NEW YORK STATE | Department of Environmental Conservation

HABs Research Guide

2026

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Document Objective

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.

What Are HABs?

- HABs in freshwater consist of cyanobacteria (also referred to as blue-green algae).
- Cyanobacteria are billions of years old and 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.

HABs can vary in appearance. They can appear in shades of green, blue-green, yellow, brown, red, or white. They can look like spilled paint, pea soup, surface streaks, or floating dots or clumps.

Background

HABs have been observed within NYS and throughout the world for many years, and cyanobacteria can negatively affect water quality, pose public health risks, and aesthetic and economic impacts (Dodds et al., 2009; Huisman et al., 2018; Prestigiacomo et al., 2023; Zhang et al., 2022). Work completed by DEC to analyze HAB frequency, intensity, and duration helped DEC refine its approach to addressing HABs (Gorney et al., 2023). New York State's holisitic approach to managing HABs and protecting public health and the environment combines understanding causes, conducting monitoring and modeling, researching and implementing prevention and mitigation methods, and advancing public engagement.

Despite decades of study by the scientific community, the need for enhanced HABs research, education, and reporting still exists (Huisman et al., 2018; Lim et al., 2023). Since 2012, DEC has documented HABs in more than 700 waterbodies throughout NYS (Figure 1). 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 be most effective to 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 (Paerl et al., 2024; Schindler et al., 2016,), and reducing HABs will require controlling both nitrogen and phosphorus inputs (Gobler et al., 2016; Lawson et al., 2025). However, water quality responses to nutrient reduction strategies do not occur immediately. Further, the impacts of climate change on the frequency, duration, and intensity of HABs are unpredictable, complicating the ability to evaluate waterbody responses to nutrient reductions (Paerl et al., 2019; Scavia et al., 2024). Research that addresses the multifaceted complexities of HABs at various scales, while taking into consideration short and long-term evaluation, is still needed.

Waterbodies with HAB Reports 2012-2025

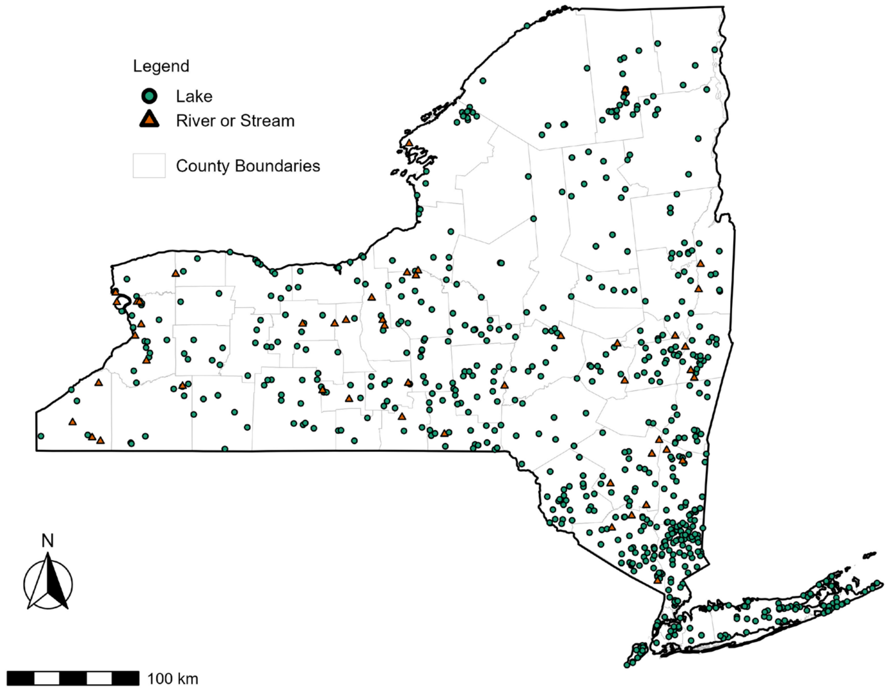

Figure 1. NYS lakes and flowing waters (rivers or streams) with confirmed HAB reports, 2012–2025.The map displays locations of waterbodies with HAB reports that were confirmed by DEC staff either visually through photographs or through laboratory analysis of water samples.

DEC's Research Strategy

This Research Guide informs applied research goals and strategies to advance HAB management across the state. Applied research uses systematic and organized inquiry to address problems or improve existing practices and create implementable solutions that inform effective HAB management. Based on program needs identified through the analysis described in Gorney et. al. (2023), DEC's Lake Classification and Inventory program, incorporated HAB sampling into its probability-based monitoring design. This approach provides a statistically robust method of documenting waterbody conditions across a broad range of waterbody sizes and condition across the state. Using this adaptive and responsive approach to monitoring based on research findings, DEC continues to modernize and adjust its programs in response to new and emerging research.

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 (Huisman et al., 2018; Scavia et al., 2024).

DEC's current strategy to reduce HABs is a holistic approach focused on controllable HAB causes that is based on completed research. This approach includes using the most up-to-date research through:

- Continued applied research on HABs that focuses on the prevention, mitigation, monitoring, and modeling of HABs;
- Deliberate Clean Water Planning to improve nutrient reduction efforts;
- Funding to implement clean water plans, best management practices, and other nutrient reduction strategies; and,
- Short-term HAB mitigation efforts to reduce in-waterbody impact from HABs.

For additional info on HABs and previous HAB research, please visit DEC's website.

Research Focus Areas

Four research focus areas (‘Prevention and Mitigation’, ‘Causes of HABs’, ‘Monitoring and Modeling’, and ‘Communication, Engagement, and Outreach’) 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 and inform management.

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; Sabo et al., 2022; 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.

Recent studies by DEC on mitigation methods include electrochemical oxidation and ultrasonic technologies. Electrochemical oxidation was found to be effective at the piloted scale, while ultrasonic technologies demonstrate unproven effectiveness (Bohrerova et al., 2023; Lürling and Mucci, 2020; Tischer et al., 2025; Vaughan et al., 2023)

Research on prevention and mitigation is happening at a national scale. The Interstate Technology and Regulatory Council provides a detailed synthesis of this research, but additional strategies and applications that build upon approaches that effectively prevent or 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; Summers and Ryder, 2023). This research will inform statewide decision-making about permitting, new technologies, pilot projects, and nutrient reduction policies.

Table 1. Focus Area: Prevention and Mitigation

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 HAB occurrence. • Develop and demonstrate new approaches for in-waterbody nutrient control and to improve water quality and reduce and/or dissipate HAB occurrence. • 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).

Causes of HABs

Many 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 drivers (Byl, et al., 2025; 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 (Briddon et al., 2022; 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 of HABs. Research is needed to characterize other causes and drivers 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.

Table 2. Focus Area: Causes of 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, seasonality shifts, 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.

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 (Chorus and Bartram, 1999; Gorney et al., 2023; Graham et al., 2008; Prestigiacomo et al., 2023; Savoy et al., 2025). 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 enhance efforts to protect to public health, specifically related to the use of water as a drinking source, and primary and secondary contact recreation. Additionally, 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 cyanotoxins in benthic zones in both lotic and lentic systems. Recent publications have advanced the use of remote sensing as a tool for estimating cyanobacteria concentrations, but additional studies are needed (Akbarnejad Nesheli et al., 2024). Overall, monitoring and modeling findings could be used to improve or expand existing monitoring programs.

Table 3. Focus Area: Monitoring and Modeling

Topic	Detail
Cyanotoxin detection	• Improve and refine existing strategies and/or methods to detect cyanotoxins and other harmful compounds associated with cyanobacteria. • Develop novel or innovative cyanotoxin monitoring methods.
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.

Communication, Engagement, and Outreach

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 (Chorus and Bartram, 1999; Gorney et al., 2023; Graham et al., 2008). 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, education, and outreach tools and resources.

Table 4. Focus Area: Communication, Engagement, and Outreach

Topic	Detail
Communication methods	• Develop or improve existing 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 including, human or animal health risks, aquatic organism health, angling, fish consumption, climate change, water quality improvement, 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.

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