Scientist collects a harmful algal bloom sample in the Apostle Islands in 2018.

LAKE SUPERIOR ALGAL BLOOMS: A CALL TO ACTION

Fall 2026

Burke Center
FOR ECOSYSTEM RESEARCH

Executive Summary

Harmful algal blooms have appeared nearly every year in Lake Superior since 2012, baffling scientists and raising worries about human health and the regional economy. Given these concerns, in June of 2026 the nonprofit, nonpartisan Burke Center for Ecosystem Research hosted a water summit for more than two dozen U.S. and Canadian researchers, resource managers, and stakeholders in Duluth, Minnesota. The objectives were to produce this white paper and a related video, followed by binational presentations to government officials and the general public to raise awareness of the algal bloom threat and generate support for urgently needed research. Experts at the summit produced the following recommendations:

Recommendation #1. Elevate the Lake Superior harmful algal bloom issue within existing policy frameworks, such as the Great Lakes Water Quality Agreement and the Great Lakes Restoration Initiative, and establish science-based measures to inform actions appropriate for the low-nutrient waters of Lake Superior.

Recommendation #2. Develop a harmful algal bloom detection network to conduct real-time/continuous long-term monitoring to identify blooms and the conditions that lead to them.

Recommendation #3. Advance research to identify the primary drivers of emerging harmful algal blooms and toxin production in the Lake Superior watershed.

Recommendation #4. Develop place-based research and monitoring priorities related to the impact of harmful algal blooms on culturally and spiritually significant species through meaningful and sustained engagement with Indigenous rights-holders.

Recommendation #5. Evaluate and address the potential impact of harmful algal blooms on Lake Superior coastal communities and economies, such as human health, tourism, fisheries, recreation, food security, cultural practices, and others.

Recommendation #6. Define science-informed adaptive-management strategies, and test and evaluate them through pilot and demonstration projects, to reduce harmful algal blooms in Lake Superior.

Recommendation #7. Evaluate and strengthen harmful algal bloom communication channels, education, and outreach capacity to support timely and informed local decision-making and public awareness.

Recommendation #8. Develop and implement harmful algal bloom forecasting and alert systems for Lake Superior and its connected waters to enhance preparedness and response.

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Harmful algal bloom sample collected at Cornucopia Beach, Wis. in August 2018.

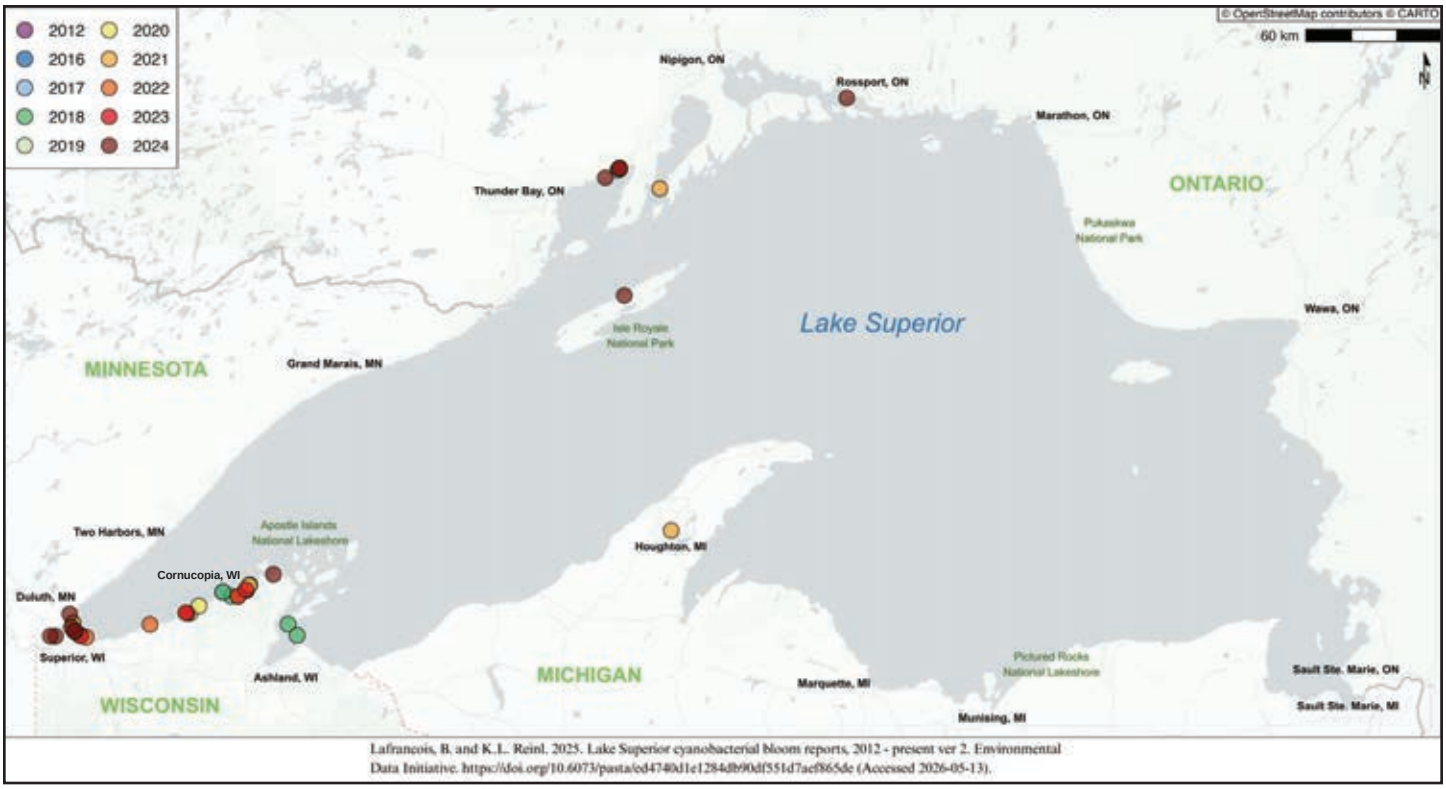
Introduction

Seemingly out of nowhere, a sprawling mass of potentially toxic algae coated the surface of southwestern Lake Superior at the height of the tourist season in August of 2018—greenish streaks stretching some 60 miles between Duluth, Minnesota, and Wisconsin's Apostle Islands National Lakeshore. While thickest close to land, the unprecedented bloom extended almost 2 miles offshore and hung around nearly a week before fading away—long enough to rattle public health officials and raise serious concerns about how the bloom would affect Lake Superior's vital tourism economy.

"We were really shocked about what we were seeing," said Chris Filstrup, a lake scientist with the University of Minnesota's Natural Resources Research Institute, who was on the water for an unrelated mission when word came of the mammoth bloom. The ship's crew rushed to the scene and dropped a bucket to collect a sample for analysis. "When we think of Lake Superior water, we think of blue water," Filstrup said. "And this was green water with these particles in it."

A bolt out of the blue, yes. But warning signs had been gathering like storm clouds on the horizon. Six years earlier, a bloom one-fifth the size of the 2018 outbreak appeared in the same area—the first-ever scientifically confirmed harmful algal outbreak of its kind on the largest and coldest of the Great Lakes. Blooms have been reported nearly every year since, mostly small clumps and slicks that fade within hours. The hottest spots are within the Duluth-Superior harbor, but the nearshore zone between Duluth and the Apostles, including Siskiwit and Mawikwe bays in Cornucopia, Wisconsin, remain problematic too. Blooms also have been detected to the north in Ontario's Thunder Bay region and as far eastward as Houghton in Michigan's Upper Peninsula. Scientists say other blooms might have gone unseen along Superior's remote, lightly settled shoreline, although the absence of a real-time monitoring system causes uncertainty about when and where additional blooms may have appeared.

It would be hard to overstate how alarming this is. Harmful algal blooms are a growing threat worldwide, but they tend to happen in warmer and more nutrient-rich waters such as Lake Erie, where they're a longstanding nemesis. Lake Superior remains famously cold and remarkably clean, although its surface temperature has edged upward in recent decades. More research is urgently needed to understand what's behind the outbreaks and, if possible, limit or even prevent them. Hanging in the balance is the health of swimmers who can become seriously ill from swallowing or inhaling algal toxins, which kill many pets and wild animals around the United States every year. Also at stake is the economic and cultural well-being of communities relying on tourism, fishing and related industries that would suffer if these blooms were to become a continuous, widespread menace.



Confirmed locations of harmful algal blooms across the Lake Superior basin between 2012-2024. Credit: Sam Blackburn

Superior's reputation as the cleanest of the Great Lakes has often made it difficult to attract funding for environmental protection and restoration to the watershed, especially when compared to the more stressed lower lakes. Now that the algal-bloom era has arrived on Lake Superior, this needs to change. More investment in the greatest of the Great Lakes is essential for understanding the mechanisms driving harmful algal growth, and for reversing this worrisome trend. "It creates a call to action," said Emily Finnell, Great Lakes Senior Advisor and Strategist at Michigan's Office of the Great Lakes, adding that the situation signals "how critical it is to protect and conserve these large freshwater lake ecosystems."

"It creates a call to action," said Emily Finnell, Great Lakes Senior Advisor and Strategist, Michigan Office of the Great Lakes

Experts Gather To Develop An Action Plan

In a search for answers, the nonprofit, nonpartisan Burke Center for Ecosystem Research convened more than two dozen U.S. and Canadian researchers, resource managers, and stakeholders in Duluth from June 1-3, 2026. The objectives of the summit were to produce this white paper and a related video, then embark on a series of regional and binational presentations to government officials and the general public to help raise awareness of the Lake Superior algal bloom problem. Over three days of intense discussion, they shared findings about possible causes of the blooms and proposed eight concrete recommendations for how to respond. "Blue-green algal blooms in Lake Superior have

Participants at the harmful algal bloom water summit in Duluth, Minn.

been a complete mystery," said Kaitlin Reinl, a lake ecologist at Rensselaer Polytechnic Institute who has extensive experience studying them. "It's breaking all the rules of what we understand for blue-green algal blooms. … We're really trying to start to understand what is going on."

Although commonly known as harmful algal blooms, they're actually clusters of cyanobacteria—single-celled organisms descended from some of the earliest life on earth. Scientists trace the origin of cyanobacteria back some 3 billion years, and credit them with creating the planet's oxygen-rich atmosphere. Today, these bacteria are an important food source for zooplankton, freshwater mussels, and other creatures that consume microscopic material. But when conditions are favorable—warmer temperatures, the right amount of light, calm waters, combined with an infusion of nutrients—their populations can explode. The resulting blooms can be unsightly, resembling spilled green paint and marring beaches with foul, scummy sludge. When they die, microorganisms that decompose the blooms suck up dissolved oxygen, often creating "dead zones" that can suffocate fish and other aquatic animals.

Some blooms also produce toxins, which have sickened many people through ingestion, inhalation or skin contact. Human deaths from harmful algal blooms are exceedingly rare in the United States; only one has been documented (not in the Great Lakes) and it was associated with paralytic shellfish poisoning. During the last decade, the U.S. Centers for Disease Control and Prevention has received many reports—not all confirmed—of such illnesses following exposure to blooms, most involving gastrointestinal ailments such as vomiting and diarrhea. Other symptoms include headache, fatigue, fever, and skin rashes. Depending on the type of toxin, blooms can injure the nervous system or the liver. They have been linked to deaths of wild animals and pets, including dogs that lick themselves after emerging from algal-fouled waters and livestock that drink from contaminated stock tanks and farm ponds.

One of the most notorious Great Lakes blooms formed in 2014 in western Lake Erie, infiltrating the water supply of Toledo, Ohio. The event prompted an unprecedented do-not-drink order for some 500,000 residents that lasted nearly three days. State and local health authorities logged numerous emergency room visits by people whose symptoms suggested algal toxin exposure. More than a dozen cities and towns draw drinking water from Lake Superior, but no evidence has surfaced of such toxins posing any threat to their drinking water supplies.

Satellite image of Lake Erie harmful algal bloom.

Harmful algal blooms are no surprise for Erie, the shallowest, southernmost and warmest of the Great Lakes, with the most heavily developed shoreline. Its annual summertime outbreaks—the largest of which have extended roughly 100 miles between Toledo and Cleveland and are visible from space—gorge on phosphorus and nitrogen that spring rains wash into tributary rivers from large livestock farms and croplands laden with manure and chemical fertilizers. Lake Superior is the opposite: It's the biggest, coldest, northernmost, and least developed North American Great Lake, with very few factory farms in its heavily forested watershed and a significantly lower nutrient content. "[In] Lake Superior, we never really thought there'd be harmful algal blooms," said Cherie Hagen, from the Wisconsin Department of Natural Resources' Office of Great Waters. "We are now starting to see them, and we need to understand why. What is that tipping point?"

Climate change might be partly responsible. Natural systems in every corner of the world are vulnerable to its grim, far-reaching ripple effects, and Lake Superior is no exception. Researchers with the University of Minnesota-Duluth's Large Lakes Observatory reported in 2007 that Superior's surface temperatures jumped an average of 4.5 degrees Fahrenheit (2.5 degrees Celsius) between 1979 and 2006, heating more quickly than the surrounding air. A 2015 analysis of nearly 250 lakes around the world flagged Superior as one of the fastest warming large lakes on earth. Most of the recent Superior harmful algal blooms have happened in late July, August and early September, when the lake is warmest. Additionally, climatologists have long predicted that climate change would increase the intensity and frequency of extreme weather, and there appears to be a connection between unusually severe storms and eruptions of harmful algal blooms on Lake Superior. Its two biggest blooms, in 2012 and 2018, came in warm-water years, weeks after rainfalls so immense, they previously could have

Harmful algal bloom in the Keweenaw Waterway in front of the campus of Michigan Technological University, Houghton, Mich. in November 2021.

been expected to occur just once every 500 to 1,000 years. Those downpours flushed huge plumes of nutrient-laden sediment into Superior's usually clear waters, and they were particularly prevalent along Wisconsin's south shore.

Yet it took 25 days after the 2012 storm for the first outsized Superior bloom to form. In 2018, the delay was 53 days between the storm and the bloom. Scientists and policymakers at the Burke summit wondered about the time lag: what went on during those intervals? And why wasn't there a bloom after a similar torrent and plume in 2016? The experts agreed they had yet to nail down the elusive combination of factors triggering these baffling, worrisome blooms—let alone what determines their size and duration.

Other questions with serious implications arose during the gathering. Why do some blooms generate toxins while others don't? Are more and bigger blooms on the way? What, if anything, can be done to stop them? If inevitable, can they at least be predicted soon enough to deliver adequate public health warnings? How do we invest in understanding and developing solutions before it is too late? Such lingering uncertainties demonstrate that more scientific investment is needed to explain Superior's algal bloom problem.

Thanks to its remote location, heavily wooded watershed, massive volume and low human population, Superior is less contaminated than the other Great Lakes. That means it often receives less funding through programs such as the binational Great Lakes Water Quality Agreement and the U.S. Great Lakes Restoration Initiative (GLRI). The GLRI, in particular, is geared primarily toward cleanup of heavily fouled sites, like the so-called Areas of Concern, rather than pollution prevention. Topping the list of recommendations from the Burke Center summit was elevating Superior's harmful algal bloom problem within such programs as an important first step toward boosting the lake's share of research and cleanup dollars.

Summit participants also called for new technologies to detect blooms and even forecast conditions when they are likely to appear. A real-time monitoring network of buoy-mounted sensors—similar to the network deployed on Lake Erie—would modernize and markedly improve a system currently based on researchers venturing onto Superior by boat to grab water samples by hand. These newer technologies would help scientists solve some remaining bloom mysteries, paving the way for future management actions. "Without a targeted investment that allows us to monitor things remotely, we're not going to be able to get a handle on what's going on," said Trista Vick-Majors, a microbial ecologist at Michigan Technological University. She and colleague Gordon Paterson spotted an algal bloom in November of 2021 in the Keweenaw Waterway—the first-ever documented Lake Superior bloom in Michigan's Upper Peninsula.

Despite spirited debate during the Burke Center gathering, there was a sense of urgency to act quickly while the Lake Superior algal bloom threat is seemingly in its early stages. Other proposals called for directing more funding into researching what causes the blooms to form and produce toxins, plus their potential effects on Indigenous communities, public health, and economic sectors such as fisheries and recreation.

A Lake Like No Other

One challenge for scientists and managers alike has been Superior's massive geography. For sheer immensity alone, the lake is almost unfathomable, creating hurdles for binational coordination among various jurisdictions and departments dealing with the emerging algal bloom issue. Superior contains 10% of all the fresh water on the earth's surface—some 2,900 cubic miles, enough to fill the other four Great Lakes and three additional Lake Eries. Its average depth is 483 feet, with a maximum of 1,332 feet. About the size of South Carolina, its surface area of 31,700 square miles is the largest of any freshwater lake in the world.

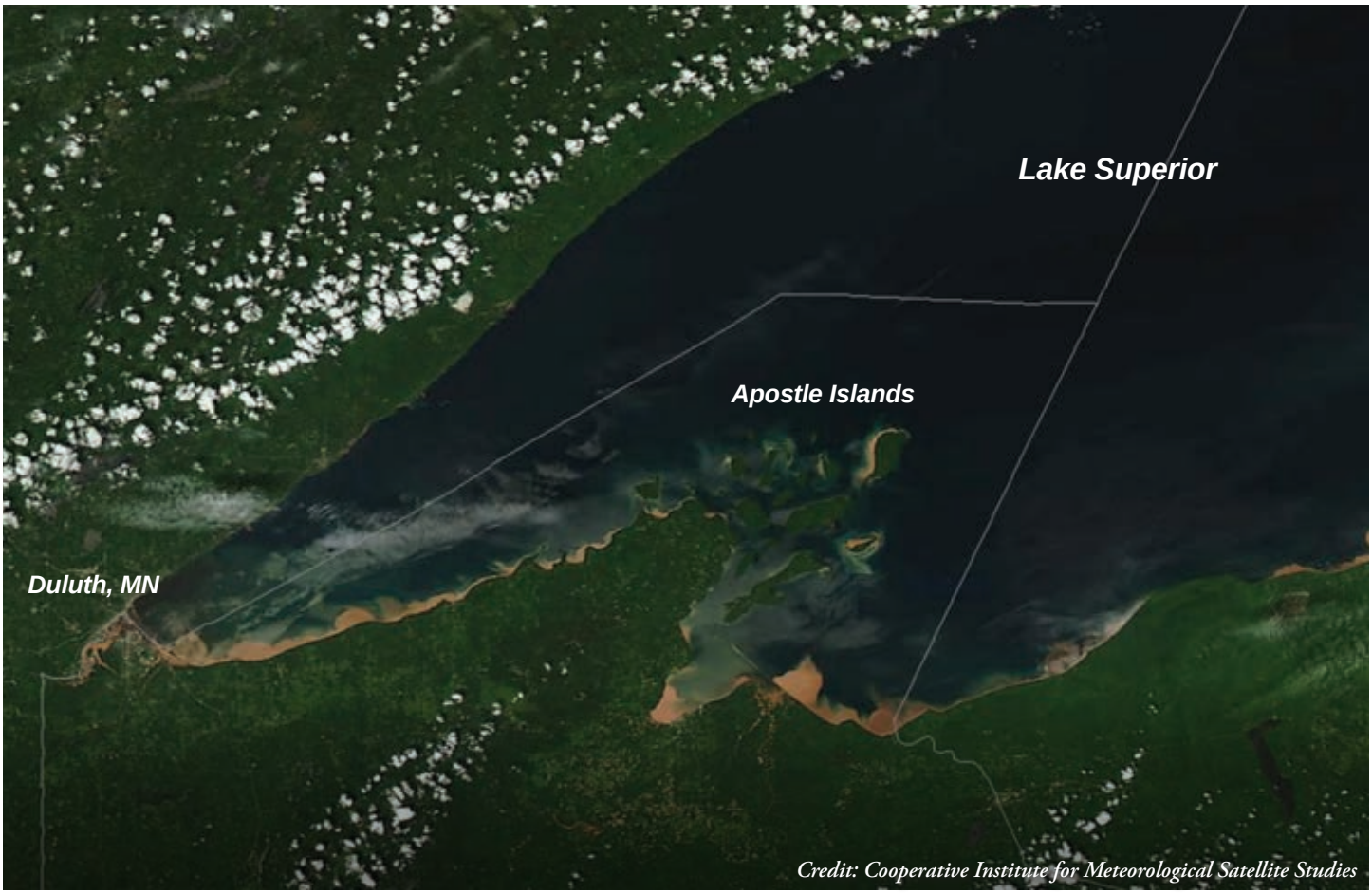
Indigenous peoples have lived in relationship with Lake Superior since time immemorial and more than 20 distinct Indigenous tribes and nations call its shores home. Hunting, fishing, trapping and harvesting manoomin—wild rice that grows in shallow waters and is a staple of the most extensive subsistence culture in the Great Lakes watershed—are historic practices for many Indigenous communities that remain critical to this day. Indigenous representatives at the Burke Center summit drew unanimous support from others in the room for making harmful algae's potential effects on subsistence animals and plants a research priority. "If a fish is swimming in an algal bloom and then I eat that fish, what does that mean for me?" asked Lydia Johnson, director of the Indigenous Great Lakes Network in Ontario.

Manoomin (wild rice).

Cutover land in northern Wisconsin.

The arrival of European explorers, fur traders and settlers to North America in the 1600s touched off what would become a radical transformation of the landscape. Over the next three centuries, immigrants to the Great Lakes region and their descendants built an economic juggernaut featuring timbering, mining, and eventually manufacturing. But colonization came at a steep ecological cost: beaver, lake sturgeon and other species were pushed to near extirpation; forests were clearcut; waterways were polluted. Many nearshore areas of Lake Superior felt the pain, although less so than the other Great Lakes, as its shoreline remained predominantly undeveloped wilderness, especially on the Canadian side. That advantage has enabled a quicker recovery than the other lakes have experienced. Today, Superior's fishery remains vibrant, its waters relatively clean. It's mostly free of invasive species that have ravaged the lower lakes, such as round goby and mussels that unravel aquatic food webs by stripping waters of phytoplankton that form the base of the food chain. Until recently, Superior also had no documented algal blooms like those that have marred portions of the other lakes—a sign that the largest lake in the world may be exhibiting new vulnerabilities.

Superior's natural beauty and recreational appeal have made tourism a leading employer. Based on recent data, the Apostle Islands National Lakeshore alone supports $17.2 million in labor income, while tourism pumps billions into the economy along Minnesota's North Shore. That raises concerns that a worsening algal bloom problem could sully the region's clean image and harm one of its top industries. A New York Times story on the 2018 bloom was one red flag. Another came in 2024, when an article on the Fodor's Travel Guide website recommended steering clear of Superior partly because of the blooms—although it oddly said nothing about avoiding Lake Erie, where the problem has long been considerably worse.



In 2018 a major storm created sediment plumes in Lake Superior that were so large they were visible from space, eventually leading to a harmful algal bloom.

The Food Source Riddle

Still another pressing need is to determine what is feeding Superior's harmful algal blooms. It took years to establish that high-intensity agriculture was the biggest source of Lake Erie's nutrient overload, with sewage treatment plants a distant second. That finding led Ohio, Ontario, and Michigan in 2015 to pledge a 40% reduction of phosphorus runoff entering Erie. Officials have imposed mandatory regulations and offered farmers incentives for voluntary cooperation. Despite progress, the phosphorus reduction goal hasn't been met and blooms persist. Unlike Erie, Lake Superior is nutrient-poor. With scant agriculture and few major sewage plants, where are the nutrients coming from to trigger Superior's blooms? Scientists believe a prime suspect is excess sediment—and phosphorus attached to that sediment—that is washed into some parts of the lake during large storms. Much of the bloom activity has been centered around southwestern Lake Superior, a region with sand and clay soils that are naturally susceptible to erosion.

Research continues on how phosphorus in sediment plumes could stimulate algal blooms in Superior. Matt Hudson, the Burke Center's associate director for the Great Lakes, said there's likely a "sweet spot" after sediments reach the lake when they release the phosphorus. If this timing coincides with the necessary variables—water temperature, sunlight, calm water—a bloom could form. The need for all those factors to fall into place might explain, in part, why it took weeks for algal blooms to form in the wake of the 2012 and 2018 storm-driven sediment plumes. Is the evidence supporting that theory solid enough to justify proposals for preventing sediment runoff? Some experts argued during the summit that practices intended to "slow the flow" of sediment into the lake could be common-sense steps that would benefit the environment—whether or not they prevent harmful algal blooms. Other participants countered that measures to reduce nutrient runoff were premature until scientists could definitively link sediment to harmful algae in Lake Superior, as they have in many other water bodies. "This is a tough one because there's not one single, rule-them-all management solution," said Cody Sheik, an associate professor with the University of Minnesota-Duluth's Large Lakes Observatory.

Recommendations

The summit produced eight recommendations intended to boost the Lake Superior bloom issue's profile while prioritizing investments in real-time monitoring, scientific research, and stronger regional communication. Participants hope the proposals will tee up specific binational management actions in the near future.

Recommendation #1. Elevate the Lake Superior harmful algal bloom issue within existing policy frameworks, such as the Great Lakes Water Quality Agreement and the Great Lakes Restoration Initiative, and establish science-based measures to inform actions appropriate for the low-nutrient waters of Lake Superior.

Government funding for research of any Great Lakes issue depends on that issue being identified as a priority in U.S. and Canadian policy guidance documents. Although Lake Superior's harmful algal bloom problem is mentioned in some of them, including Lakewide Action and Management Plans under the binational Water Quality Agreement, the Superior bloom issue deserves much stronger emphasis. Increased attention in these documents would improve funding prospects for the foundational scientific research that is greatly needed to develop effective and targeted management actions. More attention and funding, in particular, should come from the Great Lakes Restoration Initiative.

Credit: Cleveland Water Alliance and Kogent Studios

Monitoring buoy deployed in Lake Erie.

Recommendation #2. Develop a harmful algal bloom detection network to conduct real-time/continuous long-term monitoring to identify blooms and the conditions that lead to them.

This proposed Lake Superior network would include sensors mounted on buoys, augmented by satellites and underwater and aerial drones. Real-time water-quality buoys are similar to floating environmental "labs in a can," and can detect blooms and measure toxicity. Drones could help scientists and resource managers measure and monitor geographic extent and other bloom characteristics. Satellites can provide broad, distant views of the lake, providing a better understanding of blooms' frequency and size if they're large enough to be spotted. All these technologies would need to be adapted to Superior's stereotypically clear waters.

Manual sampling aboard research vessels would still be essential, helping verify data from the newer tools. But samples can take days to analyze and can't quickly inform managers and the public about blooms as they happen. In many cases, blooms are long gone before they are scientifically confirmed in the lab. A real-time monitoring system would finally bring Lake Superior's algal-bloom research and management into the modern era.

Recommendation #3. Advance research to identify the primary drivers of emerging harmful algal blooms and toxin production in the Lake Superior watershed.

Real-time data from buoys, drones and satellites should be complemented with skilled computational analysis and continued nearshore monitoring to identify the primary causes of the blooms and their toxicity. The necessary scientific expertise exists in the region, but to date, adequate funding for research and analysis has been lacking.

Recommendation #4. Develop place-based research and monitoring priorities related to the impact of harmful algal blooms on culturally and spiritually significant species through meaningful and sustained engagement with Indigenous rights-holders.

It's essential to collaborate with Tribes, First Nations and Métis, and include them in research and policy discussions. The uplifting and inclusion of Indigenous knowledge and science can provide a more holistic understanding of the impact of harmful algal blooms. The stakes couldn't be higher for Indigenous and non-Indigenous people who depend on subsistence harvesting from the waters of Lake Superior.

Recommendations
(continued)

Recommendation #5. Evaluate and address the potential impact of harmful algal blooms on Lake Superior coastal communities and economies, such as human health, tourism, fisheries, recreation, food security, cultural practices, and others.

If the algal bloom problem worsens, the region's tourism and fishing industries could be disrupted. Consuming water contaminated with algal toxins—even at low concentrations—carries documented health ramifications, as does inhalation of aerosolized toxins. There is little understanding of how algal blooms could affect the region's economy and aquatic environments. It is important to analyze all this possible fallout and recommend how coastal communities should respond.

Recommendation #6. Define science-informed adaptive-management strategies, and test and evaluate them through pilot and demonstration projects, to reduce harmful algal blooms in Lake Superior.

Scientists at the summit argued that more research needs to be completed on the causes and consequences of the blooms before heavy investment is made into specific adaptive-management actions. There is, however, an urgent need for pilot projects that reflect the latest research, which would enable road-testing of potential solutions as quickly as possible. Pilot projects could indicate how effective particular management practices might be, and computer models could, for example, offer initial assessments of ways to reduce nutrient runoff. These experimental management practices then could be more broadly tested in the field and scaled up if results look promising.

Recommendation #7. Evaluate and strengthen harmful algal bloom communication channels, education, and outreach capacity to support timely and informed local decision-making and public awareness.

For several years, a Lake Superior algal-bloom team has been coordinating communication among scientists and resource managers in the region. But there was agreement at the summit that the way information flows within and beyond this community could be improved, especially when connecting with local elected leaders and offices dealing with matters such as health and recreation. For example, it took years for word to spread within the Lake Superior algal bloom team that a harmful algal bloom had been detected in the Keweenaw Waterway in Houghton, Michigan. And it's unclear whether local officials were ever notified.

More investment is needed to establish a robust, binational, multi-jurisdictional and multidisciplinary communication and collaboration strategy, one that particularly reaches the local level. There is a demonstrated need to better inform beach managers, local officials, the media, and the wider public about the presence of blooms, their severity, and what actions should be taken and for how long.

Recommendation #8. Develop and implement harmful algal bloom forecasting and alert systems for Lake Superior and its connected waters to enhance preparedness and response.

Lake Erie scientists and officials have built a highly successful harmful algal bloom forecasting system. It should be replicated in the Lake Superior watershed. Early research into such a system has shown promise in Lake Superior's St. Louis River Estuary, where bloom activity has been most prevalent. Developing a forecasting mechanism would help raise awareness that algal blooms are a reality on Lake Superior, and that communities should prepare accordingly.

North Fish Creek sediment reduction project completed in the Town of Keystone, Wis.

Harmful algal bloom at Barker's Island Beach in Superior, Wis.

Conclusion

Much remains unknown about the harmful algal threat to the largest and most unspoiled of the Great Lakes—what causes the blooms, why some are toxic, and what might prevent them. What's beyond dispute is that Superior faces a challenge that seemed unimaginable not long ago. Left unchecked, it could gravely damage these priceless waters, the plants and animals that flourish within and near them, and the human communities that depend on them for food, employment, recreation and spiritual enrichment. While many ecological dangers lurk unnoticed until it's too late, there's reason for optimism that this hazard has been caught early enough to keep it from undermining what the big lake means to the people who live in or visit the watershed. But only if those in positions to make a difference end up rising to the occasion. Will government officials holding the checkbooks provide the money? Will scientists with expertise find answers? Will policymakers devise effective management solutions and keep the public informed? Will citizens demand that their leaders act?

"We've all come together with this common purpose in mind, and we have charted a path forward," said Minnesota's Chris Filstrup as the summit concluded. "My biggest hope is that we can get out in front of this before [it's] too late." The other summit participants shared this passion and sense of urgency. Ready or not, the algal bloom era has arrived on Lake Superior. It's time to act now, while the problem is still in its infancy, and before things take a turn for the worse.

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