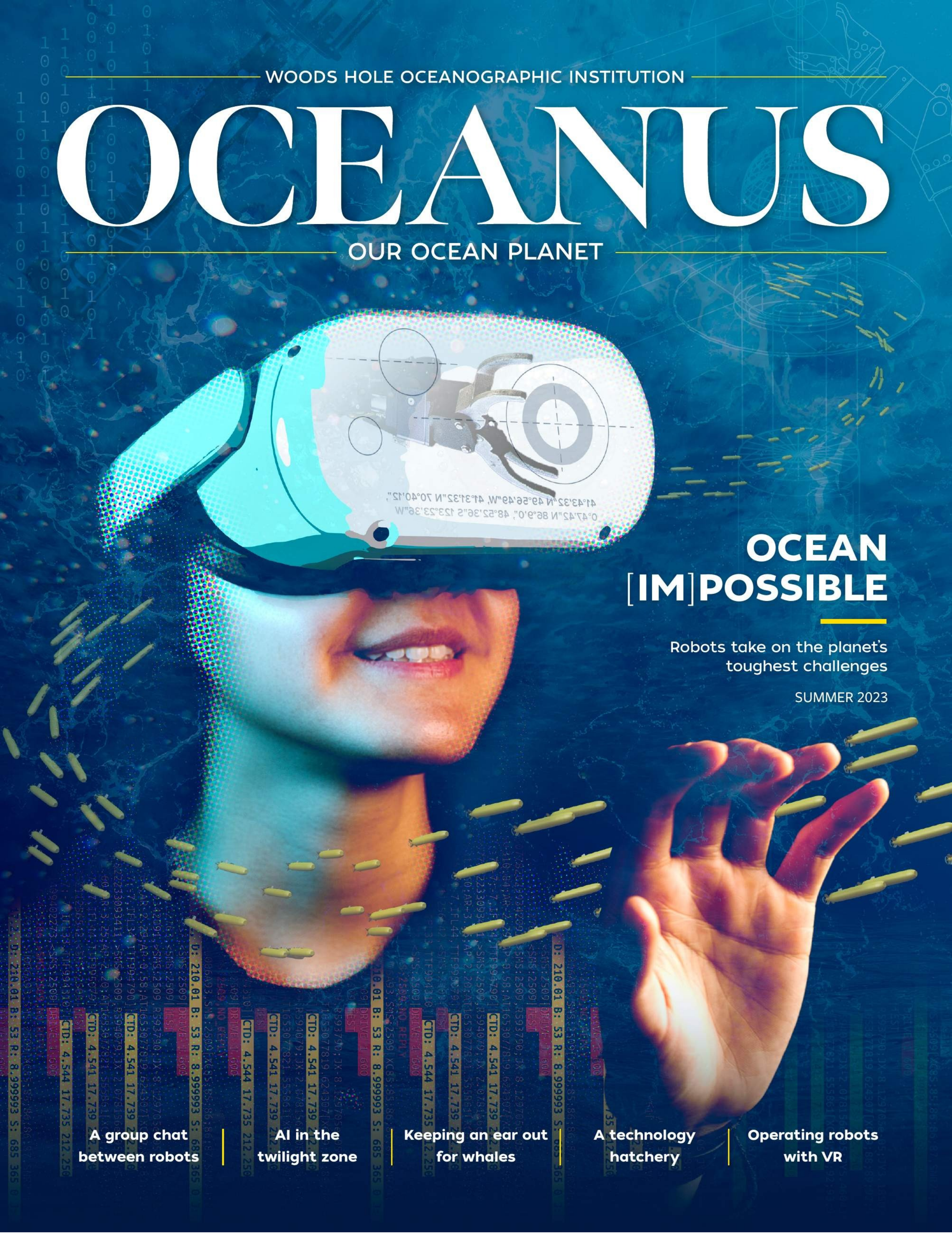
WOODS HOLE OCEANOGRAPHIC INSTITUTION

OCEANUS

OUR OCEAN PLANET



OCEAN [IM]POSSIBLE

Robots take on the planet's toughest challenges

SUMMER 2023

Imaging bot detects HABs in the Arctic

By
Daniel Hentz

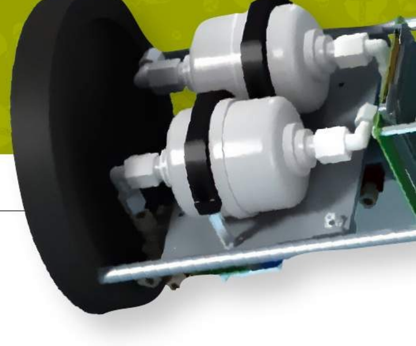
ALASKAN PUBLIC WARNED ABOUT HIGH CONCENTRATIONS OF TOXIC ALGAE

On her way to the Bering Strait for the fifth time, MIT-WHOI Joint Program student Evie Fachon hoped to learn more about a toxic species of phytoplankton known as *Alexandrium catenella*. With the Alaskan Arctic warming faster than almost anywhere in the world, she and other members of the Anderson Research Lab were concerned about the possible northward spread of this dangerous species, and since 2018, made multiple trips to sample the icy waters of the Bering Strait and the Chukchi Sea to its north. Instead of a routine cruise, the team's research became the center of the first real-time detection of an unprecedented toxic bloom in Alaskan Arctic waters, necessitating multiple risk advisories to remote communities.

Aboard Alaska Inc.'s support vessel R/V *Norseman II*, Fachon carried a draft of a health advisory intended to warn residents in the sparse communities of the Alaskan Arctic to not eat shellfish or other potentially toxic marine animals. She, along with her advisor, WHOI senior biologist Don Anderson, and the cruise's chief scientist Robert Pickart, agreed with local health officials and Alaska Sea Grant to distribute the advisory if the science team found concentrations of a toxic algae species above 1,000 cells per liter—a threshold known to be dangerous. On July 20, 2022, just five days into the 28-day cruise, the team's automated microscope, the Imaging FlowCytobot (IFCB), detected well over 18,000 cells per liter outside of Gambell, Alaska. A few days later, 30,000. Weeks later, 100,000.

A TOLL GUARD FOR HARMFUL ALGAE

When it comes to subsistence harvesting and aquaculture, algae can be like the bacteria in our guts—some are good, and some can be quite toxic. But keeping track of what's unsafe can be hard when things are so microscopic. To help monitor concentrations of harmful algae near coastal hubs, WHOI biologists Heidi Sosik and Rob Olson developed the Imaging FlowCytobot, or IFCB. About the size of a scuba tank, this tool encases an autonomous water sampler and camera that routinely photographs planktonic cells and uses a specialized algorithm to identify toxic species. Today, early commercial use of the IFCB is helping aquafarmers protect their harvest from seasonal upticks in harmful algal blooms.



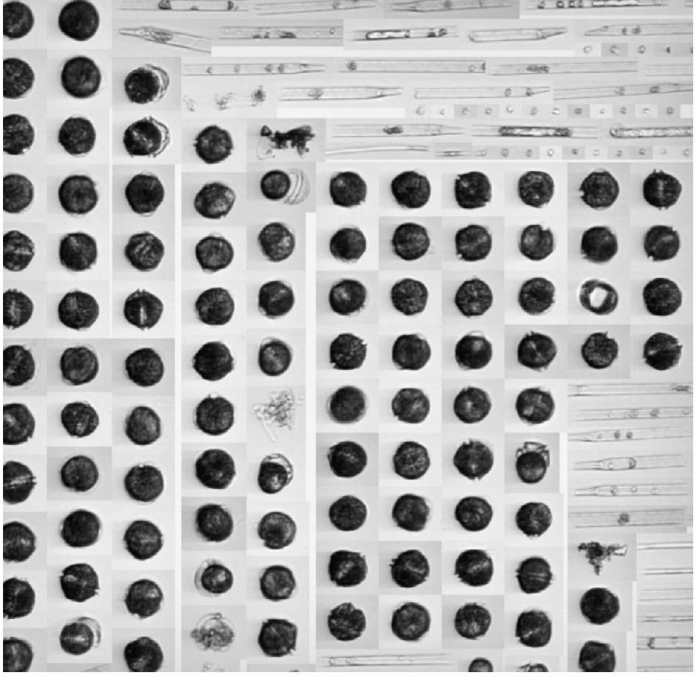
MIT-WHOI Ph.D. student Evie Fachon arranges *Alexandrium* cultures in the incubator in the Anderson Lab at WHOI to analyze their toxicity levels. (Photo by Daniel Hentz, © Woods Hole Oceanographic Institution)

"When we've been up there in the past, we've left out of Nome, Alaska, and either not seen anything or only saw very patchy blooms at relatively low densities," says Fachon. "So, I was really not expecting to warn communities so soon after we left the dock."

The culprit, *Alexandrium*, is a common catalyst behind harmful algal blooms (HABs) around the world. In areas like the Gulf of Maine, its toxins—which cause paralysis and death in humans and aquatic animals—have tainted annual shellfish harvests for decades, leading to recalls and closures. In the rugged Alaskan Arctic, where subsistence harvesting of marine life is the primary food source for many coastal communities, the risks of contamination are significant and broad. There, in the absence of routine monitoring programs, checks on food safety are hard to come by. While an advisory provides a degree of protection, it would also likely mean that many would have to buy food at grocery stores, incurring expenses they otherwise wouldn't have to bear.

Twenty-four hours after the research team notified shoreside health officials, several email advisories were sent out to residents in six major communities across the Bering Strait and Seward Peninsula. Meanwhile, the *Norseman II* team continued tracking the bloom north.

"We were fortunate on the timing of this," says Emma Pate, an environmental coordinator with Norton Sound Health Corporation who helped disseminate the advisory. If this advisory wasn't



(Left) Evie Fachon arranges *Alexandrium* cultures in the incubator at WHOI's Anderson Lab. (Right) A dashboard image from the IFCB shows high concentrations of the *Alexandrium* (dark round cells) found in a Bering Strait water sample. (In order of appearance, photos are courtesy of Daniel Hentz and Evie Fachon, © Woods Hole Oceanographic Institution)

issued, food with high concentrations of the algae could have been consumed, she adds.

According to Pate, one shellfish sample sent to NOAA's Northwest Fisheries Science Center for analysis had five times the allowable level of paralytic toxins permissible by the FDA's national food safety requirements. While shellfish are not the main staple of the Alaskan Arctic diet, walrus, whale, and sea birds that consume them, along with filter-feeding animals, are still at risk of accumulating toxins.

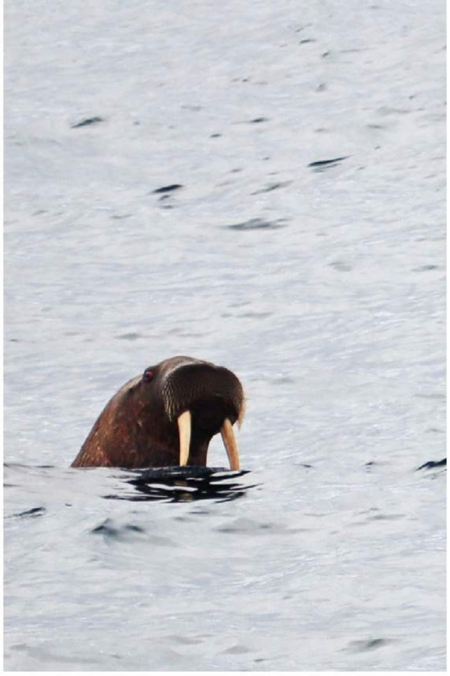
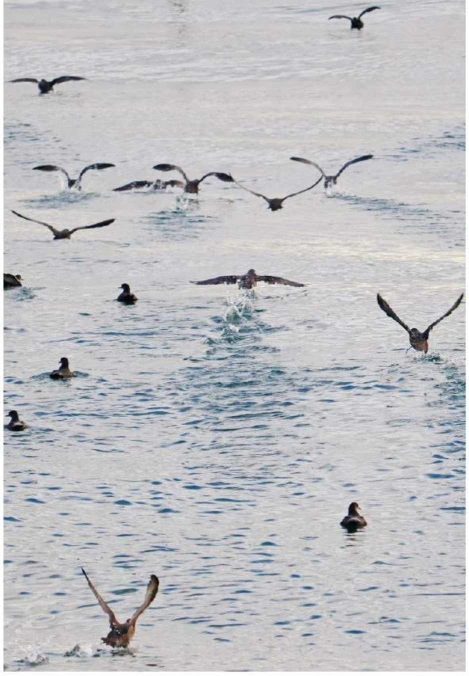
For now, the region seems to have dodged a major bullet. To date, there have been no reported illnesses or deaths. Still, the unprecedented scale of this bloom has researchers weary that residents may not be so lucky if it happens again.

"In the Gulf of Maine, where we've studied *Alexandrium* and the resulting shellfish closures, it's typical for us to see a few thousand cells per liter, and that is more than enough to cause dangerous levels of toxin in shellfish," says Anderson, who directs the U.S. National Office for Harmful Algal Blooms. "But it's a rare event when we see 20 to 30,000 or more, so this was a shock."

Historically, the frigid subarctic waters of the Bering Strait and Chukchi Sea northwest of Alaska have been a buffer against frequent HABs. As *Alexandrium* enters the strait from the northern Bering Sea, the cells transition into a non-swimming cyst state, sinking to the seafloor where they accumulate in the sediments. There, they would have stayed in this dormant state, with only a relative few hatching due to extremely cold temperatures. That's changed with planetary warming.

Since 1999, warming from climate change has increased average bottom water temperatures near the Alaskan cyst bed by 2ºC (~4ºF), more than

> **"If we weren't there at the time we were, [this HAB] is the kind of thing we might not have found out about until after someone got sick or died."** *—MIT-WHOI Joint Program student Evie Fachon*


Wildlife, like these seabirds, orcas, and walrus that were spotted during the cruise, can accumulate toxins by eating filter-feeders that concentrate harmful algal bloom toxins from the water. (Photos courtesy of Kali Horn, © Woods Hole Oceanographic Institution)

doubling the rate at which these cysts now hatch and advancing the start of the seasonal bloom by three weeks. In total, this Alaskan Arctic "cyst bed" is more than 15 times larger than that in the Gulf of Maine and is one of the densest in the world. Sometimes referred to as "a sleeping giant," it has become a point of concern for Anderson and his colleagues, who fear it could be the source of recurrent, massive blooms as waters warm. If the giant does wake, Anderson and Fachon worry it could create a cycle of locally-originating harmful algal blooms in the Chukchi Sea and north Bering Strait—something that Alaskan Arctic monitoring efforts aren't yet ready for.

"We have had to jump lightyears forward on our HAB monitoring since this happened," says Pate, who was trialing a HAB water monitoring program in 2020 before being interrupted by the COVID-19 pandemic. "We are definitely still looking to get more microscopes, so [HAB] analysis can eventually take place in the communities."

Fortunately, portable technologies like the IFCB continue to streamline HAB detection and analysis. Before the device's first use in regional HAB detection in 2018, hundreds of water samples from the region had to be flown across the country to WHOI, where algal cells were meticulously counted and analyzed under a microscope—a process that often took months. By then, an advisory to coastal communities would have been useless.

"We'll never know if we prevented people from getting sick or dying," says Anderson, "But I'd like to think we made a difference."

Today, the IFCB can help scientists image and analyze samples of tumbling *Alexandrium* cells around-the-clock, without anyone ever stepping off the boat. With it, WHOI's HAB scientists were able to provide Alaskan Arctic residents with the first real-time risk advisories, something Anderson and Fachon herald as a major advancement.

"Right now, this region of Alaska is missing offshore monitoring," says Fachon. "If we weren't there at the time we were, [this HAB] is the kind of thing we might not have found out about until after someone got sick or died. Now we have demonstrated that technology like the IFCB could be a valuable monitoring tool for the region going forward."

Funding for this cruise and the HAB-associated research was provided by the National Science Foundation, the National Oceanic and Atmospheric Administration, and the National Institutes of Environmental Health Sciences. The Imaging FlowCytobot (IFCB) used in this study was supported by WHOI scientist Mike Brosnahan and technician Mrunmayee Pathare. The instrument was originally developed by WHOI scientists Heidi Sosik and Rob Olson.

HARDWIRED TO LOVE

Our emotional connection with robots

KAITLYN TRADD
Mechanical Engineer, Applied Ocean Physics and Engineering

SINCE I CAME TO WHOI TWELVE YEARS AGO, I'VE RUN THE GAMUT OF ROBOTICS PROJECTS.

I sailed with ROVs *Jason* and *Medea*, and HOV *Alvin*, designed the skeletal frame of autonomous underwater vehicles (AUVs) like *Clio*, made pressure houses and junction boxes for hybrid vehicle *Nereid Under Ice* and *Mesobot*, and designed the towable vehicle *Deep-See*, which helps scientists estimate life in the ocean's twilight zone.

I can absolutely say it's easy to develop an emotional attachment to our robots. You spend so much time and effort creating them—sweating, and literally bleeding as you put them together; scratching your knuckles on hose clamps and swearing profusely when you drop a bolt while you're trying to finish assembling something. Over time, you can find yourself using very human language for these bots.

I was in Bermuda waiting for a robotic sediment sampler I designed called the Twilight Zone Explorer (TZEX) to return to the surface with its location after it completed its mission. I caught myself saying things like, "Now *she* needs to phone home when she needs to be picked up." For me, it feels like a preview into being the mother of a teenager—I want to say, "When you're done having fun out there, call home and I'll come and get you."

Using this language seems to be a kind of coping mechanism. At sea, we're often away from our loved ones, so making the robot feel like it's a part of your family helps you rationalize being away from home for so long.

Robots are really like our partners. I don't see it so much as master and slave, where you're driving and the robot is simply responding. We're working together. And when a robot is at risk of being lost, it's more than just your next cruise or next scientific endeavor that's at stake. It's a piece of you that could be gone.