Spring 2021

UPSTREAM

News from Itasca Biological Station and Laboratories

As we work hard to "sunrise" in 2021, the lake still awaits for sunset canoe rides.

Excuse you, lake

Study points to microbes below lake surfaces as source of nitrogen gases.

Spending summer hopping around different lakes on a boat might not sound like work for many Minnesotans, but it is for Ph.D. candidate Brianna Loeks-Johnson. During the summers of 2016 and 2017, she spent countless hours on boats equipped with a clipboard, probes and sampling devices. She ventured out to over 60 lakes across Minnesota, including several in and around Itasca State Park. Catching rides with fellow scientists, educational floats and occasionally a friendly cabin owner, she sought to assess nitrogen levels.

"By looking at nitrogen saturation in lakes, we can infer what sorts of microbial processes are going on below and how that might affect later water quality and clarity," says Loeks-Johnson.

During the sampling effort, Loeks-Johnson, a researcher in Ecology, Evolution and Behavior Professor Jim Cotner's lab, used a tube-like instrument to measure oxygen, temperature and other key metrics and a device to capture water at different depths.

Heading back to the lab, researchers analyzed water samples and found that all the lakes surveyed were emitting nitrogen gas. The results, published in the journal *Proceedings of the National Academy of Sciences* (PNAS), suggest that microbes are removing nitrogen from the lake system. "This blanket finding was a surprise," says Loeks-Johnson. "When lake managers ask researchers, 'How can we help improve the quality of lakes?' We respond 'Well, for this one particular lake…"

Recommendations are often made on a lake-by-lake basis and researchers have a good reason for doing so. Countless factors, including wind speed, surrounding topography, runoff and glacial history, all contribute to lake conditions and management decisions. However, this work shows that in some ways, lakes act predictably.

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DIRECTOR'S MESSAGE

Greetings from Itasca!

The ice is out, the birds are giddy with enthusiasm, and we have programming on the horizon. Things are looking up.

We hosted the Plant & Microbial Biology graduate student group in the fall, a COVID-era victory ahead of preparing many buildings for the cold months. Winter gave us the chill of darkness, thanks more to news of spiraling COVID infections than to cold weather. Now, after early ice-out on Lake Itasca and vaccine distributions to curb the virus, we are once again ready to safely welcome programming for 2021.

This includes our own Field Biology courses. Field Biology started in 1935 as an addition to Forestry courses, which were initiated in 1907. One Roosevelt (Teddy) ushered in an era of forest conservation and forestry schools. Another Roosevelt (Franklin Delano) rode the tail end of a 1930's dust cloud, when automobiles enabled the masses to access forests for leisure, not cutting trees. Conservation had to grow beyond tree biology. In these moments, Itasca's field-based offerings were forged, and in their heyday, Itasca became a seasonal scientific community thanks to the combination of place-based research and student training.

I love the idea of pushing this research and teaching combination again, to make Itasca the destination more than the escape. It suits us — always has.

Stay well — see you soon.

Jonathan Schilling, Director
Itasca Biological Station and Laboratories

Layered lakes fuel microbial hotspots

Some lakes in the area resemble the iron-rich and stratified ancient oceans, attracting attention from researchers who want to know why.

It should come as no surprise that plentiful lakes draw many researchers to the Itasca region. The fact that some are drawn to lakes because they resemble iron-rich oceans of a bygone era might come as a surprise.

This trait brought Betsy Swanner, an associate professor at Iowa State University, to Itasca. Now a frequent visitor, Swanner recently received a National Science Foundation (NSF) grant in the Faculty Early Career Development Program (CAREER), to continue research up north. The research team will spend most of their time visiting lakes a few miles from the station, including Deming, Budd, Arco and Josephine. These iron-rich lakes are thought to be meromictic, which means they don't mix seasonally from top to bottom.

Because of their stratified layers, the biogeochemistry of the lakes resembles iron-rich oceans from 500 million years ago. As part of the grant, Swanner aims to disentangle how carbon and oxygen move through the system and sort out what microbes are involved. The lakes might be bigger contributors to greenhouse gas emissions than previously thought.

From the lake's surface, their unique chemical signature and stratified layers aren't noticeable. A different reality unfolds below. "When oxygen levels decrease, things get weird," says Swanner. "As you get into the zone that transitions from high oxygen to low oxygen, there are hardly any fish and a plethora of unique microbes."

These low-oxygen layers are hot spots for microbial diversity, including for microbes that release oxygen and others — known as methanogens — that require a low-oxygen environment. They're at odds with each other. Researchers hope to identify the oxygen-producing organisms, and sort out how much oxygen they release in the iron-rich system.

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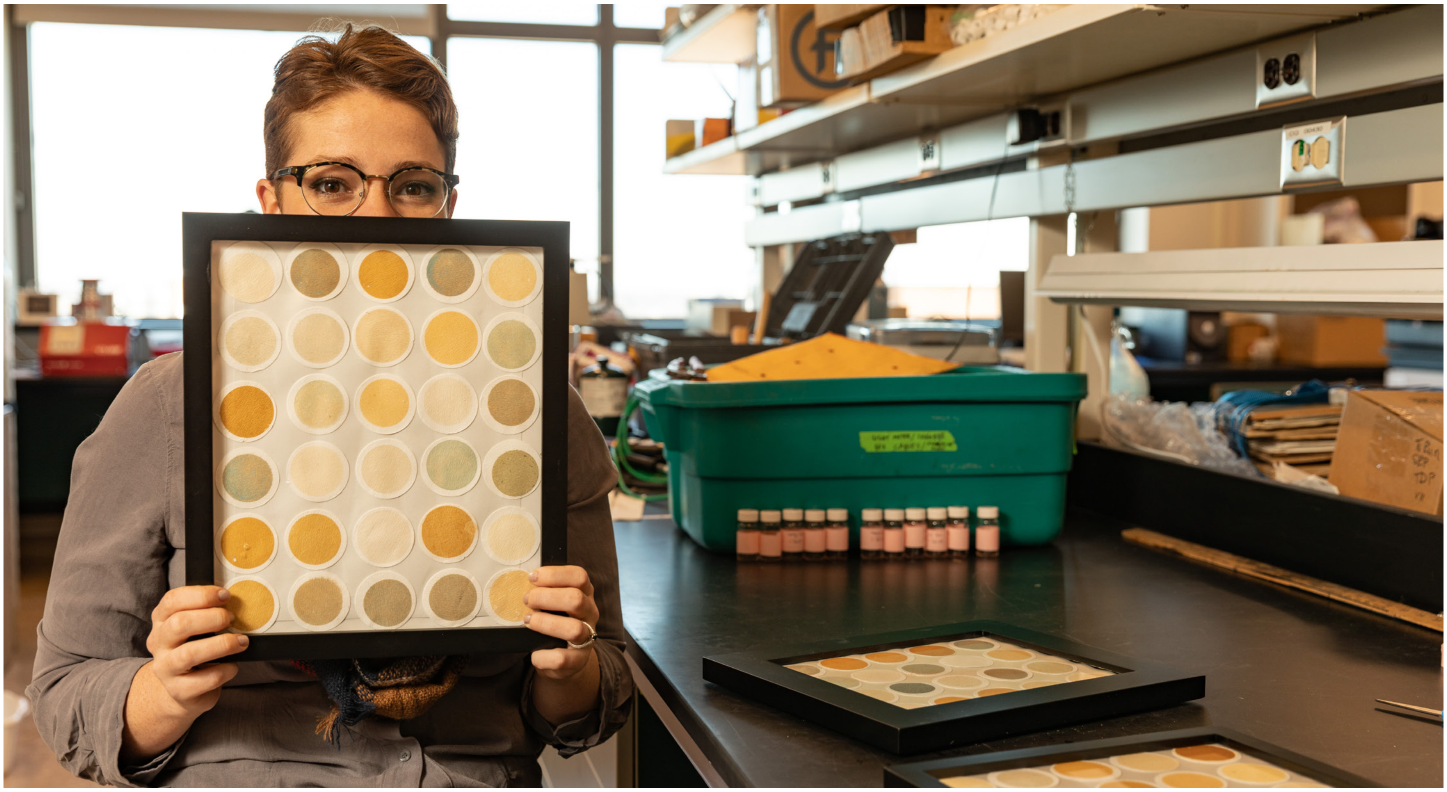

Photo: Jonathan Pavlica

Loeks-Johnson turned a collection of filters left over from sampling lake water into a display that greets visitors to the lab. The colors reflect the variation in the amount of iron, salt, fertilizer and other matter present in the water. Below: Loeks-Johnson collects samples (L) and alongside Seth Thompson, CBS' Director of Outreach (R).

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Researchers are currently working to map out the microbial communities and learn what species are "at play" in the different lakes. This will help them figure out what microbes are driving this phenomenon. Microbes — just like all living organisms — require specific nutrients to survive and thrive. Their diet requirements differ depending on the species. Some microbes can convert nitrogen gas into a nitrogen that they can then utilize for growth. Because of this, historically lake managers haven't focused on nitrogen. Since the 1970s, scientists instead focused on managing phosphorus levels in lakes to thwart harmful algal blooms or poor water quality.

However, this research shows that in some cases nitrogen might be a limiting factor for that growth. Disentangling the microbial community will help researchers get a more complete picture of what's at play, with a long-term goal of helping lake managers learn about their lakes' microbial communities and potentially leverage microbes to remove excess nitrogen.

Long days in the lab and running data analysis are worth it for Loeks-Johnson. She relishes days spent on a boat, no matter the weather. For her, the lakes around Itasca hold a special place.

"The lakes are kind of my friends up there because I know what to expect. They can get moody depending on the weather and it feels like home."

–Claire Wilson

Photo: Seth Thompson

"The lakes are kind of my friends up there because I know what to expect. They can get moody depending on the weather and it feels like home."

— Brianna Loeks-Johnson, Ph.D. candidate

Photos: Betsy Swanner

Top left to right: Betsy Swanner takes an ice core to collect winter samples at Budd Lake. Summer research, no surprise, requires a different set of gear that what is required for winter sampling. This is at Deming Lake. Bottom left to right: Students taking field courses might work into the evenings sometimes, but glorious sunsets make for solid study breaks.

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Oxygen levels dictate how active methanogens can be. Methanogens, as the name suggests, produce methane by decomposing organic products, like leaf litter. Methane is a potent greenhouse gas, and lakes and wetlands add a significant portion of methane into the atmosphere annually.

Higher iron levels might promote methane production by reducing oxygen levels. This interests Swanner because although a handful of lakes wouldn't make a big difference in global methane emissions, if these iron-rich meromictic lakes are widespread, they might. Documenting the balance of oxygen and methane production will paint a clearer picture of ancient oceans and in these lakes today.

The number of meromictic lakes might be on the rise because of human activity. "Road salt runoff is a big contributor to this," says Swanner. "Because of this, we think the estimate of iron-rich meromictic lakes in the upper Midwest and beyond is low." If iron-rich meromictic lakes are more common than scientists think, this could have a number of consequences, including for lake managers.

Swanner's lab will visit the station a couple of times a year. Whether donning a lifejacket and climbing into a boat or wearing a parka and strapping on snowshoes, they'll be out sampling microbial life of these lakes and estimating their contributions to greenhouse gas emissions. —*Claire Wilson*

New role, familiar face

Lesley Knoll moves into a leadership position at the Station.

After five years working as the Station Biologist, Lesley Knoll moves into a new role as the Associate Director. We recently caught up with her to learn more about her work.

What do you do?

I oversee day-to-day operations and work closely with Director Jonathan Schilling on long-term plans for the station. I also conduct my own research and connect with scientists who are interested in doing research onsite or nearby. Since I know the area well, I can help guide them when it comes to selecting research sites or connect them with other researchers. I also do a fair amount of engagement work with colleagues from Itasca State Park and the College.

What's a new research project you're excited about?

This past winter I worked with recent CBS graduate Ben Fry and researchers at UW-Stout. Even though frozen lakes seem barren, there's algae growing on the underside of the ice sheets. We worked on developing a new method to monitor algae growth under the ice. It was fun to get back to my ecology roots and tinker with new approaches.

Part of your work involves public engagement programming. What's one initiative that you're proud of?

Over my time here, I've thoroughly enjoyed getting to know and working with two of Itasca State Park's naturalists Connie Cox and Sandra Lichter. By fostering this partnership, I help connect park visitors with scientists. The monthly Science and Nature Program is a good example as researchers engage with the public about their science in an interactive and hands-on way.

What's your favorite season?

Up here spring is my favorite. The snow stays for a while and it's beautiful. Then pretty quickly it melts and immediately plants start sprouting up. It's such a contrast and because of that, I love it. Spring was never my favorite season until I moved here. It's a special time of year.

HISTORY

Lindeman's Ode to Lake Itasca

Raymond Lindeman revolutionized ecology with his insights into aquatic ecosystems based on field work at Cedar Bog Lake in what is now Cedar Creek Ecosystem Science Reserve. Cedar Creek is world-famous for field-shaping long-term ecological research. But before Lindeman spent time there, he roamed Itasca State Park and the field station as a student. In 1936, he penned a poem about Lake Itasca.

Here we search the placid waters,
Find a microcosmic sea
Wherein hunting, hunted microbes
Eat and live and die, as we...
Dynamic worlds are set before us,
Let us humbly seek to learn.

A fish-eat-fish world

Field courses kicked off in mid-May and the station is buzzing with activity after a relatively quiet year.

With buckets, cages and notebooks in hand, students in the animal behavior field course dodged poison ivy and headed down to the shores of Deming Lake. The path is familiar for the instructor, Brian Wisenden, who also serves as a professor at Minnesota State University Moorhead. He's been leading students down to Deming Lake for a similar experiment since 2000.

"In my course, students do what animal behaviorists do. They design experiments, collect data, conduct analyses and communicate their findings," says Wisenden.

Students studied whether small fish evade predation based on cues, which is key to understanding how individuals "make it" in their fish-eat-fish world. If organisms can't avoid high-risk areas, they likely won't survive to maturity or successfully reproduce. In this course students test this ecological concept rather than read about it.

The experiment tested whether minnows congregated (or not) depending on whether they perceive a predator recently visited the area. If there's a scent of a dead minnow, will others minnows still congregate in the area? Will related species avoid this area too? What if the "kill" happened several hours earlier? Is that area still deemed dangerous?

To test these questions, students deploy cages around the banks of the lake that contain sponges in the center. Some of the sponges contain remnants of minnows, which mimics a predator attack. For hours students weave around the lake deploying the cages at regular intervals, waiting for the "OK" of Wisenden, who serves as the conductor of the day. He keeps track of the clock and ensures the cages are in the water for equal amounts of time.

After a quick break for lunch, students head back into the field to start the second part of the experiment. Over the past 2 hours minnows were given a chance to congregate in the cages or not. On cue from Wisenden, students reel up cages from the water, pour the minnows into buckets and identify and tally species.

Efficient identification is key as students need to head to the next set of cages in less than five minutes. "Sometimes it was a race to identify all the minnows in the allotted time," says Jordi Johnson, a student in the course from Augsburg University. "I actually picked the group we thought would have the most minnows because I was excited to handle fish and identify them. In some cases we identified over 60 minnows in under five minutes."

After a full day in the field, students headed back to the station and checked for ticks. Over the next week, they merged data sets and set about analyzing the findings. This year, the data didn't line up with what Wisenden and students hypothesized. Wisenden used the moment to share that negative results are part of science, and that experiments don't always align with expectations.

"In the end, the results themselves aren't that important. The important piece for students is the process of designing and carrying out an experiment in the field," says Wisenden.

–Claire Wilson

"In my course, students do what animal behaviorists do. They design experiments, collect data, conduct analyses and communicate their findings."

— Brian Widenden, animal behavior instructor

Students in the Animal Behavior field course head to the shores of Deming Lake. There they deploy cages and later check to see what species of minnows congregate (or not) within the cages.

Itasca

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DID YOU KNOW?

In a typical May/June field course season, the dining hall staff serves around 4,000 meals. They use lots of locally sourced ingredients and are famous for their homemade fare.