New York State Department of Environmental Conservation

HABS Research Guide

2021

Andrew M. Cuomo, Governor | Basil Seggos, Commissioner

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For more information about the DEC Harmful Algal Blooms Research Guide or Harmful Algal Blooms, visit: http://www.dec.ny.gov/chemical/77118.html

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Purpose of Document

The harmful algal blooms (HABs) Research Guide prioritizes research focus areas to advance the study, management, and mitigation of HABs in New York State (NYS). This document is intended to be a resource for NYS Department of Environmental Conservation (DEC) staff, other local, state, or federal agencies and research partners to fill knowledge gaps and advance efforts to reduce HABs.

Although HABs have been observed within NYS and throughout the world for many years, recent events, such as large-scale blooms in Lake Erie and in Florida, have increased attention to HABs, and highlighted the need for enhanced HABs research, education, documentation, and reporting. Since 2012, DEC has documented HABs in over 400 waterbodies (Figure 1) throughout NYS (Figure 2). It is likely that the actual extent of HABs occurrence is even greater since most waterbodies in NYS are not routinely monitored.

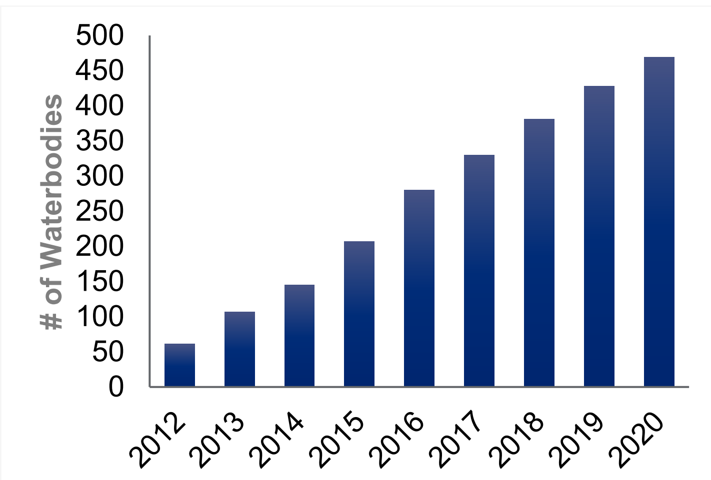

Figure 1. The cumulative number of waterbodies in NYS in which HABs have been documented by the DEC HABs Program

Figure 2. Cumulative map of locations of waterbodies with HABs occurrence in at least one year, 2012–2020

Despite decades of study by the scientific community, many unanswered questions remain about cyanobacteria HABs (Huisman et al., 2018). Several causes and contributing factors of HABs have been documented, but how those causal mechanisms interact, what management strategies could be used to reduce HABs' occurrences, and which in-waterbody controls will lessen the effects of HABs on waterbody uses (e.g., swimming, boating, fishing, etc.) remain unclear.

Nutrient reduction strategies are the most effective tool to reduce anthropogenic eutrophication (Schindler et al., 2016), and reducing HABs will require controlling both nitrogen and phosphorus inputs (Gobler et al., 2016). However, water quality responses to nutrient reduction strategies do not occur immediately. The impacts of climate change on the frequency, duration, and intensity of HABs are unpredictable, which may complicate the ability to evaluate waterbody responses to nutrient reductions (Paerl et al., 2019).

Multi- and inter-disciplinary research efforts are needed to integrate knowledge about the mechanisms of HABs' occurrence, HAB control or treatment technologies, and nutrient reduction strategies (e.g., agricultural conservation practices, best management practices, or discharge permit limits). Research is lacking regarding how these may be applied on an individual waterbody and at watershed scales as well as how to best account for the uncertainty of the pace and extent of climate change (Paerl and Huisman, 2008; Huisman et al., 2018).

Under Governor Andrew M. Cuomo's leadership, New York State has prioritized actions to address HABs. In 2018, a multiagency HABs Initiative was established between the state's DEC, Department of Health (DOH), and Department of

Agriculture and Markets (DAM). The initiative included the creation of HABs Action Plans and the 2018 regional HABs summits, and led to the development of this guide based on input from experts who participated in the summits. This is a “living document” that will be revised and updated as questions are answered, and new research areas are identified.

What Are HABs?

- HABs in freshwater consist of cyanobacteria (also referred to as blue-green algae).
- Cyanobacteria are naturally present in waterbodies in low numbers.
- Several types of cyanobacteria produce toxins and other harmful compounds that can pose health risks to people and animals.

For more information, go to on.ny.gov/hab or http://www.health.ny.gov/harmfulalgae.
Avoid contact with any water that is discolored or has algal scums.



Research Focus Areas

Four research focus areas (Prevention and Mitigation, Causes of HABs, Monitoring and Modeling, and Engagement) are intended to prioritize DEC research efforts and to lay the foundation for HABs research coordination. Sub-topics in each focus area are not intended to be a comprehensive list of knowledge gaps but are rather areas that DEC has identified as priorities. DEC encourages innovation and exploration of novel approaches that will advance the scientific knowledge of HABs.

Priority Focus Area: Prevention and Mitigation

Watershed-based reductions of point and nonpoint nutrient inputs are the primary methods to reduce waterbody nutrient concentrations (Paerl, Hall, and Calandrino, 2011; Schindler et al., 2016). However, additional research is needed to improve watershed management and inform DEC's mitigation studies, clean water programs, and permit programs.

Strategies to prevent or directly control HABs are needed. In-waterbody controls are short-term strategies to reduce the biomass of cyanobacteria and occurrences of HABs, while long-term watershed-level nutrient reductions address fundamental causes of the blooms. Research is needed to understand the factors that govern effectiveness of each strategy and implementation timescales (Chorus and Bartram, 1999; Paerl et al., 2019). This research will inform statewide decision-making about permitting, new technologies, pilot projects, and nutrient reduction policies.

Topic	Detail
Watershed nutrient control strategies	▪ Evaluate and compare the effectiveness of nutrient-loading control strategies with respect to reducing HABs. Nutrient sources of concern include point sources, storm water runoff, agricultural runoff, animal feeding operations, streambank erosion, road ditches, and on-site wastewater treatment systems. ▪ Develop planning tools, solutions, or improved management strategies that address nutrient loading patterns in the context of climate change, cost-benefit analyses, land use changes, operation and maintenance, and longevity.
In-waterbody mitigation strategies	▪ Evaluate and improve efficacy of currently available mitigation strategies to reduce and/or dissipate HABs. ▪ Develop and demonstrate new approaches for in-waterbody nutrient control and to reduce and/or dissipate blooms. ▪ Compare strategies for: application dosing and timing, water quality changes, cost-benefit analyses, energy costs, environmental impacts, applicability of treatment to varied HAB characteristics, or scalability of treatment to different waterbody sizes and types of blooms (open water, shoreline).

Priority Focus Area: Causes of HABs

Numerous complex and interacting factors cause cyanobacteria to thrive and become HABs, including geography (where the waterbody is in the state), and a waterbody's chemical, physical, or biological characteristics. Climate change and biological interactions (particularly related to invasive dreissenid mussels) may be additional important causes (Huisman et al., 2018). Other factors that contribute to the success of cyanobacteria include their ability to fix nitrogen, regulate buoyancy, avoid grazers, and tolerate higher temperatures compared to other phytoplankton, and efficiently uptake nitrogen and phosphorus (Chorus and Bartram, 1999; Dokulil and Teubner, 2000; Downing, Watson, and McCauley, 2001).

HABs typically occur in high-nutrient waterbodies, but nutrient concentrations are not the only cause. Research is needed to characterize other causes of HABs and identify local variables which can be controlled and may lead to solutions to reduce HABs. This research will inform management actions or development of tools to understand what causes HABs to form. Research in this area should be inclusive of waterbodies with and without HABs to fully understand the conditions that contribute to HABs.

Topic	Detail
Nutrient sources and dynamics	• Research is needed to understand how the amounts (loads, concentrations, or fluctuations) and forms of nitrogen and phosphorus influence HABs' occurrence, severity, toxicity, spatio-temporal variability, and duration.
Climate change	• Evaluate how climate change impacts HABs' formation, intensity, and duration. • Evaluate tools, solutions, resiliency approaches, and mitigation strategies to offset climate change impacts (e.g., rising temperatures, frequent and intense precipitation events, and drought).
Oligotrophic lakes	• Identify and characterize the factors that cause HABs in low-nutrient waterbodies. Studies should address management strategies other than nutrient control.
Paleolimnology	• Evaluate sediment coring information to identify historical HABs' causes, drivers, and patterns.
Food web dynamics	• Investigate the interactions among HABs, aquatic invasive species, fish, zooplankton, mussels, or other biota through in-waterbody experimental work or interrogation of historical datasets.
Cyanotoxin production	• Research molecular and other analytical methods to investigate the environmental conditions and/or drivers that regulate toxin production. • Develop tools to understand, quantify, or predict the mechanisms of cyanotoxin production.
Physical limnology	• Evaluate the role and interaction of physical limnological properties of waterbodies (e.g., mixing patterns, depth, and fetch) as factors that cause or contribute to HABs.

Secondary Focus Area: Monitoring and Modeling

Monitoring data supports outreach efforts, research, waterbody assessments, predictive model development, and the ability to evaluate the success of restoration, mitigation, or management efforts (Graham et al., 2008; Chorus and Bartram, 1999). In addition, monitoring and modeling practices help to define what is considered a HAB, quantify risks related to cyanotoxins, improve predictive capabilities, and provide best estimates on watershed nutrient inputs. Research is needed to evaluate monitoring strategies used by state and other governmental agencies. Research should identify monitoring approaches that are accurate, cost effective, and useful for management, including measurements of HABs' extent, duration, toxicity, species composition, and impacts. The advances can be used to better characterize cyanotoxin production mechanisms, triggers, and potential health risks. Studies should address the characterization of cyanobacteria and cyanotoxin prevalence in benthic zones in both lotic and lentic systems. These findings could be used to improve or expand existing monitoring programs.

Topic	Detail
Cyanotoxin detection	• Improve and refine existing or develop new strategies or methods to detect cyanotoxins and other harmful compounds associated with cyanobacteria.
Occurrence and monitoring strategies	• Evaluate current HABs definitions and whether these approaches adequately reflect ecosystem impacts or risks to public health. • Develop or improve monitoring strategies and/or standardized metrics to assess HABs' size, extent, duration, toxicity, and intensity. • Evaluate existing datasets or historical conditions for trends regarding HABs' occurrence or toxicity. • Develop tools, solutions, or improvements to current strategies to better monitor and document HABs.
Predictive modeling	• Evaluate which existing and/or emerging molecular, analytical, or sensor-based technologies may support predictive modeling of HABs' occurrence, spatial distribution, duration, toxicity, or intensity.
Watershed management	• Evaluate the effectiveness of nutrient-input monitoring strategies and modeling techniques to capture and simulate the parameters necessary to assess or model reductions in HABs occurrence. • Identify tools to determine critical source areas and important forms of nutrients and estimate nutrient loading from tributaries.
Flowing water and benthic habitats	• Develop and evaluate methods to characterize blooms and measure toxins in flowing water systems and benthic habitats.
Toxin transport	• Develop methods to monitor and understand toxin transport both within and from waterbodies with HABs to downstream locations.
Advanced monitoring strategies	• Develop, validate, and analyze value of continuous, automated sensor technology systems to quantify nutrient loading, nutrient cycling, and HABs indicators to inform study of HABs' occurrence or toxicity. • Advance the monitoring of HABs by developing tools that utilize a combination of traditional and advanced monitoring techniques (sampling, drone imagery, satellites, in-waterbody sensors, or algal type differentiation) to better document HABs' occurrence or toxicity.

Tertiary Focus Area: Engagement

HABs can affect many people, from recreational swimmers to drinking water providers to nearby businesses. Effective public engagement and outreach can protect human and animal health as well as provide an opportunity to educate and encourage actions to improve water quality and advance clean water planning. Many parties engage in watershed outreach, policy, and HABs reporting and management (Graham et al., 2008; Chorus and Bartram, 1999). Research is needed to develop diverse and effective solutions to involve, educate, and communicate with stakeholders. New tools and strategies can be incorporated into volunteer monitoring programs and other outreach mechanisms to improve DEC programs. The goal of research in this area should be to identify the best communication and education and outreach tools and resources.

Topic	Detail
Communication methods	• Develop or improve mechanisms to notify and inform the public or stakeholder groups about HABs and water quality, including the evaluation of bloom reports, refinement of sampling designs, and improvement of risk communication.
Outreach	• Develop or improve communication methods and mechanisms related to HABs, human or animal health risks, aquatic organism health, angling, fish consumption, climate change, ways to improve water quality, and potential economic impacts.
Stakeholder involvement	• Evaluate the best ways to engage the diverse population of the state in the implementation of mitigation and water quality improvement efforts or nutrient control plans.

DEC HABs Initiatives

DEC manages many programs that measure and report water quality; identify, investigate, and control pollution sources; and develop strategies to address water quality threats in New York

DEC activities that focus on HABs include:

- integration with ongoing DEC ambient water quality monitoring programs which are comprehensive and representative of NYS waters
- development and support of the implementation of prevention and mitigation strategies to reduce the impacts of HABs
- collection of data and information related to HABs
- compilation and interpretation of near–real-time monitoring and surveillance information through the New York Harmful Algal Bloom System (NYHABS)
- administration of several ongoing research projects
- coordination with DOH, additional state and federal agencies, local authorities, nonprofit organizations, academic partners, and others

Over 200 lakes are sampled annually through two DEC ambient lake monitoring programs: the Citizens Statewide Lake Assessment Program and the Lake Classification and Inventory Program. In recent years, both programs expanded to include substantial HABs monitoring components. Other HABs surveillance and sampling is conducted by agency staff, researchers, consultants, and lake residents, or annually as part of special studies on over 100 additional waterbodies.

Communication of information about HABs serves to inform the public's recreational choices. DEC maintains a HABs website of current and archived bloom locations and maintains a shared inter-agency database for rapid communication about HABs' occurrences (NYHABS). For more detail, see the DEC HABs Program Guide.

As part of the 2018 Governor's HABs Initiative, four regional HABs summits brought together stakeholders to identify solutions and multifaceted approaches to control and prevent HABs for representative high-profile waterbodies that have been impacted or threatened by HABs. At each summit, public evening sessions featured presentations on a range of topics and are available to view online. Over 300 national, state, and regional experts from academia, government, nonprofits, and private organizations met in day-long sessions to identify specific HABs research needs and knowledge gaps. The resulting HABs Action Plans support community-based watershed management actions and identify potential factors contributing to HABs in each waterbody.

In 2018, DEC initiated pilot projects on a few waterbodies to evaluate the use of ultrasonic devices and hydrogen peroxide to mitigate HABs. Hydrogen peroxide is a registered pesticide in New York, and ultrasonic devices have not been used extensively in the state. Water chemistry, biological parameters, and HABs' occurrence were monitored in the waterbodies throughout the pilot programs. DEC is actively researching innovative HABs treatments and will use the findings from these and future mitigation pilots to further evaluate the use of several mitigation strategies.

In 2019, DEC piloted the application of nutrient inactivants on two waterbodies. These applications were experimental in nature and designed to facilitate follow-up study through extensive monitoring that was conducted in 2018–2019 and included bathymetric mapping, biomonitoring surveys, sediment core analyses, and trophic state analyses. In the fall of 2019, DEC piloted the use of a mobile algae harvester system in one waterbody. Monitoring outcomes of this pilot project will evaluate effectiveness at removing nutrients, algal biomass, and cyanotoxins. These projects help to fill knowledge gaps regarding HABs mitigation.

DEC initiated an advanced monitoring pilot, in collaboration with the United States Geological Survey (USGS) NY Water Science Center, to monitor and understand HABs and the factors that lead to their development in the Finger Lakes region. The objectives of these studies will be met by collecting continuous and discrete water quality data, meteorological data, nutrients concentrations across the lake surface, and tributary inputs to better understand the environmental conditions, nutrient cycling, and plankton community dynamics that are driving HABs. Monitoring platforms equipped with innovative HABs and water quality monitoring sensors were installed in several Finger Lakes to collect real-time monitoring data, which are available to view online. The sensor data paired with in-waterbody sampling will help to better understand the nutrient dynamics, comprehend HABs' occurrences and toxicity, and evaluate the utility of multiple types of monitoring data.

Citations

Chorus, Ingrid, and Jamie Bartram. 1999. Toxic cyanobacteria in water: a guide to their public health consequences, monitoring and management. CRC Press.

Dokulil, Martin T, and Katrin Teubner. 2000. "Cyanobacterial dominance in lakes." Hydrobiologia 438 (1): 1-12.

Downing, John A, Susan B Watson, and Edward McCauley. 2001. "Predicting cyanobacteria dominance in lakes." Canadian Journal of Fisheries and Aquatic Sciences 58 (10): 1905-1908.

Gobler, Christopher J., JoAnn M. Burkholder, Timothy W. Davis, Matthew J. Harke, Tom Johengen, Craig A. Stow, and Dedmer B. Van de Waal. 2016. "The dual role of nitrogen supply in controlling the growth and toxicity of cyanobacterial blooms." Harmful algae 54: 87-97.

Graham, Jennifer L, Keith A Loftin, Andrew C Ziegler, and Michael T Meyer. 2008. Guidelines for design and sampling for cyanobacterial toxin and taste-and-odor studies in lakes and reservoirs. U. S. Geological Survey (U. S. Geological Survey).

Huisman, Jef, Geoffrey A. Codd, Hans W. Paerl, Bas W. Ibelings, Jolanda M. H. Verspagen, and Petra M. Visser. 2018. "Cyanobacterial blooms." Nature Reviews Microbiology 16 (8): 471-483.

Paerl, Hans W, Nathan S Hall, and Elizabeth S Calandrino. 2011. "Controlling harmful cyanobacterial blooms in a world experiencing anthropogenic and climatic-induced change." Science of the Total Environment 409 (10): 1739-1745.

Paerl, Hans W, Karl E Havens, Nathan S Hall, Timothy G Otten, Mengyuan Zhu, Hai Xu, Guangwei Zhu, and Boqiang Qin. 2019. "Mitigating a global expansion of toxic cyanobacterial blooms: confounding effects and challenges posed by climate change." Marine and Freshwater Research.

Paerl, Hans W, and Jef Huisman. 2008. "Blooms like it hot." Science 320 (5872): 57-58.

Schindler, David W, Stephen R Carpenter, Steven C Chapra, Robert E Hecky, and Diane M Orihel. 2016. "Reducing phosphorus to curb lake eutrophication is a success." Environmental Science & Technology 50: 8923−8929.

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