Great Lakes HABs Collaborative
NEWSLETTER
LINKING SCIENCE AND MANAGEMENT TO REDUCE HARMFUL ALGAL BLOOMS FALL 2023

What's happening with the HABs Collaborative?

The Great Lakes Commission's Annual Meeting: Update on Lake Erie HABs

This year, the **Great Lakes Commission** hosted their Annual Meeting in Oregon, Ohio, from October 3-5. During the meeting, a panel reported on **efforts surrounding harmful algal blooms in Lake Erie** to an audience of Great Lakes commissioners and other attendees. Representatives from Ohio's Departments of Natural Resources and Agriculture reported on their respective agency's **H2Ohio** program accomplishments. Ohio Sea Grant and the U.S. EPA Great Lakes National Program Office (GLNPO) provided updates on efforts to work with agricultural producers, researchers, and landowners to reduce nutrient flows and study the effects of algal blooms in Lake Erie.

A panel presents an update on Lake Erie's harmful algal blooms to Great Lakes commissioners and guests at the Great Lakes Commission's annual meeting at Maumee Bay State Park in Oregon, Ohio.

A **short video** provided an overview of the HAB issue in Lake Erie and how H2Ohio is investing state funds to support agricultural best management cost-share and wetland restoration programs. Through partnerships and continued state funding, **H2Ohio has restored over 150 wetlands to date in Ohio,** contributing to nutrient management and habitat restoration goals. Statewide, over $133 million has been allocated for wetland restoration, and many of those projects are concentrated in the western Lake Erie basin. H2Ohio is also partnering with an academic consortium to track progress for the nutrient reduction and habitat goals of the wetlands projects. The **Lake Erie and Aquatic Research Network (LEARN)** includes a number of HABs Collaborative members.

Additionally, H2Ohio works with agricultural producers and has **reduced nearly 300,000 pounds of phosphorus annually** through their combination of nutrient, erosion, and water management projects. With the return to a "suite of simple" practices, one in three Ohio producers have signed up to partner with H2Ohio to implement best management practices, which comprises more than 1.5 million acres.

In Ohio, efforts to understand HABs are demonstrated through state and regional programs centered around research. **The Ohio Department of Higher Education's Harmful Algal Bloom Research Initiative (HABRI)** has supported thirteen universities with over $2 million per year to fund research which informs decision-making. Research projects fall into four focus areas: tracking blooms from the source, protecting public health, producing safe drinking water, and engaging stakeholders. **In total this has mobilized $37 million and produced 33 peer-reviewed papers.**

Agencies have listed their priorities for research which include the Ohio EPA's focus on human health and Ohio Department of Natural Resources' priority for wetland monitoring. The agricultural community has spotlighted the need for research on **manure management, subsurface placement of nutrients, climate change adaptation, water management, and ways to increase farmer participation in conservation programs.** The Lake Erie Commission has prioritized research on modeling, watershed-wide pilot projects, and cost-effectiveness for best management practices. The panel also touched on regional collaborative efforts to connect research and management being done by the Great Lakes HABs Collaborative and the **Lake Erie Aquatic Research Network (LEARN).**

The U.S. EPA Great Lakes National Program Office provided an update on regional goals associated with the Great Lakes Water Quality Agreement and the Great Lakes Restoration Initiative as Lake Erie remains a high priority in their upcoming action plan. The **binational goal of a 40% reduction in phosphorus loads** was only met once in the past decade, though there has been an increase in the number of wetlands, number of cost-share agricultural projects, and a reduction in phosphorus released from the Detroit water treatment plant. Progress in a short timeline is difficult to track, especially with interannual variability; however, flow normalization data shows total phosphorus is stable and soluble reactive phosphorus may be declining. More data is needed over a longer period to determine the accuracy of these trends. A review of long-term HABs monitoring data has demonstrated a decline in HABs over the last ten years and the overall condition of HABs remains poor but is improving.

During a dialogue with Great Lakes commissioners, panelists were asked about **the role of wastewater in HABs.** Less than 10% of phosphorus from the Maumee River system is from point sources; however, panelists noted that all sources should be considered for reduction goals as every pound counts. Additionally, commissioners asked about when we could expect to see this work on the ground impacting blooms in the lake and how to communicate lag times to the public. Panelists responded that the Lake Erie system is complex and confounded by such variables as legacy phosphorus and a changing climate, and there is no silver bullet to reducing blooms. While it is important to promote the other benefits of watershed projects, such as erosion control and habitat creation, it may take another decade to see return on investments reflected as bloom reduction.

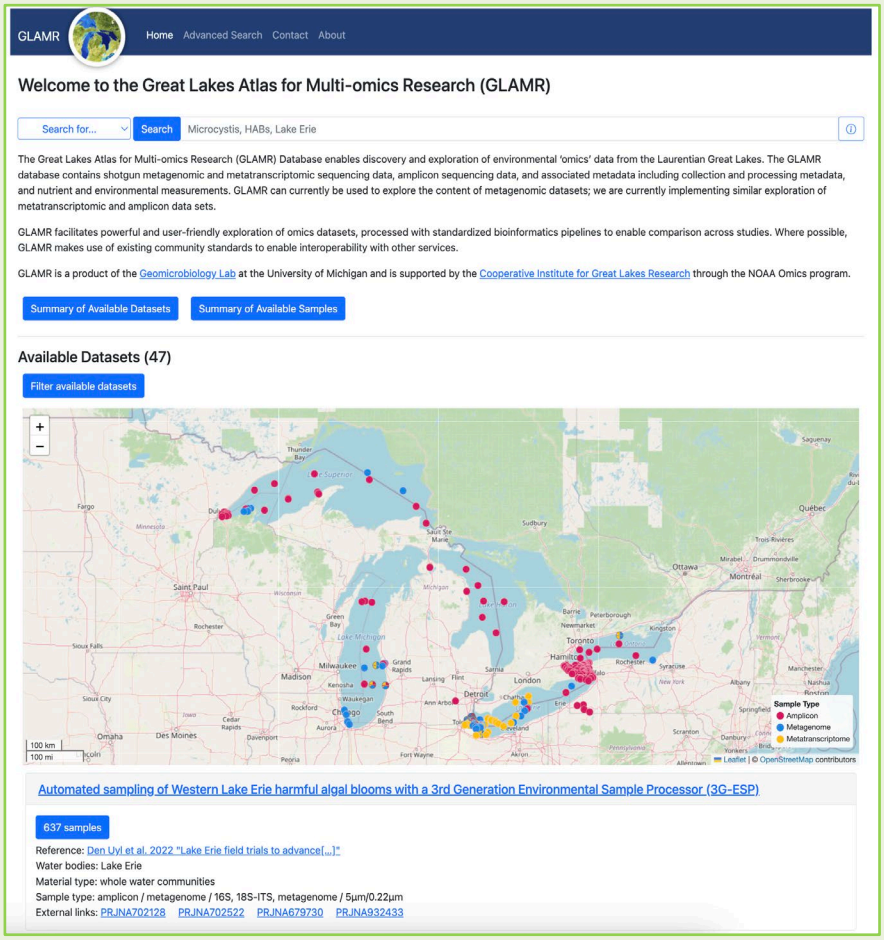
Panelists **were optimistic about increased funding for HABs projects and research in the region.** There is also an increase in communication and coordination between agencies and academic institutions, advancing water treatment protocols and knowledge of health impacts related to HABs. Panelists noted the increasing understanding

of nutrient dynamics in the Lake Erie system and how more research into legacy phosphorus and nutrient interactions in tributary systems will improve future nutrient control efforts.

Great Lakes Atlas for Multi-omics Research Database

Gregory Dick, Director, Cooperative Institute for Great Lakes Research

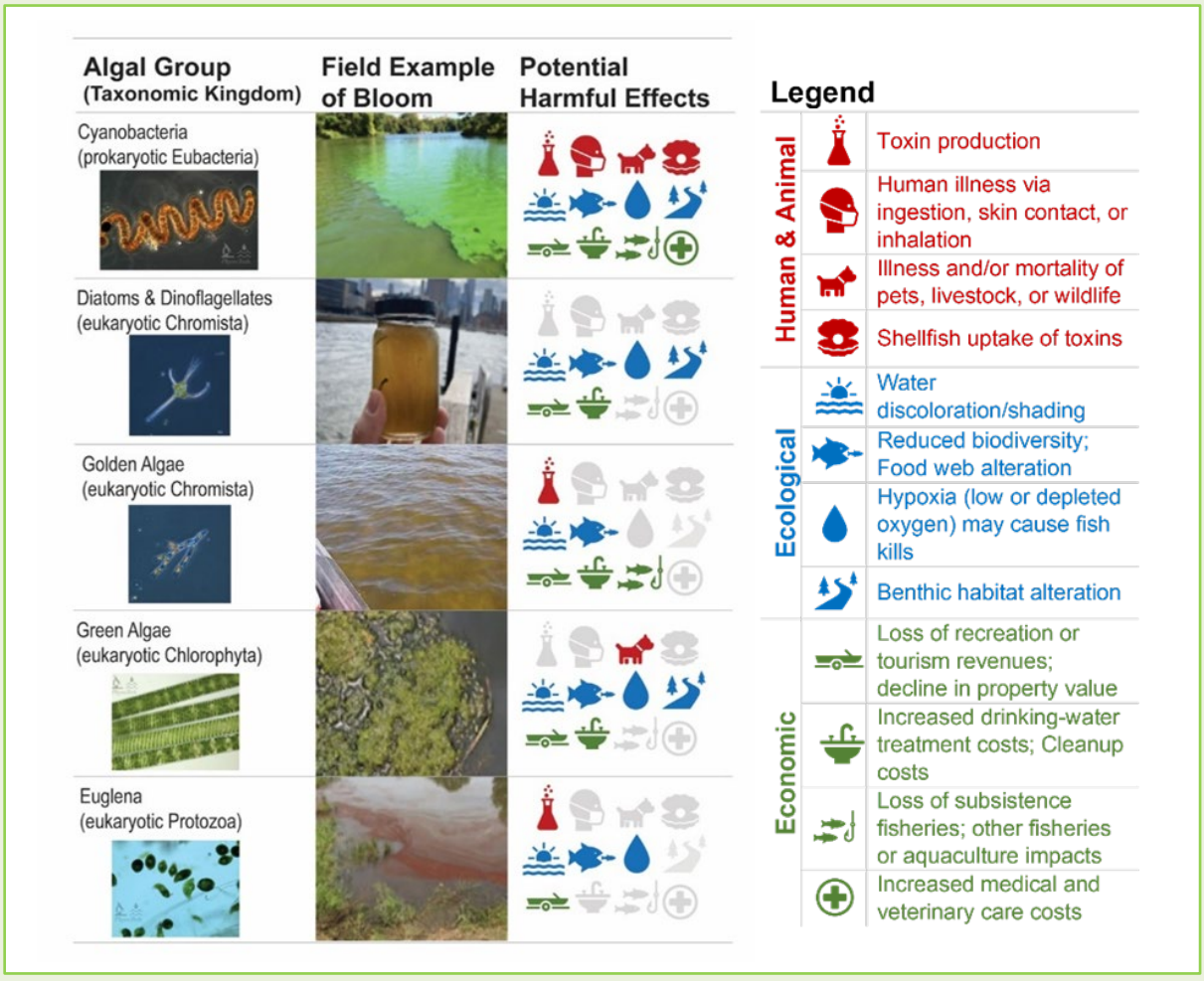
The amount of **'omics data from the Great Lakes** — i.e., data obtained with methods like DNA or RNA sequencing and metabolomics — is growing rapidly, providing valuable insight into the abundance and distribution of organisms, genes, and/or metabolites in the environment. **The Geomicrobiology Lab at the University of Michigan** is making it easier to find and explore these rich datasets with a new publicly available database and website. **Professor Greg Dick,** research scientist **Anders Kiledal,** and their team recently launched **the Great Lakes Atlas of Multi-omics Research (GLAMR) website.** Users can explore publicly available 'omics samples from many independent studies on the GLAMR website. If you have 'omics samples to contribute to GLAMR or ideas about how this website could better serve the community's needs, please email Anders Kiledal (**kiledal@umich.edu**). GLAMR is supported by the Cooperative Institute for Great Lakes Research (CIGLR) through the **NOAA Omics program.**



Two Recent Publications from USGS on Harmful Algal Blooms

U. S. Geological Survey (USGS) authors have recently published two open access works on freshwater HABs. The purpose of both publications is to continue to educate the water resources community about HABs caused by algae other than cyanobacteria. There are several freshwater algal groups that can form blooms with a wide scope of potentially harmful impacts. They are often not as well-documented as cyanobacterial HABs but pose some of the same challenges to researchers and managers (e.g., documentation of occurrence, understanding of toxicity, and communication of health risks). **Access the articles via these links:**

- **Toxic Algae in Inland Waters of the Conterminous United States — A Review and Synthesis**
- **The "H," "A," and "B" of a HAB: A definitional framework**



Potential effects on human and animal, ecological and economic health associated with common freshwater bloom-forming algal groups. Photo Credits: Microscopy Photos: (A. St. Amand, PhycoTech); Field Photo Credits: Cyanobacteria (New York State Department of Environmental Conservation), Diatoms (Hudson River Park), Golden (Texas Parks and Wildlife Department), Green (A. St. Amand, PhycoTech), Euglena (B. Rosen, Florida Gulf Coast University).

HABs Calendar

U.S. Environmental Protection Agency CyanoSymposium 2023

This October the U.S. EPA will host the **CyanoSymposium 2023**. The symposium will include four webinar sessions over four days providing an introduction to freshwater cyanobacteria and their toxins, from biology and taxonomy to ecology, monitoring (from in situ to space-based), and analysis. Click **here** to register for each webinar separately.

IAGLR's 67th Annual Conference on Great Lakes Research

Save the date for the **IAGLR Conference on Great Lakes Research** to take place in Windsor, Ontario, from May 20-24. See more event details **here.**

Association for the Sciences of Limnology and Oceanography (ASLO) Conference

Save the date for the **Association for the Sciences of Limnology and Oceanography Conference** in Madison, Wisconsin, from June 1-7. You can find more details **for the conference here.**

Share your research project on the HABs Research Mapper!

HABs Collaborative Steering Committee members have worked with the Great Lakes Commission to develop an app to increase collaboration among researchers and water managers working to investigate and address HABs in the Great Lakes basin. **Visit www.glc.org/work/habs to learn more.** Please reach out to Connor Roessler, croessler@glc.org if you have a research project to add to the mapper.

News from our HABs Collaborative Co-chairs

An update on the Maumee Watershed Nutrient TMDL

Ruth Briland of Ohio EPA

On September 28, 2023, the U.S. Environmental Protection Agency (U.S. EPA) approved Ohio EPA's restoration plan: **Maumee Watershed Nutrient Total Maximum Daily Load (TMDL)**. The western basin of Lake Erie has impaired public drinking water supply, aquatic life, and recreation uses due to harmful algae and associated cyanotoxins. To address these impairments, Ohio EPA developed the Maumee Watershed Nutrient TMDL. A TMDL is the calculation that establishes the maximum amount of a pollutant that can enter a water body so that the water body will meet and continue to meet water quality standards, and it is a planning tool for restoring waters. Springtime phosphorus loads from the Maumee River watershed have been identified as the most critical to reduce the occurrence of harmful algal blooms in the western basin of Lake Erie.

The complete TMDL report and associated documents are **available here.** Approval documents from U.S. EPA are **available here.**

Member Spotlight

We know a lot of good work is happening around the Great Lakes basin thanks to many of our collaborative members. **Help us share that work by suggesting content for the "Member Spotlight" section of this periodic newsletter.** Please share your ideas with Connor Roessler at croessler@glc.org.

Spotlight: Chelsea Salter

Chelsea Salter

Chelsea Salter recently completed a master's in environmental science at the **Great Lakes Institute for Environmental Research (GLIER) at the University of Windsor.** Her master's thesis focused on elucidating a degradation pathway for a potent cyanotoxin called microcystin (MC) using a microbial community collected from the shores of Pelee Island (Canada). Pelee Island resides in the western basin of Lake Erie, where toxic cyanobacterial blooms frequently occur.

Experimental field observations as well as municipal monitoring programs on Pelee Island have been unable to detect MC in groundwater that had been filtered through the sand on the shores of the island, even during toxic bloom events. The removal of MC has been attributed to microbial degradation by the bacterial community within the sand, as determined by Chelsea's undergraduate thesis project as a biochemistry major under the supervision of Dr. Chris Weisener. This work, titled **"Investigating the microbial dynamics of microcystin-LR degradation in Lake Erie sand,"** was published in *Chemosphere* in 2021.

Her masters expanded on this work by employing multiple "omics" tools to determine how the toxin was being broken down so that the Pelee Island microbial community could be applied as a biological water treatment solution to treat MC-contaminated waters. This work is currently under review in *Water Research* and is entitled **"Elucidating Microbial Mechanisms of Microcystin-LR Degradation in Lake Erie Beach Sand through Metabolomics and Metatranscriptomics."** Chelsea is excited to continue pursuing her passion for environmental work and begin her career working at Agriculture and Agrifoods Canada (AAFC) Harrow Research and Development Centre.

Canadian Corner

Elucidating Microbial Mechanisms of Microcystin-LR Degradation in Lake Erie Beach Sand

Chelsea Salter, MSc, Great Lakes Institute for Environmental Research, University of Windsor, and Katie Stammler, Essex Region Conservation Authority

Pelee Island is a small Canadian Island located directly east of the Maumee River in the western basin of Lake Erie (Figure 1). Due to its location, it is frequently affected by cyanoHABs and it is not uncommon for the surrounding water to have high concentrations of cyanotoxins such as microcystin (MC). Residents of Pelee Island receive their drinking water through a municipal water supply that draws water directly from Lake Erie, or individual private wells that rely on filtration via sand trenches at the island's shoreline.

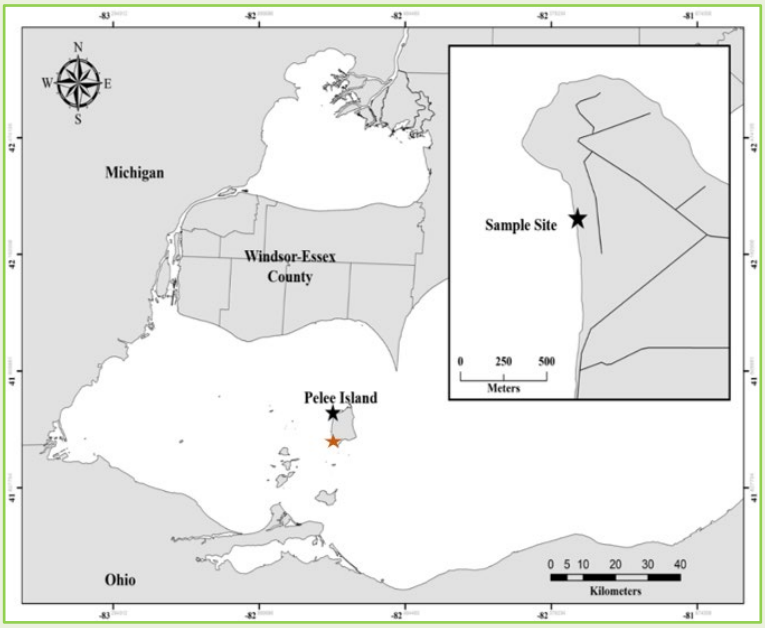


Figure 1. *Location of Pelee Island in the western basin of Lake Erie and sand sample collection site along the western shoreline of the island. Pelee Island is frequently exposed to cyanoHABs that occur in the western basin of Lake Erie. The red star indicates the location of the Pelee Island West Shore municipal drinking water intake.*

Between 2015 and 2018, the municipal drinking water operator took samples directly from Lake Erie near the intake and from an access point within the Pelee Island West Shore municipal water treatment plant. While no treatment processes occur between these two points, water does pass through a natural sand filter. The operator at that time observed that total microcystin concentration was generally below detection at the access point, regardless of conditions in Lake Erie. This is confirmed by the data, which were collected on the same date by the same operator and analyzed at the same lab by the Ministry of the Environment, Conservation and Parks (Figure 2). Experimental field projects also observed elimination of MC as contaminated water flowed from the lake, through the sand and into the island's groundwater stores. This phenomenon of MC degradation earned Pelee Island the reputation of having 'magic sand' and prompted investigation by the University of Windsor.

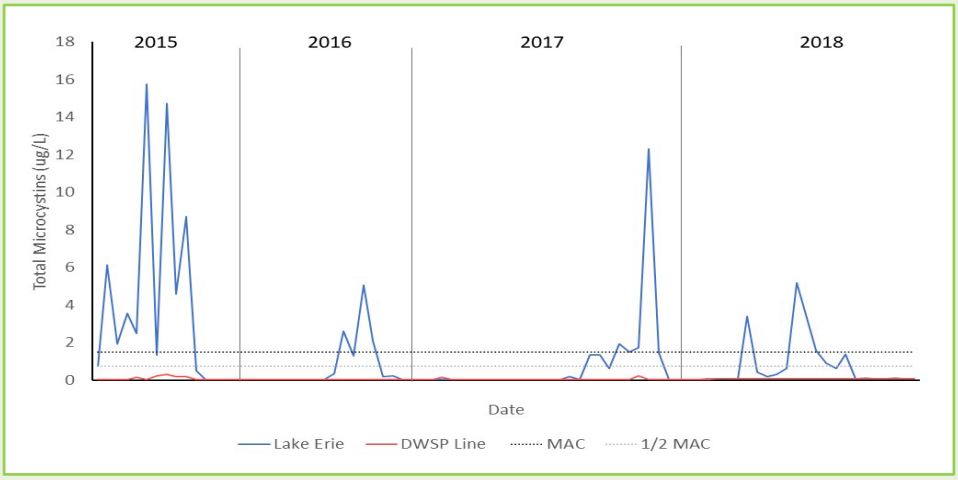


Figure 2. *Total microcystin concentration in Lake Erie (blue line) near the Pelee Island West Shore WTP and inside the same WTP after water has passed through a natural sand filter (red line). Samples were collected on the same day, but with the same operator and analyzed by the same laboratory.*

An initial study confirmed that the breakdown of MC was due to microbial activity and not a mechanical process (Salter et al., 2021). To gain a comprehensive understanding of the mechanisms controlling the degradation of MC-LR (most common and toxic variant of MC) degradation within Lake Erie, the Pelee Island sand microbial community was investigated through a series of batch experiments. Over the course of 48 hours, sand and water samples were collected from jars that combined the Pelee Island sand with Lake Erie water spiked with MC-LR. Multiple genomic tools were employed to investigate the bacteria that were activated in the presence of the toxin, the genes expressed during degradation, and the metabolic by-products released as MC-LR was broken down.

Frequent temporal water sample collection determined the microbial community within Pelee Island beach sand could completely degrade >5 ppb extracellular MC-LR within 48 hours, with 80% of toxin concentration degraded within the first 12 hours of exposure. The diversity of detected by-products and lack of a single clear degradation pathway strongly suggests the involvement of multiple microbial species which cleave the MC-LR molecule at different locations. Additionally, the significant upregulation of single-carbon metabolism pathways suggests a complete breakdown of MC-LR and their incorporation into intermediates of energy metabolism. Overall, the results revealed a complex, community-scale metabolism among the Pelee Island sand microbial community, demonstrating that MC-LR is broken down in a mutualistic and cooperative manner among several critical species.

As cyanoHABs are projected to increase in frequency and severity in Lake Erie and in many other places around the world, the need to develop strategies that can safely and efficiently remove cyanotoxins from contaminated water is critical for mitigation. Further research is required to continue to resolve the intricacies of the metabolic pathways

Figure 3. *Left: Field work in 2018 on Pelee Island led to the observed removal of MC in ground water passing though the sand. Right: Sand collected from Pelee Island was studied through batch experiments by spiking the water with MC-LR and collecting sand and water samples over 48 hours.*

employed, specifically within the first 12 hours of toxin exposure. Also, investigating the capacity of the Pelee Island microbial community to degrade other MC congeners or cyanotoxins (i.e., anatoxin and nodularin) is critical for evaluating the metabolic robustness of the microbial community. Possible additional research might include testing sand in other locations where cyanoHABs are common and/or adjacent areas without cyanoHABs (i.e., Pelee Island's east shore) or whether this metabolic degradation can be artificially initiated to replicate this natural phenomenon.

Overall, this study was able to significantly improve the current understanding of MC degradation occurring in Lake Erie and offers the first steps toward meaningful applications in providing a robust water treatment tool that could be adapted into current water treatment operations as a biological sand filter. Establishing a viable biological sand filter with the Pelee Island microbial community would mitigate the threats imposed by MC-LR in Lake Erie, which could be expanded to provide a safe and effective means treat MC-LR in all water bodies prone to cyanoHABs. This work was recently successfully defended and is in preparation for publication in *Water Research* (Salter et al, *in prep*).

Salter, C. et al. 2021. Investigating the microbial dynamics of microcystin-LR degradation in Lake Erie sand. Chemosphere. 272, 129873

Salter, C. In Prep. Elucidating Microbial Mechanisms of Microcystin-LR in Lake Erie Beach Sand through Metabolomics and Metatranscriptomics.

Funding Opportunities

NOAA NCCOS Notice of Funding Opportunities

Two **NOAA National Centers for Coastal Ocean Science (NCCOS)** funding opportunities are currently open. Information and deadlines for the **Social, Cultural and Economic Assessment of Harmful Algal Blooms** grant opportunity can be found **here.** More details and project deadlines for the **Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program** funding opportunity is available **here.**

Get involved and stay in touch!

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