

Harmful Algal Blooms Research

ISSUE SUMMARY:

Cyanobacteria, or blue-green algae, can produce dangerous toxins that can cause significant health effects and mortality. Their excess biomass alone can raise treatment costs for drinking water, cause dead zones in waterbodies, reduce recreational opportunities, and have significant economic impacts. Harmful Algal Blooms (HABs) result from complex ecological processes that are affected by a variety of factors, including nutrient and light availability, water temperature, weather patterns, limnological effects, and competing microorganisms. One of the primary causes of HABs are nutrients, which are a natural and necessary part of aquatic ecosystems. However, when excess nutrients enter a water body, water quality (including drinking water sources), aquatic life, and human health can be adversely impacted. Excess nutrients, primarily nitrogen and phosphorous, are the most common cause of water quality problems facing the United States and can exacerbate the frequency and severity of algal blooms. HABs have been observed in all 50 states. Much of what is understood about HABs is based on planktonic forms of algae or cyanobacteria in the water column or on the water surface. Less is known about benthic species that can form algal mats and produce toxins.

EPA's Office of Research and Development (ORD) provides HABs information and tools to decision makers, including states, Tribes, municipalities, and water treatment facilities. EPA researchers are:

- Maintaining EPA's [CyAN web application](#), which is available to quickly deliver cyanobacterial algal bloom satellite data for over 2,000 U.S. lakes to water quality managers and the public.
- Developing the science to forecast freshwater HABs and predict where and when a bloom may occur.
- Studying how and why cyanobacteria blooms and toxic events occur, including benthic algae.
- Understanding how cyanobacteria toxins affect humans and animals.
- Researching how HAB toxins impact drinking water.
- Identifying technologies to help communities treat their drinking water in the event of a bloom.

UPCOMING MILESTONES:

- **Work with the Office of Water to Support CyanoHAB Forecasting:** Working with the Office of Water, ORD publishes cyanoHAB forecasts for over 2,000 freshwater lakes in the U.S. during HAB season, which operationalizes a [2024 ORD publication](#). OW and ORD will continue to advance the science to support forecasting work.

BACKGROUND:

EPA's HABs research is organized into three areas:

- **Health Effects and Toxicity:** There is a pressing need to develop data, methods, and tools to advance the understanding of adverse health impacts among people, other animals and plants that are associated with exposure to HABs from both planktonic and benthic cyanobacteria. This research will: (1) examine the effects of cyanobacteria and cyanotoxins (anatoxin and its derivatives and nodularin) on animals utilizing a

complementary set of approaches to define adverse outcomes associated with individual cyanotoxins; (2) utilize a multi-faceted epidemiological approach to characterize human health effects associated with recreational and occupational exposure to cyanobacterial cells and cyanotoxins; and (3) develop methods to measure toxins in various media at more sensitive environmental concentrations and characterize basic properties of planktonic and benthic cyanobacteria and associated toxins related to observed adverse health outcomes. The approaches used will focus on toxicity using *in vivo* animal models, *in vitro* mammalian and aquatic animal toxicology, and epidemiological investigations, and by developing dose-response models using biomarkers.

- **Managing HABs in the Built and Natural Environments:** The management of HABs is dependent on the ability to systematically identify ambient waters, including source waters, and associated water treatment systems that are vulnerable to blooms, and to apply interventions at any point from the source water to the final point of use for any purpose. This research: (1) develops a rigorous framework for identifying water sources and drinking water systems vulnerable to HABs; (2) evaluates the efficacy and impacts of chemical and physical HAB interventions applied to source waters; and (3) evaluates the efficacy and impacts of interventions applied to remove cyanobacterial biomass and metabolites from drinking water. Efforts will focus on the evaluation of the efficacy of intervention processes to remove the commonly recognized toxins (microcystin, cylindrospermopsin, anatoxin, nodularin, and saxitoxin) and other less common metabolites.
- **Science of Harmful Cyanobacteria Bloom Forecasting:** There is a strong demand by EPA regions, states, and Tribes for forecasting freshwater HABs, with Office of Inspector General and Government Accountability Office audit recommendations to maintain and enhance a national program to forecast, monitor, and respond to freshwater HABs. This research will focus on developing the science required for forecasting, while not building an operational forecast tool at this time. The research focus for this research includes: (1) forecasting freshwater HABs across systems—with greater than random chance—the probability the existing system might increase, decrease, or have no change, using bioindicators; (2) quantifying environmental drivers and aquatic community structures to inform the forecast; (3) assessing model convergence to provide more confidence in forecasts; and (4) linking human populations and communities with environmental justice concerns. Model development and validation in this research will capture a range of critical ecosystem types as well as study sites that represent different community types. It is anticipated that the focus on forecast models may be primarily bioindicators based, such as biomass, not directly forecasting toxins. Early toxin warnings might be a two-step process, with an initial bioindicator forecast followed by gene profiling for early toxin detection.

KEY EXTERNAL STAKEHOLDERS:

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| ☒ Congress | ☐ Industry | ☒ States | ☒ Tribes | ☐ Media | ☐ Other Federal Agency |
| ☐ NGO | ☒ Local Government | ☐ Other (Local unions) | | | |

States, Tribes, and local governments need information to help predict and treat HABs. Congress is very interested as well.

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MOVING FORWARD:

- Continue conducting HABs research as outlined in the StRAPs (see ORD Overview Briefing Paper 1 for more information on StRAPs).
- Work with EPA's National Harmful Algal Bloom Program and federal family partners to connect ORD science to practitioners.

LEAD OFFICE/REGION: ORD

OTHER KEY OFFICES/REGIONS: OW