrupt a coral's microbiome. A coral's microbiome exists as a film of microbial life that acts as a protective barrier on coral tissue, Wear said.

If the composition of microbes is disrupted the coral colony can be more susceptible to disease and bleaching.
So while a body of research linking sewage to deteriorating coral health is lacking, it's clear the stuff in sewage can cause some damage.

The future of coral health lies onshore

The harm sewage can do to corals means researchers and conservationists ought to dedicate resources to addressing it and other onshore sources of pollution and not be overly focused on ocean-only issues, Wear said.

"We are spending all this time on restoring habitat, on fisheries conservation and fisheries regulation and marine protected areas in water that is of poor quality. We're not addressing the water quality issue," Wear said. In some places, the first step in that direction is gathering information that hasn't been gathered before.

As one example, Wear suggests deploying nitrogen sensors that can identify the source of excess nitrogen. It is possible to determine if the nitrogen is coming from human sewage or an agricultural source. Such sensors could both confirm excess nitrogen that could lead to rampant, harmful algal growth and point to an onshore solution.

Other onshore interventions could include nitrogen capture at septic tanks or wastewater recycling, where it's cleaned and used to supplement a city's water supply. "This is something you can actually do," Wear said. Projects like these are in progress. Corals' most famous and possibly greatest threat doesn't originate in the ocean either. Climate change from burning fossil fuels is raising temperatures and stressing corals around the world.

Coral reefs were on the decline before climate change, Wear said.

Now, it's exacerbating problems caused by sewage and other stressors like overfishing. Warmer water makes pathogens more harmful, increasing the likelihood of disease. Warm water also releases heavy metals from sediments, which together with the heavy metals from sewage pollution, increases the pathogenicity of microbes.

If coral reefs are in a boxing match, changing ocean chemistry and warmer water could be a knockout blow, Wear said.
But, gathering data and using it to deploy conservation strategies—many on land—could provide relief when coral reefs need it most. AB

Illustration: Emma Jones/ Fondriest Environmental

ESTERO BAY'S WATER QUALITY

TRACKING REAL-TIME CHANGES

In the past decade, the health of Estero Bay has been in decline, characterized by increased mortality rates in native oyster and seagrass populations. The hydrology of the bay is complex, and salinity and dissolved oxygen can change drastically over a tidal cycle. This is problematic for researchers using handheld sensors to monitor characteristics of the water, as they can only capture what is happening at a single time point, rather than the dynamic changes in water that seagrasses and oysters experience.

By installing 2 NexSens X2 dataloggers at Florida Gulf Coast University's Vester Field Station and at a local major pass, water quality can be monitored continuously throughout a tidal cycle. The data is primarily used for monitoring the impact of freshwater releases, extreme weather, and HAB events on water quality in the bay, but can also allow researchers to identify abnormal conditions that add stress to the system. This provides FGCU students with more complete datasets to analyze for projects and residents are given the ability to view live water quality conditions. In the future, this data will be used to inform ideal locations for restoration projects and allow researchers to assess the impacts of stressful water conditions on restored areas.

Undergraduate researcher, Alexander Donnenfeld, waving to local boaters interested in the project.

For more information, visit ***fgcu.edu/vestermarine***

Photo: Nicole Weigold, Vester Marine & Environmental Science

USGS California Water Science Center personnel (Sacramento) deploy a NexSens CB-50 buoy with YSI EXO2 multi-parameter water quality sonde.

SAN FRANCISCO BAY'S NUTRIENT PHENOMENA

From the gold rushes to the birth of Silicon Valley, the San Francisco Bay Area is known for welcoming swaths of people looking for a new frontier of culture and natural beauty.

It has had a front-row seat to some of America's most rapid industrialization and population growth for the past 200 years and is now home to over seven million people. Tourism booms as people from all around the world come to see the iconic Golden Gate Bridge and the expansive bay that lies beneath. But the bay is not just for looks. It plays an essential role in supporting modern California living–and we are not just talking about surfing.

Water from every toilet flush, shower and load of laundry is treated and pumped back into the bay. San Francisco's wastewater management processes have kept cities going and scientists busy for quite some time. The San Francisco Estuary Institute (SFEI) researchers are committed to monitoring nutrients inputs to the bay and studying the associated ecological impacts.

Derek Roberts, PhD, is an environmental scientist with SFEI's Clean Water Program, specifically the Nutrient Management Strategy (NMS), one of the nation's leading water quality science programs aimed at protecting aquatic resources.

Concern arose for the Estuary in the late '80s, and SFEI was born in 1993. More recently, environmental regulating authorities proposed that publicly owned treatment works either decrease their nutrient load or fund studies to determine the effects. Given the option, the facilities chose science over reform. This was a catalyst for the San Francisco Bay Regional Water Quality Control Board to instate the Nutrient Management Strategy as their response.

Photo: SFEI

The NMS project is a collaboration with the USGS California Water Science Center Biogeochemistry Group that spans a myriad of studies like water quality monitoring, targeted field investigations, and numerical modeling. The goal of this adaptable, ongoing study is to allow data to shape suggested practice standards. While libraries of data exist for parts of San Francisco Bay, there are lesser-studied areas that may hold the key to unlocking the nutrient mystery and identifying natural protective processes that have the potential to fail.

Nutrient Phenomenon

It is no secret that San Francisco Bay is full of nutrients. But many find it shocking that harmful algal blooms (HABs) have historically been a rare occurrence. While the potential for such issues to persist has long been present, other factors like turbidity, tides and natural processes seem to have inhibited growth in the past.

Roberts explained that "San Francisco Bay has some of the highest nutrient concentrations of any major estuary in the world but it rarely exhibits the symptoms that come with nutrient loading, like harmful algal blooms (HABs) and low dissolved oxygen...So the bay has this dynamic, complex system that has generally been resilient to pollution, but in recent years, has been showing some weaknesses."

The weaknesses Roberts alluded to are concerning. The phenomena of SF Bay's resilience to eutrophication may be dwindling, potentially increasing the risk for harmful algal blooms (HABS) and hypoxic conditions. Significant increases in phytoplankton biomass since the '90s, an unprecedented autumn phytoplankton bloom in '99, steadily decreasing DO levels and a red tide event in '04 are all red flags of a system that can't quite keep up.

The health of the bay is of utmost importance, and surprisingly, is naturally predisposed to a robust resilience against pollution. In spite of high nitrogen and phosphorus concentrations from wastewater, HABs don't seem to manifest to the extent science would expect. This phenomenon is largely due to heavy tidal flushing, multitudes of filter-feeding clams, and the turbid water conditions characteristic of San Francisco Bay.

While tides are strong, nutrient levels remain high. Clams filter feed the algae and high turbidity blocks sunlight from allowing algae to germinate, subsequently avoiding triggers that cause low dissolved oxygen. In spite of these systems that have sustained the bay for so long, standard practices may have to change in order to maintain the health of the bay.

"From historical data we believe that at any given time there are enough nutrients in the bay for algae to thrive," Roberts noted,

"But there isn't enough light in the channel for them to manifest in absent stratified conditions. However, preliminary data on the shoals may be suggesting otherwise."

A NexSens CB-50 monitoring buoy collects water quality data in the shoals of San Francisco Bay.

Topography

San Francisco Bay has a deep channel running through its center that has been closely monitored for years. The most well known area is beneath the Golden Gate Bridge that spans the deepest part of this channel, a profound 372 feet from ocean surface to floor. However, from an aerial view, wide shallow shoals on either side of the channel dominate the bay itself. Not nearly as much research has been done on the shoals and Roberts is hopeful for enlightening data that could fill in the gaps of the nutrient phenomena.

"[In the channel] Even when there is a relatively large algal bloom, we don't see nutrient levels dropping to where we would consider the system nutrient limited. However, new findings on the shoals have shown that the system may become nutrient limited but we need high frequency data to understand if and when that happens. And It's on those shallow shoals that some of the most complex biogeochemical processes happen--nutrient cycling, algae growth, etc."

In mid-August of this year, Roberts' team launched a new shoal monitoring program. Roberts suspects data may show algal blooms on the shoals that become nutrient limited. He explained that if the data supports that nutrients are the limiting factor in shallow regions, then the team will be able to better gage sensitivity to nutrient levels. He is interested to know whether or not they need to decrease, and if so, to what degree.

Approach

Two new NexSens CB-50 data buoys that now float in the shoals are equipped with a YSI EXO2 multiparameter sonde and appropriate sensors complete with a wiper for anti-fouling. The buoys are also fitted with a SUNA V2 nitrate sensor by Sea-Bird Scientific, which is suspended beneath the buoy platform inside a custom cage from NexSens Technology.

"The goal of this project is to collect a combination of water quality data, conductivity, temperature, depth, algae chlorophyll and dissolved organic matter data along with nitrate concentrations on the shoals so we can understand the interplay between shoal and channel processes and gain a fuller picture of what's going on in the bay."

The short term goal of the Nutrient Management Strategy is to come up with nutrient concentration recommendations for regulators. Long term goals include continuing baseline monitoring to flag symptoms of nutrient impacts and to build up a database on the mysterious San Francisco Bay shoals.

With potential California wastewater policy revisions looming in the future and gaps in nutrient data, the relatively new Nutrient Management Strategy is eager to play a significant role in the decision making processes as a leading research baron. BR

Photo: SFEI

CITIZEN SCIENCE AT THE ROUGE

If the Michigan Department of Natural Resources had additional funding for fish surveys in the Rouge River, where would they use it?

That's what the Friends of the Rouge posed to the agency in 2012. Limited by money and manpower and in a state with an abundance of water that needs monitoring, the DNR can't survey every part of every watershed – especially one of the largest and most industrious in Michigan.

So the Friends of the Rouge nonprofit extended an offer to help. The DNR pointed them toward looking for redside dace, an endangered minnow and monitoring the effects of dam removal.

The group started their citizen science program with a grant from the Michigan Department of Environmental Quality in 1998 and have been monitoring benthic macroinvertebrates in the stream, as well as frogs and toads, ever since.

"Our role in collecting this data is to screen for problems and pinpoint areas that need more work – help guide restoration efforts and assess if the restoration projects going online are effective," said Sally Petrella, Monitoring Manager with the Friends of the Rouge.

Prior to any consideration for the Rouge River's water quality, the 467-square-mile water basin, which drains the west side of Detroit and its north and western suburbs in southeast Michigan, served as a primary waterway for industry, supporting dozens of factories that lined the banks. Following 50 years of unregulated pollution and business, state and federal laws were enacted to protect rivers like the Rouge.

Around the same time regulations were being enforced, results from a site sampled by the DNR at Ford Field Park in Dearborn in July 1986 showed how far the river had declined. They found 33 fish; 6 species, 54% being carp or goldfish and half of those had fin rot or tumors.

"Things have gotten so much cleaner now," said Petrella, whose citizen scientists sampled the same Ford Field site in 2015. "We found 353 fish, 15 species, sensitive fish like yellow perch and we found only one carp out of those 353 fish."

Informing a lot of those efforts were groups like the Friends of the Rouge, who conduct multiple aquatic, insect and frog and toad assessments every year.

"We use biological indicators like frogs, bugs, and fish because those animals live in the system full time and so their presence or absence is an excellent indication of overall water quality," said Petrella.

Since 2012, the nonprofit has deployed between six to eight people to conduct fish surveys in the spring into early fall. Using a seine net stretched out by two poles and weighed down by a lead line, volunteers will chase the fish into the nets.

Photos: Friends of the Rouge

After nets are pulled up, fish are sorted into buckets where they are identified and measured. Teams will usually complete two sites a day, targeting all kinds of habitat so as to not miss any species. Over the past seven years, Friends of the Rouge has sampled all of the Rouge's major branches and tributaries, and even some of the lakes, in work more extensive than the last time the DNR surveyed the Rouge – in 1998.

The team has been surprised by the diversity of fish in this urbanized watershed. Sensitive fish like rainbow darters and the "hogsucker" swim around in streams in places like several metro Detroit communities. As the team began exploring lakes in the northern part of the watershed, in 2017, they found a second endangered fish that makes its home in the Rouge, the pugnose minnow.

Equally as important are the aquatic-based insects that live in the water, serving as the bedrock for the local food webs. Groups go out on bug hunts in the spring, fall, and winter – with the last being dedicated to a single insect.

"We look for just one type in January called the stonefly," Petrella said. "It's the most sensitive macroinvertebrate in the basin and they hatch in winter."

And as one of the most sensitive, the stonefly serves as a key indicator for determining the health of the entire ecosystem. When the Friends of the Rouge started sampling for insects, they didn't even know if stoneflies were able to survive in the Rouge. Then in 2002, miles north from the bulk of the point-source pollution, volunteers spotted one.

Since then, Friends of the Rouge has documented stoneflies at 43 sites, mainly in the less developed parts of the watershed, with the exception of a surprise finding in 2010 in the Main branch where water quality has been poor.

The nonprofit also tracks the number of frogs and toads by training people to listen for their breeding calls on night outings. Amphibia are good indicators for wetland health – features critical to the continued restoration of the Rouge River.

The data collected by Petrella's team is part of a growing responsibility of the general public to keep tabs on their local environments. This model for citizen science has continued to grow as funding and prioritization for environmental monitoring have declined.

"I attended a webinar where the EPA was talking about citizen science and how it's getting to the point where they are relying on volunteers more and more to collect data that they used to collect," Petrella said. "They really want more citizens to be collecting data."

Without the funding, it's tricky to know where restoration projects need to happen or how a municipality might try curbing its pollution. That's why the Friend's of the Rouge volunteered to help the DEQ decades ago.

Where interest in monitoring may be light, passion and interest in the river has only grown over the years. A program called the Rouge Education Project may be planting the seeds.

Years before starting their citizen science program, Friends of the Rouge began working with a University of Michigan professor to engage K-12 schools in testing the river for pollution. Since 1987, classes of students test the water quality at their designated site after spending two weeks learning about the river. Once their research is complete, the participants compare their findings at a student congress composed of representatives from all schools.

"It's a great program that impacts so many kids," Petrella said. "It started with 15 schools; has involved as many as 100, and has been ongoing for 32 years. So you're talking about thousands and thousands of students who have gone through the program." The first-hand experience of being out at the river has sparked an interest in many who would never have considered a career in science or the environment. It has educated generations who go on to become passionate stewards of the Rouge River. JN

Three researchers study bug samples through a microscope, identifying different insects.

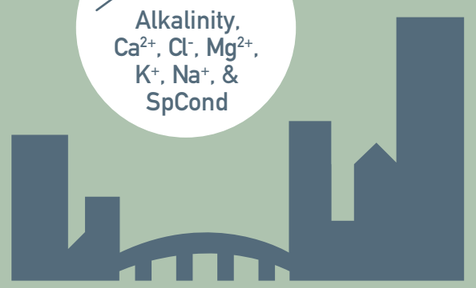
Dynamic Change in Water Quality of U.S. Rivers

In a study published in 2020, Edward Stets and a team of other USGS researchers examined changes in concentrations of 15 water quality factors from nutrients and major ions to sediment and specific conductance. The study compared water quality data from national, state and local monitoring programs with land use data taken from a 2012 national survey. They found a changing water quality landscape from 1982 to 2012. View the full publication at https://pubs.acs.org/doi/pdf/10.1021/acs.est.9b05344.

URBAN

The success or failure of pollution management plans influences the water quality within metropolitan areas. While better management of wastewater and point-sources suggests an overall decrease in nutrient concentrations, the increase in ions implies management plans have not been successful in other areas.

Alkalinity, Ca^{2+}, Cl^{-}, Mg^{2+}, K^{+}, Na^{+}, & SpCond



AGRICULTURAL

Highest concentrations of TN, NO_3^{-}, & TOC

Highest concentrations of total nitrogen, nitrates and total organic carbon of all land use.

TSS

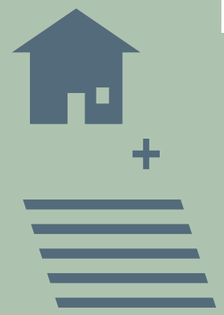
Downward trend in Ammonium

While ammonium concentrations decreased in agricultural areas, there is no clear answer for this trend as both total nitrogen and total phosphorus remained relatively stable throughout the study period. Environmental regulations have been implemented in regards to nutrient point-sources; however, non-point sources are common in agriculture and are not regulated in the same way.

MIXED

SRP

Mixed land-use has become more common as industrial, residential and commercial properties exist in the same area. While there are pollution concerns for industrial, commercial and residential zones individually, water quality concerns may be harder to identify and fix when present in mixed land use.



Alkalinity, Ca^{2+}, Cl^{-}, Mg^{2+}, K^{+}, Na^{+}, & SpCond

UNDEVELOPED

Implemented management practices and reductions to other land uses likely contribute to the trickle-down effects that are seen in watersheds that surround undeveloped land.

Lowest concentrations for ALL nutrients

It may seem obvious that undeveloped areas will not have the same water quality concerns as agricultural or urban land use. However, due to the general interconnectivity of rivers and streams within a watershed, undeveloped areas can feel the effects of water quality issues in other land uses.

Duke's Mooring WIzARD

The mooring anchor, the last piece to be deployed, is set to go overboard.

Photos: Zach Swaim/ Nicholas School of the Environment at The Duke University Marine Lab

The start of Duke University's oceanographic mooring line doesn't begin at the surface of the ocean, but 500 meters beneath it. Floating at the top of the mooring system is a 64-inch syntactic sphere with 2,500 Lbs of buoyancy. It serves a duo of roles as both a floatation device and housing for two high-end acoustic monitoring systems.

Next comes 75 meters of chains and wires before coming to two ocean current profilers, one pointing up and the other pointing down. Next to that equipment are two instruments that measure temperature and salinity.

Next comes several hundred more meters of wire before arriving at several glass balls, more floatation orbs. Finally, right before the anchor tying it all to the ground, are two acoustic releases waiting to let all of it float back to the surface.

This 500-meter ocean monitoring behemoth is the Wideband WoMBAT Integrated Autonomous mooRing for Deep water, or the WIzARD, for short. This $400,000 piece of equipment may not be the most expensive to be deployed for ocean monitoring, but it was placed in one of the ocean's most active places.

"Off Cape Hatteras is a place I like to call the Serengeti of the Atlantic," said Doug Nowacek, a professor of conservation technology in environment and engineering at Duke.

A place where a cold water current flowing from the coast of Labrador, near Newfoundland, Canada, carrying a bounty of nutrients, collides with the warm-water Gulf Stream born out of the tip of Florida. There, miles off the coast of North Carolina, warm water from the south carries nutrients brought from the north to the surface, where photosynthesis ushers in a level of productivity seldom seen anywhere else.

"It's just teeming with life," Nowacek said. "This place has the highest density and diversity of cetaceans in the Northwest Atlantic and probably the entire Atlantic Ocean."

It's the kind of productivity that "leads to small things being eaten by bigger things being eaten by bigger things which end up feeding the marine mammals," Nowacek added. That means bluefin, mahi-mahi, wahoo tuna and hammerhead sharks. Sea turtles nest on the nearby beaches as the National Seashore hosts migrating and wintering birds.

It was also a region viewed through the lens of research conducted in multi-week timespans. Before Duke's WIzARD was deployed, there had been a few oceanographic cruises that studied the area. Some ventures focused on the biological presence in the area and some on the physical conditions surrounding its flourishing life.

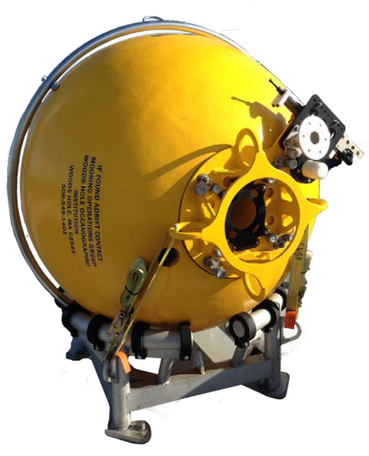
Even Duke University's Nicholas School of the Environment & Pratt School of Engineering had done some work looking at whales and dolphins.

"Our work's been mostly focused on pilot whales and what their dive behavior is," Nowacek said. "We'd put a tag on one, and they'd dive down 800 meters, you hear them click away, buzzing, but we have no idea what they're making that attempt on.

But with the WIzARD, researchers now have the capability of not taking a spatial assessment of the region, but a temporal one spanning nine months, rather than two-three week intervals.

And they also have the capability of not just assessing the biological presence surrounding the entire 900 meters of their chosen water column, but the physical factors as well. The data collection starts at the top, where the syntactic sphere is floated by 2,500 pounds of buoyancy retained in an interior foam.

Attached on the exterior of the sphere are two acoustic recording centers called Wideband Autonomous Transceiver – or WoMBAT. Each with a capability of sending out sound pulses 400 meters in a cone-shaped beam from the transducers, both have been strategically placed at the middle depth of the water column in order to cover as much of it as it can.



"(It's) a high end acoustic system that gives us target strengths of things in the water column at that frequency, which is about 75 kHz. And they sit there and they ping once a minute. And they use those pings and the returns from those pings to tell us what's in the water," said Nowacek.

The information returned from those pings comes in the form of acoustic data stored in "the brains" of the syntactic sphere, which sits inside pressure-housing built to withstand the weight of the water above.

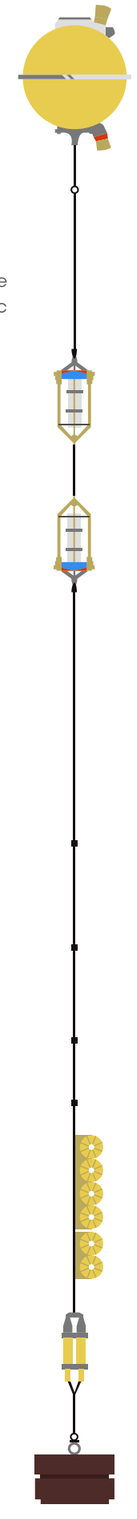
Luckily, enough research on different species in the water has rendered some useful data for the mooring system to take advantage of. Scientists have looked at the acoustic signatures of different fish and crustaceans and can do a pretty good job identifying one based on the kind of response they get.

"We don't know exactly, but we know it's not a whale, know it's not a turtle – it's some kind of class of fish," said Nowacek.

At 525 meters below sea level, the other half of Duke's mooring's capability kicks in. Two acoustic doppler current profilers (ADCP) shoot out four beams from each device with acoustic pings. These instruments apply the Doppler shift principle to measure the direction and magnitude of the current based on the returned acoustic signals.

"Understanding how the water moves is a very important part of that. What is it about this area that lends itself to this amazing mixing and production?"

But the data collection bonanza doesn't stop at meter 525 for; attached to each ADCP is a MicroCAT that can sample the conductivity, temperature and depth (CTD) of an area.



Measuring the abundance of salt ions within one location, the MicroCAT can help input basic data that scientists use to describe water masses.

"By taking the temperature of the water and the salinity, you can learn about what the water mass is and where it came from," Nowacek said. "So the CTD measurements are incredibly instructive and illustrative about what water mass you're dealing with."

Beyond the rest of the wiring is one final piece of hardware operating via acoustics. Following the rule of two, ORE acoustic releases lay just above the mooring's anchor, waiting for a coded signal from a researcher most likely looking to send a command akin to "let go."

A second one is included as a failsafe if the first one fails to release upon command. Once the mooring is unshackled, it floats to the top and is collected at the surface about eight minutes later.

Duke University's versatile system first saw action in 2016 when it was deployed. Researchers collected it in 2018, where a variety of student research groups at Savannah State University have been studying its findings.

While its anchor will be donated to the ocean bed after its release, built to become the foundation for a new reef, the rest of the mooring line will be reused for future forays into the Mid-Atlantic region. JN

(Left) The large syntactic sphere that is the top of the mooring, supplying an enormous amount of buoyancy to keep the mooring deployed correctly.

(Above) An illustration of a complete WIzARD system, from the syntactic sphere floating 500 meters below the surface, to the anchor on the ocean floor.

The Smith River:

Montana's "Unique Gem"

An unusual nuisance is slowly growing into an inexplicable problem for researchers at Montana's Department of Environmental Quality.

For the last five years, a native species of algae called Cladophora has covered large portions of the Smith River, one of the state's most popular waterways for boating, fishing and recreating. And scientists don't know why.

"It's just unusual. I don't know if it's extreme for the state of Montana as other systems have had Cladophora problems as well. But it's most unusual due to the lack of land use changes," said Chace Bell, a water quality assessment specialist with the Montana DEQ.

Historically a problem for water bodies further south; it's not unusual to see large sections of the Great Lakes colored green. Agricultural runoff, heavier precipitation and shorter winters have all contributed to an annual algal bloom that taints much of Lake Erie in the summer.

But Montana's waterways don't see the same kind of nutrient overload as Lake Erie. Warm temperatures come later in the year and don't stick around as long once they do arrive.

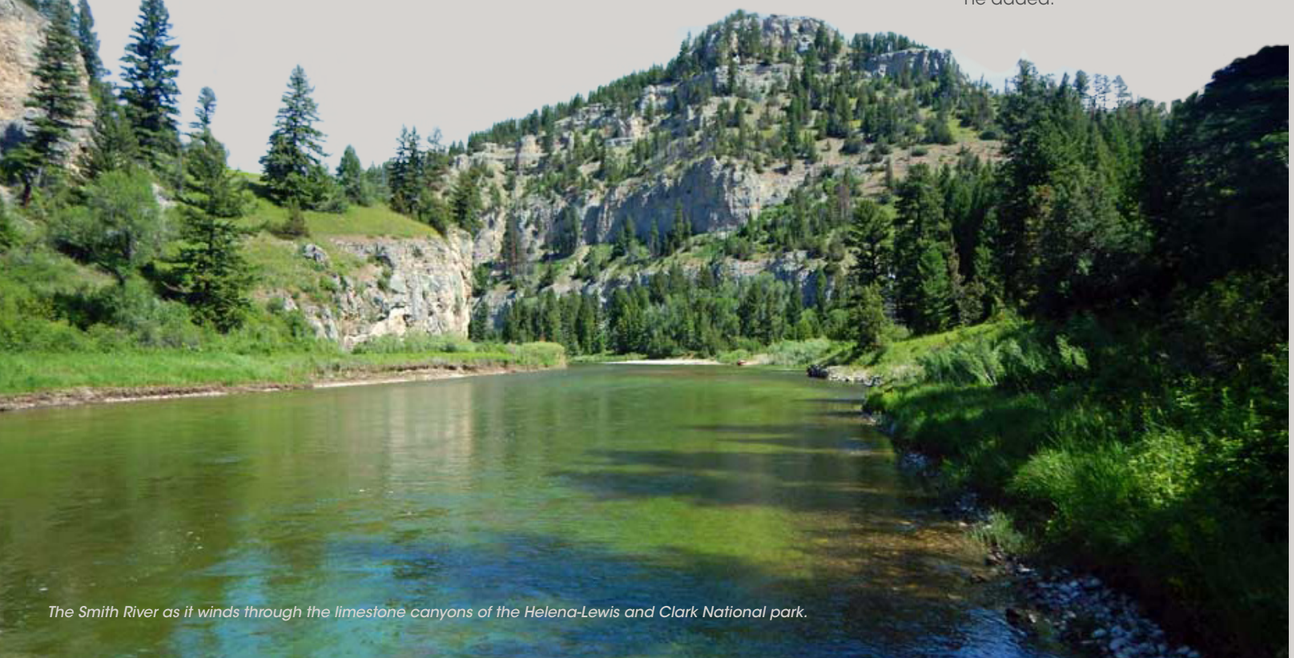
Not much of the surrounding ecosystem has changed in recent years, either.

Located approximately 60 miles east of the state's capital, the Smith River flows south from White Sulphur Spring through a 55 mile stretch of steep limestone canyons north in the Helena Lewis and Clark National Forest, eventually reaching Great Falls. A lack of development in the area, coupled with scenic views from Montana's 'unique gem,' has made the spot such a popular destination for people to travel that the state has to issue float permits through a lottery system.

While the Smith River looks much different from other water bodies that get covered with algae, it does share some similarities. Since 2015, June has registered 55 degrees or warmer. Plants can grow in temperatures lower than that but at a slow rate. Anything above that and things tend to grow more rapidly.

"We developed this overarching question, 'why is algae reaching nuisance levels in the Smith River and why now?'" Bell said. "Was it a sudden onset that was going to happen one year and not the next? Was it a complete anomaly where we have a sudden onset in 2015, then it's not as bad and doesn't reach nuisance levels the years after?"

"We used those few years to really make sure it's worth an in-depth study. And it was completely worth an in-depth study," he added.



The Smith River as it winds through the limestone canyons of the Helena-Lewis and Clark National park.

In the winter of 2018, Bell's team set lab controls, located relevant environmental research and determined the variables that influence algae growth. Among those variables are water and air temperature, magnitude and timing of discharge, nutrient concentrations, water hardness and pH.

These factors influence the abundance of phosphorus and nitrogen in the water, two key ingredients that feed algae growth. In 2019, the DEQ sought to determine the limiting nutrient by conducting a nutrient diffusing substrata (NDS) test that included vials that would hold either phosphorus, nitrogen or both phosphorus and nitrogen.

"That tells us what nutrient is not sufficiently available to support algae growth," Bell said. "In the Smith River, what we're seeing is early in the season, there's sufficient nutrients of nitrogen and phosphorus. Later in the season in August and September, we're seeing strong nutrient limitation of nitrogen and phosphorus."

Determining the source of these nutrients has proven to be a complexity with multiple layers. Along with testing dozens of sites in the water system, the DEQ also added a bio-available phosphorus study that would assess if the nutrient was also present in a dissolved form in suspended sediment particles.

It's also considering the role that different soil types most recently laid during the last ice age might have in contributing to phosphorus growth.

"Those fairly young soils have a lot of phosphorus in them and they're now leaching out into our streams and we're seeing dissolved phosphorus might be playing a role here," said Bell.

"So what we're trying to do is fit this puzzle together of increasing air temperatures in White Sulphur Springs, increasing water temperatures in June at Camp Baker," he added.

"Then there's this timeframe where we know that nutrients aren't limiting algae growth, which we know is that June timeframe into early July."

Before 2015, the water temperature eclipsed the 55-degree threshold needed for abundant algae growth in three previous years; 2003, 2006 and 2007. But no algae was ever reported.

Cladophora isn't toxic like its blue-green algae cousin that grows in Lake Erie. While it's an unsightly mess that gets caught on oars and in fishing gear and causes problems for local irrigators, it's not poisonous.

Beyond possible changes to juvenile fish populations, Bell also doesn't believe it will impact the adult fish species in the area due to the dissolved oxygen decreases that are associated with algae growth. However, it could harm the insect populations.

"From a biology standpoint, if this persists over time, we could see a taxa shift so bug communities might change in the Smith River," he said. "Mayfly, caddisfly systems might transition over time."

In partnership with the U.S. Geological Survey, the DEQ is deploying two monitoring stations on two tributaries to build on the phosphorus research conducted in 2019. It will include real-time turbidity meters and gauges, as well as an automated ISCO Sampler for measuring the water's chemistry during the rise and fall of the hydrograph – which helps Bell's team better understand phosphorus coming from the tributaries. Data from this year's study will help researchers decipher when conditions for phosphorus limitation are in play.

"We'll get a better understanding if there is something that we can do in the future to build resiliency to these algae growth events," he said. JN

Photos: Montana DEQ

CHLORIDE CONTAMINATION:

A THREAT TO THOUSANDS OF NORTHEAST AND MIDWEST LAKES

Thousands of lakes in the northeastern United States are at risk of chloride contamination.

In a 17-state area from Minnesota to Missouri to Maine, elevated chloride levels in some of the region's nearly 50,000 lakes are driven largely by landscape features that are cleared of snow and ice by road salt in the winter.

"The biggest driver of increasing chloride concentrations in these lakes was road density and development. The more developed a watershed, the more likely you are to have roads and parking lots," said Hilary Dugan, an assistant professor in the Center for Limnology at University of Wisconsin—Madison.

Dugan is the lead author on a study examining the issue recently published in Environmental Science and Technology. It uses existing records to model the extent of chloride contamination throughout the region.

Predicting chloride contamination

After their previous research showed increases in chloride in lakes throughout the 17-state region, Dugan and much of the same team shifted their focus to the geographical extent of chloride contamination.

"Instead of looking at chloride through time, we tried to look at chloride through space," Dugan said. The goal was to build a "predictive landscape model."

Dugan and team built a model using data from the National Land Cover Dataset and water quality data from the U.S. water quality portal.

That model identified predictors of elevated chloride levels and identified 1,972 lakes across the region with chloride levels at or above 50 mg L^{-1}, a good sign of anthropogenic inputs of chloride, Dugan said. The greatest predictors of elevated levels were the ways land is used near lakes and in their watersheds. Roads and development mean road salt in the winter. Salt runs off roads and into lakes.

"IF YOUR LAKE HAS A CHLORIDE CONCENTRATION OF MORE THAN 50mg L^{-1}, YOU DEFINITELY HAVE HUMAN IMPACT ON IT."

- HILARY DUGAN

"Our use of road salts is such a huge component of anthropogenic salt inputs that it kind of dominates the signal," Dugan said.

Recent data from the United States Geological Survey suggests that over 20 million metric tons of salt were spread on American roads in 2019, commonly in the states in the study.

Three of the four strongest predictors for elevated chloride levels, proximity to an interstate highway and low-density and medium-density development in the watershed, suggest road salt usage as a significant source.

(Low and medium density development areas include areas like suburbs where winter salt usage is likely to be high.)

The fourth, density of cropland, points to the use of certain synthetic fertilizers like potassium chloride. Five million tons of potassium chloride are used on crops each year.

The United States imported seven million metric tons of potassium chloride in 2016, according to the United States Geological Survey.

However, the chloride contributions of road salt can be an order of magnitude higher than that from fertilizer, the study notes.

Sodium chloride levels a call to monitor

The study sets a chloride contamination risk threshold at 50 mg L^{-1}. That number doesn't relate to any official federal or state standard.

The United States EPA sets the criterion for continuous concentration of chloride in freshwater at 230 mg L^{-1}. In Wisconsin, it's 395 mg L^{-1}. New Hampshire sets the maximum four-day average at 230 mg L^{-1}. Canada's national standard for long term chloride levels, which governs lakes adjacent to the study region, is set at 120 mg L^{-1}.

Chloride standards vary even within states and for surface water or drinking water.

Fifty milligrams per liter is a conservative standard compared to national and state standards in the region, but lakes that exceed it almost certainly are feeling the impact of humans.

"If your lake has a chloride concentration of more than 50mg L^{-1}, you definitely have human impact on it. There's a very small likelihood it's a natural concentration. In most cases it's probably ten, twenty-fold higher than it should be," Dugan said. "This is an area you should monitor."

Filling holes with monitoring and research

Dugan says ongoing and future research could benefit from increased monitoring of chloride levels across this region. A better record going forward could help researchers understand the effects of elevated chloride levels on aquatic species, identify long term trends and create opportunities for collaborative mitigation efforts between researchers and those who use road salt: both public officials and private citizens.

Though the water quality concerns of increased chloride levels are gaining more attention, many states had little or no observation data, Dugan said.

Six states in this region reported chloride levels for zero or one lake.

These gaps could be filled with a relatively simple conductivity measurement.

"There are pretty straightforward ways of getting this data," Dugan said.

More data would flesh out sparsely measured areas and catch more spikes in chloride levels throughout a year, something average chloride levels don't accurately measure. Scientific understanding of chloride levels in these lakes could move from the realm of prediction to that of empirical measurements. AB

Infographic: Emma Jones/ Fondriest Environmental

LOW TECH, LOW COST BUOYS

COMING TO MAINE'S SHELLFISH FARMERS

What might the Maine Aquaculture Innovation Center's (MAIC) buoy offer that other governments and university monitoring equipment lack? The center doesn't have MicroCAT recorders or autonomous acoustic sensing gliders. It's not deploying hundred-thousand-dollar oceanographic mooring lines gathering massive amounts of data.

So what can MAIC's three-foot prototype buoy offer that others can't? It's easy to clean and costs very little.

"One of the big issues for putting anything in the water is biofouling," said Josh Girgis, an engineer at MAIC based at the University of Maine's Darling Marine Center (DMC). "If you put a sensor in, you can only expect it to work until something starts growing on it."

For larger commercial operations, it can be tricky to clean all the bells and whistles that accompany larger equipment. That's why manufacturers use UV light to kill algae or pumps that cycle water through the system. But all of that requires power, a luxury that small, low-cost autonomous data buoys don't have.

This is why Girgis and the team of researchers opted for a simpler solution – scrubbing a sponge on the buoy's sensors.

Minimal maintenance is among the chief factors that Girgis and Chris Davis, who oversees the Maine Aquaculture Innovation Center, are prioritizing in the creation of their buoy. That's because their future customers won't be governments or research scientists – but Maine's oyster and seaweed farmers.

"Our center's goal is to develop low cost buoys with real-time data collection abilities," Davis said. "Our target is to create and sell one for about $2,500."

From Maine to Florida and from Texas to Washington State, aquaculture farming dots much of the coastal landscape surrounding the states. These shoreline farmers harvest an array of shellfish, including oysters, mussels, clams, and scallops.

In Maine alone, shellfish farming is a $20 million industry. Some mom and pop farms might grow 50,000 oysters a year, while commercial operations will yield multiple millions during harvest. But like their landfarming cousins, aquaculture farmers rely on successful harvests to turn a profit. And a profitable season might not arrive until years after getting into the industry. "To do that, you need to develop growth models using environmental controls that regulate how fast shellfish grow," Davis said. Of the myriad of variables to consider when farming, Davis, an aquaculture farmer himself, says that temperature, salinity (as measured by conductivity), and the amount of food are primary factors.

"Getting that information is expensive and you need a year's worth of data to drive the growth model at the location you pick to farm," he added.

Much like how agriculture is driven by sunlight, water, and the nutrient makeup of the soil, aquaculture farming for oysters relies on water temperatures in the high 60's and low 70's range to regulate metabolism, an abundance of chlorophyll from phytoplankton and algae to filter feed on, and enough salinity.

"Coupled with those three factors, you could plot them all on a time series chart and say 'okay, historical trends match this year or next year and allows the farmer to make decisions about what they can do and when," said Girgis.

Even before marketable oysters are grown, it can take years to acquire a permit for an aquaculture farm. If the salinity is too low or temperatures are too high or low, farmers risk wasting years before ever turning a profit.

However, the year-to-year variability of temperature, conductivity, and food doesn't change much. Measurements taken at one site will likely be reliable for decision making in the future. That means as long as farmers have the data, they know what to expect.

"Knowing water temperatures for a site from year to year can help just in managing for the farmer," Davis said. "When do you overwinter your crop? How do you control the density of your shellfish? Of the water temperature? There are ways to use the data to better manage the farm."

The buoy that Davis and Girgis want to use would take measurements of all three parameters every quarter-hour, half-hour, or hour, depending on the farmer's preference, and wirelessly transmit it to a website or one's cell phone. The data would be communicated from a cellular modem. The makeup of the buoy prototypes is essentially a combination of circuit boards contained within the buoy's hull. Wires connect the circuit boards to probes that protrude from the bottom on an external plate.

"You have to figure out how to make all that watertight as it's mostly circuit boards inside the hull," Girgis said.

In the first four prototypes, the team used a combination of commercial and custom-made parts to build the buoys, which helped keep the cost down. Temperature is measured by a precision thermistor built from a combination of the market and modifications from Girgis.

However, in later renditions of the buoy, the team hopes to install modified fluorometers, in addition to the conductivity sensor that Girgis built. Future conductivity sensors will be built from readily available components.

A working model ready for release is still months away as physically fitting modified sensors takes time. However, researchers at the Darling Marine Center envision a future where they could be leased to farmers on an annual basis and the data they collect available to the public. JN

Photo: Maine Aquaculture Innovation Center

(Left) A prototype buoy built from the Maine Aquaculture Innovation Center. The final version will measure three environmental conditions, temperature, salinity, chlorophyll content, the most important factors for shellfish farmers must consider when growing oysters.

GAR-BAGE FISH NO MORE

IT'S TIME TO RESPECT GAR

Gar are a mean-looking fish, which along with their reputation as predators has earned them disregard and persecution for a long time.

But that's starting to change and it's about time, says Solomon David, who's watching with hope as gar are increasingly valued for their role in their ecosystems and as sport fish.

"These attitudes are shifting, but there's plenty of work to do," said David, who is an assistant professor of biological sciences at Nicholls State University in Louisiana.

While understanding of gar's scientific and recreational value is increasing, gar still face the harmful effects of old beliefs and new challenges.

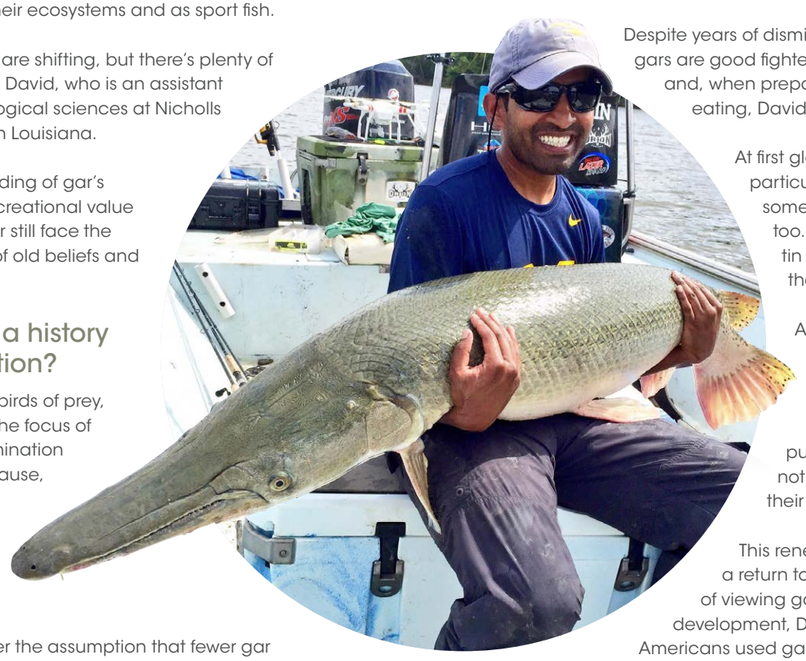
The end of a history of persecution?

Like wolves and birds of prey, gar have been the focus of control or extermination campaigns because, in some cases, they eat economically valuable animals.

In the past, under the assumption that fewer gar meant more fish they'd like to catch, anglers and fisheries managers have sometimes tried to remove as many gar as possible. They used dynamite and electrocution and killed any gar caught while fishing for something else. For at least a few years in Iowa, it was illegal to return a gar to the water after it had been caught, biology professor Dennis Scarnecchia wrote in 1992.

But just like other predators, gar are increasingly appreciated as their role in maintaining ecosystem function is better understood.

"If you think of them like wolves in Yellowstone, they maintain balance," David said. Within the ecosystem, gar keep prey fish populations in check, improving the overall health of prey fish in that area. When wolves were returned to Yellowstone, it's likely that biodiversity increased. Gar eat what's most plentiful, ensuring balance in the ecosystem.



Despite years of dismissal by many anglers, gars are good fighters when on the line and, when prepared right, good eating, David said.

At first glance, they don't look particularly tasty. They take some special preparation, too. Anglers regularly use tin snips to get through their tough, scaly skin.

According to David, their growing reputation as good fighters has led to more anglers pursuing them for sport, not just to control their population.

This renewed interest is a return to an older way of viewing gar, not a new development, David said. Native Americans used gar skin for tools and weapons. And, because they're regularly eaten in Mexico, Cuba, and Central America, many of the techniques used to raise gar in captivity were pioneered there and then borrowed by North American scientists when they turned their attention to the fish.

(Above) Solomon David holds an alligator gar in Texas.

(Right) A longnose gar from the Mississippi River floodplain on the Louisiana-Mississippi border.

Science catches up to gar

Economically or recreationally valuable fish (which is often the same thing) get most of the conservation and research attention and funding. That leaves fish not targeted by recreational or commercial fishers out in the cold.

"That's the conservation conundrum in a nutshell," David said. Although gar have been studied for years, recently their contribution to science has been more widely appreciated.

David's own research revealed growth rate adaptations in gar influenced by latitude. Those gar living at the northern parts of their range—in the vicinity of the Great Lakes—have much more rapid growth rates than their southern relatives. This is likely an adaptation to the shorter northern growing season, where fish have less time to bulk up before facing down lean winter months. What's particularly interesting is that gar have remained mostly the same over millions of years. Still, in the 8,000 years or so since they've arrived in the northern portions of their range, they've significantly adapted their growth rate.

Besides insights into evolutionary biology, gar might provide answers for other areas of science as well.

Spotted gar, one of the seven gar species, have been identified as a genetic bridge between zebrafish and humans by Dr. Ingo Braasch and his team. Zebrafish are often used in biomedical research, but their genetic differences from humans can make translating experimental results difficult or confusing. Because they have similarities to humans and zebrafish, spotted gar can help researchers choose the best zebrafish genes to compare to humans and make experiments in zebrafish even more relevant to humans.

Alligator gar, one of North America's more southern species, can also serve as an indicator of ecosystem health. They prefer inundated river floodplains to reproduce. Finding alligator gar in all stages of life means the ecosystem is "doing at least alright," David said. In that way, successful alligator gar reproduction can point to the success of certain restoration projects as well.

Continued threats to gar

Although it's no longer illegal to release a gar after catching it, there are still challenges facing them today.

Many states lack any regulation on the number of gar an angler can catch. Given the relative dearth of long-term research on gar, it's hard to say how far below historical levels their populations are. Unregulated harvest could harm gar populations and in a few states they are considered threatened or endangered species. The range of alligator gar, for example, has been greatly reduced.

David is concerned about unregulated catch, such as bowfishing tournaments where participants shoot fish with bows and arrows, earning prizes for the biggest fish caught. Because the biggest gar are often reproducing females, tournaments could have a serious impact on gar populations. Not to mention, removing an ecosystem's apex predators often comes at the cost of ecological imbalance.

Being fished recreationally can be good for a species. It brings research money and anglers are often effective conservationists. The same can happen for economically or scientifically useful fish, like spotted gar. If you can't be charismatic, be valuable.

Still, for gar researchers and enthusiasts like David, it would be nice if they could be valued simply for being a unique part of aquatic biodiversity.

But in a world of limited research dollars and limited attention, it's probably simpler to convince people that gar are economically, scientifically and recreationally valuable than intrinsically so as the weird, slimy, fierce-looking ancient fish they are.

"I think it's human nature," David said.

Regardless of the reason, it seems gar are garnering more interest and respect, a fitting development for a respectable fish. AB

Photos: Solomon David

PLENTY OF PLASTIC

Despite the high profile of plastic pollution in the ocean, the same problem in the Great Lakes is poorly understood.

"Believe it or not, we're kind of in the early stages of understanding plastic pollution in the Great Lakes," said Sherri Mason, sustainability coordinator and professor of chemistry at Penn State—Behrend. She's one author of research published in April 2020 in the Journal of Great Lakes Research examining the levels of plastic in Lake Erie and, for the first time, Lake Ontario.

The research revealed the highest level of plastic pollution in the Great Lakes occurs in Lake Ontario. Lake Erie was a distant second.

Trawling for Plastic

Mason's research relied on opportunistic sampling of the lakes.

"I made use of whatever boat I can," she said. "Between 2012 and 2014, I went out on at least 10 different vessels." When a boat was available, it was rigged with a manta trawl, a net that skims the surface of the water and collects what's floating near the top of the lake. After a half-hour, whatever the trawl collected was removed and packaged up to be taken back to a lab.

In the lab, any organic material was decomposed and the remaining plastic was analyzed for abundance, shape and size. That information, run through a computer model, provided a lake-wide look at the plastic in Lake Erie. With the model, researchers estimated that Lake Erie's surface had 475 million plastic particles, weighing 6.45 metric tons (over 14,000 pounds).

While it wasn't possible to run the same models for Lake Ontario, it's clear from the samples that Lake Ontario has far more plastic. Lake Erie had an average of 45,000 particles per square kilometer, while Lake Ontario averaged 230,000. "It's a lot of plastic," Mason said.

Great Lakes plastic through Ontario

Lake Ontario has high numbers of plastic particles for a reason, Mason said. With few exceptions, every scrap of plastic in the Great Lakes will flow through it before reaching the sea. But, Lake Ontario also gets a lot of plastic waste from several major metropolitan areas, like Toronto, which hosts major plastic production. The sample with the highest amount of plastics came from right outside of Toronto.

The plastic's morphology helps tell the story of plastic pollution in the Great Lakes. Pellet-shaped plastics are most likely pre-production plastics. Those plastics were never likely used by a consumer, Mason said. Forty-six percent of the plastic removed from Lake Erie was pellets, while 12% from Lake Ontario was. Pellets could also be microbeads from personal care products. Future sampling would likely see a decline in microbeads since the United States banned them in 2015. Canada did the same in 2018.

A smaller percentage of plastics in both lakes came from fibers (9% in Lake Erie and 2% in Lake Ontario). This is evidence of clothes made from plastic, which shed fibers in the wash, Mason said.

Overall, most of the plastic found in the lakes are fragments of larger plastic items that have broken down. In Lake Erie, 42% of particles were fragments. In Lake Ontario, 76% were. These fragments come from plastics that have been manufactured, used, and discarded.

"It's the stuff that we're using that we find out there," Mason said. "As a consumer, if you make conscious choices to use less plastics, we are going to find less plastic in the water. It's that simple."

Plastic production is set to increase for years to come, but there is evidence that the public is interested in reducing plastic consumption.

Mason doesn't lay all the blame at the feet of the public. Industry should be responsible for their products, she said. But she is optimistic about the power of people to shift the trends of plastic pollution for the Great Lakes. "We're all part of the problem, but we're all part of the solution," she said. If a solution is found, it will still be some time before the Great Lakes are plastic free. AB

Sherri Mason holds a manta trawl used to collect microplastics from the Great Lakes. (Above)

Photo: Sherri Mason

Special Offer

NexSens CB-25 Buoy

The CB-25 is a compact and lightweight (18" diameter and 30lbs) data buoy. Designed for drifting or tethering, the buoy is a versatile platform for many projects with easy integration of wave, position, water quality and atmospheric measurements.

Powered by either alkalines or a rechargeable battery with solar charging, the NexSens buoy collects data and transmits it to the cloud. Wireless communication options include 4G cellular or Iridium satellite. Data is accessible at WQData LIVE.

Price includes CB-25 data buoy with solar charging, X2-SDLMC data logger with 4G cellular modem & Basic WQData LIVE account. Sensors and cellular data account sold separately.

~~$5680~~ **$4995.00***

Integral cellular modem sends data to the cloud-based WQData LIVE datacenter.

Special Offer

YSI ProSolo DO Meter

The YSI ProSolo is a professional-grade field meter and when paired with the ODO/T optical oxygen probe, the system offers years of reliable service. It is YSI's premium DO meter with a 3-year meter warranty and 2-year cable/probe warranty.

The optical sensor technology offers high accuracy, no stirring dependence, less maintenance, less drift and extended calibration frequency. The system automatically recognizes sensor changes with calibration stored in the probe.

Price includes YSI ProSolo Digital Water Quality Meter, 4-meter cable assembly with optical DO & temperature sensors, and soft-sided carrying case.

~~$1530~~ **$1453.50***

Assembled, calibrated and tested at the Fondriest factory certified repair center.

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