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SUMMARY

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Freshwater Harmful Algal Blooms: Causes, Challenges, and Policy Considerations

Scientific research indicates that in recent years, the frequency and geographic distribution of harmful algal blooms (HABs) have been increasing nationally and globally. Because the impacts of HABs can be severe and widespread—often with interstate implications—these issues have been a perennial interest for Congress. While algal communities are natural components of healthy aquatic ecosystems, under certain conditions (e.g., increased temperatures and nutrient concentrations), algae may grow excessively, or "bloom," and produce toxins that can harm human health, animals, aquatic ecosystems, and the economy.

In 2014, a cyanobacterial HAB in Lake Erie affected the drinking water for more than 500,000 people in Toledo, Ohio. In 2016, a massive HAB in Florida's Lake Okeechobee negatively impacted tourism and aquatic life. HABs have been recorded in every state and have become a concern nationwide.

Many types of algae can cause HABs in freshwater systems. The most frequent and severe blooms involve the proliferation of cyanobacteria. Some cyanobacteria species can produce toxins—cyanotoxins—that can cause mild to severe health effects in humans and kill aquatic life and other animals.

HABs can also contribute to deteriorating water quality and ecosystem health. As masses of cyanobacteria or other algae die and decompose, they consume oxygen, sometimes forming "dead zones" where life cannot survive. These areas can kill fish and organisms, such as crabs and clams, and have detrimental economic effects.

Scientists widely consider nutrient enrichment to be a key cause of HAB formation. While nutrients are essential to plants and natural parts of aquatic ecosystems, excessive amounts can overstimulate algal growth. Sources include point sources (e.g., municipal wastewater discharges) and nonpoint sources (e.g., fertilizer runoff from agricultural and urban areas).

Congress, federal agencies, and states have taken steps to address HABs and nutrients that contribute to their occurrence. The Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 (HABHRCA), as amended, established an interagency task force, required the task force to prepare reports and plans addressing marine and freshwater HABs, and authorized funding for research, education, monitoring activities, etc.

In June 2019, the Environmental Protection Agency (EPA) used its authority under the Clean Water Act (CWA) to publish final water quality criteria for two algal toxins in waters used for recreational purposes. States may consider such criteria when developing water quality standards—measures that describe the desired condition or level of protection of a water body and what is needed for protection. Alternatively, they may use these values as the basis of swimming advisories for public notification purposes at recreational waters.

Further, EPA has emphasized the need to reduce nutrient pollution from *all* sources to reduce public health and environmental impacts associated with HABs. The CWA does not authorize EPA to regulate all sources. It authorizes EPA to regulate point (direct) sources of nutrients but does not authorize EPA to regulate nonpoint (diffuse) sources of nutrient pollution.

Some states have developed guidelines for algal toxins, primarily for use in guiding swimming advisories. Also, states have listed waters as impaired, or not meeting water quality standards, for algal blooms or algal toxins. Some of these states have begun to develop Total Maximum Daily Loads (TMDLs)—essentially pollution budgets—to address them. Most states have identified nutrient-related pollution as a priority to be addressed by their TMDLs and/or alternative restoration plans. States rely heavily on financial assistance from EPA in implementing these plans and, more broadly, in addressing nonpoint source pollution that leads to degraded water quality and HAB formation. Congress has long provided financial assistance through EPA for regional, state, and local programs through CWA Sections 106 and 319 planning grants, geographic programs (such as the Chesapeake Bay and Great Lakes), and other sources. The President's FY2020 budget request for most of these programs is either eliminated or significantly reduced.

Congress continues to show interest in addressing HABs. This interest has largely focused on funding research to close research gaps identified by scientists and decisionmakers and to coordinate the efforts of federal agencies and their partners to study and address HABs.

Contents

Figures

Tables

Contacts

Introduction

Scientific research indicates that in recent years, the frequency and geographic distribution of harmful algal blooms (HABs) have been increasing nationally and globally.[1] HABs can be detrimental to human health, animals, aquatic ecosystems, and local economies. In 2014, a major HAB in Lake Erie caused the city of Toledo, Ohio, to issue a "do not drink" order for tap water that left more than 500,000 people without drinking water for two days and had an estimated impact of $65 million in lost benefits.[2] In the summer of 2016, a massive HAB in Lake Okeechobee—Florida's largest freshwater lake—resulted in beach closures, losses to the tourism industry, and negative impacts on marine life. According to the U.S. Environmental Protection Agency (EPA), between June 2 and August 1, 2017, states reported at least 281 notices for freshwater HABs, including cautions, warnings, public health advisories, and public health warnings.[3]

Congress, many federal agencies, states, localities, and other partners have taken and continue to take steps to address the rising trend in HABs and their impacts. However, there are many gaps in current scientific understanding of HABs among the research and management communities and considerable debate as to how best to address the issue from a regulatory standpoint. This report explores these issues as they pertain to HABs in freshwater systems. Specifically, it addresses the conditions and activities that contribute to the occurrence of freshwater HABs; steps that Congress, federal agencies—particularly EPA—and their partners are taking to address and mitigate their occurrence; and the current knowledge gaps on this issue. This report is focused on freshwater HABs, not marine or coastal HABs or issues associated with HABs in drinking water supplies.[4]

Background

What Are Harmful Algal Blooms?

Algal communities are naturally occurring components of healthy aquatic ecosystems, such as lakes, rivers, and estuaries. However, under certain environmental conditions, such as increased temperatures and nutrient concentrations (e.g., nitrogen and phosphorus), colonies of algae can grow excessively, or "bloom," and produce toxins that pose a threat to human and aquatic ecosystem health and potentially cause economic damage. These HABs sometimes produce discolorations in the water that can appear as scums, paint-like slicks, clotted mats, or foam that

[1] NOAA, *State of the Science Fact Sheet—Harmful Algal Blooms*, September 2016, http://nrc.noaa.gov/CouncilProducts/ScienceFactSheets.aspx; U.S. Environmental Protection Agency, "Causes and Prevention," https://www.epa.gov/nutrient-policy-data/causes-and-prevention; National Office for Harmful Algal Blooms at Woods Hole Oceanographic Institution, "Recent Trends: National Changes," July 11, 2016, https://www.whoi.edu/redtide/regions/us/recent-trends. C. B. Lopez et al., *Scientific Assessment of Freshwater Harmful Algal Blooms*, Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology, 2008.

[2] M. Bingham et al., *Economic Benefits of Reducing Harmful Algal Blooms in Lake Erie*, Environmental Consulting and Technology, submitted to the International Joint Commission, October 2015.

[3] EPA, Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin, May 2019, https://www.epa.gov/sites/production/files/2019-05/documents/hh-rec-criteria-habs-document-2019.pdf.

[4] For a discussion of algal toxins in drinking water, see CRS In Focus IF10269, *Algal Toxins in Drinking Water: EPA Health Advisories*, by Mary Tiemann.

may vary in color (i.e., light to dark green, yellow, red, or brown). Even when visible signs of a bloom are absent, however, algal toxins may still cause harmful effects.[5] **Figure 1** shows an aerial view of a HAB that produced visible green scums in Lake Okeechobee, Florida, in July 2016.

Figure 1. Aerial view of a July 2016 Harmful Algal Bloom in Lake Okeechobee, Florida

Source: USGS, https://www.usgs.gov/news/science-harmful-algae-blooms.

HAB Types and Impacts

While many types of algae can cause HABs in bodies of freshwater, cyanobacteria (sometimes referred to as blue-green algae) typically cause the most frequent and severe blooms.[6] Cyanobacterial HABs pose a threat to human and aquatic ecosystem health and can kill pets, livestock, and wildlife. Some species of cyanobacteria produce toxins, called cyanotoxins, which can cause hepatic (liver-related), neurologic, respiratory, dermatologic, and other symptoms.[7] These may be acute or chronic, mild or severe, and in some cases may be fatal. Humans may be exposed to cyanotoxins by consuming tainted drinking water, fish, or shellfish; swimming or recreating in waters with certain concentrations of cyanotoxins present; or inhaling aerosolized

[5] Lopez et al., *Scientific Assessment of Freshwater Harmful Algal Blooms*.

[6] J. L. Graham et al., *Cyanobacterial Harmful Algal Blooms and U.S. Geological Survey Science Capabilities*, U.S. Geological Survey, 2016.

[7] Centers for Disease Control and Prevention, "Harmful Algal Bloom (HAB)-Associated Illness," https://www.cdc.gov/habs/illness-symptoms-freshwater.html.

toxins.[8] The cyanotoxins associated with these HABs can contaminate fish, interfere with a variety of recreational activities, and cause other economic and environmental damages.

There are many types of cyanotoxins, which may have multiple variants with a wide range of toxicities.[9] The most commonly occurring and most studied cyanotoxin is microcystin.[10]

Although cyanobacterial HABs are considered to be the most prevalent and toxic types of HABs, blooms of "golden algae" (*Prymnesium parvum*) are an emerging problem and likely the most problematic of non-cyanobacterial freshwater HAB taxa (i.e., group of related organisms classified as a unit).[11] Golden algal HABs have caused large fish kills worldwide, including millions of fish in Texas. Most of the major fish kills have occurred since 2000. Golden algae thrive in brackish water, such as the rivers and reservoirs found in areas of Texas, Oklahoma, and Wyoming. The toxins produced by golden algae target gill-breathing organisms, such as fish, clams, and mussels. According to information from two states that experience golden algal blooms, there is currently no evidence that golden algal toxins pose a direct threat to humans, other mammals, or birds.[12] Effects of cyanobacterial HABs and golden algae HABs are detailed in **Table 1**.

In addition to the effects of algal toxins on human and animal health, HABs can also contribute to deteriorating water quality and ecosystem health. An overabundance of cyanobacteria or other algae can block out sunlight and clog fish gills. In addition, as the algae die and decompose, they consume oxygen, leaving waterways in a hypoxic (or low oxygen) state, sometimes forming "dead zones"—areas where life cannot survive due to lack of oxygen. Low oxygen areas can suffocate and kill fish and bottom-dwelling organisms such as crabs and clams. According to EPA, over 166 dead zones have been documented nationwide, including in waterbodies such as the Chesapeake Bay and the Gulf of Mexico.[13] Significant economic losses have occurred as a result of hypoxia.[14]

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[8] Graham et al., *Cyanobacterial Harmful Algal Blooms*.

[9] Graham et al., *Cyanobacterial Harmful Algal Blooms*.

[10] Graham et al., *Cyanobacterial Harmful Algal Blooms*; and Keith A. Loftin et al., "Cyanotoxins in Inland Lakes of the United States: Occurrence and Potential Recreational Health Risks in the EPA National Lakes Assessment 2007," *Harmful Algae*, vol. 56 (2016), pp. 77-90. Other common cyanotoxins that can have adverse environmental health effects include anatoxins, cylindrospermopsins, and saxitoxins.

[11] National Office for Harmful Algal Blooms at Woods Hole Oceanographic Institution, "Golden Algae," July 11, 2016, https://www.whoi.edu/redtide/impacts/freshwater/golden-algae.

[12] Texas Parks and Wildlife, Texas Commission on Environmental Quality, and U.S. Fish and Wildlife Service, "Texas Golden Alga Facts," http://www.tceq.texas.gov/publications/gi/gi-378.html/at_download/file; Arizona Game and Fish Department, "Golden Alga Frequently Asked Questions," http://www.azgfd.gov/temp/golden_alga_faqs.shtml.

[13] EPA, "Nutrient Pollution, The Effects: Environment," https://www.epa.gov/nutrientpollution/effects-environment.

[14] National Science and Technology Council, Committee on Environment and Natural Resources, *An Assessment of Coastal Hypoxia and Eutrophication in U.S. Waters*, November 2003.

Table 1. Selected Freshwater Harmful Algal Bloom (HAB) Taxa and Toxins and Their Effects

HAB Taxa	Toxins	Human Health Effects	Animal Health Effects	Environmental Effects	Economic Effects	Affected Areas in U.S.
Cyanobacteria	Microcystins, cylindrospermopsin, anatoxin-a, saxitoxins	Liver and kidney toxicity, neurotoxicity, paralysis, gastrointestinal effects, dermatitis, respiratory illness	Pet, farm animal, and wildlife mortality; fish kills	Water discoloration, foul odors	Loss of tourism, contamination of drinking water requiring additional expensive water treatment or alternate water sources, taste problems in farmed and wild-caught fish (making them inedible)	Great Lakes and many inland water bodies
Haptophytes (e.g., *Prymnesium parvum*, or "golden algae")	Prymnesins, ichthyotoxins (i.e., fish toxin)	No apparent adverse effects	Kills fish and other gill-breathing organisms, such as clams and mussels	Water discoloration, foam formation	Loss of fishing income, clean-up costs	Alabama, Alaska, Colorado, Florida, Georgia, Nebraska, New Mexico, North Carolina, Oklahoma, Pennsylvania, South Carolina, Texas, and Wyoming

Source: Adapted from National Science and Technology Council, Subcommittee on Ocean Science and Technology, *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report*, Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act, February 11, 2016, p. 49.

Notes: Table includes information only on Freshwater HAB taxa and toxins discussed in this report. For a complete list of freshwater and marine HABs, toxins, and their effects, see the source above, Appendix 1, pp. 49-52.

Factors Contributing to HAB Formation

Many factors may influence the occurrence and prevalence of HABs in freshwater, including nutrient concentrations, water temperature, availability of light, pH, and water circulation. Nutrient enrichment is widely recognized as one of the key causes of HAB formation.[15] Nutrients, such as nitrogen and phosphorus, are essential to plant growth and natural parts of aquatic ecosystems. However, when high levels of nutrients enter a body of water, they stimulate plant and algal growth, which can lead to depletion of dissolved oxygen (as explained above), reduced transparency (i.e., turbidity), changes to the biological community (e.g., loss of sportfish, such as bass), and degradation of the aesthetic appeal of the water (i.e., from odor and scums). This process is called eutrophication.[16]

While some sources of nutrients in water bodies are natural, many anthropogenic activities contribute nutrients to waterbodies from a number of point and nonpoint sources. Point sources include municipal and industrial wastewater discharges and concentrated animal feeding operations (CAFOs).[17] Nonpoint sources include urban stormwater runoff, failing septic systems, atmospheric deposition of nitrogen from fossil fuel emissions, runoff from fertilized cropland, and manure runoff from cropland, pastures, and animal feeding operations. See **Table 2** for more information on these sources.

Studies also indicate that increased temperatures and changes in frequency and intensity of rainfall associated with climate change may also favor HAB formation.[18] HABs generally proliferate in warmer waters. In addition, some studies have found that swings between flooding and drought may enhance HAB formation. For example, if intense rainfall is followed by a drought, the nutrients washed into receiving water bodies may remain in them longer, increasing the potential for HABs.[19]

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[15] Graham et al., *Cyanobacterial Harmful Algal Blooms*; and Lopez et al., *Scientific Assessment of Freshwater Harmful Algal Blooms*.

[16] EPA, "Preventing Eutrophication: Scientific Support for Dual Nutrient Criteria," February 2015, https://www.epa.gov/sites/production/files/documents/nandpfactsheet.pdf.

[17] CAFOs are point sources, as defined by CWA Section 502(14). CAFOs are agricultural operations where animals are kept and raised in confined situations that meet criteria established in EPA's CAFO regulation (40 C.F.R. 122.23). These criteria include specific numbers of confined animals and designation as a significant contributor of pollutants.

[18] H. W. Paerl and J. Huisman, "Climate Change: A Catalyst for Global Expansion of Harmful Cyanobacterial Blooms," *Environmental Microbiology Reports*, vol. 1, no. 1 (February 2009), pp. 27-37; National Science and Technology Council, Subcommittee on Ocean Science and Technology, *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report*, Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act, February 11, 2016; Jerry M. Melillo et al., *Climate Change Impacts in the United States: The Third National Climate Assessment*, U.S. Global Change Research Program, October 2014, pp. 79, 198, 216.

[19] Paerl and Huisman, "Climate Change," pp. 27-37.

Table 2. Anthropogenic Sources of Nutrients in Water

Source	Source Type	Details
Municipal wastewater discharges	Point	Municipal wastewater treatment plants process wastewater from homes and businesses. The wastewater contains nitrogen and phosphorus from human waste, food, and phosphate-containing soaps and detergents. Some wastewater treatment plants have upgraded their systems and are able to remove more nitrogen and phosphorus than others.
Industrial wastewater discharges	Point	Industrial wastewater treatment plants process wastewater from a variety of manufacturing or industrial activities. According to EPA, certain types of industrial waste tend to possess higher quantities of nutrients, such as those from processors of food, beverages, livestock, and agricultural products.
Concentrated animal feeding operations (CAFOs)	Point[a]	CAFOs are animal feeding operations (see entry below) that meet numeric thresholds for the number of animals they contain and/or meet certain pollution discharge criteria.[b] Manure discharge can contribute nitrogen and phosphorus to waterways.
Animal feeding operations (AFO)	Nonpoint	AFOs are facilities in which livestock or poultry are kept and raised in confinement that meet certain conditions. Manure runoff and wastewater from AFOs can contribute nitrogen and phosphorus to waterways.[c]
Agricultural runoff	Nonpoint	Excess fertilizer applied to crops and fields, animal manure, and soil erosion can all contribute to increased nitrogen and phosphorus entering water bodies during rainfall events.
Urban stormwater runoff	Nonpoint	During rainfall or snowmelt events, water carries nitrogen and phosphorus across paved surfaces and buildings and into local water bodies or storm drains. Fertilizers, yard and pet waste, and phosphate-containing soaps and detergents can contribute to higher nutrient concentrations in stormwater.
Failing septic systems	Nonpoint	If septic systems are improperly managed, elevated nitrogen and phosphorus levels can be released into local water bodies or groundwater. Common causes of failure include aging, inappropriate design, overloading the system, and poor maintenance.
Fossil fuels	Nonpoint	Combustion of fossil fuels by electric power generation, industry, transportation, and agriculture release nitrogen oxides into the atmosphere. Nitrogen oxides are deposited back onto land and can be washed into nearby waters during rainfall events.

Sources: EPA "Nutrient Pollution: Sources and Solutions," https://www.epa.gov/nutrientpollution/sources-and-solutions; EPA, Office of Water, *A Compilation of Cost Data Associated with the Impacts and Control of Nutrient Pollution*, EPA 820-F-15-096, May 2015, pp. IV-23.

Notes:

a. Under CWA Section 502(14), CAFOs are point sources. However, the definition of point sources specifically excludes agricultural stormwater discharges. Therefore, agricultural stormwater discharges from CAFOs are nonpoint sources.

b. For EPA's regulatory definitions of Large CAFOs, Medium CAFOs, and Small CAFOs, see 40 C.F.R. Section 122.23.

c. The conditions for an AFO include (1) animals are confined or maintained for a total of 45 days or more in any 12-month period, and (2) crops are not sustained in the normal growing season over any portion of the lot or facility. See 40 C.F.R. Section 122.23.

Incidence and Trends

Scientists largely agree that the frequency and distribution of HABs, the economic losses from them, the types of resources affected, and the number of toxins and toxic species have all increased in recent years.[20] Some scientists note that factors such as better detection methods and increased reporting have contributed to the upward trend. HABs, including cyanobacterial HABs, have been recorded in the waters of all 50 states, with some HABs crossing state lines.[21] **Figure 2** shows the generalized distribution of selected freshwater HAB events (cyanobacterial HABs and golden algal HABs) that took place between 2006 and 2015 across the United States.

The findings of EPA's most recent national assessment of lakes[22] are consistent with other reports of the rising trend in HABs. In EPA's 2012 National Lake Assessment, EPA concluded that there was little change from its 2007 survey of lakes, with two exceptions—trends in algal toxin and nutrient measures.[23] In 2012, EPA and its partners detected microcystin in 39% of lakes, a 9.5% increase from 2007.[24] EPA noted, however, that for both studies, the concentrations of microcystin remained low and rarely exceeded the levels of concern established by the World Health Organization (WHO) for recreational uses (see "Regulatory Efforts and Guidelines"). EPA also found an 8.3% increase in the percentage of lakes in the "most disturbed condition" category when analyzing the density of cyanobacterial cells (i.e., an indicator of risk for exposure to algal toxins because the cells may produce toxins).[25] Finally, EPA found an overall increase in the median concentration of phosphorus across all lakes[26] and a "dramatic" decline (18.2%) in the percentage of lakes with low nutrients and high oxygen levels.[27] These findings are important because in many lakes, phosphorus is considered the limiting nutrient, meaning that the available quantity of this nutrient controls the pace of algal production. It also means that even small increases in phosphorus can lead to very rapid increases in algal growth.[28] More broadly, the study found that nutrient pollution is a widespread problem across the country. Approximately 35% of lakes have excessive levels of total nitrogen, and 40% of lakes have excessive levels of total phosphorus.[29]

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[20] See footnote 1.

[21] National Office for Harmful Algal Blooms at Woods Hole Oceanographic Institution, "Distribution of HABs in the U.S.," August 15, 2016, https://www.whoi.edu/redtide/regions/us-distribution.

[22] EPA, *National Lakes Assessment 2012: A Collaborative Survey of Lakes in the United States*, December 2016. Every five years, EPA and its partners sample more than 1,000 lakes to inform the agency's National Lakes Assessment, a statistically based assessment of the biological, chemical, physical, and recreational condition of the nation's lakes.

[23] EPA, *National Lakes Assessment 2012*, pp. 1-2.

[24] EPA, *National Lakes Assessment 2012*, pp. 1, 18.

[25] EPA, *National Lakes Assessment 2012*, p. 28. Note that according to the assessment, 15% of lakes are in the most disturbed condition using cyanobacteria cell counts as an indicator of risk for exposure to algal toxins.

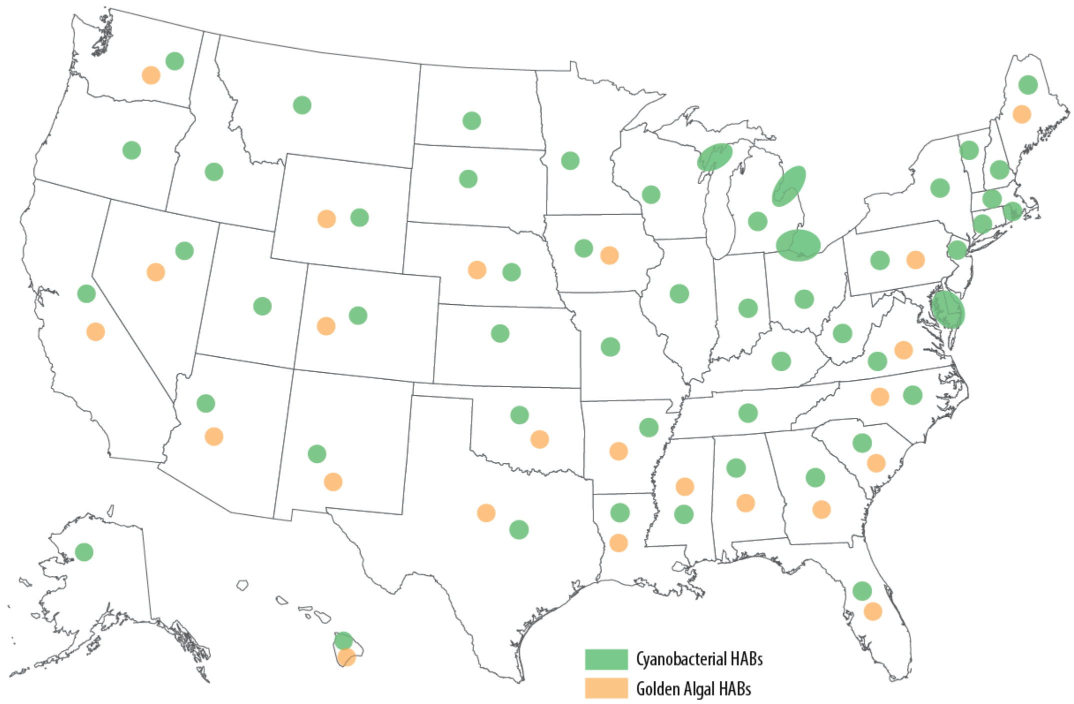
[26] EPA, *National Lakes Assessment 2012*, p. 2, 13. The median concentration of phosphorus increased from 20 µg/L in 2007 to 37 µg/L in 2012.

[27] EPA, *National Lakes Assessment 2012*, pp. 2, 13. In 2012, EPA found 18.2% fewer oligotrophic lakes (i.e., lakes with low nutrients and high oxygen levels) than in 2007.

[28] EPA, *National Lakes Assessment 2012*, p. 12.

[29] The terms *total nitrogen* and *total phosphorus* include all forms of the nutrient in the sample. For example, *total phosphorus* includes a measurement of orthophosphate, condensed phosphate, and organic phosphate.

Figure 2. Generalized Distribution of Selected Freshwater Harmful Algal Blooms (HABs) in the United States



Sources: Graphic adapted from a National Office of Harmful Algal Blooms at Woods Hole Oceanographic Institution map of HABs that occurred between 2006 and 2015 (available at http://whoi.edu/redtide/regions/us-distribution) and an EPA adaptation of the map that reflects input from HAB experts with broad experience in HAB events and reports to the U.S. National Office for Harmful Algal Blooms (see EPA, *Draft Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin*, December 2016, p. 4).

Notes: Each state that has experienced one or more cyanobacterial HABs or golden algal HABs is indicated with a single dot. Larger green ovals mark areas where more widespread cyanobacterial HAB problems occurred.

Efforts to Address Harmful Algal Blooms

Enacted Legislation

Congress has recognized the increasing frequency of HABs and has passed legislation in an effort to address public health, economic, and environmental consequences of HABs. In 1998, Congress passed the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA), which established an Interagency Task Force on Harmful Algal Blooms and Hypoxia.[30] It required the task force to prepare reports assessing HABs and hypoxia with a focus on coastal waters and authorized funding for HAB and hypoxia-related research, education, and monitoring activities. The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA)

[30] P.L. 105-383.

chaired the task force. In 2004, Congress reauthorized HABHRCA and expanded it to include assessments of HABs in freshwater.[31] In 2014, Congress again reauthorized HABHRCA and established a national HAB and Hypoxia Program to be maintained by NOAA through the task force.[32] It identified NOAA and EPA as the lead federal agencies for marine and freshwater aspects of the program, respectively, and required additional reports and a comprehensive research plan and action strategy. Congress most recently reauthorized HABHRCA in January 2019 through the Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2017, included within the National Integrated Drought Information System Reauthorization Act of 2018 (P.L. 115-423). The HABHRCA amendments require the task force to submit a scientific assessment of HABs in U.S. coastal and freshwater systems once every five years to Congress, require NOAA to develop and maintain a public website that provides information on HAB and Hypoxia Program activities, and added a section that authorizes NOAA or EPA to determine that a hypoxia or HAB event is an event of national significance (for marine and freshwater systems, respectively). If an event is designated, the legislation authorizes NOAA or EPA to make funds available to the affected state or locality to assess and mitigate the detrimental environmental, economic, subsistence use, and public health effects of the event.

In 2015, in response to public safety concerns arising from the Toledo, Ohio, HAB event, Congress passed legislation addressing algal toxins in drinking water. The Drinking Water Protection Act amended the Safe Drinking Water Act to require EPA to develop a strategic plan to assess and manage the risks associated with algal toxins in public drinking water supplies.[33]

The following year, Congress included a provision in the Water Infrastructure Improvements for the Nation (WIIN) Act that required EPA to designate a Harmful Algal Bloom Coordinator to coordinate projects and activities under the Great Lakes Restoration Initiative involving HABs in the Great Lakes.[34] **Table 3** provides a list and description of the HAB-specific legislation enacted since 1998.

Table 3. Harmful Algal Bloom (HAB)-Related Legislation

Law	Description
Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA), 1998 (P.L. 105-383)	• Established an Interagency Task Force of Harmful Algal Blooms and Hypoxia, chaired by the Department of Commerce, to consist of representatives from nine federal agencies, the Office of Science and Technology Policy, the Council on Environmental Quality, and "such other Federal agencies as the President considers appropriate" • Required the task force to prepare reports assessing HABs and hypoxia, with a focus on coastal waters • Authorized funding for research, education, and monitoring activities related to HABs and hypoxia: $15,000,000 for FY1999; $18,250,000 for FY2000; and $19,000,000 for FY2001

31 P.L. 108-456.

32 P.L. 113-124.

33 P.L. 114-45.

34 P.L. 114-322.

Law	Description
Harmful Algal Bloom and Hypoxia Amendments Act of 2004 (P.L. 108-456)	• Retained the Interagency Task Force (which the President could have disestablished under the 1998 act) • Expanded the focus of the act to include assessments of HABs in freshwater • Mandated five reports, one of which was to assess current knowledge about HABs in freshwater, including a research plan for coordinating federal efforts to better understand freshwater HABs • Required the task force to complete a scientific assessment of HABs at least once every five years—an assessment that shall examine marine *and freshwater* blooms after the initial assessment was complete • Reauthorized funding for research, education, and monitoring activities: $23,500,000 for FY2005; $24,500,000 for FY2006; $25,000,000 for FY2007; and $25,500,000 for FY2008[a]
Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014 (P.L. 113-124)	• Established a National HAB and Hypoxia program to be maintained and enhanced by the National Oceanic and Atmospheric Administration (NOAA)[b] through the interagency task force • Identified NOAA[b] as the lead federal agency with primary responsibility for administering the program and directed EPA to lead the freshwater aspects of the program • Added the Centers for Disease Control and Prevention as a member of the interagency task force • Required the interagency task force to develop a comprehensive research plan and action strategy to address marine and freshwater HABs and hypoxia • Required regional reports, including a progress report on Northern Gulf of Mexico hypoxia and an integrated assessment of and plan to address hypoxia and HABs in the Great Lakes • Reauthorized funding to implement the program and research plan and action strategy: $20,500,000 for each of FY2014-FY2018
Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2017 (P.L. 115-423)[c]	• Requires the interagency task force to complete, and submit to Congress, a scientific assessment of HABs in U.S. coastal waters and freshwater systems once every five years • Added the Army Corps of Engineers as a member of the interagency task force • Requires NOAA to develop and maintain a publicly accessible website that provides information on the HAB and Hypoxia Program activities • Added an objective for peer-reviewed, merit-based, competitive grant funding to include accelerating the use of effective methods of intervention and mitigation to reduce the frequency, severity, and impacts of HABs and hypoxia events • Added a section that allows NOAA or EPA to determine that a hypoxia or HAB event is an event of national significance, which then authorizes NOAA or EPA to make sums available to the affected state or locality for the purposes of assessing and mitigating the detrimental environmental, economic, subsistence use, and public health effects of the event (additionally outlines federal share requirements and authorizes the acceptance of donations) • Reauthorized funding to implement the HAB and Hypoxia program: $20,500,000 for each of FY2019-FY2023

Law	Description
Drinking Water Protection Act (P.L. 114-45)	• Amended the Safe Drinking Water Act to require EPA to develop—and submit to Congress—a strategic plan to assess and manage the risks associated with algal toxins in public drinking water supplies[d] • Required EPA to include in the plan steps and schedules for EPA to (1) assess health risks of algal toxins in drinking water, (2) publish a list of toxins likely to pose risks and summarize their health effects, (3) determine whether to issue health advisories for listed toxins, (4) publish guidance on feasible methods to identify and measure the algal toxins in water, (5) recommend feasible treatment and source water protection options, and (6) provide technical assistance to states and water systems. • Required the Government Accountability Office to report to Congress on federal funds expended for each of FY2010-FY2014 to examine toxin-producing cyanobacteria and algae or address public health concerns related to harmful algal blooms[e]
Water Infrastructure Improvements for the Nation (WIIN) Act (P.L. 114-322)	• One of the act's provisions directed the EPA Administrator to designate a Harmful Algal Bloom Coordinator to coordinate—with federal partners, Great Lakes states, Indian tribes, and other nonfederal stakeholders—projects and activities under the Great Lakes Restoration Initiative involving HABs in the Great Lakes[f]

Source: CRS.

Notes: This table does not include legislation pertaining to cyanobacteria or cyanotoxins in drinking water.

a. The reauthorization expired in 2008, however, the Consolidated Appropriations Act of 2008 (P.L. 110-161) provided authorizations of $30,000,000 for each of FY2008-FY2010.

b. The act specifies that the Under Secretary of the Department of Commerce shall have this role. The Under Secretary of Commerce for Oceans and Atmosphere is the administrator of NOAA.

c. The Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2017 was enacted as P.L. 115-423 on January 7, 2019.

d. EPA, Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water: Strategy Submitted to Congress to Meet the Requirements of P.L. 114-45, 810R04003, November 2015.

e. U.S. Government Accountability Office, *Environmental Protection: Information on Federal Agencies' Expenditures and Coordination Related to Harmful Algae*, GAO-17-119, October 2016.

f. According to EPA, the administrator designated the Great Lakes National Program Office Director as the Harmful Algal Bloom Coordinator.

In addition to HAB-specific legislation, the Clean Water Act (CWA) authorizes EPA to address water quality concerns associated with HABs.[35] The act establishes a system, under Section 303, for states to adopt ambient water quality standards consisting of the designated use or uses of a water body (e.g., recreational, public water supply, or aquatic life) and the water quality criteria that are necessary to protect the use or uses.[36] States then use their water quality standards to determine which waters must be cleaned up, how much effluent may be discharged, and what is needed for protection.

Section 304(a) requires the EPA Administrator to publish and, from time to time, revise water quality criteria that accurately reflect the latest scientific knowledge on the kind and extent of all identifiable effects on human health and the environment that might be expected from the

[35] Clean Water Act, as amended (33 U.S.C. §1251 *et seq.*)

[36] 33 U.S.C. §1313.

presence of pollutants.[37] These criteria constitute guidance that states use in adopting their water quality standards. As recognized by Section 510 of the CWA,[38] states may develop water quality standards that are more stringent than required by EPA regulations. EPA's water quality standards regulations[39] require that in developing water quality standards, states must adopt water quality criteria that protect the designated use. States are to establish *numerical criteria*—based on (1) EPA's recommended criteria, (2) EPA's criteria modified to reflect site-specific conditions, or (3) other scientifically defensible methods—and establish *narrative* criteria or criteria based on biomonitoring methods where numerical criteria cannot be established or to supplement numerical criteria.

Section 303(d) of the CWA requires states to identify waters that are impaired by pollution, even after application of pollution controls.[40] For those waters, states must establish a Total Maximum Daily Load (TMDL) of pollutants to ensure that water quality standards can be attained. A TMDL is a quantitative assessment of pollution sources and pollutant reductions needed to restore and protect U.S. waters; it is also a planning process for attaining water quality standards. TMDLs may address all pollution sources, including point sources, such as municipal sewage treatment or industrial plant discharges, and nonpoint sources such as urban runoff and agricultural runoff.

Also, Section 118 of the CWA provides that the United States should seek to attain the goals embodied in the Great Lakes Water Quality Agreement of 1978, as amended by the Water Quality Agreement of 1987 and any other agreements and amendments.[41] It tasks EPA to take the lead in the effort to meet the agreement's goals, working with other federal agencies, states, and localities. As seen in the text box, the most recent amendment includes a HAB-related goal.

Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement, which was first signed in 1972, is a commitment between the United States and Canada to restore and protect the waters of the Great Lakes.[42] It was amended most recently in 2012 to better identify and manage current environmental issues and prevent emerging environmental issues from affecting the waters of the Great Lakes while upholding and modernizing commitments made in previous agreements. One of the nine objectives of the 2012 agreement is that the waters of the Great Lakes should "be free from nutrients that directly or indirectly enter the water as a result of human activity, in amounts that promote growth of algae and cyanobacteria that interfere with aquatic ecosystem health, or human use of the ecosystem." Although previous agreements had also included efforts to reduce nutrients and prevent excessive algal growth, the 2012 amendments were the first to specifically include cyanobacteria.

Federal Agency Efforts

Many federal agencies are involved in carrying out various HAB-related activities, including conducting HAB research, monitoring algal toxins and water quality, forecasting HABs, supporting projects to improve water quality, and facilitating community outreach efforts. Some in Congress, however, have expressed concern about the activities and expenditures of various agencies and potential redundancies. In the Drinking Water Protection Act (P.L. 114-45), enacted

[37] 33 U.S.C. §1314.

[38] 33 U.S.C. §1370.

[39] 40 CFR 131.

[40] 33 U.S.C. §1313.

[41] 33 U.S.C. §1269. In 1987 amendments to the CWA (P.L. 100-4) Congress affirmed the goals of the amended Great Lakes Water Quality Agreement of 1978.

[42] Great Lakes Water Quality Agreement, U.S.-Canada, as amended, September, 7, 2012.

August 7, 2015, Congress directed the Government Accountability Office (GAO) to inventory funds expended by federal agencies to examine toxin-producing cyanobacteria and algae or address public health concerns related to harmful algal blooms. GAO was to recommend ways to improve interagency coordination and reduce duplication of efforts. According to the 2016 GAO report that responded to the mandate, 17 agencies conducted research, monitoring, response, or other HAB-related activities between FY2013 and FY2015.[43] The GAO report provides detailed information on federal agencies' key HAB-related activities, expenditures, and specific statutory authorities, and, thus, this report will not discuss these in detail. Rather, this section identifies the federal agencies involved in a key interagency effort and highlights actions EPA specifically is taking in its role as the leader of freshwater HAB issues.

As previously mentioned, HABHRCA established an interagency task force that is charged with

- promoting a national strategy to help communities understand, predict, control, and mitigate freshwater and marine HAB and hypoxia events;
- enhancing, coordinating, and assessing the activities of existing HABs and hypoxia programs; and
- providing for development of a comprehensive research plan and action strategy.

Table 4 provides a list of the federal agencies and organizations specifically required in HABHRCA to participate on the task force. The reauthorization of HABHRCA in 2014 reconstituted the task force as the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act (IWG-HABHRCA), responsible for maintaining a national HAB/hypoxia program. NOAA and EPA share primary responsibility under HABHRCA for administering the national HAB and hypoxia program, with NOAA leading marine aspects of the program and EPA in charge of freshwater aspects.

[43] GAO, *Environmental Protection: Information on Federal Agencies' Expenditures and Coordination Related to Harmful Algae*, GAO-17-119, October 2016, p. 5. Note that GAO identified 17 agencies that have conducted research, monitoring, or other HAB-related activities in FY2013-FY2015. However, the report focuses on 12 federal agencies whose data was sufficiently reliable for the purposes of the report.

Table 4. Interagency Task Force on Harmful Algal Blooms (HABs) and Hypoxia

Representatives Specifically Named in HABHRCA

Agency
Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)[a]
Environmental Protection Agency (EPA)[a]
Department of Agriculture
Department of the Interior
Department of the Navy
Department of Health and Human Services
National Science Foundation
National Aeronautics and Space Administration
Food and Drug Administration
Office of Science and Technology Policy
Council on Environmental Quality
Centers for Disease Control and Prevention
Army Corps of Engineers

Source: CRS.

Notes: NOAA and EPA serve as cochairs of the interagency task force. HABHRCA states that the task force shall also include "such other Federal agencies as the President considers appropriate."

a. NOAA and EPA serve as cochairs on the task force.

In its role under HABHRCA and the CWA, EPA's efforts to address HABs include coordinating the efforts of multiple entities, developing regulations and guidelines to protect water quality (see "Regulatory Efforts and Guidelines" section), conducting research, providing financial assistance through grants and other agreements, and educating the public.[44] In its coordination role, EPA leads, chairs, or cochairs several working groups or task forces, including the IWG-HABHRCA, the Inland HAB Discussion Group, the Great Lakes Interagency Task Force, and the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force). See **Table 5** for a description of these efforts.

EPA has also conducted internal research on HABs and their toxins focused on water quality (including how different factors such as nutrients, light, temperature, etc., affect HAB occurrence and toxicity), human and ecological health effects, monitoring and analytical methods research, and drinking water treatment research.[45] The agency also provides research grants, such as those provided through the Science to Achieve Results (STAR) program, focused on topic areas including the prediction, prevention, control, and mitigation of freshwater HABs and the fate and effects from less-common emerging HABs.[46]

EPA also provides financial assistance to states, tribes, and others to address water pollution, including nonpoint source pollution. Examples of such assistance include nonpoint source

[44] Education efforts include communication and outreach, such as newsletters and videos, to increase public awareness regarding the adverse effects of nutrient pollution and HABs.

[45] GAO, *Environmental Protection: Information on Federal Agencies' Expenditures and Coordination Related to Harmful Algae*, GAO-17-119, October 2016.

[46] EPA "Freshwater Harmful Algal Blooms," Funding Opportunity Announcement Number EPA-G2017-STAR-A1, Office of Research and Development, October 28, 2016.

implementation grants under CWA Section 319, capitalization grants under the Clean Water State Revolving Fund, and grants under CWA Section 106, which are provided to states, interstate agencies, and tribes to administer programs that prevent, reduce, and eliminate water pollution.

Table 5. EPA Efforts to Coordinate Freshwater HAB-Related Activities

Coordination Effort	Description
Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act (IWG-HABHRCA)	Created after the HABHRCA amendments of 2014, this interagency working group is the primary, government-wide mechanism through which federal agencies coordinate their HAB-related activities and report on specific topics to Congress, such as research plans and action strategies for addressing HABs and hypoxia. The group meets twice a month and is cochaired by the NOAA and EPA.
Inland HAB Discussion Group	Led by EPA, the U.S. Geological Survey, and the Centers for Disease Control and Prevention to share information among federal, state, local, and industry stakeholders through free webinars, this informal discussion group was created out of an expressed need by federal researchers and state agencies to bridge a communication gap with respect to inland HAB research, monitoring, human and ecological health risk assessment, education, and outreach.
Great Lakes Interagency Task Force	Chaired by EPA, this task force consists of 11 Cabinet and other federal agency heads to coordinate the restoration of the Great Lakes. Created by a May 18, 2004, executive order,[a] the task force, among other things, coordinates the development of consistent federal policies, strategies, projects, and priorities pertaining to the restoration and protection of the Great Lakes. According to EPA officials, since 2009, the task force has overseen the implementation of the Great Lakes Restoration Initiative (GLRI),[b] a federally led effort to carry out programs and projects for Great Lakes protection and restoration. In particular, the task force has overseen the development of comprehensive, multiyear action plans that identify goals, objectives, measurable ecological targets, and specific actions for four GLRI focus areas. One of these focus areas is reducing nutrient runoff that contributes to harmful/nuisance algal blooms.
Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force)	Through this EPA-led task force, federal agencies coordinate with 12 states and a national tribal representative to address hypoxia in the Mississippi River and the northern Gulf of Mexico.

Source: Excerpted from U.S. Government Accountability Office, *Environmental Protection: Information on Federal Agencies' Expenditures and Coordination Related to Harmful Algae*, GAO-17-119, October 2016, p. 23.

Notes:

a. Executive Order 13340, "Establishment of Great Lakes Interagency Task Force and Promotion of a Regional Collaboration of National Significance for the Great Lakes," 69 *Federal Register* 29043-29045, May 18, 2004.

b. The 114th Congress codified the GLRI in P.L. 114-322, Section 5005. As noted, this provision directed the EPA Administrator to designate a coordinator for GLRI HAB activities.

Regulatory Efforts and Guidelines

EPA and states have also taken steps to address HABs and nutrient loads that contribute to their proliferation through regulatory efforts and guidelines. This section focuses on regulatory efforts and guidelines related to EPA's authorities under the CWA and specifically excludes efforts under the Safe Drinking Water Act.

HABs, Cyanobacteria, and Cyanotoxins

EPA, WHO, and many states have developed guidelines for cyanotoxins in recreational waters.[47] These guidelines are summarized in **Table 6** and discussed below.

Table 6. Summary of EPA, WHO, and State Guidelines for Cyanotoxins in Recreational Waters

Organization	Microcystin	Cylindrospermopsin	Action
EPA	8 μg/L	15 μg/L	Swimming advisory triggered if value is exceeded for one day EPA recommends that when more than three excursions (an exceedance during a 10-day assessment period) occur within a recreational season and that pattern reoccurs in more than one year, it is an indication the water quality is or is becoming degraded such that the water body no longer supports a recreational designated use
WHO[a]	Low < 10 μg/L Moderate = 10-20 μg/L High = 20-2,000 μg/L Very High > 2,000	No guideline	Low: Post on-site risk advisory signs; inform relevant authorities Moderate: Watch for scums or conditions conducive to scums; discourage swimming and further investigate hazard; post on-site risk advisory signs; inform relevant authorities High: Immediate action to control contact with scums; possible prohibition of swimming and other water contact activities; public health follow-up investigation; inform public and relevant authorities
States[b]	0.8 μg/L-20 μg/L	1 μg/L-10 μg/L	Variety of actions, including issuing advisories, closing beaches, and increasing sampling

Sources: CRS analysis from the following sources:

EPA, "Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin," May 2019; and WHO, "Guidelines for Safe Recreational Water Environments: Volume 1," Coastal and Fresh Waters, 2003.

Notes:

a. Low, moderate, high, and very high refer to the probability of adverse health effects. No additional actions were specifically listed for the "very high" probability category.

b. Among the 24 states that have quantitative guidelines for cyanotoxins, these values represent the range of the lowest recreational water guideline or action levels that trigger or recommend a health protective action. For additional information on state guidelines and action levels, see table source 1, pp. 23-25 for a list of the lowest recreational water guideline or action level for each state and Appendix B for a more complete list of state guidelines, action levels, and recommended actions.

[47] EPA has also developed recommended levels for drinking water for microcystin and cylindrospermopsin through health advisories. See CRS In Focus IF10269, *Algal Toxins in Drinking Water: EPA Health Advisories*, by Mary Tiemann.

EPA Guidelines

In December 2016, EPA issued draft recreational water quality criteria or swimming advisories for microcystins and cylindrospermopsin for public comment.[48] According to EPA, these criteria reflected the concentrations of two cyanotoxins that would be protective of human health in recreational waters used for swimming or other activities: 4 µg/L for microcystin and 8 µg/L for cylindrospermopsin.[49] EPA suggested that states could consider using the proposed values when determining whether to post swimming advisories in recreational waters and could consider using the same values when adopting new or revised water quality standards.

Many entities—including states, representatives of publicly owned treatment works,[50] agricultural organizations, and environmental groups—provided comments on the draft criteria:[51]

- Some commenters, including states, were supportive of the criteria for purposes of informing swimming advisory decisions but did not support the use of the criteria for developing water quality standards, noting, among other concerns, that cyanotoxins are not a pollutant discharged into waterways but rather result from other pollutants (nutrients) entering waterways and other factors. Environmental groups generally supported EPA's criteria for use in both swimming advisories and development of water quality standards.
- Commenters' opinions varied regarding the proposed concentrations of microcystin and cylindrospermopsin in the draft criteria. Some states felt the levels were appropriate, environmental groups felt they should be more stringent, and other states suggested they are overly protective, particularly when compared to the WHO guideline for microcystin.

Many commenters—particularly states, publicly owned treatment works, and agricultural groups—expressed a number of implementation concerns. One key concern raised was that these criteria, if used for water quality standards, would improperly regulate response organisms rather than a discharged pollutant. Some argued that algal toxins are not a pollutant that CWA permittees discharge. Rather, the discharge of other pollutants, such as excess nutrients, may lead to HAB formation. In its draft criteria document, EPA explained that it does not anticipate states using the criteria alone for permitting purposes, recognizing that cyanobacteria and their toxins are not typically present in permitted discharges. EPA goes on to say the following:

> Permits are more likely to be written to address point source discharges of the causal pollutants, such as nutrients, on a waterbody-specific or watershed basis, where the permit

[48] As discussed above, CWA Section 304(a) directs EPA to develop and publish and, from time to time, revise criteria for water quality that accurately reflect the latest scientific knowledge. EPA, "Request for Scientific Views: Draft Human Health Recreational Ambient Water Quality Criteria and/or Swimming Advisories for Microcystins and Cylindrospermopsin," 81 *Federal Register* 91929-91931, December 19, 2016. Note this comment period was extended. See EPA, "Extension of Public Comment Period: Draft Human Health Recreational Ambient Water Quality Criteria and/or Swimming Advisories for Microcystins and Cylindrospermopsin," 82 *Federal Register* 10766-10767, February 15, 2017.

[49] EPA, *Draft Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin*, EPA 822-P-16-002, December 2016.

[50] The National Association of Clean Water Agencies, which represents the interests of publicly owned treatment works (i.e., municipal wastewater treatment facilities), provided comments on behalf of its members.

[51] Comments discussed in this section are available in Docket ID No. EPA-HQ-OW-2016-0715, available at https://www.regulations.gov/docket?D=EPA-HQ-OW-2016-0715.

> writer has determined there is a reasonable potential for the causal pollutants in the discharge to cause or contribute to an exceedance of the cyanotoxin standards.[52]

In this regard, some commenters expressed concern that it is not known precisely what level of nutrients will result in a bloom, nor is it understood what factors will trigger the release of toxins. Several commenters suggested that EPA explore these issues further before moving forward with water quality criteria for purposes other than guiding advisory levels for swimming.

Many commenters also expressed implementation concerns regarding monitoring and sampling. According to the Association of Clean Water Administrators[53] many states do not currently have mechanisms in place to adequately sample for the levels of the toxins specified by EPA or lack adequate lab capacity to process increased samples. Some states, publicly owned treatment works, and agricultural groups also commented that the variability of HABs within a body of water and over even short spans of time can make sampling and analysis complicated, particularly when using the data to determine if a water body is impaired. The commenters urged EPA to address these issues in detail before moving forward with the criteria.

In June 2019, EPA announced the final recommended recreational water quality criteria or swimming advisories for microcystins and cylindrospermopsin.[54] EPA's recommended concentrations in recreational waters protective of human health while swimming or participating in primary contact recreational activities on the water are 8 μg/L for microcystin and 15 μg/L for cylindrospermopsin. In the *Federal Register* notice announcing the release of the criteria, EPA noted that, in response to public comments, the agency did not apply a relative source contribution term in deriving the final criteria.[55] Additionally, EPA stated that the primary factor for the change in recommended values was an updated ingestion rate, which reflected a study published in 2017.[56]

WHO Guidelines

In 2003, WHO proposed guideline values for protection from adverse health outcomes associated with cyanobacteria blooms in fresh water used for recreational purposes.[57] The guidelines are defined at three levels: low, moderate, and high probability of adverse health effects. WHO concluded that a single guideline value was not appropriate because "it is necessary to differentiate between the chiefly irritative symptoms caused by unknown cyanobacterial substances and the potentially more severe hazard of exposure to high concentrations of known cyanotoxins, particularly microcystins." **Table 6** shows the WHO guideline levels for microcystin.[58]

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[52] EPA, *Draft Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin*.

[53] The Association of Clean Water Administrators is a nonpartisan, national organization of state, interstate, and territorial water program managers who implement CWA programs.

[54] EPA, "Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin," 84 *Federal Register* 26413, June 6, 2019.

[55] In calculating water quality criteria, EPA uses a relative source contribution to allow a percentage of the exposure to a contaminant to include other potential sources. For the recreational water quality criteria for microcystin and cylindrospermopsin, EPA assumed that all cyanotoxins exposure is from incidental exposure of water while recreating and therefore did not apply a relative source contribution.

[56] EPA, "Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin," 84 *Federal Register* 26413, June 6, 2019.

[57] WHO, *Guidelines for Safe Recreational Water Environments: Volume 1, Coastal and Fresh Waters*, 2003.

[58] WHO also established guidance values for cyanobacteria and chlorophyll-a.

State Guidelines

According to EPA, approximately 35 states have implemented cyanobacterial HAB guidelines for recreational waterways as of March 2018. Some of these states use qualitative guidelines only (i.e., visual inspection for blooms rather than quantitative detection methods) or quantitative guidelines for cyanobacterial cell density rather than guidelines for the specific cyanotoxins.

Of the 35 states that have implemented cyanobacterial HAB guidelines, 24 have established numeric guidelines for microcystin or cylindrospermopsin. The levels and associated actions vary considerably among states (see **Table 6**). California has adopted the strictest concentrations for both cyanotoxins (0.8 µg/L for microcystin and 1 µg/L for cylindrospermopsin). Several states have adopted the WHO value of 20 µg/L for microcystin. Ten states have adopted quantitative guidelines for cylindrospermopsin.

Some states have also added waters affected by algal blooms and algal toxins to their impaired water lists (i.e., Section 303(d) lists) for algal blooms and algal toxins. According to data from EPA's Assessment and Total Maximum Daily Load Tracking and Implementation System, 30 states have listed waters as impaired for algal blooms, and three states—California, Iowa, and New Hampshire—have listed waters as impaired for algal toxins (see **Table 7**). California and Iowa have listed six and one of their waters, respectively, as impaired for algal toxins but have not yet developed TMDLs. New Hampshire has listed 80 of its waters as impaired for algal toxins and has developed 17 TMDLs.[59] The New Hampshire TMDLs use nutrients, namely phosphorus, as a surrogate for cyanobacteria (as well as for some other nutrient-associated parameters such as chlorophyll A and dissolved oxygen in some cases).[60] They establish a total phosphorus loading target that, if met, is expected to achieve state water quality criteria and thresholds for cyanobacteria (as well as for other nutrient associated parameters, such as chlorophyll A, for some of the TMDLs).

Table 7. State Algal Bloom and Algal Toxin Impaired Waters Listings and TMDLs

Cause of Impairment	Number of States	Number of Waters Listed as Impaired	Number of Waters with TMDLs
Algal Bloom	30	1,495	445
Algal Toxin	3	87	17

Source: EPA data from the Assessment and Total Maximum Daily Load Tracking and Implementation System as of August 30, 2019.

Note: These data reflect the most recent assessed waters and impaired waters reports provided to EPA by each of the states, ranging from 2012 to 2018.

[59] According to information provided in a TMDL for Phillips Pond in Sandown, NH, lakes were listed as impaired for swimming if surface blooms or "scums" of cyanobacteria were present—even if present only along a downwind shore. New Hampshire Department of Environmental Services, *Final Total Maximum Daily Load for Phosphorus for Phillips Pond, Sandown, NH*, September 2018, p. 1-1, https://www.des.nh.gov/organization/commissioner/pip/publications/documents/r-wd-18-11.pdf.

[60] New Hampshire Department of Environmental Services, *Final Total Maximum Daily Load for Phosphorus for Phillips Pond, Sandown, NH*. See also New Hampshire Department of Environmental Services, *Total Maximum Daily Load for Hunkins Pond, Sanbornton, NH*, January 2011, p. 1-1, https://www.des.nh.gov/organization/divisions/water/wmb/tmdl/documents/hunkins-pond.pdf.

Nutrient Management

Scientists and policymakers widely recognize the need to reduce nutrient inputs to aquatic systems to limit eutrophication and proliferation of HABs. According to EPA, nitrogen and phosphorus pollution is one of the most serious and pervasive water quality problems in the United States.[61] While EPA and states have worked to address nutrient pollution for over a decade, many observers believe more progress is needed to reduce the threat to water quality and public health. EPA has acknowledged that without greater progress, "the successes to date will likely be outpaced by the rapidly increasing population and the resulting increase in the rate and impact of nitrogen and phosphorus pollution."[62]

According to EPA, as of 2016, 45 states identified nutrient-related pollution as a priority to be addressed by TMDLs and/or alternative restoration plans in setting long-term priorities for their CWA Section 303(d) programs.[63] As of May 2016, more than 8,600 nutrient-related TMDLs had been established, primarily by states, to guide nutrient reduction efforts in more than 5,800 waterbodies.[64]

In 2016, EPA issued a memorandum with a renewed call to states and stakeholders to intensify their efforts, in collaboration with EPA, to reduce nutrient pollution.[65] The memorandum emphasized EPA's support for state planning or implementation of watershed-based, multistakeholder projects to reduce the impacts to public health from nitrogen and phosphorus pollution contributing to HABs. EPA listed and described key elements of its plans for working with partners and stakeholders over the next several years, including prioritizing watersheds and setting load reduction goals, developing numeric nutrient criteria, reducing point sources of nutrient pollution, reducing nutrient loads from nonpoint sources, and providing financial and technical assistance.

For almost two decades, EPA has expressed support for developing numeric criteria for nutrients. In a memorandum issued in 2011, EPA stated that "it has long been EPA's position that numeric criteria targeted at different categories of water bodies and informed by scientific understanding of the relationship between nutrient loadings and water quality impairment are ultimately necessary for effective state programs."[66] To this end, EPA has provided 30 states with technical assistance for numeric nutrient criteria development through its Nutrient Scientific Technical Exchange Partnership and Support Program.[67] As of 2018, 23 states had adopted numeric criteria into their water quality standards for nitrogen and/or phosphorus for at least one of their water

[61] EPA, Office of Water, *FY2016-2017 National Water Program Guidance*, EPA 420-R-15-008, April 2015.

[62] EPA, Office of Water, *Actions to Help States Address Barriers to Numeric Nutrient Criteria Implementation*, EPA 820-F-13-011, August 2013.

[63] Joel Beauvais, Deputy Assistant Administrator, EPA, memorandum to State Environmental Commissioners, State Water Directors, "Renewed Call to Action to Reduce Nutrient Pollution and Support for Incremental Actions to Protect Water Quality and Public Health," September 22, 2016, https://www.epa.gov/nutrient-policy-data/renewed-call-action-reduce-nutrient-pollution-and-support-incremental-actions.

[64] Beauvais, "Renewed Call to Action to Reduce Nutrient Pollution." EPA has approved approximately 74,000 TMDLs in total since 1995 to address impairments from many different pollutant types. See https://ofmpub.epa.gov/waters10/attains_nation_cy.control#tmdls_by_state.

[65] Beauvais, "Renewed Call to Action to Reduce Nutrient Pollution."

[66] Nancy K. Stoner, Acting Assistant Administrator, EPA, memorandum to Regional Administrators, Regions 1-10, "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions," March 16, 2011, https://www.epa.gov/nutrient-policy-data/working-partnership-states-address-phosphorus-and-nitrogen-pollution-through.

[67] Beauvais, "Renewed Call to Action to Reduce Nutrient Pollution."

bodies.[68] In 2013, EPA outlined barriers to numeric nutrient criteria implementation and actions to help states address them.[69] The barriers included, among other things, an inability to reduce nonpoint source loads of nitrogen and phosphorus and problems implementing water-quality-based limits.

EPA has also emphasized the need to focus on reducing nutrients from all sources—both point and nonpoint sources.[70] Under the CWA, EPA has authority to regulate discharges from point sources.[71] However, the CWA does not authorize EPA to regulate nonpoint sources. EPA can influence activities of nonpoint sources only through use of grants and funding—such as CWA Section 319, which addresses nonpoint source pollution through state-run nonpoint pollution management programs—and related technical assistance.[72] Through such programs, states may, for example, ask farmers or ranchers to use alternative methods in their operations to prevent fertilizers from reaching streams and may provide funds to help them install on-farm pollution management systems or practices. In its document addressing barriers to numeric nutrient criteria, EPA proposed actions to address them, including continuing to collaborate with the U.S. Department of Agriculture to leverage resources for conservation practices[73] and to better quantify the environmental results of best management practices and other efforts, continuing to implement the Section 319 grant program, and addressing the challenges of manure management by working with large animal growers and poultry integrators to develop sustainability agreements and practices that reduce nutrient pollution.[74]

Some observers argue that the voluntary nature of controlling nonpoint sources is a key challenge in developing and implementing TMDLs, a primary tool that states are employing to address nutrient pollution. Farming and forestry groups have long been concerned about how their activities might be addressed in TMDLs and whether they might be subject to CWA regulation of some sort, even though the act does not provide EPA with regulatory authority over nonpoint sources. Municipalities and industries contend that regulating only point sources imposes disproportionate requirements on their operations, especially in waters that are impaired both by point and nonpoint sources.

Federal Financial Assistance

Recognizing that a critical role for EPA in addressing nutrient pollution is supporting watershed-based efforts at the state and local level, in its 2016 memorandum, the agency stated that the Office of Water would continue to provide financial assistance to states through CWA Section 106

[68] EPA, "State Progress Toward Developing Numeric Nutrient Water Quality Criteria for Nitrogen and Phosphorus," https://www.epa.gov/nutrient-policy-data/state-progress-toward-developing-numeric-nutrient-water-quality-criteria. Accessed August 14, 2019. Website last updated May 2, 2018. One state (Hawaii) and three territories have adopted numeric criteria for nitrogen and phosphorus for all applicable water types (lakes/reservoirs, rivers/streams, estuaries).

[69] EPA, *Actions to Help States Address Barriers*.

[70] Beauvais, "Renewed Call to Action to Reduce Nutrient Pollution."

[71] CWA §402; 33 U.S.C. §1342.

[72] While the 319 program is voluntary at the federal level, states may include regulatory components in their 319 programs.

[73] A number of U.S. Department of Agriculture agencies provide support through education, outreach, and research, while federal funds are provided through conservation programs to help agricultural producers adopt best management practices for nutrient reduction. Examples of such programs include the Environmental Quality Incentives Program and the Conservation Stewardship Program. For more information see CRS Report R43919, *Nutrients in Agricultural Production: A Water Quality Overview*, by Megan Stubbs.

[74] EPA, *Actions to Help States Address Barriers*.

and Section 319 grant programs and the Clean Water State Revolving Fund (CWSRF) Program, as well as Section 604(b) planning grants,[75] Wetland Program Development grants, and grants targeted toward specific geographic locations, such as the Chesapeake Bay, Great Lakes, and other water bodies. The President's FY2020 budget request for EPA proposes that funding for these programs, with the exception of the CWSRF, be eliminated or significantly reduced (see **Table 8**).[76] The proportion of funds provided to nonpoint source pollution projects through the CWSRF program is relatively minor compared to the amount provided to publicly owned treatment works for infrastructure projects. As reported by EPA, 96% of the cumulative assistance provided through the CWSRF as of 2016 has been provided to publicly owned treatment works; 4% was provided to nonpoint source pollution projects and National Estuary Program projects.[77] It is unclear how, considering EPA's long-standing emphasis on using these programs to address nonpoint source pollution, the FY2019 budget would support the goals of the agency in its efforts to reduce nutrient pollution, and ultimately reduce the occurrence and frequency of HABs.

Table 8 presents a comparison of the President's FY2019 budget request with the FY2016-FY2018 enacted appropriations for selected grants and programs referenced above that include funding support for addressing nonpoint source pollution. These grants and programs are funded within the EPA State and Tribal Assistance Grants and the Environmental Programs and Management appropriations accounts.

Table 8. FY2016-FY2019 Enacted Appropriations and FY2020 Requested for Selected EPA Grants and Programs That Include Assistance to Address Nonpoint Source Pollution

(Dollars in Millions)

EPA Appropriations Acct. and Grants/Programs	FY2016 Enacted[a]	FY2017 Enacted[a]	FY2018 Enacted[a]	FY2019 Enacted[a]	FY2020 Budget Request
State and Tribal Assistance Grants Acct.					
Infrastructure Assistance					
Clean Water State Revolving Fund Program	$1,393.9	$1,393.9	$1,693.9[b]	$1,394.0	$1,120.0
Categorical Grants					
CWA Section 106 Grants	$230.8	$230.8	$230.8	$230.8	$141.8
CWA Section 319 Grants	$164.9	$170.9	$170.9	$170.9	$0.0
Wetland Program Development Grants	$14.7	$14.7	$14.7	$14.7	$9.8
Environmental Programs and Management Acct.					
Geographic Programs[c]					
Chesapeake Bay Program	$73.0	$73.0	$73.0	$73.0	$7.3

[75] CWA Section 604(b) requires states to reserve a small portion of each its CWSRF allotment each fiscal year—1% for most states—to carry out planning under CWA Sections 205(j) and 303(e). States generally use Section 604(b) grants to fund regional comprehensive water quality management planning activities to improve local water quality.

[76] EPA, *Fiscal Year 2018 Justification of Appropriation Estimates for the Committee on Appropriations*, EPA-190-K-17-002, May 2017, pp. 114, 456-457.

[77] EPA, *2016 Annual Report – Clean Water State Revolving Fund Programs*, 2016, https://www.epa.gov/sites/production/files/2017-03/documents/2016_cwsrf_annual_report.pdf.

EPA Appropriations Acct. and Grants/Programs	FY2016 Enacted[a]	FY2017 Enacted[a]	FY2018 Enacted[a]	FY2019 Enacted[a]	FY2020 Budget Request
Great Lakes Restoration Program	$300.0	$300.0	$300.0	$300.0	$300.0[d]
Gulf of Mexico Program	$4.5	$8.5	$12.5	$14.5	$0.0
Lake Champlain	$4.4	$4.4	$8.4	$11.0	$0.0
Long Island Sound	$3.9	$8.0	$12.0	$14.0	$0.0
Puget Sound Program	$28.0	$28.0	$28.0	$28.0	$0.0
South Florida Program	$1.7	$1.7	$1.7	$3.2	$0.0
San Francisco Bay	$4.8	$4.8	$4.8	$4.8	$0.0
Lake Pontchartrain	$0.9	$0.9	$0.9	$0.9	$0.0
Southern New England Estuaries	$5.0	$5.0	$5.0	$5.0	$0.0
Other Geographic Activities	$1.4	$1.4	$1.4	$1.4	$0.0

Sources: FY2016 enacted amounts are as reported in the "Explanatory Statement" accompanying the Consolidated Appropriations Act, 2017 (P.L. 115-31), as published in the *Congressional Record*, vol. 163, no. 76-Book II (May 3, 2017), https://www.gpo.gov/fdsys/pkg/CREC-2017-05-03/pdf/CREC-2017-05-03-bk2.pdf. Under Division G, see the funding tables beginning p. H3922 and p. H3926.

FY2017 enacted amounts are as reported in the "Explanatory Statement" accompanying the (P.L. 115-141), as published in the *Congressional* Record, vol. 164, no. 50-Book II (March 22, 2018), https://www.congress.gov/crec/2018/03/22/CREC-2018-03-22-bk2.pdf. Under Division G, see the funding tables beginning p. H2667 and p. H2671.

FY2018 enacted amounts are as reported in the "Explanatory Statement" accompanying the Consolidated Appropriations Act, 2019 (P.L. 116-6), as published in H.Rept. 116-9. See the funding tables beginning on p. 795 and p. 800.

FY2019 enacted amounts are as reported in the "Explanatory Statement" accompanying the Department of the Interior, Environment, and Related Agencies Appropriations Bill, 2020 (H.R. 3052), as published in H.Rept. 116-100. See the funding tables beginning on p. 212 and p. 217.

FY2020 requested amounts are as reported in EPA's *Fiscal Year 2020 Justification of Appropriation Estimates for the Committee on Appropriations,* March 2019, pp. 150-151, and pp. 543-544, https://www.epa.gov/planandbudget/fy-2020-justification-appropriation-estimates-committee-appropriations.

Notes: Most of these grants provide financial assistance that supports and addresses many water quality improvement projects and other activities in addition to nonpoint source pollution.

a. Amounts presented in the table do not reflect account specific rescissions.
b. The FY2018 enacted amount for the Clean Water State Revolving Fund Program includes an additional $300 million provided under Title IV of P.L. 115-141.
c. Although some of the geographic programs' water bodies are estuarine in nature (outside the scope of this report), their watersheds include freshwater sources. Funding may therefore support efforts to reduce nonpoint source pollution contributions to the freshwater sources.
d. The President's FY2020 budget request initially proposed $30.0 million for the Great Lakes Restoration Program. Subsequently, in a May 13, 2019, letter to the Speaker of the House, President Trump proposed amendments to the FY2020 budget request. The amendments included an additional $270.0 million for the Great Lakes Restoration Program, thus requesting $300.0 million overall for FY2020.

Research Gaps

In addition to the challenges of reducing nutrient pollution contributing to HABs, scientists widely recognize key research gaps that hinder the ability to prevent, predict, minimize, and suppress HABs. In reauthorizing HABHRCA in 2014, as discussed above, Congress directed

NOAA—through the IWG-HABHRCA—to prepare a comprehensive research plan and action strategy to address marine and freshwater harmful algal blooms and hypoxia. The February 2016 task force report[78] includes a discussion of the key challenges in HAB and hypoxia management and discusses the many gaps in the research and management communities' knowledge of HAB and hypoxia events. Federal agencies—including USGS,[79] EPA,[80] and NOAA[81]—and research efforts sponsored by these agencies cite similar gaps and areas needing continuing research. The following text box summarizes some of these key research areas.

HAB Research Gaps

- Ability to predict the timing, species composition, and toxicity of HABs (including the environmental triggers for toxicity)
- More information on the influence that excess nutrients and other factors (e.g., climate) play in the occurrence and distribution of HABs
- Need to strengthen and integrate new and existing monitoring programs (i.e., expand river, stream, and watershed monitoring of nutrients and toxins, coupled with increased modeling information)
- Need to develop standardized and validated detection and analysis methods for algal toxins
- Need for more effective methods for suppressing, mitigating, or controlling HABs
- Need to understand less-common HAB species that produce toxins
- Better understanding of the human health effects of HAB exposure
- Better understanding of the environmental, economic, and social impacts of HABs
- Improvements in public outreach and communication strategies and tools

Legislation in the 116th Congress

Congressional interest in freshwater HABs has largely focused on funding further research, improving monitoring of HABs, and coordinating the efforts of federal agencies and their partners to study and address HABs. HAB-related bills introduced in the 116th Congress include the following:

- S. 10 and H.R. 335, companion bills, would require the IWG-HABHRCA to prepare an assessment and a plan for reducing, mitigating, and controlling HABs and hypoxia in south Florida, similar to what the working group has completed at a national level and for the Great Lakes region.
- H.R. 414 would amend the Robert T. Stafford Disaster Relief and Emergency Assistance Act[82] to include algal blooms in the definition of *major disaster*.
- H.Amdt. 284—included in the House-passed version of the Labor, Health and Human Services, Education, Defense, State, Foreign Operations, and Energy and

[78] National Science and Technology Council, Subcommittee on Ocean Science and Technology, *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy*.

[79] Graham et al., *Cyanobacterial Harmful Algal Blooms*.

[80] Lesley V. D'Anglada, EPA, "Editorial on the Special Issue 'Harmful Algal Blooms (HABs) and Public Health: Progress and Current Challenges,'" *Toxins*, vol. 7 (October 2015), pp. 4437-4441. Also, EPA's solicitation for grant proposals regarding HABs lists specific research gaps the applications should address. EPA "Freshwater Harmful Algal Blooms," Funding Opportunity Announcement Number EPA-G2017-STAR-A1, Office of Research and Development, October 28, 2016.

[81] NOAA, *State of the Science Fact Sheet—Harmful Algal Blooms*, September 2016, http://nrc.noaa.gov/CouncilProducts/ScienceFactSheets.aspx.

[82] 42 U.S.C. §5121 *et seq.*

Water Development Appropriations Act, 2020—would redirect $6.25 million in funding for the National Institute of Environmental Health Sciences under the National Institutes of Health in order to support research into the impact of red tide and other HABs on human health.

- S. 910 and H.R. 2405 would reauthorize and amend the National Sea Grant College Program Act, which would continue to make funds available for HAB research through competitive grants.
- S. 914 would amend the Integrated Coastal and Ocean Observation System Act of 2009. Specific to HABs, the bill would add, as a purpose of the system, a focus on monitoring and modeling "changes in the oceans and Great Lakes, including with respect to chemistry, harmful algal blooms, hypoxia, water levels, and other phenomena."
- H.R. 3297 would amend HABHRCA to clarify that during a lapse in appropriations, certain services relating to the HAB Operational Forecasting System are excepted services under the Anti-Deficiency Act.
- H.R. 3324 would, among other things, require the Army Corps of Engineers to modify operations of projects in central and south Florida to ensure that "public health" overlays all authorized project purposes. The bill defines *public health* to include managing Lake Okeechobee and the central and southern Florida system in a way that minimizes HABs and prevents discharges containing cyanobacteria and their toxins into the St. Lucie and Caloosahatchee watersheds, among other goals.

Conclusion

Recent HAB events highlight the public health, economic, and environmental consequences that communities in the United States may continue to experience, perhaps on a more frequent basis. EPA, NOAA, and other federal agencies are working together to conduct important HAB-related research in an effort to close the gaps in the scientific and management community's understanding of how best to prevent, predict, minimize, and suppress HABs. EPA, states, and their partners are working to identify and restore waterbodies that are affected by HABs and the excess nutrients that contribute to their formation. Congress has passed legislation to help drive and fund research efforts and improve collaboration among the many federal agencies involved in HAB-related activities. Moving forward, Congress may be interested in oversight of the Administration's efforts to implement HABHRCA and other HAB-related authorities. While Congress, federal agencies, and states are taking steps to address HABs, many observers assert that further action is needed to make progress that outpaces the growing consequences of nutrient pollution.

Most observers agree that further research is needed to understand the most appropriate way to predict, minimize, and suppress HAB outbreaks, including whether and how to regulate algal toxins. These advocates assert that Congress should ensure that adequate funding is available for such research. To control HABs, some advocate for regulation of nonpoint source pollution, arguing that point sources are disproportionately regulated and that nonpoint sources are the larger contributors to nutrient pollution. Instead of regulation, some argue that EPA and other federal agencies should continue to focus on collaborative, voluntary watershed-level efforts to address nonpoint source pollution that contributes to HAB formation and that Congress should ensure that financial assistance for these efforts continues.

Controlling nonpoint sources of excess nutrients that contribute to HAB formation is challenging. They are diffuse and pervasive and often attributable to many sources and activities rather than a single cause. Yet, scientists generally agree that the current trends in overenriched waters and HAB events cannot be corrected without addressing nonpoint source nutrient pollution in a significant way and that controlling point sources alone is not enough. Given the consequences of HABs and the difficulty in controlling nonpoint sources of the nutrients that contribute to their formation, challenges and issues associated with HABs are likely to remain of interest to Congress.

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