

8. Recommendations

Through this 2-year process, the HCB team identified information gaps and research needs related to HCBs. In this Section, we provide a series of recommendations for policy makers, researchers, states, and others that will inform and support future monitoring, response, management, and prevention of HCBs.

We have two overarching recommendations:

- Develop a common language to be used by all involved in HCB management and response. The common language should be applied to identifying cyanobacteria, describing prevalence or abundance of cyanobacteria, defining events of concern, and taking protective actions.
- Establish a national HCB freshwater response, management, and control planning structure like that which exists for the marine ecosystem. The funding and coordination such a structure brings would tremendously expand future management and response to HCBs that threaten our water resources and public health, especially as we seek to understand the implications of a warming planet. The need for a national freshwater HCB response structure is currently being discussed for inclusion in the national, multi-agency [Harmful Algal Research and Response National Environmental Scientific Strategy](#) (HARRNESS).

8.1 Overall understanding of cyanobacteria and cyanotoxins and their potential impacts

8.1.1 Health Impacts and Exposure Routes

- Continue to research the human health impacts of ingestion, inhalation, and dermal exposure to cyanobacteria, cyanotoxins, and cyanopeptides.
- Conduct critical assessments of toxicities of known and emerging cyanotoxins, cyanopeptides, and other cyanobacteria compounds to inform health advisory guidance.
- Conduct research on additive, synergistic, and chronic effects of exposure.
- Continue to research the impacts of cyanobacteria and cyanotoxins on domestic animals.
- Develop a greater understanding of the movement of cyanotoxins through the environment and food web (such as by species or trophic level) and predictors based on concentrations observed in the field. It is also important to understand how timing and succession of the HCB taxa and cyanotoxin production may affect organism accumulation and depuration. Specifically:
 - Fish and shellfish: Learn more about factors that affect the uptake and fate of cyanotoxins in fish and shellfish tissue, including whether biomagnification occurs, accumulation in muscle tissue versus organs, and trophic level differences.
 - Plants and fruit: Learn more about the uptake and fate of cyanotoxins in food crops and agricultural soils.
 - Human consumption of livestock and wildlife: Learn more about the uptake and fate of cyanotoxins in animal-based foods.
 - Irrigation and non-potable waters: Learn more about how cyanotoxins may move through water distribution systems, how irrigation system type (for example, drip versus spray) may influence exposure, and persistence of cyanotoxins within the system.
- Continue to identify, characterize, and assess the impacts of cyanobacteria and cyanotoxins on drinking water treatment. Areas of specific interest include:
 - appropriate treatments for emerging cyanotoxins
 - effect of cyanotoxin treatments on other aspects of drinking water treatment
 - disinfection by-products and degraded cyanotoxin compounds
 - guidance for homeowners and small facilities on appropriate treatments for HCBs and cyanotoxins

8.1.2 Cyanobacteria Ecology and Environmental Interactions

- Continue to research triggers stimulating the growth of cyanobacteria—both planktonic and benthic forms—and the production of cyanotoxins.
- Continue to research the role of nutrients and other factors for the management of HCBs in the freshwater environment. Areas of particular interest include:
 - better understanding phosphorus, nitrogen, and their combined role with other environmental

- factors in promoting HCBs
 - better understanding the role of nutrients in production of cyanotoxins
- Continue to document the impact of climate change on ecology and environmental interactions of HCBs, for both planktonic and benthic cyanobacteria. We need to better understand:
 - how higher temperatures select for cyanobacteria
 - how extreme weather events (storms and droughts) select for cyanobacteria
 - the role of wildfires in selection for cyanobacteria through changes in nutrient delivery, impacts of firefighting chemicals, or changes in water body pH (see [“Wildfires Affect Resources Long After the Smoke Clears” \(Sever 2019\)](#) and [“Wildfires: How Do They Affect Our Water Supplies?”](#))
 - changes in the typical annual cyanobacteria population cycles, such as HCB magnitude, extent, duration, and composition

8.2 HCB Monitoring

8.2.1 Remote Sensing

- Expand the number of water bodies that can be evaluated using remote sensing for HCBs by developing and providing access to smaller spatial scale data and products. This includes:
 - improving modeling performance
 - developing early warning systems

8.2.2 Pigments

- Develop phycocyanin and phycoerythrin concentration thresholds to support rapid assessment of HCB conditions in recreational and source waters. In addition:
 - develop and increase availability of analytical standards
 - develop standard methods for field and laboratory analysis

8.2.3 Cyanotoxin Testing

- Expand cyanotoxin testing to include:
 - a greater range of the potential variants for each cyanotoxin class, including development of certified reference materials and analytical standards
 - capacity to run more cyanotoxins simultaneously with reduced turnaround time
 - “unknown,” emerging, or less studied cyanotoxins
- Continue to develop standardized methods and commercially available tests for cyanotoxins in:
 - human samples, such as serum and urine
 - animal, fish, and plant tissues (including tightly bound cyanotoxins)

8.2.4 Sample Collection for Cyanobacteria and Cyanotoxins

- Develop standardized sampling methods for airborne cyanobacteria and cyanotoxins to help establish a greater understanding of this component of potential exposure.
- Develop standardized sampling methods for benthic cyanobacteria and their cyanotoxins.
- Develop or improve technologies of monitoring platforms for inland water bodies, particularly:
 - real-time, *in situ* measurement of cyanotoxins
 - real-time nutrient sensing
 - real-time taxonomic identification

8.3 Strategic Communication and Response Planning

- Develop and use a common language (including synonyms) related to cyanobacteria and HCBs.
- Develop standardized, flexible, and revisable guidance documents that help lake managers monitor, manage, control, and communicate about HCBs.

8.3.1 HCB Advisory Thresholds

- Continue work developing national advisory levels and health guidance for cyanobacteria and cyanotoxins.

8.3.2 Drinking Water Supply Emergency Response Plans

- Adopt recommended drinking water facility infrastructure and treatment methods to address all known and emerging cyanotoxins, cyanopeptides, and their treatment derivatives on a national basis.

8.3.3 Outreach

- Incorporate messaging in outreach materials to address benthic cyanobacteria.
- Incorporate messaging in outreach materials about the connection between a warming climate and HCB development.

8.3.4 Monitoring Plans

- Identify monitoring plans suitable for a wide array of water body types and provide examples for local managers and officials.
- Address future climate in HCB monitoring plans by tracking relevant water quality parameters (such as trends toward higher water and air temperatures, changes in precipitation, and drought patterns).
- Address the lack of specific benthic cyanobacteria field methods in monitoring plans.

8.3.5 Reporting, Notification, and Coordination

- Develop and use a common approach at the state, regional, and national level for data management and storage.
- Encourage and facilitate data sharing at the local, state, regional, and national level.

8.4 HCB Management and Control Strategies

- Establish sustained funding to conduct scientific investigations focused on control and management of freshwater HCBs as outlined in the pending [HARRNESS](#) guidance for research on harmful algae in the United States.
- Document and distribute peer-reviewed studies of both HCB treatment successes and failures.
- Assess effectiveness of emerging management and control strategies on an ongoing basis and distribute the assessment results.
- Document costs for implementation and operation of existing HCB treatment strategies. Assess potential costs for emerging treatments.

8.5 HCB Prevention Through Nutrient Reduction

- Identify effective nutrient reduction practices that successfully reduce the frequency, magnitude, or toxicity of cyanobacteria populations, likely associated with specific land uses and receiving water characteristics.
- Rigorously monitor (and identify organizations that compile these data) the efficiency and success of nutrient management BMPs, including long-term maintenance requirements and changes in effectiveness over time and climate.
- Document and distribute peer-reviewed studies of both nutrient management practice successes and failures.
- Prioritize appropriate nutrient management planning for HCB-affected water bodies. This should be based on:
 - historical and current monitoring data that quantify loading
 - source identification using available forensic tools, particularly where sources are mixed or not known
 - likelihood of successful control given relative loading and bioavailability
 - modeling to evaluate the level of reduction needed by source
 - leveraging of existing regulations and requirements to maximize benefits and outcomes
- Increase funding to support nutrient management on private lands surrounding public waters.