# Icy research drills down on summer algae blooms

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Where’s the phosphorous? Historically, there have been few wintertime studies of lakes. Students Peter Isles and Trevor Gearhart are helping to change that as they cut through twenty-seven inches of ice to collect mud from the bottom of Lake Champlain. They’d like to know where algae-enabling nutrient pollution is lurking. Credit: Joshua Brown

We've walked a mile out on the frozen skin of Missisquoi Bay. Clouds, snow and ice blend into an abstract collage of white shapes. To the west, a thin grey line, the New York shore, cuts the world in two. To the south, a pea-size pick-up truck creeps over the lake toward a pinhead-size ice-fishing shack. Trevor Gearhart checks our location on a handheld GPS. "Yep, this is it," he says. Peter Isles fires up a reassuringly large, safety-yellow drill.

Isles and Gearhart are doctoral students on a large project called RACC—for Research on Adaptation to Climate Change. Involving nearly thirty faculty members from UVM and other Vermont colleges, the project has funding from the National Science Foundation's EPSCoR program to explore two difficult questions: how will Lake Champlain react to the double whammy of climate change and land use change? And how might different land management and policy choices affect these impacts on the lake?

## Booming blooms

As one step toward answering these questions, Isles grips both handles of the drill as the auger disappears into the ice down its full length, almost three feet. Lake water comes surging to the surface. "You could drive a tank out here," he says, looking down into the black hole.

Unlike most people who schlep a sled full of gear onto this bay in March, Isles is not looking for fish. He's come with Gearhart and two other researchers to collect water, mud from the bottom—and plankton. He's especially interested in three types of cyanobacteria—sometimes called blue-green algae—Aphanizomenon, Microcystis, and the benign-sounding Anabaena.

These are microscopic plankton that float around in Lake Champlain. They're native, but not always benign. Given a diet of phosphorous pollution, they become major culprits in algae blooms that can foul beaches, produce dangerous toxins and suck the oxygen that fish need out of the water.

Cyanobacteria are single-celled organisms that photosynthesize, making their own food from sunlight and carbon dioxide. They're like plants, but on a different, more ancient, branch of the tree of life. When excess nutrients wash off the land—sometimes from farm fields, roadways, eroding streambanks or wastewater treatment plants—cyanobacteria chow down like a teenager. They can reproduce rapidly, forming a suffocating green scum that drives out other species of plankton and harms critters up the food chain.

Heading west, for science.

In Missisquoi Bay, phosphorus concentrations have been increasing steadily for two decades, blowing past targets established by the EPA. Like some other shallow parts of Lake Champlain, the ecosystem in Missisquoi Bay is now dominated by cyanobacteria. "And we would expect that climate change is going to worsen the problem," Isles says.

## In the water column

Gearhart sits on a blue cooler, filling bottles with lake water from a hose attached to a small, chugging pump. "We collect right below the ice, a meter below the ice, a meter from bottom, half a meter from bottom, and as close to the bottom as we can get without pulling up sediment," he says. He'll take these back to the lab to "see how nutrient and phytoplankton composition changes through the water column," he says.

A few yards away, Peter Isles lowers a long metal tube into another hole he's cut in the ice. This is a sophisticated optical sensor that records pH, dissolved oxygen, conductivity, several pigments specific to cyanobacteria and other measures of the water.

This spot on the ice is the same place where a buoy floats in the summer, sending the same kind of sensor up and down through the water. Other sensors in the lake and nearby rivers and streams do the same. "We're looking over the course of the year to see where the nutrients—mostly phosphorous and nitrogen—come from, how they're stored and cycled within the lake," Isles explains, "and how does that contribute to algae blooms and other effects on the lake's ecosystems?"

In the summer, cyanobacteria get busy. "Their population can double or cut in half overnight," Isles says, which is why the sensors on the buoy can take measurements remotely every hour. It's like taking the pulse of the lake, says UVM geologist Andrew Schroth. He and biologist Jason Stockwell, director of UVM's Rubenstein Ecosystem Science Laboratory, are supervising these students as they all look for the geochemical triggers for sudden blooms.

On this freezing morning, no cyanobacteria populations are ready to bloom. "But what is the summer going to start with? How many nutrients? What are the plankton doing? Where are they hanging out below the ice?" Gearhart wonders. "We're looking now, in winter, to get a better answer to these questions."

With this kind of information, the RACC project is building computer models that refine global-scale climate forecasts down to the scale of Lake Champlain. These will let scientists and policymakers make educated guesses about what will happen to the health of the lake in a warmer future—and consider the effects of hypothetical choices about, say, the size of agricultural field buffers or the amount of pavement in a watershed. "We hope it will help people balance what they want the lake to look like with what they want to use the land for," say Gearhart.

## State change

"There is no 'environment' in some independent and abstract sense," writes the great geneticist Richard Lewontin, "Organisms do not experience environments. They create them." Cyanobacteria, it appears, are now creating Missisquoi Bay in their own image.

The bay may well now be in what biologists call an "alternate stable state." The zooplankton that eat phytoplankton have a hard time dealing with too many cyanobacteria. Fish may not get the nutrients—especially certain fatty acids—they need when they live in cyanobacteria-dominated waters. Decaying algae create low-oxygen conditions that release more phosphorous from sediment into the water. A cyanobacteria monoculture often reigns. "These are self-reinforcing systems," Isles says. "Once you flip it over, it's hard to flip back."

There is at least one other stable state: one "with relatively clear water and lots of aquatic plants, fish, and not too many cyanobacteria," Isles says. The RACC project, among its many goals, aims to help people figure out what they'd need to do to flip Missisquoi Bay back to that state—or how easy it might be for other parts of a climate-changed Lake Champlain, even deeper colder parts, to flip to algae blooms.

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